Pathways for the Indian Steel Sector: Realizing low carbon industrial clusters in eastern India through a place-based approach

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Introduction – reconceptualizing industrial decarbonization pathways – through people and places

There is an increasing realization that effective low carbon growth of our societies requires urgent, broad-scale changes at a systemic level in how we manufacture and consume products (Meadowcroft et al., 2019; Bataille, 2020). One such area of focus is the production of iron and steel, which among heavy industries is the largest source of CO_2 emissions and the second largest energy user, responsible for around 7% of global emissions from the energy system (IEA, 2020). Iron and steel production is heavily dependent on fossil fuels due to the high heat requirements needed in these processes. Furthermore, attention on the potential to decarbonize heavy industry has turned to the global South as these countries serve as engines of growth globally. Steel production serves as the backbone to economies as they industrialize and grow – abundant in contemporary societies as manifested in buildings, vehicles, and infrastructure such as bridges, ports, and railways. To reduce carbon emissions from production processes effectively, nothing short of industrial transformation is required (Nilsson et al., 2021).

In India, for instance, to achieve low carbon steel production, numerous strategies and roadmaps are being proposed that assume rapid and widespread carbon capture utilization and storage (CCUS) and green hydrogen Direct Reduced Iron (DRI) adoption. However, these strategies at the sector level may not be as applicable for certain industrial clusters in India.

At the same time, there are growing calls for 'just transitions'; arguing that typical ways of responding to change (e.g., opening or closing a factory), which emphasize economic growth and profit maximization, exacerbate environmental and health impacts and socio-economic inequities between regions. Often these decisions are conducted in a top-down manner (Upham et al., 2022). For instance, in India, research and analysis on Just Transitions in that context is emphasizing the need for structural transformation of the coal mining sector – including governance reform to realize a comprehensive framework at the national, state, and local level that involves consensus building, socio-economic transformation, and green development (TERI, 2023) and highlighting the social effects of moving away from coal (Pai, 2021). Furthermore, research has focused on potential implications of these changes on certain subpopulations such as women (Singh & Victor, 2023).

Sometimes termed 'transition-vulnerable', or those regions/industries that are high carbon or dependent on high carbon activities (e.g., internal combustion engine automobile manufacturing and steel production) (Canadian Climate Institute, 2021), one study noted that of the 718 districts in India, 120—with an estimated 20 million workers—are significantly dependent on coal or other fossil fuel-dependent industries (Bhushan & Banerjee, 2021).

A focus on steel production in India is important where the sector is responsible for 2% of Gross Domestic Production (GDP) and provides an estimated 2.5 million jobs in India (Government of India, 2017). The sector is relatively heterogenous with wide variety of technologies and sizes/types of firms. Furthermore, steel production is responsible for 272 Mt CO_2 emissions and the sector's emission intensity is high at 2.55tCO_2/t of steel produced due to the low quality of war materials and high contribution of coal for DRI and sub-optimal production capacity. The crude steel production was about 127 Mt in FY 2022–23 and is expected to double (reach 255 Mt) by FY 2030–31 (National Steel Policy, 2017; Annual Statistics, 2022–23).

Building upon this approach, our research distinguishes itself by **focusing on people *and* geographic settings or places**. It does so firstly through focusing on **industrial clusters** (versus technology and/or sectors). For example, when looking to decarbonize industrial clusters, a focus on industrial workers, estimated to be 23% of workers globally (Rattle et al., 2023) as well as everyone else affected in the clusters, such as communities, families and people providing goods and services to the workers is therefore key. Furthermore, there exists a juxtaposition around industrial clusters. On the one hand they are highlighted as being key sources of economic growth, while on the other hand they have often been treated as 'sacrifice zones', or places that are often neglected and stigmatized. These areas—and the people that live there, who are often lower income and from groups marginal within society—suffer so that the economy can grow (Lopes de Sousa, 2020). These clusters often face environmental issues without reaping the bulk of economic benefits at the local level. This approach also occurs to the whole area—plants, animals including humans, infrastructure such as roads, and the biosphere. Ecosystems which are not considered to be worth the attention of authorities. These industrial zones are often sanctioned by governments, who designate them as industrial zones even though people and ecosystems—forming long-standing identities—have been in existence in these places over generations (Lopes de Sousa, 2020).

