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What is stopping India's rapid decarbonisation? Examining social factors, speed, and institutions in Odisha

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ABSTRACT

To avoid the worst effects of climate change, the world needs to phase out fossil fuel use rapidly and at scale. While there is increasing attention to the temporal dynamics shaping country-specific transition challenges, sub-national level assessments of transition implications, especially in the Global South remain critically under-studied. This is an area of increasing significance due to the highly localised nature of the complex social institutional context shaping global energy futures. India presents a particularly challenging setting for a smooth energy transition. It has one of the world's most ambitious renewable energy development plans. At the same time, its reliance on coal – for reliable and affordable energy, to support its economically upward movement – is expected to continue for several decades. This paper analyses potential bottlenecks to India's decarbonisation plans drawing on a case study in the eastern state of Odisha. It considers coal's deep ties with local and regional economic, industrial, political, and social institutions, that have caused India's sub-national political economies to be deeply complex and multi-dimensional. The paper highlights significant bottlenecks that may threaten India's efforts towards rapid decarbonisation, and presents potential pathways forward.

1. Introduction

Coal as an energy source is critical to the global decarbonisation narrative. Its continued use or abandonment will significantly influence the outcomes of our combined action on climate mitigation over coming decades. The Paris Agreement established a universal ambition to keep the increase in global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the increase to 1.5 °C. The world's reliance on fossil fuels needs to reduce heavily and rapidly in favour of other alternatives, to sustain any hope of achieving that ambition [1]. Yet, coal use remains alarmingly high, driven largely by growth in coal generation investment in developing Asia, where coal consumption has more than doubled this century [2].

In many ways, well-intentioned government efforts around the world to underpin living standards with reliable and affordable energy services have created path-dependencies which have the potential to prolong the use of coal. As argued by several scholars [3–5], a transformative shift in innovation, grounded in social practice can, to some extent, counteract these path dependencies. However, such ideas call for substantial, complementary investment of resources in R&D, infrastructure development, and large-scale industrial transformation, never seen or experienced in history at the scale and pace now urgently needed [6–8].

Furthermore, carbon mitigation entails, among other things, fundamental behavioural, political and economic shifts across institutions, and public and private energy producers and users [9]. Such shifts could potentially be resisted if they conflict with development agendas, thereby slowing the pace at which the world needs to decarbonise [10,11]. For these reasons, countries in the Global South find the tension between decarbonisation and development particularly difficult to navigate, often forced to choose 'between imperfect alternatives' [3,5,7]. Paradoxically, it is also these regions – emerging economies with an increasing share of the global energy use – where the biggest and the most rapid shifts in energy patterns are needed globally. India is a compelling case in point. It is a key player that, together with China, will significantly influence the world's decarbonisation trajectory. With a third of its population living in poverty (< $3.2/ person/day), it has some of the world's most pressing development needs. Its global share of energy use continues to expand with some outlooks predicting it to experience the world's largest growth in energy consumption between 2000 and 2040 [2]. With coal at the heart of its energy narrative, India's decarbonisation challenges are without doubt, complex and multi-dimensional [12].

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Within the energy transitions space, a large part of the research focus has remained on techno-economic policy design and implementation with increasing attention to the temporal dynamics shaping country-specific transition challenges [9,13]. At the same time, there is acknowledgment of an urgent need for sub-national level assessments of transition implications [14], including institutional bottlenecks and social factors, particularly for coal dependent regions [7,15]. The impact of potential closure of the coal industry on regions with strong historical and cultural identities shaped by the presence of the resource remains critically understudied. Some progress on this front is evident in the OECD: notably across Europe, including Poland [16], Germany [17], the UK [18], and the Czech Republic [19] and the US [20]. Comparable studies of sub-national transition complexities in the Global South however, remain absent [5,21]. The paper contributes to this research gap by focusing on India's sub-national transition challenges. We argue that localised insights into the sub-national political economy of transitions is pivotal in facilitating coherent national policy efforts.

Furthermore, these localised insights allow 'ground truthing' regional economic and institutional transition readiness against ambitious decarbonisation targets set by India's policymakers nationally [22]. Although critical and necessary, the socio-economic viability of rapid energy system transitions remains uncertain [9]. For example, some projections see India retiring its coal fleet at half their usual retirement age [23]. A pro-active assessment of bottlenecks and unintended consequences that may likely emanate from India's coal bearing regions, and resist a low-carbon energy transition, is critical in deepening our understanding of the transitions dynamics.

This paper, therefore, has a two-fold purpose: firstly, to unpack the links between global expectations for India to decarbonise rapidly and at scale, and the potential risks to the well-being of regional governments and communities living across its vast coal heartland. Secondly, to understand how, if at all, a deeply entrenched coal identity may manifest in a variety of economic, institutional, industrial and social bottlenecks that could run the risk of slowing down India's efforts towards rapid decarbonisation [21,24].

2. India's transition challenges in the global energy context and lessons from other regions

The world acknowledges a 'fundamental shift that is taking place in the geography of global energy demand towards developing economies' [25] (Table 1). Rising energy and coal demands from China and India carry significant implications for global climate targets. Any increase in energy demand that is not met from a decarbonised resource threatens our collective sustainability and pushes the Paris targets further afield.

The expectation for India to decarbonise its energy services, and to do so rapidly and permanently, without compromising its national social and economic development targets is unprecedented in modern history. In particular, the central role of coal cannot be overstated, as India's coal demand between 2018 and 2040 is projected to see the biggest increase of the four critical world regions. These global estimates are supported by India's own assessment of coal continuing as the mainstay of its energy growth plans for the foreseeable future [11]. As a case in point, for 2021–22, coal's share in India's total installed capacity remains at 45%, with an additional 8,600 MW of coal plants under construction [28]. This aligns with the IEA's estimate of India's coal power generation increasing by 4.6% annually through to 2024 [30].

Despite India's absolute growth in both energy and coal demand, its per capita emissions remain modest when compared with those of other energy-intensive world regions [31]. On the one hand, this provides some relief in terms of perhaps a less-aggressive interaction between India's decarbonisation plans and its development trajectory. On the other hand, India's infrastructural, industrial and technological choices around energy use are set to spark growth in electricity demand which will, in turn, extend the country's already growing energy footprint.

Table 1
Global energy and coal demand (2017/18–40) .

	Energy demand (EJ, exajoules)	*Coal demand* (Mtce)*
	(%) change (2017–40)	% CAGR (2018–40)
US	2%	−2.3
EU	16%	−5.7
China	21%	−0.4
India	**90%**	**3.1**
World	20%	−0.1

*According to IEA's Stated Policies Scenario (SPS) which considers the full suite of policies already announced by 2019 alongside the evolving nature of technological investment to present a plausible energy future.
Source: [26,27]

2.1. The outlook for India's power sector

India's power sector remains heavily skewed towards thermal capacity, mostly driven by coal, with a smaller contribution from gas. Renewable energy, on the other hand, is a critical feature of India's evolving power landscape and includes small hydro, biomass, urban & industrial waste, solar, and wind resources (Table 2).

