How Many People Live Near Protected Areas in Developing Countries? Estimates from Gridded Population Data (2000–2020)

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Abstract   Protected areas (PAs) are the mainstream instrument for biodiversity conservation, but their creation and expansion can have mixed socioeconomic impacts on local populations. While some research has examined the implications of conservation policies, the number of people affected by PAs remains unquantified. We estimate the population living within and near PAs in 2000 to 2020 in 76 countries classified as low- and lower-middle-income by the World bank in 2020. Using Google Earth Engine, we analyze changes in PA-surrounding populations by aggregating population estimates from two high-resolution gridded dataset over the buffered boundaries provided by the World Database on Protected Areas. While terrestrial PA coverage in developing countries increased from 9.3% in 2000 to 12.9% in 2020, our results indicate that the share of the population living within 10 km of a PA rose from 16.4% to 21.8% over the same period. This global average is largely driven by India, due to its demographic size and almost null PA expansion. For the 74 other countries, PA coverage increased from 10.2% in 2000 to 14.1% in 2020, and population living within 10 km of a PA from 26.5% to 33.5%. These figures highlight the magnitude of the socioeconomic implications of conservation, particularly as global commitments aim to expand PA coverage to 30% of terrestrial land by 2030.

1 Introduction

Protected areas (PAs) are a cornerstone of biodiversity conservation, primarily established for ecological purposes (Maxwell et al. 2020). However, their creation can have positive or negative consequences for local populations (Kandel et al. 2022). On the one hand, PAs may impose socio-economic constraints by restricting access to natural resources (e.g., gathering, hunting, fishing, medicinal plants), limiting land availability, and curbing economic activities such as agriculture, livestock, and construction. On the other hand, they can provide benefits through compensation measures (e.g., local development projects, cash transfers), job creation (e.g., conservation-related employment, tourism), and enhanced ecosystem services (e.g., improved water resources, erosion control, fire prevention).

The impact of conservation on local well-being has long been debated in the scientific community (Adams et al. 2004). Yet, to our knowledge, no study has systematically quantified the share of the population affected by PAs. While some research has examined population density trends around PAs [joppa2009b; geldmann2019], none have assessed the direct demographic implications of PA creation or expansion.

The proportion of the population directly impacted by PAs is a critical issue for conservation planning, as it influences the distribution of benefits and burdens across social groups, shaping both local reception and long-term feasibility. This political dimension helps explain why communities near PAs are often framed as either "dependents"—receiving symbolic recognition but little tangible support—or "deviants"—facing restrictions and criminalization, while more influential conservation actors shape policies to their advantage (Schneider and Ingram 1993). PA creation and expansion are thus not purely ecological decisions but political ones, affecting policy support from local elites, voters, and decision-makers, who balance conservation goals with social welfare mandates (Mangonnet, Kopas, and Urpelainen 2022). Recognizing the demographic scope of PA-affected populations is therefore essential, as overlooking their socioeconomic realities risks generating resistance and conflict, ultimately threatening conservation legitimacy and effectiveness.

The rapid expansion of protected areas makes this issue even more pressing. Between 2000 and 2023, terrestrial PA coverage increased by 62%, now covering 17.6% of the global land area (UNEP-WCMC and IUCN 2024). This growth is set to accelerate with the COP15 global commitment to expand PA coverage to 30% of terrestrial land by 2030. While these efforts are crucial for biodiversity conservation, they also raise urgent questions about their socioeconomic implications. As more land falls under protection, more people will be affected, either through restricted access to resources or through conservation-driven economic opportunities. Gauging how many people live within or near newly designated PAs is essential for designing conservation policies that balance ecological goals with human well-being.

2 Methods

2.1 Study Area

The study focuses on countries classified by the World Bank as low-income and lower-middle-income economies in 2020. The World Bank's income classification is widely used in international research and policy discussions, as it provides a standardized framework based on Gross National Income (GNI) per capita, adjusted using the Atlas method (Vaggi 2017). We did not include South Sudan and Timor Leste, as these countries did not exist in 2000. To enable spatial comparability between 2000 and 2020, the areas currently corresponding to Indonesia and South Sudan were removed from the 2000 areas computed for Indonesia and Sudan.

We set a threshold of 10 km to define the treatment group, as is common practice to measure the socioeconomic impacts of protected areas within a 10 km radius in developing countries (Naidoo et al. 2019; Oldekop et al. 2016).

