Can political representation improve forest conservation? The Indian experience

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Abstract
Forest conservation is key to mitigating climate change and preserving biodiversity. Many argue that indigenous communities serve as stewards of forests, and can greatly improve conservation outcomes if given control over forest management. Few, however, have examined the conservation effects of *political* representation by indigenous communities. Potentially, representatives could promote either better conservation or greater extraction for revenue gains.

This paper examines the effect of indigenous political representation on forest cover, using the unique opportunity offered by India's multilayered enactments, which have granted Scheduled Tribes political control over local forests, in constituencies reserved for them in state assemblies and village councils. Taking Chhattisgarh state as an illustration, the paper draws especially on geospatial technologies to compare the state's 20,000-odd villages across reserved and unreserved categories, differentiating between Assembly Constituency (AC) reservations and PESA (Panchayat Extension to Scheduled Areas) reservations, the former being at the assembly level and the latter at the village council level.

We find that between 2001 and 2019, Chhattisgarh's village area under tree cover increased by almost 240,000 ha in aggregate for the 10,554 villages with any reservation (AC or PESA). This was four times the increase in never-reserved villages. Also, for the period 2009-2019, our regressions show that the likelihood of a 5 percentage point increase in tree cover was significantly greater in villages under only AC reservations than in never-reserved ones. In contrast, the likelihood of tree cover rise was *lower* in villages reserved under PESA alone than in never-reserved villages. Non-village forests also improved more in AC reserved areas. The results suggest a policy win-win for assembly-level political reservations, promoting both social inclusion and conservation. But divergent interests could play out in village-level reservations, stymying conservation. Here, additional incentives to conserve may be needed.

This is the first study globally to examine the conservation effect of indigenous political representation at multiple levels, covering two decades. It will have relevance for other countries with large forest areas and substantial indigenous populations.

Keywords
Forest conservation, political reservation, Scheduled Tribe, indigenous communities, Chhattisgarh, India

JEL Codes
Q2, Q13, Q56, J15

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Image source
Photo of Teerathgarh Falls, Chhattisgarh, India by Shubhro from Canva Pro.

List of acronyms

AC	Assembly constituency
GP	Gram Panchayat (village council)
MLA	Member of the State Legislative Assembly
PESA	Panchayat Extension to Scheduled Areas Act
PRIs	Panchayat Raj institutions
RNV	Rural non-village area
ST	Scheduled Tribe
SC	Scheduled Caste

1. Introduction

The critical role of forest conservation in mitigating climate change and preserving biodiversity is well recognised. The relationship between forests and indigenous communities has also long been emphasised. Can these links provide new policy pathways for conserving nature?

Although indigenous communities comprise only about 5% of the world's population, they use or manage areas which cover an estimated 25% of the planet's land surface, intersecting with some 40% of all protected areas and ecologically intact landscapes, especially forests (Garnett et al, 2018).[1] Indigenous people are also seen to have deep economic and cultural ties with forests (World Bank, 2022). Many argue that these connections – and especially the dependence of indigenous people on forests for everyday needs – give them a high stake in forest protection. Hence, granting them greater legal rights in the ecological systems on which they depend will enhance conservation.

This is part of a larger argument dating to the 1980s, made by civil society groups and social movements across many countries, that forests would be better protected by local communities (indigenous or other) who live in close proximity to them, rather than top-down by governments. The importance of involving communities in forest protection was also recognised by the Brundtland Report (1987). Indeed, by 1999, over 50 countries were pursing partnerships between governments and local communities to better protect their forests (Agrawal & Gibson, 2001).

However, this focus on community forest governance was not specific to *indigenous* communities, nor did it involve the *political* representation of these communities. Hence, while a considerable literature emerged on the impact of forest co-management (such as on Joint Forest Management (JFM) in India and Nepal, launched in the early 1990s),[2] it still left open the question of whether the political representation of indigenous communities could improve forest conditions.

If, indeed, indigenous political representation leads to enhanced conservation, this would point to a policy win-win, offering a mechanism for simultaneously promoting

[1] In fact, the global narrative is that 80% of the world's remaining forest biodiversity lies within indigenous peoples' territories. See https://www.statista.com/chart/27805/indigenous-communities-protect-biodiversity/; and https://www.nationalgeographic.com/environment/article/can-indigenous-land-stewardship-protect-biodiversity-.

[2] Notably, in the decade 1991–2001 after JFM was launched, forest cover in India increased by 3.6 million hectares (Agarwal, 2010), whereas earlier it was declining rapidly.

social inclusion and forest protection internationally. And it would be of particular interest for rainforest rich regions with large indigenous populations, such as Indonesia in Asia, or the Amazon basin in Latin America. In the latter, Brazil holds 58% of the rainforest basin but has no political representation by indigenous communities in Congress, while Bolivia which does well with some 25% of seats occupied by indigenous communities in Congress holds only 7.7% of the Amazon rainforest (see Appendix Table A1).

We cannot, however, automatically assume a win-win between political representation and conservation. The proposition needs testing. On the one hand, it is argued that indigenous communities are potential stewards of forests, and indigenous political control over forest management can thus greatly improve conservation (see, eg, Gulzar et al, 2023). On the other hand, it can also be argued that, given their dependence thereon, increasing indigenous community control over forests might encourage more extraction and hence degradation. Moreover, indigenous political representatives might have other motivations: for example, they might favour extraction for short-term revenue gains, might cater to their elite, or prioritise infrastructure, and may thus need additional incentives to conserve.

India offers a unique and globally relevant opportunity to test these opposing propositions. First, it has one of the largest forest-dependent populations in the world (World Bank, 2005; TEEB, 2009),[3] a vast majority of which is constituted of tribal (indigenous) communities, formally termed Scheduled Tribes (STs) in India's Constitution. India's more than 104 million STs make up 8.6% of its population, according to the country's 2011 demographic census. Second, since 1951, India has enacted several laws, multi-layered and staggered over time, granting STs political power through ST representatives elected to reserved constituencies in state assemblies and village councils. These representatives also have control over resources (including forests).

To elaborate, under the 'People's Representation Act of 1951', Independent India launched an ambitious programme of political inclusion through reservations for the two most socially disadvantaged categories: STs and Scheduled Castes (SCs). Political constituencies with a high percentage of STs and/or SCs were reserved for these groups both in the central and the state governments, with parliamentary constituencies (PCs) at the federal level, and assembly constituencies (ACs) at the state

[3] Forest dependence is different from forest proximity, since not everyone living near forests may be dependent on them. See Newton et al (2020), who map 'forest-proximate' people globally.

level. Additionally, in the early 1990s, based on caste/tribe and gender, seats were reserved in local institutions of governance for elected representatives. These Panchayati Raj institutions (PRIs), as they were termed, operated at the district, block and village council (Gram Panchayat – GP) levels. PRI reservations were not linked to forests, although *panchayats* could have common pool resources with some forests under their jurisdiction.

In 1996, the PRI reservations were extended to areas with large tribal populations (termed 'Scheduled Areas'[4]) through the Panchayat Extension to Scheduled Areas (PESA) Act, although implementation in some states came much later. The PESA *panchayats* were distinct from non-Scheduled Area *panchayats*, not only in being specifically reserved for tribal populations on a permanent basis, but also in being granted particular rights in forest resources.

We therefore see two parallel but important shifts in policy relating to local forest governance in India. One shift was from state-driven to community-led forest protection in 1990 via the Joint Forest Management programme, which enabled participating communities to manage forest resources jointly with the forest department, in order to regenerate degraded forest land.[5] Although not specifically focused on tribal communities, the geographic overlap of tribal people and forests meant that the communities managing forests often had tribal concentrations. The second shift was from granting STs a few legal rights in forests to granting them enhanced rights as well as substantial political oversight over forests, through their elected representatives in reserved constituencies. These two shifts underlie the central research question driving this paper: what has been the impact on forest conservation of granting tribal communities political control over regions which also have considerable forests, and of giving them greater rights in forest governance and use?