It is projected that the share of electricity in India's energy demand will rise from 17% in 2014 to nearly 26% by 2040, while per capita electricity consumption will more than triple in this period. India is already the world's third largest electricity market, with escalating power sector demand from the buildings sector, and a rising middle class demanding higher appliance ownership. Consequently, India's total electricity capacity is expected to rise nearly six times from its 2012 level to approximately 1,230 GW by 2040 [29] whilst the peak electricity demand by 2030 is set to increase by 50% compared to 2021–22 [28]. This increase will rely heavily on coal, thereby causing a sharp surge in power sector-related CO_2 emissions by 2040, making India the world's second largest GHG emitter after China [27].

To counter this rise in CO_2 emissions, India has one of the most ambitious renewable energy expansion and development plans globally (Table 2). By 2022, the government has set a renewable energy capacity target of 175 GW that includes 60 GW of utility-scale solar, 40 GW of rooftop solar, 60 GW of wind, 10 GW of bioenergy and 5 GW of small hydro. In addition to this, India's decarbonisation plans also include expanding nuclear capacity from 7 to 19 GW by 2030 [28,33]. India's Nationally Determined Commitments in response to the Paris Agreement are a further testament to its significant energy ambitions [34]. The feasibility of the pace at which the government is hoping to operationalise these renewable and nuclear energy targets however, remains to be verified.

As such, it is reasonable to suggest that India's decarbonisation

Table 2
India's projected electricity generation by fuel mix (2040) .

Electricity Generation (TWh)				
Fuel source	*2012*	*2019–20*	*Average 2040**	*2040 share of total (%)*
Coal	708	1132	2295	48
Gas	115	71	242	5
Nuclear	27	46	200	4
Hydro	144	174	286	6
Solar (PV + CSP)	2	50	600	13
Wind (On-shore + Off-shore)	32	66	483	10
Other	46	55	557	12
Imports	5	n/a	99	2
Total	1,079	1,594	4,762	100

*average of NITI Aayog's Business-As-Usual and Ambitious scenarios – based on varied levels of demand side energy efficiency and technological measures.
Source: [29,32]

ambitions may be vulnerable to several technological, socio-economic and institutional bottlenecks. A number of these challenges have already been observed and documented elsewhere [11,35–37]. These include, inter alia, grid integration challenges, further exacerbated by increasing renewable energy penetration; underdeveloped manufacturing capacities; existing grid issues (e.g. T&D losses); slow government approvals; unrealistic timelines; policy inaction on maintaining grid balance; renewable energy's limited role in meeting peak power demand; and lack of investments in clean energy finance, particularly in solar-thermal power (CSP) development [38].

2.2. Transitioning from coal: Lessons from other world regions

The way various countries, regions, and communities dependent on coal and coal mining continue to navigate energy transitions has been a critical area of research over the last decade. Studies across Europe [39,40] and the United States [20,41] provide insightful localised experiences that may well inform India's current and future policy efforts towards decarbonisation. These studies remind the force of underlying resource regionalism[1] in shaping socio-economic and institutional interactions between politics, resources and communities in a rapidly shifting discourse on energy transitions [43].

As argued elsewhere [44], a region's energy transition is 'also a social process' where identity, belongingness, and democratic deficit are critical narratives to be optimally managed. Darby [18] argues in her study of former coal-producing communities in Scotland that ultimately, energy transition is 'not a uniform process but one influenced by space and time rooted in localised geography and history'. This dynamic process is particularly relevant to India as it navigates its 'latecomer' status in scripting a multi-pronged decarbonisation trajectory [3].

Furthermore, diverse actors play their part in enabling or blocking pathways to a successful transition. On the one hand, Osička et al [45] outline, for example, the divisive role that media continues to play in shaping narratives around the future of coal in Europe, most notably across Germany, Poland and the Czech Republic. On the other hand, Kuchler and Bridge [40] highlight how political elites across Poland continue to take pride in the 'coal for prosperity' mantra with little regard for broader EU climate and energy policies. By considering coal as an 'instrument of …[reimagined] modernity', they highlight its potentially enduring role as 'a core tradition through which Poland's present has been secured, and that may yet be reassembled and transformed into something new and potent that can continue to sustain the nation.'

As also noted in Germany [46], widespread political support for coal as well as limited effectiveness of public protests to coal projects have been some of the most significant factors leading to a national 'dash for coal'. As one of the world's most developed nations with communities both aware and empowered, Germany's struggle with tackling coal resurgence is noteworthy. This sentiment is shared by Černoch et al [47] who note in their framings of coal narratives that coal stances truly divide societies along ideological orientations. The latter often lead actors with seemingly aligned views on coal to take opposing positions for a variety of reasons. This has valuable resonance for policy makers to grasp the full range of views on an issue as divisive as coal. The Czech Republic is a particularly interesting case in point where place attachment on the one hand, drives anti-coal sentiments while deep-rooted attachments to job opportunities on the other hand, impede the chances of phasing out coal mines in the country [39].

In this context, a localised, spatially-targeted scheme that addresses potential impacts on local communities is vital. In a study of socio-economic vulnerabilities confronting coal dependent communities in the US, Snyder [20] argues that although such programs may be an expensive solution to start with, they are likely to ensure a fair, just and smooth transition in the long-term. This need for rigorous thinking and discussion on the concept of 'just transitions' is reiterated by others [48,49]. While there is some indication that certain coal communities in the US may have already transitioned to life beyond coal [41], such cases remain few and far between.

Decarbonisation in India as a 'social process' is particularly difficult to map. There has been a long history of bi-partisan support for coal and allied industry in the country's mineral-rich belts. At the same time, communities across these regions continue to struggle with widespread socio-economic and institutional marginalisation. The three 'problem[s] of collectives, expertise and institutions' in discussing Africa's tryst with energy transitions is likely to find tremendous resonance with coal phase-out decision making in regions across India [50]. An energy system thriving on coal provides a powerful socio-technical boost for India's coal regions in much the same way as it has for over five decades in Poland [40] or the American West [51]. Lahiri Dutt's [52] study on the value proposition of coal in India, including its perceived role of nothing less than a 'national treasure' is poignant in understanding how post-British India continues to take pride in, and rely on, coal for material development.

What these experiences from across the world demonstrate is a multilayered, complex landscape of energy systems that calls for newer, more accommodating systems of energy production and use that are cognisant of local values and place-based realities [53]. For India, achieving these shifts is not as straightforward due to a reluctance to change, manifesting in a suite of 'distortions' across coal production, grid integration and supply [11]. These distortions are particularly pronounced – as noted above – in coal-intensive mining regions, resulting in a range of social barriers and grassroots resistance points, thus influencing future energy transitions. This paper identifies key bottlenecks and explores how they shape and inform local, regional and national relationships with coal ecosystems. We achieve this through a case study of India's largest coal mining region in the state of Odisha.