Secondly, the research also highlights the role of geographic settings or places in which these changes are set to occur. For example, any movement away from coal in India will have the most impact on central and eastern states of the country. The most vulnerable states will be West Bengal, Chhattisgarh, Jharkhand, Madhya Pradesh, and Odisha (Dsouza & Singhal, 2021). Using a **place-based approach**, recognises that industrial clusters are also places that many call home and conjure a sense of identity; acknowledging that people develop attachments to these places, providing a sense of identity and belonging (Devine-Wright, 2022). In addition, visual public spaces and objects are more than 'things' (Thomas, 2022) but are intwined with people's identity to a place. Place attachment, where people have emotional cognitive bonds to places (physical settings, activities) takes time to develop (Mondal & Mistri, 2021). This also highlights the important role that history can play in ascertaining a region's propensity to accelerate or hinder energy transition efforts. Economies that are centred around high carbon industries that are entrenched, will be more 'locked in' to these pathways (Unruh, 2000).

The approach also acknowledges the social and psychological implications of forced change from a location. For instance, Asia is the continent with the highest rate of displacement where people are forced to relocate (even if monetarily compensated at times). In India, 77% of displacement is caused by industrial activity (Mondal & Mistri, 2021) and between 1950–2000, ~ 60 million people have been displaced or affected by projects in the country and at least 40% of these people are Adivasi and 20% Dalits and only 25% have been rehabilitated (IWGIA, 2022). Moreover, people living and working in these places have often developed a series of specialized skills, networks and supply chains as these clusters have grown alongside transportation and infrastructure developments, often tailored to those industries (Rattle et al., 2023). This is important as the ability to adapt to current vulnerabilities requires building on the specific resources, assets, and capacities of individual regions (or places) (OECD, 2020).

The call to achieve low carbon industrial growth, while concurrently being attentive to the socio-economic and environmental implications of doing so, highlight the immense challenge faced by decision makers; a situation particularly acute in a fast-growing economy such as India. How can we design and recommend policy options for low carbon growth of steel industry clusters that are effective and inclusive?

To look at place-based approaches as concrete ways in which to make green industrial transformation without exacerbating socio-economic and environmental disparities a reality, information was collected from key steel clusters surrounding the Chota Nagpur plateau. Our case studies include steel clusters in West Bengal (Durgapur), Jharkhand (Giridih), and Chhattisgarh (Raipur). Team members from TERI and Carleton worked with a local survey agency with previous experience in the region (MART Global Management Solutions, Kolkata). Methods include surveys, focus group discussions (FDGs), and interviews with key informants such as formal/informal industrial workers, supervisors/ technicians, executives/ engineers, industrialist/factory owners, local NGOs/community groups/ SHGs, and representatives (DIC, MSME-DFO, etc).

Results – across clusters

- **Energy transitions will also have profound effects on downstream sectors heavily reliant on fossil fuels.** To date, the bulk of studies in India around just transitions tend to highlight the anticipated effects on the upstream sectors of fossil fuels, such as coal mining. In addition, energy transitions will also have profound impacts on the downstream sectors, or those heavily reliant on fossil fuels within their production processes, such as steel production.
- **Cost** is paramount for industry while for workers, key issues are low wages, job security, health and safety, contractor code of conduct.
- **Little to no awareness of energy transitions**, moving away from coal, from workers, while for industry, degrees of awareness varied.
- **Implications of decarbonization efforts will be most pronounced at the local/district/regional levels**. Millions of workers in the steel industry whose livelihoods depend on the transportation of coal for the industry, loading/ unloading of coal, or burning of coal for DRI, are at utmost risk during the transition in India – the implications of which will be most pronounced at the local/district/regional levels. The energy shift will lead to significant job losses among the coal-dependent industries causing economic downturns in affected regions. Local communities built around the coal industry in the region will face displacement and workers will struggle with skills mismatches while transitioning to new sectors.
- **Many workers are particularly vulnerable in the clusters**. There is a high percentage of contract and unskilled workers (termed helpers)—or workers who lack job and social security, often have lower wages, lack health benefits and legal protection, etc. (Law, Lawyers, and Legal

Resources, n.d.)—in the clusters and worker benefits have generally decreased over time. This is part of a trend seeing an increase in contract workers (in the manufacturing sector) in India. Furthermore, vulnerable workers (contract or 'off-role' workers and without formal training for their skills) often undertake **more hazardous activities** such as heating the furnace, removal of slag and melting of raw material; a facet also noted in other studies on manufacturing in India (Dsouza & Singhal, 2021). Skills are mainly learned on the job (experiential) versus through formal education. There is no organization focusing on increasing awareness or skill development of the workers in these areas.