Potentially, the impact could be either positive or negative. It could be positive if the ST representatives promote forest conservation, and tribal communities work to conserve the resources they use. It could be negative if the ST political representatives, given short-term tenures, allow their forest-dependent constituents to extract more forest products for income gain, with an eye to increased revenue, or prioritise infrastructure development over conservation, since areas with high tribal concentrations tend to be poorly developed. In fact, countries around the world have to balance the competing

[4] These areas are described in the 'Fifth Schedule' of the Indian Constitution. In addition, a few states with large tribal populations fall under the 'Sixth Schedule'. These are treated differently, and PESA does not apply to them.

[5] In practice, the degree of power sharing between local communities and the forest department varied across states (World Bank, 2014; Baumann & Farrington, 2003).

demands of environmental preservation and economic growth. It could even be argued that states with a high proportion of land under forests have 'saved up' natural capital which they could exploit for promoting growth, while still maintaining a substantial proportion of their geo-area under forest.

Moreover, ST communities can be economically and culturally heterogeneous (India has over 705 ethnic groups: Xaxa, 2014), leading to divergent interests within them. Elite STs may be more interested in timber extraction while poor STs may favour the collection of non-timber forest produce in a sustainable way, as found in Jharkhand state (Kumar, 2002). This again creates a counter-pull to the standard assumption that tribal/indigenous communities will necessarily be 'stewards' of the environment.

In our paper we test the effects of a multi-layered and multi-temporal process of political reservation, using India as an example. Globally, only one prior study, that by Gulzar et al, (2023), which is also on India, has examined the link between political reservation and forest conservation. Their study covers several states, but is limited to the impact of PESA. Our paper is focused on one state but covers not just PESA but also AC reservation areas. In addition, unlike Gulzar et al, we spatially separate forest cover within village boundaries from that which lies outside village boundaries. These non-village forests (reserved, protected or unclassified) can affect village forest use and hence village forest conservation. We take these non-village forests, as well as government plantation policies, into account.

Focusing on Chhattisgarh state, which has 41% of its geo-area under forest cover and one-third of whose population is tribal, we conducted a state-level analysis based on its 20,000-odd villages, to examine the effect of both AC and PESA reservations on change in forest cover over time (2001–19), and across combinations of reservations.[6]

Our analysis provides an understanding of reservation dynamics for the full state, while also shedding light on the relationship between forest change and other explanatory variables at the village level, such as village population increase, dependence on cultivation, new roads built, distance from large towns, and proximity to forests in rural non-village areas (RNVs). RNVs include all state land that falls outside the census village boundaries but excludes urban settlements. We examined changes over time and by degree and type of reservation, including overlaps between AC and PESA villages.

[6] Specifically for AC reservations, we also tried a boundary matching method to identify villages on the left-hand side (reserved) of AC boundaries drawn in 2008 and the right-hand side (unreserved). Boundary matching is often done to affirm causality. But the complexity of multi-layered, time-shifting reservation makes this a fraught exercise, since some villages under AC reservation may also have PESA reservations while others may not.

We relied largely on geo-spatial technologies to create and categorise our databases, drawing on the Geographic Information System (GIS) to identify AC and PESA reservations, using village maps, block maps and electoral boundaries. For forest change we used the MODIS Vegetation Continuous Fields (VCF), Version 6.1, and for socioeconomic variables, we drew on the SHRUG platform (Socioeconomic High-resolution Rural–Urban Geographic Dataset for India) supplemented by decennial village census data.

The rest of the paper is organised as follows: Section 2 provides some background to India's electoral system and political reservation for disadvantaged groups. Section 3 examines relevant existing studies. Sections 4 and 5 focus on methodology, regression models and data. Section 6 discusses our results, and Section 7 provides concluding reflections.

2 Background

To understand the system of political representation for STs, a brief outline of India's electoral system is provided below, as well as its methods of political representation and reservation.

2.1 Electoral system and political representation

India's electoral system consists of a three-tier structure of representation:

(1) Central government. The Parliament at the Centre is based on parliamentary constituencies, distributed across the 29 states and eight Union Territories, each of which elects a Member of Parliament.

(2) State governments. Each of the 29 states has several assembly constituencies, and each one is represented by a Member of the Legislative Assembly (MLA).

All assembly and parliamentary constituencies are delimited on the basis of the preceding decennial census figures. Each AC in a state has to be delimited such that the populations of all constituencies, to the extent practical, are the same throughout the state.

(3) Local bodies. Within each state, in rural areas, there are district councils at the top, block councils in the middle, and village councils, or GPs, at the bottom. Similarly, urban areas have different tiers of local bodies.

Central and state legislatures (PCs and ACs) have different geographies of operation from those of the local government. Administratively, Indian states are divided into multiple districts and a village is the lowest administrative unit within a district. One or several villages can constitute a GP, while an AC can be made up of several GPs. A district can have one or more ACs. We used GIS to map the ACs with their constituent villages and GP boundaries.[7]

Each state holds elections every five years to elect MLAs who represent their ACs in the state legislature. The ACs were created under the People's Representation Act of 1951, following India's independence from British colonial rule. MLAs legislate on items mentioned in the state list or in the concurrent list (which is shared by the central and state governments) given in the Constitution of India. These list-items include forests. MLAs also receive area development funds to promote development activities within their constituencies; to assist their constituents in accessing government schemes (Jensenius, 2015); and to seek to attract development and business projects to their constituency (Asher & Novosad, 2017).

Sarpanches (GP/village council heads) are elected every five years to represent their GP. The GP system currently in place was initiated in 1992 through the 73rd amendment of the Constitution, and in 1996 was extended to the Scheduled Areas through the PESA Act (Government of India, nd). The key role of the *sarpanch* is to lead the GP council in village development, including overseeing village resources such as forests.

Although ACs and GPs are not directly linked politically, they are indirectly connected because MLAs are in charge of all the villages in their constituencies. Moreover, since local governments come under the jurisdiction of state legislatures, MLAs can directly affect the structure and power of the GPs.

2.2 Reservation system

India's Constitution recognised the social and economic disadvantage faced historically by STs and SCs, and reserved seats for them in educational institutions and public employment in all states. In addition, political representation was promoted in states with a concentration of STs or SCs. Our focus here is on this political representation.

Today, India has political reservations for STs and SCs in both the PCs and ACs, and for the three tiers of PRIs. In the PCs and ACs, the current practice of delimiting reserved constituencies for STs began in 1961. A complex multi-step procedure is followed for

[7] Mapping can be done in two ways: by using digitised spatial boundaries of ACs and villages and overlaying them through the GIS (as we have done); or by using information from the Delimitation Commission or electoral rolls (see also Alam, 2010).

identifying the states where constituencies are to be reserved and estimating the total number of AC seats to be reserved, taking into account the proportion of STs in the state's population (and further in the district's population within the state), using the preceding population census (for details, see Ambagudia, 2019). At present, there are reserved constituencies in 24 states.

On PRIs, the 73rd amendment to India's Constitution in 1972 reserved seats for SC and ST communities, devolving power to local governments on several issues including forestry. In GPs, 33% of the seats were reserved for SCs or STs. However, as noted, these reservations did not cover the Scheduled Areas, which have a high proportion of tribal populations and are found in 10 states. Within these states, some districts are fully or partially designated as Scheduled Areas (Xaxa, 2014). This designation is based solely on a district's ST population and is not linked to its forest area.

PESA reservations _ extended to Scheduled Areas in 1996 – differ from non-Scheduled Area GP reservations in that in PESA GPs all *sarpanch* positions are permanently reserved for ST candidates, while in non-PESA GPs, reserved seats rotate every five years. Indirectly, PESA reservations also strengthened the link between STs and forests since the Act devolved powers over community resources, including minor forest produce, to PESA *panchayats*.