3. Methods

The research draws on a qualitative case study of Talcher coalfields in Odisha's Angul district – one of India's fastest growing industrial hubs [54]. The research design and data collection methods were carefully chosen keeping in mind the complex – and potentially, even provocative – research questions the paper sought to ask in a socio-economically and politically charged case study region [55]. At a deeper level, the research design allowed what Goodman and Marshall [56] refer to as 'engaged on-the-ground investigation'.

An initial reconnaissance visit to Talcher took place in October 2018. This visit was useful in establishing a broad understanding of the socio-economic landscape of the mining region as well as making contacts with a local in-country partner, the Foundation for Ecological Security (FES). The authors have had a long-term international collaboration with FES over several student-led PhD fieldwork visits and joint publications. Our past relationship with FES demonstrated excellent professional and ethical integrity. FES also had a strong track record working with communities and governments in and around Angul on a number of energy, forestry, and livelihood issues.[2] Their well-respected ongoing work in Angul combined with our past productive collaborative experience provided the primary researcher immense confidence in undertaking extended fieldwork in a foreign – on occasion, even isolated and risky – coal mining region. In designing the research and identifying field interlocutors, the primary author was particularly cognisant of several ethical dilemmas reported elsewhere [57].

[1] Mostly discussed in the context of the oil economies of the Middle East, resource regionalism refers to communities in resource-rich regions demanding a greater, fairer share of resource revenues [42]. If improperly managed, it may further spatial inequalities and manifest in deeper disadvantage and marginalisation for the local population.

[2] http://fes.org.in/includeAll.php?pId=My00MS0z

Primary data collection was conducted between December 2018 and January 2019 in the region indicated in Fig. 1. Two methods for data collection were employed: semi-structured, qualitative in-depth interviews; and focus group discussions. These were chosen in light of our research aims and the methods' inherent ability to support an exploratory, inductive deep-dive into key objects of inquiry [55,58]. Interviews allowed targeted discussions, including on topics that were otherwise limited to deliberations in closed circles in the local dialect of Odia. Interviews thus provided a salient opportunity to harness the informants' deep knowledge of the local political economy, as well as the links between coal mining and local and state development agendas.

In total, 25 in-depth interviews were conducted, in a combination of English and Hindi. Each interview lasted between 45 and 90 min. The nature of the research questions dictated that interviewees represent three key stakeholder groups: government (including, senior local and state bureaucrats, current and recently retired); industry (public and private) and civil society (including academics, journalists and local activists) (Table 3a). Interviews were conducted in Bhubaneswar (state capital) and Angul. Detailed notes were taken and subsequently synthesised to draw common themes for final analysis. All data was collected in accordance with The University of Queensland's Human Research Ethics Guidelines.[3]

Additionally, focus group discussions (FGDs) were undertaken in two of the three mining-intensive blocks[4] of Angul district. FGDs have been noted as helpful tools in energy social science research and have found relevance in research concerning energy transition in coal regions [41]. To optimise time and resources available in the field, FGDs offered a powerful methodological instrument to understand a wide range of community perspectives around coal mining and potential coal phase-out in the region. Importantly, these discussions highlighted – both to the researcher and amongst participants – interpersonal divergence in views on mining, employment, social-political risk perceptions and future development aspirations [59]. In doing so, the discussion reiterated the scale of heterogeneity and complexities underlying local narratives on the coal-development nexus, thereby highlighting what Jasanoff [10] refers to as globally 'unsettled ethical conundrums'.

The locations for these FGDs were guided by consultation with FES field staff, district collector's office, and a review of current and planned mining activities in the region. The first FGD was undertaken in Talcher Block which has had a long history of coal mining and continues to host large scale mining operations. A second FGD was organised in Chhendipada Block which has hosted mining activities in the past and whilst there are no active mines, widescale land acquisition and resettlement discussions are underway in anticipation of mining resurgence in the near future (as highlighted in multiple field interviews).

29 people participated across the two FGDs that lasted between 60 and 75 min (Table 3b). Both were audio recorded and conducted in a combination of Hindi, English and Odia. A local research assistant helped with Odia to Hindi translation where necessary; the first author being fluent in Hindi. The FGDs were conducted at the village school in one location, and the local village council office in the second location. Participation was voluntary and participants were recruited in consultation with the village chiefs, who were, in turn, proposed by the local government designate to be the primary gatekeepers for their respective areas. Where possible, balance across participant gender, age and livelihood activities was sought. Despite these efforts, the FGD in Chhendipada mostly had male representation from the village as the local gatekeeper displayed hesitation in including women. He defended this stance by arguing that 'mining jobs and businesses were primarily men's responsibility' and that the women residents were satisfied with men representing them. This observation – whilst beyond the immediate control of the researcher and her field interlocutor – strongly aligns with other scholarly work examining gendered marginalisation across Talcher coalfields [54].

[3] https://www.nhmrc.gov.au/about-us/publications/national-statement-ethical-conduct-human-research-2007-updated-2018#toc_155

[4] Each district in India is divided into several administrative sub-divisions. Angul has 8 rural blocks.

4. Setting the scene: Significance of coal for Angul and Odisha

Throughout India's economic history, coal has offered a reliable, secure, and affordable lifeline that has, in turn, led to a strong cultural and social identity for communities in coal-bearing regions. As a national resource, coal has critically shaped the political economy of at least four eastern Indian states, namely Jharkhand, Odisha, Chhattisgarh and West Bengal, where more than 70% of India's coal reserves are found (Table 4) [11,24,60].

Of these states, Odisha is a particularly interesting case. It has had a largely stable political history focused on development through industrialisation [61]. The presence of mining and links with other coal-dependent industry in the state dates to the early 1900s. Odisha's economic development opportunities are also bolstered by large endowments of other minerals as well as a strong industrial base. Besides coal, Odisha hosts 96% of India's Chromite reserves, 53% of national Bauxite and 35% of Iron reserves (leading to a quarter of India's total steel production) [62]. The presence of abundant coal and other mineral reserves together with a pro-industry state policy has triggered the establishment of a suite of allied industries – steel, cement, fertiliser and bauxite smelters – all critically dependent on cheap coal for power [63].

This heavy reliance on industrialisation however, continues to be confronted by Odisha's low HDI rank, high poverty rate (higher than the all-India average), deep-rooted marginalisation of vulnerable communities (particularly, Indigenous peoples, the Scheduled Tribes), and a consistent institutional failure to recognise, and support, its agrarian economy upon which the majority of its labour force (56%) depends [61].