- **Existing economic growth model has brought some benefits to the clusters but, at the expense of others such as health and well-being of workers/communities and local environmental quality**. Like many parts of the world, one could argue that these industrial clusters have historically and/or contemporarily served as 'sacrifice zones' in India, where these regions face disproportionate negative effects (health, environment, less social and economic support for workers/families), without receiving as much socio-economic benefits at the local level. For example, discussions with informants in Durgapur highlighted deteriorating air quality in the region after the opening of factories in the region and they did not consider agriculture to be a viable economic alternative option there.

Results – between clusters

- **Rules and regulations (e.g., environment, worker well-being) and level of awareness of rights/ programmes varied depending on the cluster.** For instance, Durgapur exhibited relatively better work conditions such as job security, employment opportunities, awareness levels, literacy rates, daily wage rates, working hours, and benefits. In general, employment conditions are found to be less favourable than Durgapur for workers in Raipur and Giridih, although specific nuances varied from factory to factory.
- **Understanding history, identity and local socio-economic dynamics can help determine propensity for change.** For example, in Durgapur, West Bengal (WB), the state possesses a history of active workers movements and generally workers are slightly more educated and more aware of their rights. Furthermore, the central and state governments have a noticeable presence in Durgapur. There also exists a broader suite of social government programmes in WB such as 'Duare Sarkar' or government at your doorstep. Although the local economy is heavily dependent on carbon, the region is larger, urban, and more economically diverse and possesses lower carbon alternatives (e.g., the Dobhi-Durgapur natural gas pipeline). The Durgapur Steel Plant of the Steel Authority of India (SAIL) has been a foundational presence in the cluster since 1959 where steel has become a strong identity of the place.
- In Giridih, Jharkhand, carbon and mining have played a prominent role for a long time in the local economy. At the same time, in Giridih—where famous Indian poet, philosopher, and writer Rabindranath Tagore spent time— identity is also intertwined with special cultural, spiritual, natural significance such as Khandoli Dam-cum-Park, Usri Falls and Jain temples at Parasnath Hills nearby. Here, there is strong place attachment, where coal, mining and industry are important to the local economy in this 'land of the forest' state. Having a strong place attachment can accelerate (e.g., if change is seen as improving the place) while concurrently hinder transitions (e.g., if changes are viewed as having a negative role) (Cowell, 2020; Thomas, 2022).

Policy recommendations

- **India's efforts towards net zero must be attuned to local context**. The steel industry is a key employer in the Chota Nagpur Plateau, and another industrial cluster for steel is Raipur district in Chhattisgarh in central India— where public and private sector steel majors hold operations as well as a plethora of micro, small and medium enterprises (MSMEs). There are less economic alternatives available in the industrial clusters in the region. For example, given the important role of the Durgapur Steel Plant to the local economy and place, it will be important for the plant to weather any transition.