The timing of PESA implementation, however, varied by state. In Chhattisgarh, PESA was not implemented until after 2005, when the new state's first *panchayat* elections were held. And PESA rules are only now being strengthened, following a 2021 petition from the state's tribal representatives to their Chief Minister. These amended rules will further strengthen the jurisdiction of PESA *panchayats* over minor forest produce in the state (Verma, 2021).

3 Existing studies

In our paper we examine a triangulated relationship between community management of forests, political reservations/representation for minorities, and conservation outcomes.

While many studies globally have examined the links between community forest management and conservation outcomes, and some have focused on political representation for minorities and socioeconomic outcomes (not specifically forest-related), only Gulzar et al (2023) consider all three aspects, and even they confine themselves, as noted, to PESA. In this section we provide a broad overview of this range of studies, to place our work in context.

3.1 Community forest management and forest cover

Globally, the impact of community forest management on conservation outcomes has been fairly well studied from diverse angles since the 1980s. The Bruntland Report (1987) and Elinor Ostrom (1990) argued that local resource management would be more effective in environmental governance than centralised government management. Several empirical studies affirmed this argument and found a positive relationship between community forest management and improved forest condition.[8] A review of World Bank interventions also showed that community participation in forest management was more effective than other interventions, such as protected areas or payments for forest-related services, and had a positive impact on both environmental outcomes and their sustainability (World Bank, 2014).

Only a few studies found no significant links between local decision making and improvement in forest management (Buntaine et al, 2015; BenYishay et al, 2017; Slough et al, 2021). This neutral effect is attributed by some to the limited empowerment of local decision makers in the process of democratic decentralisation (Gulzar et al, 2023), or too much interference by local political leaders or the forest department, even after handing forest-management responsibilities to communities (Sarin et al, 2003; World Bank, 2005).

3.2 Political representation and economic benefits

A second body of studies which focuses specifically on India examines the effect of political representation by minorities on development outcomes unrelated to forests.[9] Most studies focus on SC representation and only a few on STs, or both.

At the GP level, most scholars report positive effects from political reservation. Duflo and Fischer (2017), for example, find that SC hamlets received 14% more investment in goods in SC-reserved GPs compared to non-SC GPs. Bardhan et al (2010) find that SC or ST reserved villages had better intra-village targeting of SC and ST households. Besley et al (2005) also note a correlation between a higher proportion of SC politicians and benefits for SC communities. Gulzar et al (2020) examine the borders of Scheduled Areas and find that PESA reservations are strongly related to better outcomes for STs in

[8] See, for example, Agarwal (2010), Agrawal et al (2014), Baland & Platteau (1996), Baragwanath & Bayi (2020), Blackman et al (2017), Bonilla-Mejıa & Higuera-Mendieta (2019), Nepstad et al (2006), Nolte et al (2013) and Robinson et al (2014).

[9] See, for example, Bardhan et al (2010), Besley et al (2005), Duflo and Fisher (2017), Dunning and Nilekani (2013), Jensenius (2015), Gulzar et al (2020), Krishnan (2007), Besley et al (2005) and Pande (2003).

terms of The Mahatama Gandhi Rural Employment Guarantee Scheme, and the provision of public infrastructure such as roads, water and electricity. Only Dunning and Nilekani (2013) find no relationship between GP reservations and the channelling of development funds to the leader's community groups.

At the AC level, however, the effects are weak or mixed. Jensenius (2015), for example, studied over 3,100 ACs in 15 states, using a propensity score-matching technique and found "no detectable constituency-level effect on overall development or redistribution to SCs in an SC-reserved constituency" (Jensenius, 2015, p 198). Further, her qualitative data revealed that SC politicians were unable to work for their own groups, even when they wanted to, because, to win elections, they also had to cater to the general caste groups. Similarly, Chin and Prakash (2010) found no significant relationship between SC reservations and poverty among SCs. Pande (2003), on the other hand, found a positive relationship between AC reservation for SCs and quotas for SCs in government jobs.

Notably, when some of these studies examine AC reservations for STs rather than SCs, they find positive effects on welfare spending (Pande, 2003) and poverty reduction among ST communities (Chin & Prakash, 2010). A possible reason (following Jensenius's logic) could be that, unlike SC constituencies, ST constituencies have a higher concentration of tribal populations. On average, an SC constituency has 25% SCs while an ST constituency has 51% STs, so ST politicians would need to rely less on votes from the non-ST population.

Finally, some scholars have examined SC or ST access to public goods relative to non-SCs and STs, but these studies are not specifically linked to political reservations (ACs or PESA). Therefore, we have not focused on them, although some have interesting insights of tangential interest to us. Banerjee and Somanathan (2007), for example, on examining 500 rural PCs find that, while overall regions with a high concentration of SC and ST populations have lower access to all public goods, over time there has been a notable increase in access to high schools, health centres and piped water in SC areas but rather little in ST areas. They attribute the improvement in SC areas to "increased assertiveness and political representation" of SC communities, while STs have remained "largely invisible on the political stage" until the 1990s. Asher et al (2022) similarly find that, although STs show intergenerational upward mobility, they remain far behind the general population and even SCs. In other words, STs still remain seriously disadvantaged in developmental terms. This could impinge on how political representatives approach forest resources.

3.3 Political reservations and forest outcomes

The link between political reservation for STs and forest conservation has, however, been little examined, either in India or elsewhere. To our knowledge, globally, only Gulzar et al (2023) have done so. They compare Scheduled Areas with non-Scheduled Areas in nine Indian states. But they focus only on PESA 1996, using difference-in-difference and propensity score-matching methods to assess how PESA affects forest improvement. They report that formal representation for PESA GPs led to an "average increase of tree canopy by 3% per year as well as a reduction in the rate of deforestation" (Gulzar et al 2023: 3). They offer two explanations for this: first that STs tend to work as stewards of forests and can pursue their economic interests better with political reservation; second that STs oppose mining.

However, both factors are conjectural. The authors' assumption that the economic interests of STs automatically lie in protecting forests needs testing, given that STs also depend on forests for their livelihood and could overdraw, while mines tend to be locationally concentrated and can even provide an alternative income source and so reduce forest extraction.

More importantly, their paper is confined to PESA, which relates to village-council level reservations, and does not cover AC reservations, or the overlap of AC and PESA. Hence, the positive conservation outcomes that they attribute to PESA could be due to AC reservations, at least in part. In fact, as our results show, AC reservations are linked to significantly greater improvements in forest cover relative to never-reserved areas, while PESA areas do worse than never-reserved areas. Moreover, two other important factors are not considered by Gulzar et al (2023): first, the effect of non-village forests on village forest change; and, second, the effect of tree planting undertaken both within village boundaries and in rural non-village areas, by the government alone, or by both the government and private parties as compensatory afforestation, or by villagers themselves.

Our paper analyses the effect of the two levels of political reservations (AC and PESA) both separately and overlapping, as well as changes in forest cover over time. It controls for socioeconomic factors which can impinge on conservation outcomes and takes account of the effect of non-village forests as well as of plantation policies.

4 Methodology

4.1 Choice of state

We selected Chhattisgarh state in central India because it has a high proportion of tribal people in its population and a high proportion of its geographic area is under

forest cover. The state was formed in November 2000 after a split from a larger state, Madhya Pradesh. In 2021, 41.2% of Chhattisgarh's geographic area was forested (Government of India, 2021, ch 2). Also, 29 of the state's 90 ACs were reserved for ST candidates. This means that 32.2% of all ACs were reserved for STs, relative to 9.4% in India as a whole. Moreover, 19 districts in the state are fully or partially designated as Scheduled Areas, and thus subject to reservations under PESA. This enables us to assess the effects of both AC and PESA reservations.

4.2 Reservation categories

When created in November 2001, Chhattisgarh inherited the prior reservation status assigned to Madhya Pradesh. This persisted until 2008 when a new delimitation exercise changed the electoral boundaries for ACs in keeping with the 2001 census.