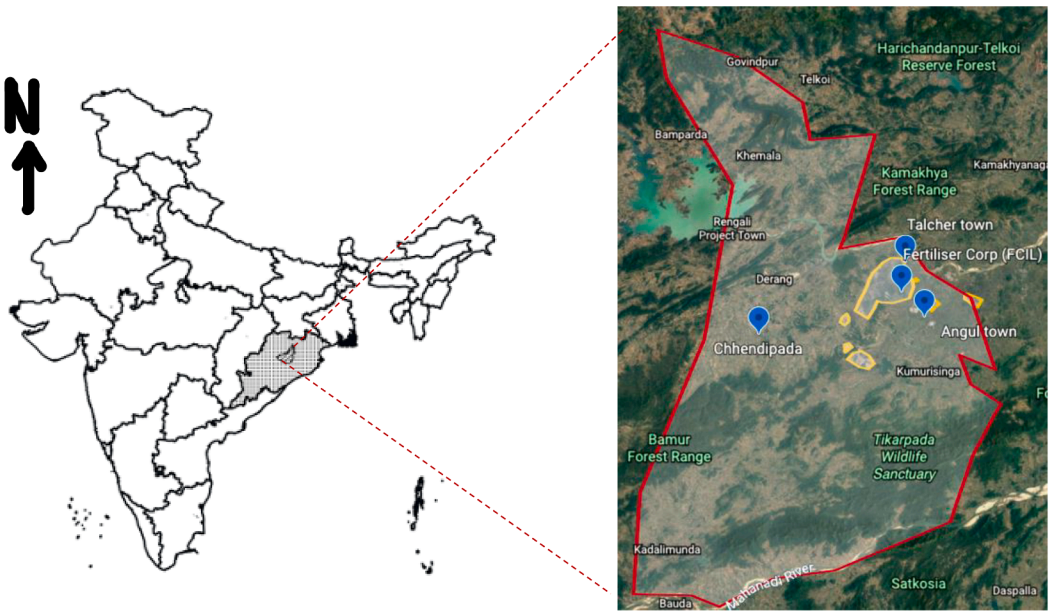
Angul district (Table 5) hosts most of Odisha's coal mining [54]. In Talcher coalfields, eight open cast and six underground mines currently operate. Together with two thermal power plants owned by the National Thermal Power Corporation (NTPC), more than 15% of Talcher's total population is engaged with coal business directly or indirectly [66]. Additionally, long-term demands for Angul's coal resources are being locked in. A fertilizer plant is set to be commissioned by 2023 in Talcher with its own captive coal mine that will provide up to 2.5 million tonnes of coal annually [67]. The plant promises up to 10,000 jobs during the construction period and up to 4,000 after commissioning [67,68].

5. Results: Identifying bottlenecks to deep (and rapid) decarbonisation in India

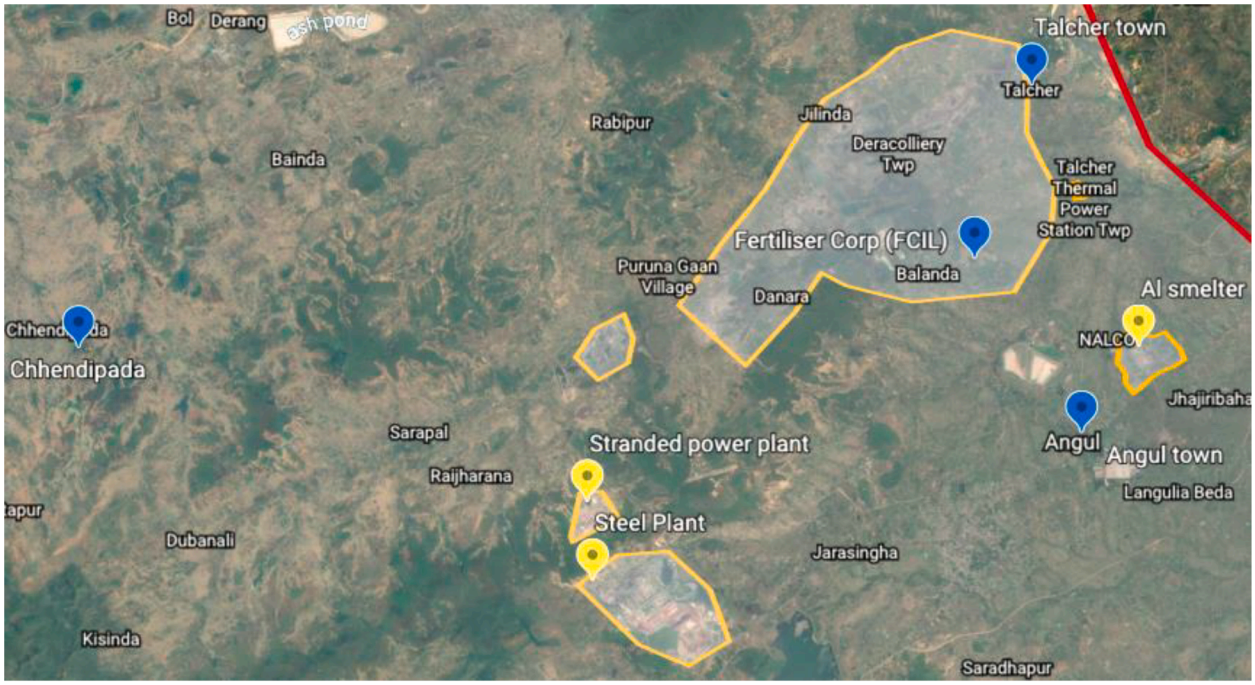
As the discussion below highlights, Odisha's relationship with coal is multi-layered and socially and economically divisive across scale.

5.1. Grassroots interactions with coal

Communities across Angul provide a largely mixed response to decarbonisation-led potential coal phase-out and local impacts over time. Amongst disadvantaged coal communities in central-eastern India, there is little to no knowledge about the links between ongoing coal use and climate change [57]. In Angul, this further extends to widespread ignorance about Odisha's contribution to national GHG emissions. From a local perspective, coal is strongly tied to widespread environmental degradation including localised air, water and land pollution [69–72]. A persistent community of NGOs, local activists, and media thus resist any further local or state government efforts to expand mining zones. In fact, several respondents argued that if coal mining were to ever cease in Odisha, the chief reason would likely be environmental pollution (CC1): 'particularly the issue of dust due to heavy truck use [for coal transportation] … not global warming' (AC 5). Another interviewee



(a): Odisha, India. (b): Angul district boundary in red



(c): Field locations.

Coal mining and allied industry Key towns covered in the field trip

Fig. 1. Map of Angul district with key locations (Note: maps not to scale).

Table 3a
Interview participants across stakeholder groups.

Stakeholder category	*Identifier code*	*No. of participants*
Government		
Current	CG	4
Retired	RG	3
Community		
Academic	AC	5
Civil Society	CC	7
Industry	IC	6

Table 3b
Focus Group Discussion participants.