2.2 Data Sources

This study integrates three geospatial datasets: geoBoundaries for the administrative area, the World Database on Protected Areas (WDPA) for PA boundaries and establishment years, and two gridded population global datasets: Worldpop and the Global Human Settlement Layer (GHSL).

The national areas were selected using geoBoundaries (v.6.0.0). This dataset provides an open, standardized, and regularly updated collection of political boundary data, including administrative divisions from ADM0 (national) to ADM4 (local) levels, covering over 200 countries and territories (Runfola et al. 2020).

The WDPA (February 2025 edition), managed by the United Nations Environment Programme's World Conservation Monitoring Centre (UNEP-WCMC), is considered as the most comprehensive and regularly updated global dataset on protected areas (Bingham et al. 2019). It is produced in collaboration with the International Union for Conservation of Nature (IUCN) and is updated monthly with submissions from national governments, non-governmental organizations, landowners, and local communities (UNEP-WCMC and IUCN 2023). The database provides spatial and tabular information on over 200,000 protected areas worldwide, covering both terrestrial and marine environments. Each PA in the WDPA is associated with attributes such as designation type, management category, governance structure, and legal status. Notably, the status year field records the year in which a site was formally designated, allowing for historical analyses of PA expansion.

GHSL draws from another dataset, the Density of Gridded Population of the World, version 4 (GPWv4), produced by Center for International Earth Science Information Network (CIESIN), at Columbia University. GPWv4 is based on the 2010 official census and estimated population estimated data, completed with the United Nation's World Population Prospect. GPWv4 has a spatial resolution of 1km and assumes that populations are evenly distributed in space, which is unreasonable (Chen et al. 2020). GHSL leverages remote sensing and crowdsourced data to identify human settlements and uses linear regression methods to provide a more reliable and higher resolution (250m) spatial distribution of GPWv4 information. As we will further elaborate in the discussion section, GHSL has been evaluated as the most reliable global population gridded dataset (Chen, Yan, Liu, Du, and Yang 2020).

The dataset that was considered as the second-best is WorldPop, which trains a random forest algorithm on various data sources from censuses, administrative data, elevation, slope, land cover, infrastructure, satellite data, and mobile phone communication to provides high-resolution (100-meter) population estimates based on a combination of census data, satellite imagery, and geospatial modeling techniques (Stevens et al. 2015). It enables spatially explicit analyses of population distribution over time, making it well suited for evaluating human presence near protected areas. We use WorldPop's 2000 and 2020 population datasets (WorldPop and CIESIN 2020).

2.3 Analytical approach

We used Google Earth Engine (GEE), a cloud-based geospatial platform for large-scale environmental analysis (Gorelick et al. 2017). GEE enabled efficient processing of high-resolution population estimates within and around protected areas across 75 countries in 2000 and 2020, handling

billions of pixels over 50 hours of computation, executed in six iterative batches due to system constraints.

We extracted protected area boundaries from the World Database on Protected Areas (WDPA), excluding UNESCO-MAB Biosphere Reserves, which often lack legal protection (Hanson 2022; Coetzer, Witkowski, and Erasmus 2014). We retained the WDPA polygons or the portion of them that intersect with national terrestrial boundaries from GeoBoundaries, retaining terrestrial PAs or the terrestrial portion of coastal PAs. Purely offshore PAs with no overlap on land were excluded. We generated binary PA presence layers at 100m resolution and created 10-km buffer zones to assess population proximity over time. To estimate populations inside and near PAs, we applied zonal statistics to WorldPop data, aggregating results at the national level for small and medium-sized countries. For large countries (>1,000,000 km²), we conducted the analysis at the subnational (ADM1) level using geoBoundaries to avoid memory usage limits. The output dataset provides national and subnational statistics on PA coverage and population proximity for 2000 and 2020. The GEE JavaScript code used for this analysis and the output dataset is included in the replication package available online [Include repo citation].

To assess the consistency of population estimates from GHSL and WorldPop within and near protected areas, we compare their values for each country and year. Simple absolute differences are not a suitable means of comparison, as they are influenced by the estimate levels, which vary significantly across countries and depending on whether we consider PAs or surrounding areas. Instead, we use the Standardized Mean Difference (SMD), which standardizes the difference by accounting for variations in scale and dispersion. It is computed as:

$$SMD = \frac{\left| \bar{X_1} - \bar{X_2} \right|}{\sqrt{\frac{\sigma_1^2 + \sigma_2^2}{2}}}$$

where $barX_1$ and $barX_1$ are the mean population estimates from WorldPop and GHSL, respectively, and σ_1^2 and σ_2^2 are their variances.