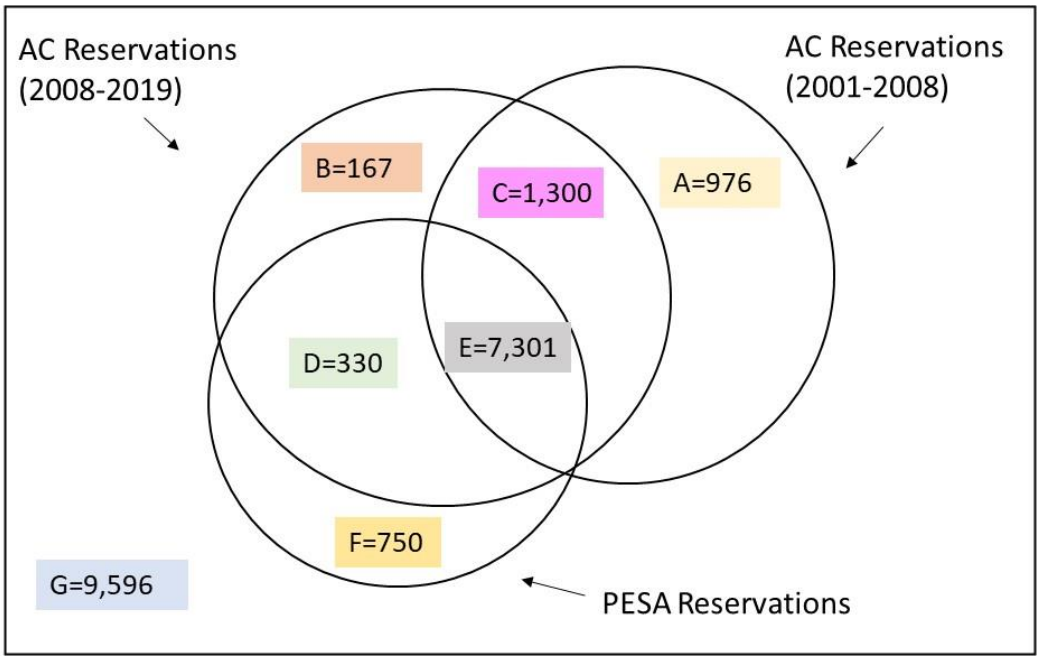
To untangle the impact of AC and PESA reservations we sought to create seven non-overlapping categories of reservation and time periods, as given in Figure 1 and Table 1. The spaces A, B and C in Figure 1 cover AC reservations for the periods 2001–08 (eight years), 2009–19 (11 years) and 2001–19 (19 years), respectively. F represents only PESA reservations.[10] D and E have overlapping AC and PESA reservations, while villages in the G area have had no AC or PESA reservation at any time.

Table 2 supplements Figure 1 and shows the number of years of reservation as well as the number of villages in each category. These categories form the basis of our graded reservation and inter-temporal analysis.

We take all the villages in Chhattisgarh to analyse the effect of the different combinations of reservations identified above.

[10] Although this does not affect our identification of PESA villages, pinpointing the precise year of PESA's effective implementation is not straightforward. Chhattisgarh's first *panchayat* elections were held in 2005, but a 2012 Report of the Ministry of Panchayati Raj (Government of India, 2012) noted that (1) Chhattisgarh (like most states) was not complying with the PESA Act on minor forest produce; and (2) the Backward Regional Grant Fund launched by the central government in 2006 (and budgeted in 2006–07), with special provisions for SCs and STs, had scarcely been used by the state. Around 2008–09, however, it appears, discussions were initiated to strengthen PESA rules, and legal inputs were also solicited (Enviro Legal Defence Firm, 2011). We have thus taken 2008–09 as the approximate time when implementation moved forward. This is also close to the date of AC delimitation in 2008.

Figure 1: Non-overlapping reservation categories



Notes:
A= villages under only AC reservation 2001–08;
B = villages under only AC reservation 2009–19;
C = villages under AC 2001–08 reservation and AC 2009–19 reservation;
D= villages under AC 2009–19 reservation and PESA reservation;
E= villages under AC 2001–08 reservation, AC 2009–19 reservation and PESA reservation;
F= villages under only PESA reservation;
G= villages never reserved under either AC or PESA.
Source: Authors' calculations.

Table 2: Villages under AC and PESA reservation (non-overlapping categories)

Reservation category	Number of villages in the state	Years of AC reservation
A: AC 2001–08 only	976	8
B: AC 2009–19 only	167	11
C : AC 2001–08 and 2009–19, no PESA	1,300	19
D: AC 2009-2019 and PESA	330	11
E: AC 2001–08 and AC 2009–19 and PESA	7,031	19
F : PESA only	750	0
G: Neither AC nor PESA	9,596	0

Note: Villages in the 2001–08 group were reserved before the 2008 AC delimitation. Villages in the 2009–19 group are those reserved after the 2008 delimitation.
Source: Calculated by the authors.

4.3 Full state analysis

Chhattisgarh has 20,167 inhabited villages (uninhabited ones are not counted) but data on reservations only covered 20,150 villages (Figure 1) and full socioeconomic data could be obtained only for 17,606. We base our analysis on these villages, starting in 2001 after Chhattisgarh was formed. We use logistic regressions to examine the effects of AC and PESA reservations for STs on change in forest cover between 2001–19. The change is represented by a dummy variable that takes the value 1 if forest cover increased between 2001 and 2019 by at least five percentage points and 0 for a lower increase or a decline. We use a five percentage point positive change to ensure that we are capturing more than non-trivial effects.[11] This is the dependent variable across all the regression models.

We assess the effects of AC and PESA reservations separately and then simultaneously. These specifications constitute three models, with varying levels of reservation, each without and with specified control variables (described further below). Model 1 compares villages which have had AC reservations with all other villages. In Model 2, we disaggregate the effects of AC and PESA reservations as well as of AC reservations for different time periods; and, in Model 3, we compare villages which have had some form of reservation (AC or PESA) in any time period, with those which have never been reserved by either AC or PESA since Chhattisgarh was formed.[12]

In addition, we examine changes in RNV forests over 2001–19, and the proportions of tree cover attributable to plantations both within villages and in RNV areas, in descriptive terms.

The models used for regressions are detailed below, using Figure 1 as a reference point for clarity. All variables are identified at the village level. The actual equations are specified further below.

Model 1 (AC reserved villages only)

We compare all villages that have had AC reservation, whether or not they are under PESA, with villages that have not had AC reservation.

Equation 1a: $D_{AC} = A+B+C+D+E = 1; F+G = 0$

Equation 1b: As equation 1a but with control variables

[11] We got similar results for a ten percentage point improvement. There are few villages above ten points: 54 at a 15 percentage point improvement, four at 20 points, and none at 25 points.
[12] In fact, they had not been reserved since at least 1974, when the previous delimitation was done under the unified Madhya Pradesh state.

Model 2 (both AC and PESA reserved villages disaggregated)

We compare never-reserved villages with villages that have had varying levels of reservation, disaggregated as follows: AC (2001–08), AC (2009–19), AC (2001–19) and PESA.

Equation 2a. $D_{AC2001to2008} = A$; $D_{AC2009to2019} = B$; $D_{AC2001to2019} = C$; $D_{AC\ and\ PESA} = D+E$; $D_{PESA} = F$; $D_{Unreserved} = G$ (reference category)

Equation 2b. As 2a but with control variables

Model 3 (All reservations, AC or PESA)

We compare villages that have had any reservation (AC or PESA) over any time period with never-reserved villages.

Equation 3a: $D_{reserved} = A+B+C+D+E+F = 1$; $D_{unreserved}$ $G = 0$ (reference category)

Equation 3b: As 3a but with control variables

4.4 Village control variables: some hypotheses

Apart from reservations, a range of additional factors could affect forest cover. The 'control variables' we use are: percentage of village households below the poverty line, increase in population (2001–11), percentage of cultivators in the working population, whether the village was connected by a new paved road during 2001–11, distance of the village from a town (Class II and above),[13] and distance of the village from the nearest RNV forest. These variables could affect forest cover either positively or negatively.