	Talcher	*Chhendipada*
Male participants	6	11
Female participants	10	2
Participant age range (years)	22–57	23–46
Total participants	**16**	**13**

Table 4
Odisha vis-à-vis other coal-rich states .

State	*Coal reserves(Billion Tonnes)(% of total)*	*Coal's share of SDP (%)*	*Odisha's performance across key areas (rank out of 21 mainland states)*			*HDI rank (out of 36)*
			Economy	*Agriculture*	*Governance*	
Jharkhand	83 (26)	11	13	16	15	34
Odisha	**79 (25)**	**6**	**9**	**19**	**19**	32
Chhattisgarh	57 (18)	9	12	21	9	31
West Bengal	31 (10)	8	16	7	12	28
India	319	12				

Source: [52,62,64,65]

Table 5
Angul/ Talcher/ Chhendipada at a glance .

	Population	*No. of operational mines*	*Key industries*
Angul	1.2 million	11	Power generation, Aluminium smelter, Coal mining, Agriculture
Talcher	81,000	10	Coal mining
Chhendipada	1,24,000	0	Agriculture

Source: [65]

concurred with mining-led pollution and poor regulatory controls in the region

> 'pollution is key… five or six [most polluted] cities have been identified centrally and Angul-Talcher region is one of them … 1 million tonnes coal burns per day here … black soot settles overnight … the state government refuses to address this problem' (CC 6).

According to a Talcher-based journalist, little to no habitation planning was evident. Open cut coal mines regularly shared borders with coal dumping yards and over burden yards interspersed with small inhabited villages [63]. 'How can coal-sandwiched villages survive with 30,000 trucks operating every day in the area?' (CC 1). There appears little empathy in the community for the central government in New Delhi with respect to its climate ambitions. Rather, the concern comes from a place of local pragmatism as a local academic (AC 3) argued for phasing out coal mining to alleviate ecological costs "directly borne by the communities living in and around Angul for generations."

Despite Talcher experiencing these significant ecological ramifications, most of Angul's residents felt a deep connection to coal due to an overwhelming sense of livelihood dependence (FGD 1). While women participants were critical of inadequate compensation, particularly for those who had no land rights [54], overall, the sense was of deep reliance on mining for day-to-day survival. One participant argued saying 'even if all the water is polluted and five inches of dust settles on our well, we would prefer mining to continue as my family's survival depends on [the contract with the mining company].' In Chhendipada specifically, several young men belonging to low socio-economic, largely traditional farming families appeared keen for the local government to acquire their land for mining purposes [63]. In the FGD, only two out of 13 participants seemed less disposed to mining. The others considered their farming land as an asset, to be sold to the mining companies for a significant sum of money that would, in turn, allow them to start a business, buy a car, or arrange a marriage in the family (FGD 2) [72].

Chhendipada locals believed this thinking was justified given the lack of any other economic activity in the region. According to one FGD participant, "the farming land where my father and grandfather raised us is not productive at all … land size is insufficient for yearly survival … we are in huge debt and selling our land is the only option" (FGD 2). Another participant observed that "even if I am reluctant to sell my land, if my neighbours are happily letting the company acquire their land in return for large sums of money, what option do I have … the mining company forces us to sell and then I cannot even demand a reasonable return for my land as I lose my negotiating power if I am the last to surrender" (FGD 2). A locally elected people's representative said in clear terms 'people in [my village] want mining to start … we will go to [Bhubaneshwar] to ask the government to bring it here as soon as possible' (CC 4). Several field interviews corroborated this. Nearly 60% of Chhendipada's population preferred mining in the absence of other suitable opportunities for economic sustenance (CG3). The remaining 40% were 'happy with agriculture … but remained worried that mining would eventually make agriculture impossible' (CC4).

Grassroots views on the continued operation of coal mines thus vary significantly across Talcher and Chhendipada, two areas 60 km apart within Angul. Talcher's residents oppose coal business drawing on their decades of first-hand experience of environmental and social decline. On the other hand, Chhendipada has not seen significant mining yet. If large scale mining begins, 150 out of its 189 villages are expected to be directly impacted (CG3) [66]. For many of these residents, mining, and its co-existence with other large industries, is almost aspirational in its potential to offer livelihood opportunities for economic sustenance. That this will likely unleash further 'coal capitalism' [72] and come at a 'major environmental and social cost that will only get worse over time' remains an insignificant concern yet for locals (RG 2). These divergent views nonetheless, point to the complexity likely to confront local and state officials in their discussions regarding phasing coal out.

5.2. Local interactions with coal - district minerals Foundation for Angul

In 2015, an amendment was made to India's Mines and Minerals Act of 1957 to include a District Minerals Foundation (DMF). Part of the *Pradhan Mantri Khanij Kshetra Kalyan Yojna* (PMKKY) – roughly translating to the 'Prime Minister's mining regions' development scheme' – the DMF was initiated to prevent deep-seated, localised socio-economic disadvantage experienced by mineral-rich regions [73].[5] According to Harika et al [75], DMFs are 'established by Indian states as a vehicle to collect a percentage of mining revenue for the *direct benefit of affected communities* [emphasis added], and which the district administration … govern[s] in conjunction with those communities and local stakeholders.' At least 60% of the DMF funds accrued are directed to be spent on local WASH challenges, education, skill development, women and children's care, and environment conservation. The remaining may be spent on furthering local economic opportunities through infrastructure spending on transport, energy, and agriculture. Nationally, 44% of the total DMF collection is from the coal and lignite mining industry [76], and of all mineral-rich states in India, Odisha's DMF collection has been the highest so far [73].

Although a welcome move, the introduction of DMF has unknowingly led Angul to be far more dependent on the coal economy for local development. During field interviews, Angul's rapidly growing DMF budget was referred to on multiple occasions as demonstrative of the ever-greater significance of coal for the region. A senior district bureaucrat mentioned that Angul's total DMF collection over 2016–17 and 2017–18 had been over INR 975 crore (approximately 128 million

[5] Also referred to as 'resource curse' [74].

USD). Considered a 'very significant amount' for Angul, it was highlighted that development 'not undertaken for centuries … can now happen' (CG 2). Another local bureaucrat commented thus: 'for 1.2 million people in Angul spread across 2000 villages in total, the DMF will allow our services to reach the most remote corners … finally people will be able to see the benefit of mining' (CG 3). Several critical services are underway, most notably a multiyear, multimillion-dollar commitment using DMF funds to tap surface water from local rivers to cover over 800 villages in the district. This is an incredibly important development in Angul, one of eastern India's most water scarce regions (CG 2).

Yet, concerns are emerging with regard to the limited reach of DMF [24]. 'Mining is clearly clashing with rural development,' as one bureaucrat explained in the field:

> '[since] there are local areas marked for land acquisition, [DMF regulations prevent us from] supporting any development activities … yet people continue to live there in the hopes of additional compensation … more than 100 such villages [identified] in Angul within 10 km of existing mining activity – all to be razed over in the coming years … as DMF administrators, this is frustrating but more importantly, [this is] a lost opportunity for villagers to benefit from DMF support' (CG3).