The results are further analyzed using R (R Core Team 2023) and helper functions (Wickham et al. 2019) to be displayed thanks to packages optimized for data visualisation (Wickham 2016; Slowikowski 2023; Wilke 2024) and tabular result presentation (Iannone et al. 2023).

3 Results

3.1 Population

Table 1 summarizes the extent of PAs and population proximity to PAs in low- and lower-middle-income countries. It presents the percentage of national land within PAs and the percentage of population within 10 km of PAs for the years 2000 and 2020. Due to its large population and relatively low PA coverage, India has an overwhelming impact on the global average for developing countries. To account for this, we provide two totals: one including India and another excluding it.

Table 1: PA Coverage and Population Proximity (2000-2020)

Percentage of land and population within and near protected areas

| Country | % land within (WDPA) | | | | % population (GHSL) | | | | % population (WorldPop) | | | |
| | within PAs | | 10km of PAs | | within PAs | | 10km of PAs | | within PAs | | 10km of PAs | |
	2000	2020	2000	2020	2000	2020	2000	2020	2000	2020	2000	2020
Total	9.3	12.9	21.0	27.2	0.9	1.8	16.4	21.8	1.8	2.7	16.2	21.8
Total without India	10.2	14.1	22.9	29.5	1.4	2.8	26.5	33.5	2.8	4.2	26.1	33.6
Afghanistan	0.1	3.7	0.6	6.0	0.1	1.2	0.6	14.9	0.1	1.1	0.6	13.6
Angola	5.4	10.8	9.0	15.8	0.4	1.0	2.5	4.3	0.9	1.3	3.0	5.0
Burundi	5.4	5.4	40.8	41.4	0.3	0.3	40.1	44.7	2.8	2.6	39.6	43.9
Benin	23.7	23.7	54.9	54.9	1.7	1.8	25.7	25.7	5.2	5.7	25.8	26.5
Burkina Faso	14.2	16.6	33.3	38.8	3.3	4.0	31.0	42.7	6.1	7.8	31.5	45.8
Bangladesh	4.0	4.5	9.8	17.8	0.3	0.5	5.0	18.8	0.6	1.0	4.6	18.3
Bolivia	20.9	23.3	33.4	38.4	22.2	31.0	61.3	68.8	21.1	25.8	58.3	63.0
Bhutan	38.5	51.1	72.0	80.5	4.4	4.5	55.2	56.1	11.2	11.6	56.2	58.4
Central African Republic	14.0	14.0	21.8	21.9	0.6	0.6	19.8	21.3	2.0	1.8	22.2	23.1
Côte d'Ivoire	21.5	21.7	69.5	70.0	5.1	5.6	69.7	71.6	10.0	9.3	71.4	72.6
Cameroon	5.2	11.1	13.0	25.4	0.1	3.3	4.5	25.1	0.9	6.0	5.2	24.4
Congo, Dem. Rep.	9.0	14.9	14.9	23.0	2.5	6.1	23.3	28.1	3.9	7.3	22.7	24.5
Congo, Rep.	9.3	36.5	16.3	53.1	0.7	13.2	49.2	74.3	3.3	26.9	31.7	66.4
Comoros	0.8	33.0	6.5	97.8	0.5	11.9	36.1	99.5	1.7	38.7	21.7	98.9
Cabo Verde	0.0	18.4	0.0	94.9	0.0	8.8	0.0	96.0	0.0	14.1	0.0	94.6
Djibouti	0.0	1.3	0.0	8.3	0.0	0.0	0.0	1.4	0.0	0.8	0.0	7.8
Egypt, Arab Rep.	4.3	11.2	6.5	15.7	0.1	0.3	12.6	13.4	0.4	0.5	11.2	11.3
Eritrea	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.9	0.0	0.0	0.0	1.6
Ethiopia	10.4	17.0	17.6	27.2	3.2	7.0	9.8	17.4	3.8	7.7	9.8	17.8
Micronesia, Fed. Sts.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ghana	14.7	14.9	56.9	57.2	−1.2	−0.2	68.2	69.0	6.2	5.0	69.1	68.9
Guinea	7.9	23.7	35.9	52.3	2.6	14.9	46.7	57.1	4.0	15.4	47.3	59.0
Gambia, The	5.1	8.0	32.2	61.8	0.2	1.0	57.2	79.2	2.8	8.8	55.8	78.9