The incidence of poverty, for example, can have a positive effect in that the poor are more forest-dependent (Vira et al, 2016) and would thus have a stake in conserving their local forests by, say, keeping out intruders. But poverty can also have a negative effect in that high dependence can lead to high extraction.

An increase in population density can affect forests by putting additional pressure on the forest reserve. We use a dummy variable for population increase greater than 1% between 2001 and 2011. The percentage of households dependent on cultivation as their main income source can affect forests either positively or negatively. On the one hand, since cultivators depend on forests for green manure and fodder, we expect

[13] Class II towns in the census are those with a population of at least 50,000 people. We took distance from larger towns, assuming they are more likely to have an impact than small towns.

them to have a stake in conservation. On the other hand, farmers may clear forests for cultivation, thereby reducing tree cover (FAO, 2016).

Roads are usually expected to reduce forest area not only because forests may be cleared for their construction but also because roads can facilitate the commercial exploitation of forests (Freitas et al, 2010). Urbanisation can have a similar effect, so we use distance of the village from a Class II town as a control variable.[14]

In addition, the proximity of a village to non-village forests can matter. Villagers draw upon forests for their daily needs, such as firewood, fodder and other products. However, if they have other forests nearby, they are likely to draw upon these, either to supplement or in lieu of exploiting their own village forest. Since women, in particular, do most collection on foot, distances matter. We examine the effect of RNV forests located at 5 km and 10 km from the village boundary to test this hypothesis. In a household survey by Khanwilkara et al (2022) for three states, including Chhattisgarh, women reported walking 2.74 km on average for firewood across the seasons. We took a somewhat higher figure of 5 km to capture all geographic landscapes in the state, with 10 km as the upper bound.

4.5 Logistic regression equations

We use the following equations for our regression analysis.

Model 1

$$(Equation\ 1a)\ Y_i = \beta_0 + \beta_1 D_{AC} + \in$$

$$(Equation\ 1b)\ Y_i = \beta_0 + \beta_1 D_{AC} + \beta_2 poverty + \beta_3 D_{popchange} + \beta_4 pcult + \beta_5 D_{newroad} + \beta_6 town + \beta_7 D_{RNVforest5} + \beta_8 D_{RNVforest10} + \in$$

Model 2

$$(Equation\ 2a)\ Y_i = \beta_0 + \beta_1 D_{AC2001to2008} + \beta_2 D_{AC2009to2019} + \beta_3 D_{AC2001to2019} + \beta_4 D_{PESA} + \beta_5 D_{AC\ and\ PESA} + \in$$

$$(Equation\ 2b)\ Y_i = \beta_0 + \beta_1 D_{AC2001to2008} + \beta_2 D_{AC2009to2019} + \beta_3 D_{AC2001to2019} + \beta_4 D_{PESA} + \beta_5 D_{AC\ and\ PESA} + \beta_6 poverty + \beta_7 D_{popchange} : + \beta_8 pcult + \beta_9 D_{newroad} + \beta_{10} town + + \beta_{11} D_{RNVforest5} + \beta_{12} D_{RNVforest10} + \in$$

[14] We also tried distance of the village from coal mines. This too was negatively significant (as found in some other studies, eg Mishra et al, 2022). However, coal mine distance and town distance were strongly correlated. We kept only town distance for several reasons: towns are spatially dispersed across the state, while coal mines are concentrated in northern Chhattisgarh; the impact of towns on forests is dynamic, while land use change around mines would be sporadic; and we could only access data on coal mines, which is limited since the state also has a sizeable number of iron-ore and other mines.

Model 3

$(Equation\ 3a)\ Y_i = \beta_0 + \beta_1 D_{reserved} + \in$

$(Equation\ 3b)\ Y_i = \beta_0 + \beta_1 D_{reserved} + \beta_2 poverty + \beta_3 D_{popchange} + \beta_4 pcult + \beta_5 D_{newroad} + \beta_6 town + \beta_7 D_{RNVforest5} + \beta_8 D_{RNVforest10} + \in$

where, Y_i: Dummy: villages with positive forest cover change ≥ 5 percentage points (2001–19) =1; forest cover change <5 percentage points or negative (2001–19) = 0.

D_{AC}: Dummy where all AC reserved villages =1; rest = 0.

$D_{AC2001to2008}$: Dummy: only AC reserved villages (2001–08) =1; rest = 0

$D_{AC2009to2019}$: Dummy: only AC reserved villages (2009–19) =1; rest = 0

$D_{AC2001to2019}$: Dummy: only AC reserved villages (2001–19) =1; rest = 0

D_{PESA}: Dummy: only PESA reserved villages = 1; rest = 0.

$D_{AC\ and\ PESA}$: Dummy: villages with different combinations of PESA and AC reservations =1; rest=0

$D_{reserved}$: Dummy: villages with any reservation =1; rest=0

$D_{unreserved}$: Dummy: villages that have never been reserved =1; rest=0

$Poverty$: Proportion of village households below the poverty line

$D_{popchange}$: Dummy: villages over 1% increase in population (2001–11) =1; rest = 0.

$pcult$: Proportion of village households dependent on cultivation as the main income source

$D_{newroad}$: Dummy: villages with new paved road made between 2001 and 2011= 1. Rest = 0

$town$: Distance of a village from the nearest town (km) in 2011

$D_{RNVforest9,}$ $D_{RNVforest10,}$: Two dummies for distance of village from RNV forests, one for ≤5 km = 1, another for >5 to ≤10 km = 1. The reference category is >10 km = 0.

5 Data

We needed five main categories of data for our analysis: (1) on political reservation; (2) on village area under tree cover; (3) on socioeconomic factors; (4) on RNV forests; and

(5) on tree plantations. For this purpose, we collated both spatial and statistical indicators from various sources (see Appendix Table A2 for details).

Political reservation data consist of AC boundaries and GIS shapefiles (village maps). The AC shapefiles were obtained from DataMeet (https://github.com/datameet/maps), while the village shapefiles were obtained by digitising the *Administrative Atlas* of India's 2011 Census. These AC and village maps were spatially adjusted and the AC boundaries laid over village boundaries to ascertain whether a village fell under an ST or a non-ST constituency pre- and post- the 2008 delimitation. The PESA reservations were identified through the lists of districts and blocks with Scheduled Areas, as specified in The Scheduled Areas (States of Chhattisgarh, Jharkhand and Madhya Pradesh) Order, 2003 (see Table A2 for details). We matched these to the list of districts and blocks given in the Primary Census Abstract of the Census of India 2011.

For forest area, we use the digitised VCF product (Version 6.1), derived from the MODIS TERA satellite imagery with a spatial resolution of 250 m, to obtain the percentage area under tree cover for each village. This percentage was weighted by the fraction of each VCF pixel which intersected with the village area. We then multiplied this share and total village area to get the overall tree cover in the village in square kilometres. A similar method was used to derive tree cover in RNV areas. 'Tree cover' includes woody plants greater than 5m in height (DiMiceli et al, 2021).

For data on socioeconomic indicators, such as roads, population, percentage of cultivators, etc, we used mainly the SHRUG platform, which extracts this information from India's decennial population censuses. Gaps in the SHRUG database (such as missing information) were filled directly from the decennial censuses. In addition, we used SHRUG's estimates of the poverty rate, that is, the proportion of village households living below the poverty line.[15] The distance of the village from the nearest town was calculated using locational data from the 2011 Census *Administrative Atlas*. Villages with missing data on any of the above counts were excluded from the analysis.

In addition, we accessed spatial data on plantations from the e-greenwatch website, to capture the percentage of tree cover area constituted by plantations, both within and outside village boundaries.

[15] To arrive at poverty estimates, the SHRUG team used the Government of India's 2011–12 Socio-economic and Caste Census and the India Human Development Survey (IHDS-II, 2012–13) for consumption data on which India's poverty estimates are normally based.

6 Results

We first make a broad comparison of forest area by reservation categories, followed by a discussion of the regression results.