Another significant bottleneck for local development was the bureaucratic machinery within which rural development officers operated. According to a local development officer, no matter how comprehensively their team was able to work with local communities to identify key development priorities for the region, by the time their proposed plan received authorisation from disconnected, arbitrary higher authorities, the plans were wholly rewritten, and the process 'shift[ed] from bottom-up to completely top-down directive' (CG 4). This is also reflected in the slow uptake of DMF funds across the state, with only 24% of the sanctioned amount used thus far. As of January 2019, less than 40% of the allocated amount had been expended across planned programs in health, education and women's and children's care in Angul [66].

DMF offers an important consideration in the narrative on potential coal phase-out in Odisha. Notwithstanding the perceived enormity of its monetary contribution to further development outcomes in Angul, the government has yet been unable to tap into this opportunity arising from coal mining [24]. It is unclear thus as to whether the DMF may truly represent a barrier to India's decarbonisation plans. Considering DMF's nascent presence, perhaps more longitudinal studies are needed to identify two critical knowledge gaps. Firstly, to establish with certainty DMF's role in improving long-term social development outcomes across mining regions, and secondly to gauge the reliance of these regions upon DMF funds for local development.

5.3. Regional and national interactions with coal

A number of industry stakeholders, both regionally and nationally are critically dependent on Odisha's coal [63,77]. Coal-based dependencies reach far and wide across the country, starting with India's rail network [11]. Indian Railways – the largest domestic employer – transport 60% of all coal used in India's electricity generation, collecting, in turn, 44% of their total freight revenues [78]. These revenues allow the railways to heavily subsidise passenger fares, keeping public transportation affordable [60]. According to an industry informant, railways will be 'undoubtedly the most significant sector impacted and its beneficiaries – you and me – will lose the most. India is still 80% poor [to low income] … railways is our dream and coal enables that dream' (IC 3).

At the state level, coal dependencies extend to a suite of industries, including large-scale steel manufacturing hubs, power producers, aluminium smelters, refineries, bauxite mining operations, and ferro alloy manufacturers. Of these industries, two entities, the National Aluminium Company Limited (Nalco) and Mahanadi Coalfields Limited (MCL), are particularly relevant in understanding potential bottlenecks to decarbonisation for two important reasons: first, both have had a critical role in shaping Odisha's socio-economic development trajectory. Second, a coal phase-out – in the absence of a reliable, scalable and affordable energy source – may mean significant repercussions in the form of business interruption and/or loss of global cost competitiveness that would have impact well beyond Odisha's borders.

Nalco contributed nearly INR 128 crores (~US$17 million) in royalty payments to the Odisha government and an additional INR 40 crores (~US$5 million) in mining-related development funds such as DMF in 2017–18. It contributes approx. INR 300 crores (~40 million US$) to the state's economy annually through procurement of goods and services from Odisha's medium and small enterprises. Nalco's Corporate Social Responsibility programs are the largest in Odisha. In 2019, Nalco spent INR 3,035 Lac (~US$ 4 million) on activities ranging from health, WASH and education to environmental and cultural preservation [79]. More than half of all activities were focused on Angul. Additionally, Nalco is India's third highest net foreign exchange earning public sector enterprise, and therefore remains critical for the national economy [79].

It is not an overstatement then that Nalco's reliance on locally sourced coal as a reliable, affordable source of energy is likely to present significant barriers to any potential plans of a coal phase-out in Odisha. This was corroborated by a senior Nalco official (IC 4) who argued:

> '[a phase-out of coal mining] even 20–30 years from now will be an important political setback for the state government due to loss of revenue but also from a workforce/ labour management issue … [Considering that] our current Bauxite reserves will go for at least another 30 years, coal is critical to Nalco'.

Another interviewee in Talcher believed that if coal was to be phased-out, Nalco as '"Odisha's pride" will automatically breakdown since hydropower will not be sufficient [for its energy demands] and diesel and petrol are not viable options' (CC 6). They feared that Odisha might see a long-term economic demise if significant partnerships between industrial and government organisations both nationally and state-wide 'that all involve coal in some form' begin to break down (AC 4).

Besides Nalco, Coal India Limited (CIL), the world's largest coal company, has perhaps the largest stake in the decarbonisation narrative [11,36]. Currently, most coal mines in Odisha are owned and managed by Mahanadi Coalfields Limited (MCL), one of CIL's eight subsidiaries and its best financial performer [80]. In total, MCL operates 22 mines, including 6 underground and 16 open cast mines. An additional five projects with a total annual capacity of 67 MT are at an advanced stage of development for future expansion.

Interviews with MCL and state bureaucrats suggested that coal was highly reliable, cheap and therefore, 'competitive' until at least 2050. They highlighted several factors that would diminish any likelihood for the state to focus away from coal over the next two to three decades: a) close political interface with coal mining, including bi-partisan support for coal mining and coal-dependent industrial development, b) concentrated nature of coal activities, the absence of which would devastate local economies such as Angul's, c) lack of comparable energy alternatives in Odisha, with 'large scale solar yet to see a future in the state', and d) competition from neighbouring coal-rich states who would see Odisha's closure of coal mining as an economic opportunity, thereby forcing industry to move, making it a 'catastrophic situation for Odisha' (IC 2, CG 2) [24,81,82].

Furthermore, MCL continues to make heavy investments to streamline its operations and achieve higher levels of efficiency [83,84]. These include dedicated railway lines to mine pit tops for coal transfer (first phase costing over US$131 million), road infrastructure (approximately US$197 million), and six new coal handling plants and washeries

(approximately US$333 million). With this level of investment, the risk of stranding assets would present a further bottleneck to a potential coal phase-out.

Additionally, several interviewees believed that besides coal-dependent industry, other groups protesting against plans to decarbonise would comprise local politicians, Members of Parliament, truck and lorry driver unions, contractual labour bodies, and similar outfits that have political and/or economically vested interests in maintaining the status quo (CC 3, AC4). They see coal business as a 'milking cow' and will enforce widespread 'shutdowns' (RG 2). The absence of legal right to appropriate compensation [54,72] – India only proposes a policy to resettle those whose lands have been acquired for development purposes – and lack of sustainable livelihood alternatives allow these groups to 'brainwash local populations' to support coal business (CC5, AC3).

Another argument observed in the field related to inter-regional politics across the state borders [24]. Coal from MCL-owned Talcher mines travels across the country, feeding several power generators in neighbouring West Bengal and southern Indian states. So far, little is known about potential flow-on political ramifications from coal phase-out discussions in Odisha. According to one respondent, 'It will not be too impetuous to suggest [given current levels of dependencies on Odisha's coal across much of India], political disagreements amongst various states as well as between the state and central government could emerge that could be unsettling for national peace and security' (AC 4). A senior bureaucrat in Angul also felt "it would be very difficult for the state government to close down its coal business, although may be easier for the central government [in New Delhi] to proclaim that coal is bad for us all" (CG 3).