Source: Analysis based on WDPA, WorldPop & GHSL data (2000-2020)

Table 1: PA Coverage and Population Proximity (2000-2020)

Percentage of land and population within and near protected areas

Country	% land within (WDPA)				% population (GHSL)				% population (WorldPop)			
	within PAs		10km of PAs		within PAs		10km of PAs		within PAs		10km of PAs	
	2000	2020	2000	2020	2000	2020	2000	2020	2000	2020	2000	2020
Guinea-Bissau	18.0	24.4	40.8	49.9	2.8	5.8	16.7	20.7	5.8	9.4	20.9	25.3
Honduras	20.4	23.0	54.6	63.7	4.0	5.6	67.5	76.3	8.2	9.2	65.5	74.1
Haiti	2.2	7.4	16.6	46.0	0.9	3.3	10.4	50.8	1.0	3.2	10.8	54.4
Indonesia	11.5	11.9	31.5	33.9	0.2	0.5	32.1	34.6	1.7	2.2	31.7	34.6
India	0.2	0.5	1.1	2.4	0.0	0.0	0.5	1.1	0.1	0.1	0.5	1.1
Kenya	10.8	12.7	32.4	38.2	2.2	2.7	57.0	59.4	4.0	4.2	59.4	60.7
Kyrgyz Republic	6.4	6.7	21.6	23.3	0.6	0.6	17.0	16.7	1.2	1.1	15.1	14.7
Cambodia	14.1	39.9	34.3	68.5	2.1	5.3	13.5	30.7	2.4	7.7	13.6	31.3
Kiribati	0.0	4.6	0.0	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lao PDR	8.9	15.9	23.1	40.0	1.4	3.2	19.2	31.0	1.9	3.8	18.7	28.6
Liberia	1.7	3.7	6.6	12.3	0.0	0.9	3.7	10.0	0.2	1.8	3.5	10.2
Lesotho	2.0	23.5	19.0	40.1	0.3	8.6	10.9	27.2	0.8	9.9	11.2	25.8
Morocco	0.6	2.2	2.6	11.9	0.1	1.0	6.3	20.4	0.2	1.5	5.8	19.5
Moldova	9.1	9.1	86.1	86.4	1.4	1.6	91.5	91.5	6.3	6.0	83.2	82.1
Madagascar	4.3	12.8	14.0	35.8	0.2	4.8	7.7	41.7	1.6	8.0	8.4	40.2
Mali	3.3	7.5	9.1	15.9	3.4	12.1	36.7	50.7	4.5	11.9	36.2	52.0
Myanmar	1.6	6.6	7.2	18.1	0.2	0.6	7.7	12.0	0.4	1.1	8.0	12.7
Mongolia	14.8	19.7	23.4	32.1	1.7	2.2	36.2	54.4	5.5	6.1	33.1	55.5
Mozambique	21.1	29.4	33.2	42.9	3.6	8.8	11.5	28.8	4.5	9.8	11.9	28.2
Mauritania	0.6	0.6	1.0	1.0	0.4	0.1	1.2	0.8	0.4	0.1	1.1	0.7
Malawi	18.0	18.7	61.2	63.2	1.9	2.0	63.3	63.9	2.2	2.5	62.6	62.4
Niger	7.4	17.0	9.5	20.7	2.1	5.0	5.0	10.3	2.7	5.3	6.0	10.7
Nigeria	12.0	13.3	57.6	59.4	1.5	2.2	51.0	51.7	4.4	4.6	53.0	54.0
Nicaragua	14.0	21.5	42.2	55.8	2.5	5.4	65.0	70.3	5.5	9.3	65.0	70.5
Nepal	18.9	23.5	35.2	42.8	2.6	5.5	24.4	35.8	2.9	5.6	21.2	41.6
Pakistan	7.2	7.7	15.2	17.1	1.3	1.4	11.3	11.4	1.7	1.7	10.8	11.1
Philippines	8.7	15.9	30.3	54.6	3.5	4.7	35.5	57.1	3.6	5.2	36.3	58.3

Source: Analysis based on WDPA, WorldPop & GHSL data (2000-2020)