6.1 Cross-tabulations

Table 3 presents changes in forest cover over time for 20,150 villages by different reservation categories. We note that in villages with AC reservation between 2001-2019, forest cover increased on average by 23.93 ha per village (row 1).

However, when we disaggregate the AC reserved villages by different time periods (that is, before and after the 2008 delimitation), we find an average decline in forest cover of 11.95 ha per village between 2001 and 2008 (row 2a), and an increase of 17.38 ha between 2009 and 2019 (row 2b), while villages which had both AC and PESA reservations over 2009-2019 show a mean increase of 17.63 ha (row 2e). It is, however, villages which remained solely AC reserved over the entire period, 2001–19, which show the highest increase of 27.81 ha (row 2c), All these differences are statistically significant. The percentage increase, however, was highest among AC reserved villages over 2009-2019.

Villages with at least one type of reservation (row 3) show a mean increase of 22.7 ha between 2001 and 2019.This amounts to a total rise in tree covered area of over 239,576 ha for the 10,554 villages aggregated. In contrast, in the 9,596 villages with no reservation, the mean increase in tree cover was only 5.38 ha per village over the same period, amounting to an aggregate rise of 51,626 ha for these villages. Hence, although unreserved villages also showed improvement, the average increase in tree cover in reserved villages was over four times greater (row 3 vs row 4c).

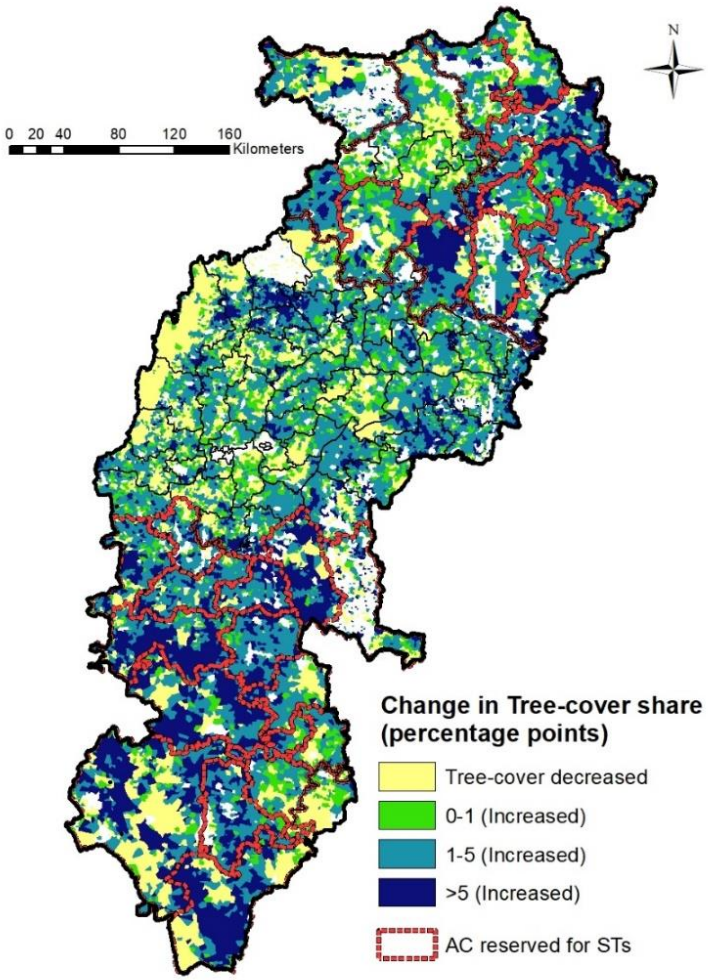
Also, in the period 2001–08, although both the unreserved and reserved villages performed poorly, with a decline in forest covered area in both cases, in the subsequent period the reserved villages picked up much more substantially than the unreserved ones.

Table 3: Comparisons of forest area by type and period of reservation

Models (N=20,150)	**Forest area means (ha) by reservation categories**		**Difference in means of forest area (ha)**	***t*-values for difference in means (2-1)**	**% forest change**
	1	**2**	**3**	**4**	**5**
(1) AC 2001–19	**AC 2001 (N=9,804)**	**AC 2019 (N=9,804)**			
Forest (ha)	109.42	133.33	23.93	36.87***	2.93%
2 (a) AC 2001–08	**AC 2001 (N=976)**	**AC 2008 (N=976)**			
Forest (ha)	83.35	71.40	-11.95	-5.517***	-1.55%
2 (b) AC 2009–19	**AC 2009 (N=167)**	**AC 2019 (N=167)**			
Forest (ha)	55.26	72.64	17.38	6.13***	3.10%
2 (c) AC 2001–19	**AC 2001 (N=1,300)**	**AC 2019 (N=1,300)**			
Forest (ha)	270.06	297.87	27.81	9.72***	2.69%
2 (d) PESA	**PESA 2009 (N=750)**	**PESA 2019 (N=750)**			
Forest (ha)	23.67	32.80	9.13	6.78***	2.23%
2 (e) AC and PESA (2009–19)	**AC and PESA 2009 (N=7,361)**	**AC and PESA 2019 (N=7,361)**			
Forest (ha)	93.70	111.34	17.63	25.01***	2.24%
(3) Any reservation 2001–19	**Any reservation 2001 (N=10,554)**	**Any reservation 2019 (N=10,554)**			
Forest (ha)	103.49	126.21	22.71	37.38***	2.88%
4 (a) No reservation 2001–08	**No reservation 2001 (N=9,596)**	**No reservation 2008 (N=9,596)**			
Forest (ha)	31.71	29.08	-2.62	-6.23***	-0.64%
4 (b) No reservation 2009–19	**No reservation 2009 (N=9,596)**	**No reservation 2019 (N=9,596)**			
Forest (ha)	29.45	37.09	7.64	33.87***	1.89%
4 (c) No reservation 2001–19	**No reservation 2001 (N=9,596)**	**No reservation 2019 (N=9,596)**			
Forest (ha)	31.71	37.09	5.38	26.95***	1.32%

Source: Calculated by the authors.

Figure 2: Change in village tree cover, 2001–19



The change in village tree cover over the whole period, 2001-2019, is mapped visually in Figure 2. The areas within the red outlines are those that fall under AC reservation for STs after the 2008 delimitation exercise. Most of the land with over 1 percentage point increase in forest cover is seen to lie in AC reserved areas.

We now turn to the regression results.

6.2 Regression results

Table 4 presents the results for the three regression models (six equations) first without and then with control variables (see Appendix Table A3 for the summary statistics). Only the marginal effects are presented here.

Table 4. Factors affecting forest conservation outcomes (logistic regressions): marginal effects

Dependent variable	**Forest cover (dummy: rise in forest cover of at least 5%)**						
Model number	Model 1	Model 2	Model 3		Model 1	Model 2	Model 3
Pseudo R^2	0.0211	0.0343	0.0170		0.0472	0.0542	0.0464
N	17,606	17,606	17,606		17,606	17,606	17,606
	No controls				**With controls**		
Equation number	1a	2a	3a		1b	2b	3b
Explanatory variables	Forest chng 2001–19	Forest chng 2001–19	Forest chng 2001–19		Forest chng 2001–19	Forest chng 2001–19	Forest chng 2001–19
D: AC reservation 2001–19	0.109** (0.000)				0.041*** (0.000)		
D: AC 2001–08		-0.079*** (0.000)				-0.079*** (0.000)	
D: AC-2009–19		0.277*** (0.000)				0.293*** (0.000)	
D: AC 2001–19		0.229*** (0.000)				0.034*** (0.000)	
D: PESA		-0.047*** (0.002)				-0.040* (0.014)	
D: AC AND PESA (2009–19)		0.111*** (0.000)				0.048*** (0.000)	
D: ANY RESERVATION			0.097*** (0.000)				0.032*** (0.000)
Poverty					0.167*** (0.000)	0.171*** (0.000)	0.171*** (0.000)
D: Population increase >1% (2001–11)					-0.045*** (0.000)	-0.048*** (0.000)	-0.045*** (0.000)
% HHs with cultivation as main income source					0.063*** (0.000)	0.062*** (0.000)	0.068*** (0.000)
D: New road (built 2001-2011)					-0.018** (0.000)	-0.020*** (0.000)	-0.018** (0.002)
Distance from nearest town (km)					0.0009*** (0.000)	0.0008*** (0.000)	0.0009*** (0.000)
D: Nearest RNV forest within 5 km of village					0.058*** (0.003)	0.064*** (0.001)	0.060*** (0.002)
D: Nearest RNV forest within 10 km of village					0.012 (0.208)	0.011 (0.228)	0.013 (0.164)

Notes: [a] A number of villages had to be dropped because of incomplete socioeconomic information for controls.
All estimates are derived using robust standard errors. 'D' indicates dummy variables.
p-values are in brackets. Significance levels: *** 1%, ** 5%, * 10%.
RNV forest dummies: differences between 5 km and 10 km dummies are significant at the 1% level.