- This means that **interventions and policies must be targeted and must not exacerbate existing regional inequities**. To ensure equitable and sustainable development to improve the overall well-being and livelihoods of workers across industrial clusters it is important to design and execute strategies and actions that are appropriate for that particular cluster. For example, as the identity in Durgapur is around steel versus coal, transitioning away from this fuel may be more feasible. At the same time, it will be important for governments to provide support for SAIL, which plays an outsized role in the local economy, where SAIL's Durgapur Steel Plant, dubbed '[temples] of the working class' (Thomas, 2022) serve as a dominating anchor to the local economy. The Public Sector Undertaking (PSU) could be a frontrunner but will also need to withstand risks. Alternatively, in Giridih, Jharkhand, a smaller cluster in a more rural/less economically diverse area, given the long-standing history of coal mining and the important role of industry there, combined with the fact that the cluster is surrounded by places of significance, pursuing energy transitions here will require more care so that these special places are less subjected to change and so that the area which has suffered from previous transitions (e.g., Forest Act which made mica mining illegal and more automation of coal mining in 1980s/90s) does not suffer again.
- **Systemic approach to industrial clusters with mutually reinforcing strategies needed.** Also, as coal/carbon is deeply ingrained in the culture and more entrenched, and plays an important role for industry, for energy transitions to be effective, decarbonization efforts must concurrently support moving away from coal through incentives such as innovation and technology (carrots) and regulations (sticks) (termed deliberate decline – Rosenbloom & Rinscheid, 2020) that can bring local benefits such as local pollution reduction (Bataille, 2022). Other researchers also highlight the importance of undertaking a systemic approach; arguing that these transitions are not limited to shifting of fuel and technology but also involve forming an economy that includes reskilling/upskilling of workers, and institutional and strong policy interventions, to facilitate the use of low-carbon technologies (Janardhanan & Tamura, 2020; TERI, 2023).
- **Relatedly, efforts aimed at energy transitions must include local/regional benefits** (such as support for alternative livelihoods and training/skill provision and social supports). Policies need to be formulated at two levels, one at the national level and the other at the local level for district and local bodies. The policy for local level should be tailored to the regional and local needs and aspirations. For instance, models to explore further include India's District Mineral Foundation (DMF) (TERI, 2023) and Canada's experience with Indigenous populations and community benefit agreements or impact benefit agreements (Irlbacher-Fox, 2009) and co-management boards (White, 2020) where settler and Indigenous governments and firms work together. In Texas—arguably the heart of the oil and gas industry for the country—the state is also a key producer of wind power where there is little opposition as the specific risks and benefits between the relevant parties are laid out clearly (Branstromm, 2024).
- **Industries and workers who are most vulnerable to energy transitions must be prioritized.** Within industry, support for MSMEs and smaller clusters is key. Policies must take into account key stakeholders with special emphasis on vulnerable sections such as informal workers, women, and children. For workers, strengthening skill development programmes in developing countries—where those employed in fossil fuel sectors have historically had limited educational opportunities—will be of utmost importance. Necessary funds should be mobilized through DMF or other such source.

- **A robust policy framework is needed to help upskill and reskill workers who are at risk of losing their jobs**. There is a robust framework for skilling which encompasses ITIs with whom focussed tie-up can be established. Also, it would be useful to identify the relevant Skill Sector Councils for skilling and entrepreneurship. A platform that facilitates investment in such alternative business units with support from SIDBI should be developed. Moreover, it will be critical for the government to monitor and evaluate the implementation of this programme on the ground and for the various levels of governments to work with each other and firms to ensure that these programmes are attuned to meet the needs of workers and firms that live and work in the region, respectively. For example, switching from coal to gas for sponge iron making will require complete technology shift from a horizontal kiln that uses coal to a vertical one that uses either natural gas and/or hydrogen. This will require a different set of skills for operators and technical staff. Acknowledging this need, the Ministry of Steel in India has created a separate task force on this topic, where skilling has been identified as an opportunity to avoid widening inequalities during the transition.
- **Support to cultivate alternative economic opportunities within the steel clusters is required.** Both the central, state, and district governments ought to support the diversification of the regional economy by investing in alternative sources to generate income within and surrounding the clusters. Examples include renewable energy, tourism, agriculture, animal husbandry, and the cultivation of other products from forests. A diverse economy can help to provide alternative livelihoods to vulnerable workers. The government should quantify the investments needed for alternate livelihoods and just transition. This estimation will act as an important narrative for financing just transitions as these numbers can provide a sense of the budget required for assisting alternate economies. In addition to government support, private banks can also mandate funding for projects that address climate change (with appropriate verification mechanisms). Given their important role in the economy, they can provide credit to projects, specifically looking at the social dimensions of the transition. For instance, projects working on reskilling labour for alternative employment generation. Other studies also highlight that financial commitments from both the public and private sectors will provide a safety net for vulnerable workers (Bhushan & Banerjee, 2023). Although, the study focused on secondary steel clusters like Durgapur, Giridih and Raipur, the policy recommendations are broadly applicable for many other coal-based industrial sectors/clusters in India that face similar energy transition challenges. It would help to do a gap analysis and identify the most effective options and policies in different situations so that modifications could be made in the suggested way forward.
- **Facilitate transfer of low carbon technologies through national and international initiatives**. Government has a key role to play in facilitating access to low carbon technologies available in other parts of the globe for local industries and supporting its wider adoption. For instance, bio char as an alternative fuel source would require handholding policy of Government. Further, local adaptation of the transferred technology should be incentivized through funding provisions like a technology access fund.

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