Finally, although of 'gigantic proportions' (RG 3), socio-economic impacts of a potential coal phase-out could well be managed as seen in cases discussed earlier (section 2.2). However, this would necessitate alternative comparable opportunities both for cleaner energy and local and regional livelihoods. With a historically neglected agricultural sector [61,82] and one of the slowest rates of renewable energy growth nationally [29,85], Odisha's decarbonisation pathways remain unclear. A solar energy industry representative admitted inadequate state government interest in facilitating renewable energy development (IC 5). In a comparative analysis of key states and territories nationally, although Odisha ranked 10th in terms of estimated potential (~27 GW), only 0.54% of this potential had been converted to grid-interactive installed renewable energy capacity [29].

6. Discussion

Field insights point to a clear duality existing within Odisha. On the one hand, coal mining along with allied industries dependent on local coal is part of a complex, multilayered landscape with vested interests in keeping the coal industry alive. On the other hand, emerging awareness amongst grassroots communities is leading to voices – albeit, currently few and far between – that call for reducing coal dependence pro-actively and sensitively. As a state, Odisha's positions on coal are far removed from the global discourse on decarbonisation. Instead, they are highly localised and by virtue of that, invoke reflection based on socio-political identities and development opportunities (or lack thereof). As Tongia [11] asserts, 'At the end of the day … coal is less about technology or even economics and more about policies and political choices'. Odisha embodies this tension neatly, highlighting three areas of concern for India's decarbonisation planning.

a) The role of the state

Odisha's government has an important role to play in determining how, when, and at what speed a coal phase-out may be possible. The shut down of its largest industry is a difficult transition for any state government to manage, but it is essential that the government has a long-term vision and commitment to pro-actively navigate potential roadblocks, including socio-economic consequences. Currently however, decarbonisation and a coal-free future is not evident on the government's agenda. Nearly 80% of field respondents categorically mentioned the Odisha government as very much a part of the state's coal lobby. The state's dependence on ongoing industrialisation – largely coal-dependent – is intricate, deep rooted and at least in the short to medium-term, irrevocable [24]. Bi-partisan support for coal resulting in close linkages between the industry and politics suggests that top-down resistance from within coal regions would be a serious impediment to national decarbonisation efforts [77,82].

Additionally, and perhaps because of the above, the state has poor enforcement of environmental regulations. A submissive compliance climate across the board – government representatives, industrial unit heads, village council chiefs – is rife. As an example, MCL was likened to the East India company for its insensitivity towards mining-affected communities and a single-minded focus on cost-cutting. Yet, it remained the preferred choice for prospective land acquisition compared to the private sector whose reputation and ethics around compensation were considered much worse (as also mentioned in [11,24]).

There is also the issue of poor coordination between various state government departments. A critical example is Odisha Renewable Energy Development Agency (OREDA), the state's nodal agency for green energy development. Its positioning within the Department of Science and Technology allows for little interaction with the State's Department of Energy that deals primarily with coal and hydro-based power generation and distribution. The state's lack of interest in developing solar, for example, has further inhibited OREDA's capacity to bring about a shift in Odisha's energy landscape [85].

Presently, the government continues to defend its position on coal by arguing that coal provides an indispensable economic lifeline to the state [86] and any effort towards energy transition will divert critical resources away from pressing local development needs. Yet, as noted earlier, slow uptake of DMF funds is but one example of the institutions' failure to improve the quality of life for much of Angul.

b) Quality of life in coal regions

Angul-Talcher region is considered one of Asia's worst polluted regions owing to decades of incessant mining and industrial activity. With mining zones and coal-dedicated railway lines passing through paddy fields, agricultural productivity has declined over time. Rural development agendas have been short-lived, often set within six months of an election deadline, then frequently changed, shifted, before being neglected or completely abandoned.

Much of Odisha's rural development planning suffers from a narrow interpretation of livelihoods. Not only has there been a systematic marginalisation of the agrarian economy, there is also limited attention given to alternative vocational skill development. This is a significant bottleneck for any anticipatory preparation for a gradual coal phase-out in Odisha. DMF funds provide an opportune resource, but current guidelines prevent action on building and strengthening alternative sources of income generation. The low human resource-intensive nature of renewable energy instils little confidence about livelihood options available for the vast numbers of people likely to be impacted by a coal phase out.

It was suggested during several interviews that international intervention through development agencies may be needed to strengthen Odisha's communities so they can rightfully seek an improved quality of life, better development outcomes and a stronger civil society. There seems to be a small – but growing – acknowledgment for the need of a bottom-up movement to force the government to identify and decide on an optimum threshold for ongoing coal mining [24]. Such a threshold would need to be non-negotiable and consider the many decades of social and environmental neglect experienced by the region's communities.

Finally, if there were any possibility for Odisha to consider a focus away from coal, communities, particularly in Angul, will be critical stakeholders. Evidence exists in middle-income countries such as Chile, Thailand and the Philippines of the power of local mobilisation in

shaping energy transitions [87]. Odisha has also witnessed for over a decade widespread community-led action and activism to stop bauxite mining [88,89]. What is perhaps missing in Odisha's broader energy transition narrative is the bridging and aligning of differences between the local pro-mining groups and grassroots environmentalists, as observed elsewhere [43]. Although locals' frustration with the top-down polity of the extractives sector, complemented by a strengthened civil society voice is beginning to show signs of resistance to unchecked industrialisation, the scale of these efforts remains too small and localised [77].

c) Choice between imperfect alternatives?

An obvious and significant bottleneck in India's decarbonisation is the lack of an easy alternative energy resource [11]. For Odisha specifically, the lack of energy options is further compounded by the state's extensive reliance on the industry for its multiplier effect on employment and social contributions [24], whilst neglecting to build a strong renewable energy portfolio [85]. These concerns were shared widely in the field with many inquiring: 'transitioning from coal to what?' At this stage, there seems no clear answer to this question. With its heavily forested areas and lack of expansive flat land, ongoing land access challenges, low political priority for alternative energy, and localised effects of climate change leading to reduced levels of precipitation and dry rivers, Odisha's energy landscape seems incapable of bringing about the much-needed transformative shift away from coal. Despite one of the earliest to bring about significant reforms to its electricity sector [61,90], Odisha's energy systems continue to struggle to provide the state with a reliable, affordable and scalable access to sustain its strong industrial base whilst also supporting local and regional development. Findings from a recent state-wide comparison of solar capacity addition point to Odisha as a 'laggard' state which, despite high solar potential, remains poorly aligned with Central government's ambition of high growth in solar capacity [85].