Without controls, barring one exception (the period 2001–08), there is a consistently significant and positive relationship between AC reservation and improvements in tree cover (whether we take AC reserved villages only, or both AC and PESA reserved

villages) (Models 1 to 3, equations 1a, 2a and 3a). The highest effect is with AC reservation over 2009–19, with a 27.7 percentage point greater likelihood of tree cover increase (Equation 2a) relative to never-reserved villages. The one exception relates to 2001–08, when AC reserved villages show a decline in forest cover, the likelihood of a decline being 7.9 percentage points more than in never-reserved villages. (We discuss the factors impinging on this period and shifts thereof in Section 6 of the paper.)

PESA reserved villages do worse than never-reserved ones even in the 2009-19 period. They show a 4.7 percentage point less likelihood of improvement relative to unreserved villages (Model 2, equation 2a).

The inclusion of other explanatory variables makes no difference to the overall results in this regard (Equations 1b, 2b, 3b). The likelihood of at least a 5 percentage point improvement in forest cover remains statistically significant with AC reservation of any kind relative to unreserved villages, across all time periods except 2001–08,[16] while PESA villages again show worse results than never-reserved villages.

The explanatory variables are themselves interesting. We find a consistency across all three models (equations 1b, 2b. 3b): villages with higher percentages of poor households and of cultivator households show a significantly positive relationship with improvement in tree cover, while those with an increase in population, a new road built during 2001–11, or a location near a large town, show a negative relationship. The results for RNV forest distances are also interesting. Villages located within 5 km are likely to be better conserved, after which the relationship becomes insignificant.

One additional point is noteworthy. Although we cannot fine-tune forest cover density in Chhattisgarh from our data, the *State of the Forest Report* of 2021, published by the Forest Survey of India (Government of India, 2021, ch 2), shows a notable increase in the proportion of forest canopy area that is very dense (>70% canopy). This is accounted for mainly by a decline in the proportion that is moderately dense (40–70% canopy) and some decrease in open forest area (10–40% canopy). Notably, too, the growth in very dense tree cover is more pronounced in predominantly tribal districts.

6.3 Non-village forests

Finally, consider the link between AC reservations and RNV tree cover. In Table 5, we note that as with village forests so with non-village forests, there is a substantial improvement over the period 2009–19 but a decline between 2001–08, across all village

[16] We also conducted sensitivity analysis for 10 percentage point forest improvement. Our results were consistent with those presented here.

categories, reserved or not. Notably, the biggest percentage point increase during this period (4.79) was in areas which were under AC reservation between 2009 and 2019.

Table 5: Changes in rural non-village forest cover by AC reservation periods

RNV reservation type	% RNV area under tree cover				Percentage point changes in RNV tree cover		
	2001	2008	2009	2019	2001–08	2009–19	2001–19
AC reserved 2001–19	21.45	14.98	19.69	24.17	-6.48	4.48	2.72
AC reserved 2001–08	18.11	14.33	17.59	21.83	-3.77	4.24	3.72
AC reserved 2009–19	20.22	17.55	19.66	24.45	-2.67	4.79	4.23
Never reserved	19.91	12.76	16.40	20.33	-7.14	3.93	0.43

Source: Authors' calculations.

6.4 Insights into changes

Our results for both village tree cover and RNV tree cover show a poor performance between 2001-2008 and a notable improvement between 2009-2019.

A number of factors help explain the poor performance before 2008 (the AC delimitation year) and the positive shift after that date. To begin with, 2007 and especially 2008, were drought years and this affected forest vegetation, which picked up subsequently. Moreover, in 2001, soon after Chhattisgarh became a separate state, it framed a new forest policy which was notably pro-conservation (Government of Chhattisgarh, 2001; Marothia, 2009). However, the implementation of the policy, and hence its gains, came into effect only after a time lag. Similarly, higher pay scales were approved for forest guards in 2003 but only implemented in 2008 (Putul, 2022). Forest guards play a critical role in protecting forests against illegal logging and forest fires. Hence, while the period 2001–08 showed a decline in average tree cover in both AC reserved and non-reserved areas, this changed for the better after 2008, and much more substantially in the reserved areas.

Most importantly, between 2005 and 2008, Chhattisgarh launched several tree planting schemes, in particular the Hariyali Prasar Yojna (HPY) in 2005,[17] and set up the Compensatory Afforestation Fund Management and Planning Authority (CAMPA) post-2008. The HPY encouraged villagers to fulfil their firewood and other household needs and raise incomes by planting trees on wasteland, fallow land and field boundaries, and by practising agro-forestry. CAMPA was ordered to be established by India's Supreme Court in all states in 2001, to promote

[17] See Government of Chhattisgarh, Forest and climate change department website (in Hindi) at http://www.forest.cg.gov.in/posts/research-extension?l=Hindi.

afforestation in non-forest areas as a compensation for the loss of forests resulting from industrial or other activities. Under the law, a company diverting forest land to other uses needs to pay for tree planting on alternative land provided to the state. However, the Bill to fund CAMPA was only passed by Parliament in 2008,[18] and CAMPA was formally launched in Chhattisgarh only in July 2009.[19]

We examined the contribution of plantations to the change in tree cover between 2009 and 2019, both within villages and in RNV areas (Tables 6 and 7).[20]

Table 6: Contributions of plantations to change in village tree cover

Reserva-tion	Total tree area (ha)	Planta-tion area (ha)	% planta-tion to tree area	Total tree area (ha)	Planta-tion area (ha)	% planta-tion to tree area	Change in tree area (ha)	Change in planta-tion area	Share of plantation in change in tree area
	2009			2019			2009–19		
AC reserved	9854.36	117.86	1.20	12189.6	136.17	1.11	2335.24	18.31	0.78
Non-AC reserved	3791.66	62.98	1.66	4690.55	80.94	1.73	898.89	17.96	2.00
All villages	13646.02	180.84	1.33	16880.15	217.11	1.29	3234.13	36.27	1.12

Source: Authors' calculations.

[18] The Compensatory Afforestation Bill 2008. See https://prsindia.org/billtrack/the-compensatory-afforestation-fund-bill-2008.

[19] CAMPA, Performance Report of Chhattisgarh. http://www.forest.cg.gov.in/cms/media/44fb7b85-c08f-4fb1-884c-8f249e88d91e_campa_performance31616.pdf.

[20] The spatial data on plantations from e-greenwatch gave us 3,446 plantation areas/shapes (=1,357.91 sq km). Of these, we considered 1,749 plantation areas (=1,221.79 sq km), distributed across villages and RNV areas. We included all compensatory afforestation and other kinds of plantations, but excluded plantations in urban areas and those along roads and canals.

Table 7: Contributions of plantations to change in RNV tree cover

Reservation	Total tree area (ha)	Plantation area (ha)	% plantation to total tree area	Total tree area (ha)	Plantation area (ha)	% plantation to tree area	Change in tree area (ha)	Change in plantation area	Share of plantation in tree area change
	2009			2019			2009–19		
AC reserved	1364.04	23.67	1.74	1675.94	27.22	1.62	311.9	3.55	1.14
Non-AC reserved	573.24	10.99	1.92	719.05	14.1	1.96	145.81	3.11	2.13
All RNVs	1937.28	34.66	1.79	2394.99	41.32	1.73	457.71	6.66	1.46

Source: Authors' calculations.