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| | within PAs | | 10km of PAs | | within PAs | | 10km of PAs | | within PAs | | 10km of PAs | |
	2000	2020	2000	2020	2000	2020	2000	2020	2000	2020	2000	2020
Papua New Guinea	2.9	3.7	8.6	11.5	1.2	1.2	11.1	11.8	1.5	1.7	11.6	12.7
Korea, Dem. Rep.	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4
Rwanda	8.7	9.3	29.7	41.3	0.0	0.2	21.0	30.7	0.3	0.7	21.5	31.5
Sudan	1.4	1.4	1.8	2.0	0.1	0.1	0.2	0.2	0.4	0.3	0.6	0.5
Senegal	25.5	26.5	60.1	61.4	3.1	4.1	39.5	62.1	7.6	9.4	40.8	63.4
Solomon Islands	1.0	1.5	2.1	11.6	5.2	5.7	4.9	3.6	0.1	0.2	2.4	8.1
Sierra Leone	9.4	13.0	50.3	60.1	2.5	5.6	59.2	68.5	5.8	9.1	58.9	68.7
El Salvador	0.1	8.6	8.2	80.7	0.0	2.9	4.2	90.2	0.0	3.8	4.2	90.3
Somalia	0.0	0.0	0.1	0.2	0.0	0.0	0.2	0.2	0.0	0.0	0.1	0.1
São Tomé and Príncipe	0.0	32.5	0.0	93.8	0.0	0.1	0.0	49.5	0.0	9.1	0.0	58.2
Eswatini	4.1	4.4	28.3	38.4	0.2	0.1	34.1	41.8	1.6	1.5	30.7	39.5
Syrian Arab Republic	0.0	0.1	0.2	0.9	0.0	0.0	0.1	0.6	0.0	0.0	0.1	0.6
Chad	11.4	13.9	14.7	18.4	3.8	3.8	11.8	13.6	6.5	7.7	11.7	16.8
Togo	12.2	12.8	62.8	66.4	3.8	4.4	49.9	65.3	5.9	6.3	49.9	66.5
Tajikistan	18.7	21.8	35.1	40.9	0.6	0.7	13.3	15.7	1.5	1.7	12.5	15.2
Tunisia	5.1	8.0	18.1	33.5	0.1	0.3	26.1	49.7	0.8	1.5	27.6	58.5
Tanzania	36.4	39.9	65.8	69.1	4.9	6.1	60.5	66.0	8.6	9.7	61.3	67.5
Uganda	13.2	15.2	72.0	74.2	2.3	2.8	85.6	86.4	6.7	7.3	86.0	87.0
Ukraine	18.1	18.1	82.5	82.5	1.2	1.2	89.5	89.9	9.6	9.2	85.6	86.4
Uzbekistan	2.9	7.9	8.1	17.0	0.1	0.3	2.4	10.0	0.9	1.1	4.9	10.6
Viet Nam	1.9	7.6	14.9	40.1	0.5	1.1	9.1	20.4	0.9	2.0	10.4	21.9
Vanuatu	3.9	3.9	37.0	37.0	0.0	−0.1	−5.8	−11.2	0.6	0.7	48.1	55.2
Yemen, Rep.	1.0	1.1	1.5	2.6	1.0	2.0	3.1	10.4	1.0	2.0	3.2	10.4
Zambia	38.1	38.9	71.3	72.1	10.5	10.6	76.4	75.6	17.4	16.2	74.2	72.7
Zimbabwe	17.8	28.2	38.1	49.8	1.6	6.8	31.6	39.8	4.4	9.1	32.0	42.8

Source: Analysis based on WDPA, WorldPop & GHSL data (2000-2020)

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Percentage of land and population within and near protected areas

| Country | % land within (WDPA) | | | | % population (GHSL) | | | | % population (WorldPop) | | | |
| | within PAs | | 10km of PAs | | within PAs | | 10km of PAs | | within PAs | | 10km of PAs | |
	2000	2020	2000	2020	2000	2020	2000	2020	2000	2020	2000	2020
West Bank and Gaza	NA	NA	NA	NA	0.5	0.4	60.9	62.5	NA	NA	NA	NA

Source: Analysis based on WDPA, WorldPop & GHSL data (2000-2020)

Terrestrial PA coverage in developing countries increased from 9.3 % in 2000 (3.4 million km2) to 12.9 % in 2020 (4.7 million km2), while the share of the population living within 10 km of a PA according to GHSL rose from 16.4 % (446.5 million people) to 21.8 % (844.4 million people) over the same period. This global average is largely driven by India, due to its demographic size and almost null PA expansion. For the 75 other countries, PA coverage increased from 10.2 % in 2000 (3.4 million km2) to 14.1 % in 2020 (4.7 million km2), while the share of the population living within 10 km of a PA according to GHSL rose from 26.5 % (441.6 million people) to 33.5 % (829.6 million people).