As a result, there is indeed a genuine, holistic dependence on coal in Odisha for maintaining livelihoods, employment, revenues, and state services. Coal remains at the core of the state's political economy and as one informant argued, it is going to be extremely difficult to 'let the only real industry go' (CC 5). Nationally, Odisha is India's second highest CO_2 emitter per capita owing to its heavy industrial base. In fact, a recent study identified Angul as one of the top five CO_2 emission hotspot districts in India [91]. Consider this in light of Odisha's poor human development performance with one of the lowest rates of rural electrification (43%), large proportion of its population below the poverty line (42%) and human development index lower than the national average [92]. This points to the overwhelming dichotomy across Odisha's social and politico-economic landscape and reiterates the need to look closer at sub-national CO_2 emissions and implications for development in the Global South [14].

Perhaps there is good reason for a coal phase-out to be delayed until such time as alternative options to build technological and socio-economic resilience become available. To wait for these opportunities, however, would be reckless. A greater show of intent is expected from the state's leadership to invest, economically and politically, in diversifying both the economy *and* its energy portfolio [77]. Whether these solutions truly lead to a just energy transition, or merely work as energy additions in the interim [93] are subjects for another discussion. What is certain though is that seeking these solutions will be a long-drawn-out process, best summarised thus by a field respondent (AC 1):

> 'Really, the government's action on [renewable energy] has been so slow that it gives little confidence to anyone to say with surety that in 20 years' time, Odisha would have closed its coal mines. If it happens, it would be the state's biggest victory for its people and the world generally'.

7. Conclusion

This paper has focused on a critical, but under-studied, aspect of contemporary decarbonisation discourse, namely the sub-national political economies of energy transitions. This is an area of increasing significance due to the highly localised nature of the complex social institutional context shaping global energy futures.

Coal production and consumption in 2018 grew at rates not experienced since 2013. For its significant role in this growth, India is now under mounting global pressure to reduce its coal dependence and systematically, but rapidly, decarbonise. These expectations are likely to catapult India into unchartered space for several reasons, not least due to coal's complex, epochal relationship with multiple sub-national political economies. Across much of central and eastern India, the significance of coal is wrongly limited to its economic contributions. Doing so ignores its deep cultural, historical, socio-economic, and political ties, which, over the years, have led to a multi-faceted chasm between the state and the nation-state. Through a study grounded in the lived realities of the coal economy in one of India's most prolific coal mining belts, our findings highlight three areas relevant to India's energy transition: firstly, the lack of a local alternative economy in coal-reliant regions implicitly generates local support for coal and allied industry. Secondly, political and economic institutions in coal regions continue to maintain an unapologetic focus on mining and industrialisation as the panacea for social and economic advancement. Finally, coal remains central to several national institutions such as the Railways. The magnitude of their reliance on coal and our limited understanding of the complexities that may arise from dis-entangling this reliance highlights the temporally chaotic nature of much of India's decarbonisation journey.

Finally, we conclude with four observations that provide pointers for further research and thinking to extend ongoing discussions on India's energy transitions.

a) *Theorising the notion of common but differentiated responsibility* – climate change has brought attention to the idea of 'common but differentiated responsibility and respective capabilities' globally, to better link causes with capabilities, and allow for leadership and assistance from the Global North to regions in the Global South [94]. For decarbonisation to be rapid and at scale in India, there is merit in exploring – and applying – this concept sub-nationally. This would likely entail a degree of handholding from the central government and other states that are reliant on coal, but much less reliant on the coal economy per se. For regions such as Angul, this may provide assurance that extends far beyond economic instruments such as the DMF and indicate a broader willingness to springboard alternative industrial planning activities to complement the gradual decline in regional coal economies.

b) *Practicing bi-partisan appreciation of, and support for, a coal-free future for India* – Political interlinkages with the coal economy are widely recognised and remain rampant across India. India's decarbonisation narrative is contingent upon dis-entangling these interlinkages. This is practically not impossible, but extremely challenging in some regions more than others. Considering Odisha's 'neo-patrimonial' [77] development trajectory thus far, a gradual phase out of coal will see most resistance from these elitist politico-business links. Until such times as close business-state relationships exist, a unifying national-state energy transition agenda is highly unlikely.

c) *Practicing the idea of a national taskforce for energy transition* – this may be a welcome tool to help address the two observations made above. Although at a different spatial and temporal scale, there are lessons nonetheless that can be drawn from the Covid-19 pandemic experience around the world for energy planners going forward [95]. Among other things, the pandemic has reinstated the value of governance that cuts through disciplinary silos, works inclusively bringing along both top-down and bottom-up actors and influencers,

garners political support from across ideological divides, and works towards gaining public trust and confidence [96]. India's coal governance is particularly complex [86]. Despite the states carrying the burden of coal mining, they have very little influence in coal-related decision making. Being a national resource, decisions on coal – e.g. opening and closing of mines – are made in New Delhi. In light of these federal-state tensions, and deep sub-national socio-economic inequities, a unifying taskforce will help realise energy transition as a product of transformative shifts needed in social, cultural, technical, political, and economic value systems. Ideally, such a taskforce would comprise representation from fossil and non-fossil energy industry; key allied industry (steel, cement, manufacturing, other minerals) reliant on a robust energy supply; multiple academic and scientific disciplines; national and state-level climate policy makers; and civil society organisations working on the ground with communities at risk of potential policy impact.

d) *Re-thinking the energy-extractives relations* – At face value, Odisha's economic development may seem strongly tied with ongoing coal dependence. Yet, phasing out coal does not portend an 'all is lost' scenario for Odisha as a viscerally complex and divisive industrial microcosm within India. Its diverse resource endowment will continue to play a significant role in India's future energy transition pathways. If anything, a discussion of gradual decline in the state's coal economy provides an opportunity to undertake a systematic assessment of alternative industries that remain critical to the transitions narrative globally. Among others, these would include already-significant iron ore, bauxite, chromite, and manganese mining sectors for their role as critical energy transition metals [97] as well as medium and small enterprises for manufacturing [77]. Thus far, these sectors have invited – quite rightly – strong scrutiny for either gross social and environmental violations or pure institutional neglect. Re-imagining the energy-resources links can push for structural reforms in the state's institutions and practices to build public trust and redress injustices of the past while still building on the state's rich resource legacy.

This paper has provided an exploratory commentary on the dichotomy underlying India's energy transition. As observed in Odisha, owing to its rich coal reserves, and deep political patronage, the state has been able to successfully chart its political journey from 'the margins to the centre of the Indian economy' [82, p.248]. This evolution is indicative of the complex and multi-dimensional nature of India's sub-national political economies where coal is found, extracted, and used for economic advancement. It is reasonable to suggest that the future of India's energy landscape will both shape, and be intrinsically shaped by, the character and fabric of many such social and institutional currents that extend far beyond the remit of thinkers and doers in New Delhi.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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