Several points are notable here. Overall, the share of plantations to total tree cover is relatively small (≤2% in all cases), and, within this, the figures are slightly lower in AC reserved villages relative to unreserved villages, in both 2009 and 2019. This is also the case in RNV non-reserved areas vs RNV reserved areas in 2019. In addition, where changes over the 2009–19 period are concerned, the contribution of plantations to the increase in tree cover area is greater in non-reserved villages and RNVs than in reserved villages and RNVs. This suggests that the improvement in forest cover in AC reserved areas (relative to unreserved areas) depends less on plantations and more on protection and conservation by the tribal communities.

7 Discussion and conclusions

In this paper we have probed the effect of political representation for STs on forest conservation, using India's Chhattisgarh state as an example.

Our most important finding is that political representation for STs at the AC level is linked with significantly improved forest cover, with the exception of the early years following the state's formation. We had earlier noted the possibility of tribal MLAs being conflicted between the goals of development and the goals of conservation. If such conflict exists, it does not appear to be undermining conservation so far. Indeed, conservation goals have been given particular importance, both in the shaping of forest

policy when the state was formed in 2001, and in the implementation of afforestation policies from 2008 onwards.

On PESA, however, the results are somewhat discouraging. Solely PESA reserved villages do less well than never-reserved ones (controlling for AC reservation). For a start, the jurisdiction of PESA villages over forest produce was initially limited. It is only recently that the Chhattisgarh government has been preparing rules to strengthen that jurisdiction (Verma, 2021). But, more particularly, at the village level, representatives are likely to be susceptible to contradictory pulls and pressures from different segments of the community, including from any local elite STs wanting to exploit the forest.

Other factors that we examined for their effect on forest cover are also interesting, and show consistency. We find significantly positive conservation outcomes where villagers are more dependent on forests for complementary inputs, such as green manure and fodder, as well as in villages with a high proportion of cultivators, than in villages with a high proportion of landless people. The latter tend to depend more on forests for saleable items, especially minor forest produce. We also have better conservation outcomes where villagers have easier access to non-village forests in the vicinity. But we get worse outcomes where villages are located near large towns or have had new roads built that can facilitate the commercial exploitation of forests.

It should be mentioned that our results differ from the sole study by Gulzar et al (2023). Those authors focused only on PESA reservations and report significantly positive effects on conservation, while we found that PESA areas performed worse than never-reserved areas, wheras AC villages performed significantly better, both on their own and along with PESA. Hence, the positive PESA effects observed by Gulzar et al could be attributable, at least in part, to AC reservations rather than PESA reservations.

Finally, our results open up some notable possibilities for improving forest cover and biodiversity internationally, via a route which could prove to be a win-win, namely the political inclusion of socially disadvantaged communities at high levels of governance. At lower levels of governance, say at that of local communities, political representation may not have this effect, or even have a contrary effect if villagers who favour forest exploitation supersede those who favour conservation. This does not imply, however, that village communities should not be accorded political control over local resources. Rather, in such cases, the way forward would be to provide indigenous communities with incentives (financial or non-financial) for protecting their forests, recognising that they could face conflicting livelihood choices, and may not uniformly or necessarily

serve as forest stewards. These results should prove relevant for a number of countries which have both large forest areas and substantial indigenous populations.

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APPENDIX

Table A1: Amazon rainforest and political representation of indigenous people by country

Country	Amazon forest basin (2011) (%)	Indigenous people as a percentage of the country's total population (2015) (%)	Percentage of total seats in the country's Congress held by indigenous people (2015)
Brazil	58.4	0.5	0
Peru	12.8	26.0	6.9
Bolivia	7.7	41.0	24.7
Colombia	7.1	3.3	1.1
Venezuela	6.1	2.8	1.82
Guyana	3.1	ni	ni
Suriname	2.5	ni	ni
French Guiana	1.4	ni	ni
Ecuador	1.0	7.0	5.11
Total	100.0		

Sources: For Amazon forest shares, see, Castro, et al (2013: 3). For indigenous populations and seats in Congress, see Global Americans (2017: Table 2).

Table A2: Data sources

Type of indicators	Nature of data	Source	Description of the data	Temporal profile
Reservation	AC boundaries	DataMeet (https://github.com/datameet/maps)	GIS shapefiles of ACs	After the 2008 delimitation
	Village boundaries	*Administrative Atlas of India*	GIS shapefiles of villages	As per Census, 2011
	PESA reservation status; block boundaries	Government of India, Ministry of Tribal Development[2]	Villages that have PESA reservations and other villages	–
Forest area changes	MODIS Vegetation Continuous Fields (VCF), Version 6.1	Raw data extracted from https://lpdaac.usgs.gov/products/mod44bv061/	Percentage tree cover derived at 250 meters resolution[1]	2001–19
	Spatial data of plantation areas	e-greenwatch website[3]	Areas covered by plantation	2009–19
Developmental/other factors	Location of towns with ≥ 50,000 people (Class II and above)	Census of India, 2011		2011
	Village population	SHRUG[4]	Population of villages	2001 and 2011
	Proportion of households in a village dependent on cultivation as the main source of income	Census of India, 2011	Cultivators (people who are engaged in agriculture and own land)	2011
	Paved road in the village	SHRUG[4]	Whether the village has access to a paved road	2011
	Proportion of households below the poverty line (INR 28) in a village	SHRUG[4]	Small area estimates of poverty ratios at the village level	2012–13

Notes:

[1] The percentage tree cover from MODIS VCF is measured on the basis of "the portion of the skylight orthogonal to the surface which is intercepted by trees". As noted, it defines 'tree' as a woody plants >5 m in height.

Sources:

[2] See https://tribal.nic.in/downloads/CLM/CLM_Declare/3.pdf. This source in Hindi provides the list of districts and blocks under PESA in Chhattisgarh.

[3] See https://egreenwatch.nic.in/WorksAndEstimate/Public/KMLs/View_Download_Work_KML.aspx.

[4] See https://shrug-assets-ddl.s3.amazonaws.com/static/main/assets/other/shrug-codebook.pdf

Table A3. Summary statistics for dependent and explanatory variables in the regression analysis

Variable	Mean	CV	Min	Max
Dependent variables (N=17,606)				
% Change in forest area, 2001–19	2.27	1.57	-23.09	22.03
Dummy: villages with positive forest change ≥ 5 percentage points =1	0.183	2.11	0	1
Explanatory variables (N=17,606)				
Dummy: AC reserved villages all, 2001–19 =1	0.487	1.02	0	1
Dummy: AC reserved villages, only 2001–08 =1	0.044	4.65	0	1
Dummy: AC reserved villages, only 2009–19 =1	0.008	10.82	0	1
Dummy: AC reserved villages, only 2001–19 =1	0.058	3.99	0	1
Dummy: PESA reserved villages only = 1	0.032	5.44	0	1
Dummy: AC and PESA (2009–19) =1	0.376	1.29	0	1
Dummy: villages with any reservation (AC or PESA), 2001-2019 =1	0.520	0.96	0	1
Dummy: villages with ≥ 1% increase in population	0.927	0.27	0	1
Dummy: villages with a new road	0.339	1.39	0	1
Distance of village from town 2011 (km)	51.75	0.64	1.74	188.11
Proportion of households in poverty	0.535	0.31	0.009	1
Proportion of households dependent on cultivation as the main source of income	0.472	0.60	0.001	1
Distance of village from RNV (km)	25.92	0.59	1.19	106.13
Dummy: nearest RNV forest ≤ 5 km of village	0.028	5.79	0	1
Dummy: nearest RNV forest > 5 km and ≤10 km of village =1	0.106	2.89	0	1