The expansion of PA coverage was contrasted across countries. Some countries saw substantial increases, such as Bhutan (38.5% to 51.1%) and Cambodia (14.1% to 39.9%), while others experienced minimal growth (0.17% to 0.52%), such as Indi . Other countries already had high PA coverage in 2000 and only saw marginal increases, such as Zambia (38.1% to 38.9%) and Tanzania (36.4% to 39.9%). A few countries had almost no change in PA coverage, such as Ghana (14.7% to 14.9%) and Côte d'Ivoire (21.5% to 21.7%).

3.2 Shifts in Shares of Population Near Protected Areas (2000–2020)

Figure 1 illustrates country-level changes in the percentage of population residing within 10 km of protected areas between 2000 and 2020. The points represent the population share near PAs in both years, while the connecting lines indicate whether the trend is increasing (blue) or decreasing (red).

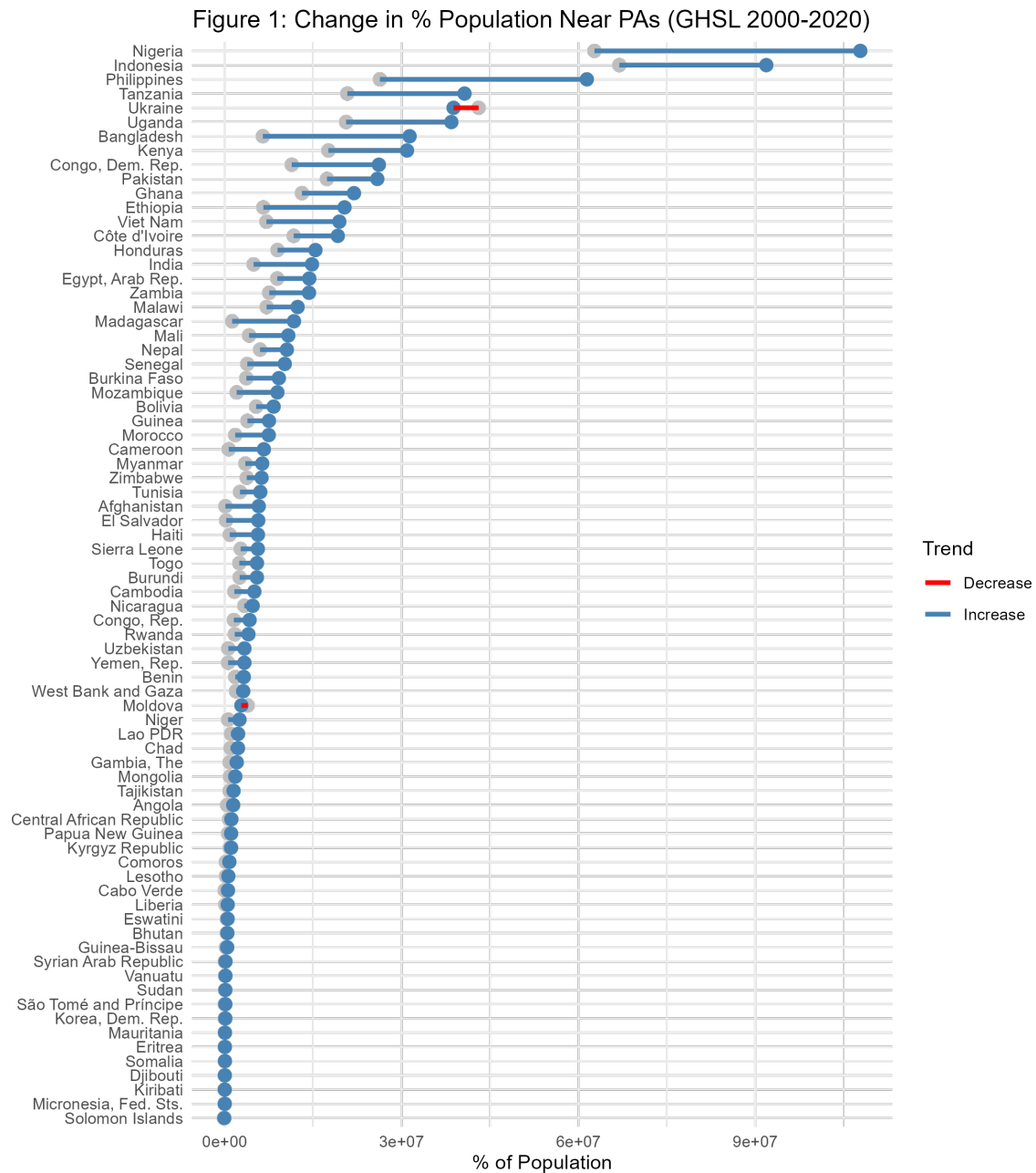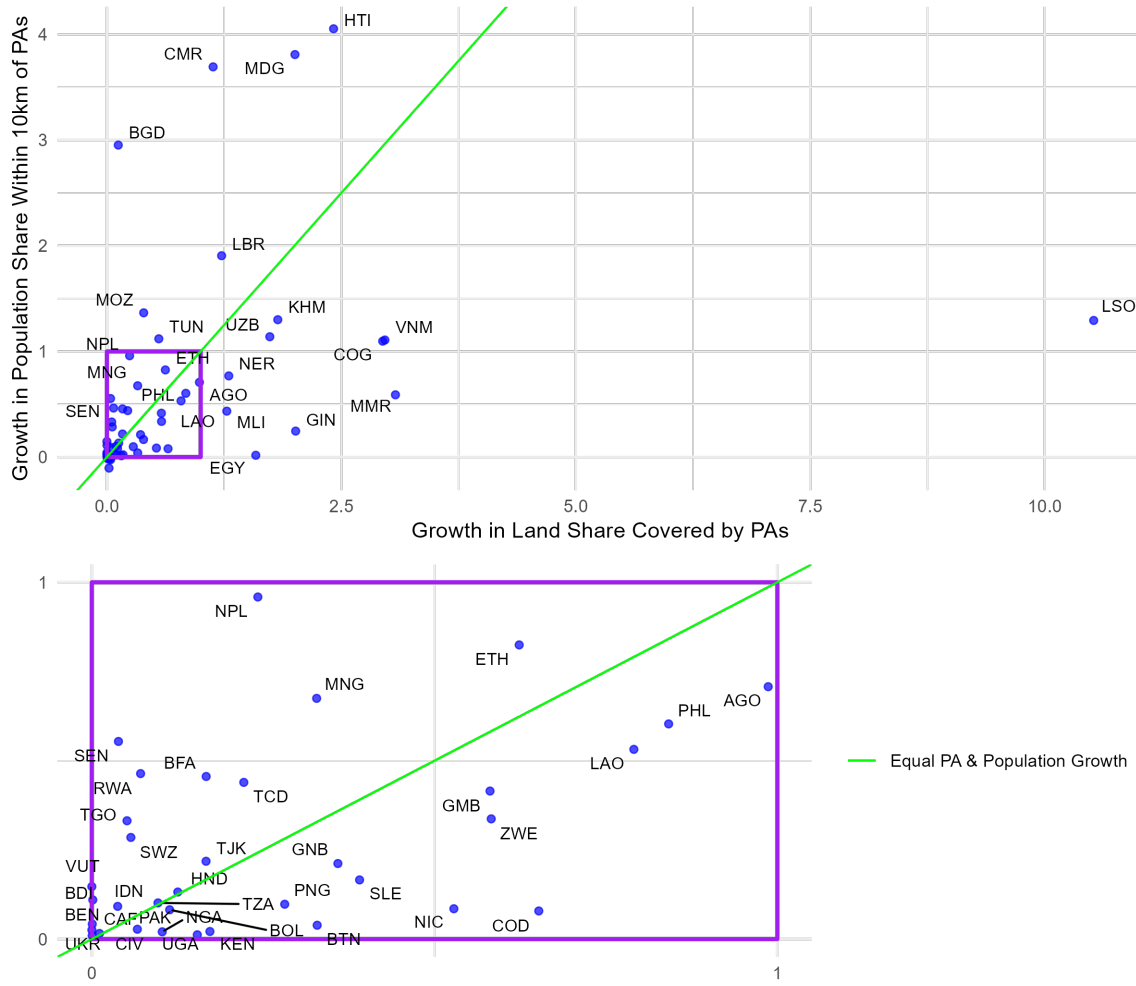Figure 1: Change in % Population Near PAs (GHSL 2000-2020)

Figure 1 indicate a widespread increase in the proportion of people living near PAs, with particularly sharp rises in Comoros, Cabo Verde, El Salvador, Tunisia, São Tomé and Príncipe, Haiti, and Madagascar, where PA expansion combined with high population density has intensified human proximity. In countries such as Uganda, Ukraine, Côte d'Ivoire, Kenya, and Nigeria, PA coverage was already relatively high in 2000 and saw little expansion. In Ukraine and Moldova, where PA coverage remained stable, urban demographic growth reduced the relative share of populations near PAs, leading to slight declines.

3.3 Growth of PA Coverage and Population near PAs between 2000 and 2020

Figure 2 presents the country-level changes in PA land coverage and the percentage of the population living within 10 km of PAs from 2000 to 2020 according to GHSL. The diagonal green line represents equal growth in PA coverage and nearby population share. Countries above the line saw a faster increase in PA-adjacent populations than PA spatial expansion. We excluded countries with less than 1% PA coverage in 2000 to prevent distortions, as even small PA expansions in these cases would appear as disproportionately large growth ratios due to their low starting point.

Figure 2: Evolution of PA Land Coverage and Nearby Population Share (GHSL 2000-2020)

Subsample of 58 countries classified as Low- or Low-Middle Income in 2020, with at least 1% PA coverage in 2000

Country codes: AFG: Afghanistan, AGO: Angola, BDI: Burundi, BEN: Benin, BFA: Burkina Faso, BGD: Bangladesh, BOL: Bolivia, BTN: Bhutan, CAF: Central African Republic, CIV: Côte d'Ivoire, CMR: Cameroon, COD: Congo, Dem. Rep., COG: Congo, Rep., COM: Comoros, CPV: Cabo Verde, DJI: Djibouti, EGY: Egypt, Arab Rep., ERI: Eritrea, ETH: Ethiopia, FSM: Micronesia, Fed. Sts., GHA: Ghana, GIN: Guinea, GMB: Gambia, The, GNB: Guinea-Bissau, HND: Honduras, HTI: Haiti, IDN: Indonesia, IND: India, KEN: Kenya, KGZ: Kyrgyz Republic, KHM: Cambodia, KIR: Kiribati, LAO: Lao PDR, LBR: Liberia, LSO: Lesotho, MAR: Morocco, MDA: Moldova, MDG: Madagascar, MLI: Mali, MMR: Myanmar, MNG: Mongolia, MOZ: Mozambique, MRT: Mauritania, MWI: Malawi, NER: Niger, NGA: Nigeria, NIC: Nicaragua, NPL: Nepal, PAK: Pakistan, PHL: Philippines, PNG: Papua New Guinea, PRK: Korea, Dem. Rep., PSE: West Bank and Gaza, RWA: Rwanda, SDN: Sudan, SEN: Senegal, SLB: Solomon Islands, SLE: Sierra Leone, SLV: El Salvador, SOM: Somalia, STP: São Tomé and Príncipe, SWZ: Eswatini, SYR: Syrian Arab Republic, TCD: Chad, TGO: Togo, TJK: Tajikistan, TUN: Tunisia, TZA: Tanzania, UGA: Uganda, UKR: Ukraine, UZB: Uzbekistan, VNM: Viet Nam, VUT: Vanuatu, YEM: Yemen, Rep., ZMB: Zambia, ZWE: Zimbabwe

The majority of countries fall below the diagonal in Figure 2, meaning that their PA expansion outpaced the growth of adjacent populations. Lesotho in particular, exhibit large PA expansions with relatively small shifts in population share, indicating that new PAs were primarily established in low-density areas. This reflect the classical trend of PAs to be typically established "high and far", where pressure for land conversion is lower (Joppa and Pfaff 2009).

In contrast, countries in the top left quarter of Figure 2 experienced a much larger increase in the percentage of their population near PAs than in PA coverage, indicating that new PAs or

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expansions occurred in relatively high-density areas. Such pattern is expected in countries with predominantly rural populations, such as Madagascar, Bangladesh, and Mozambique, where PA establishment is more likely to affect human settlements In other cases, such as Haiti, Cameroon, and Liberia, the trend appears to result from deliberate conservation choices to designate PAs in more densely inhabited regions, rather than in remote areas. The zoomed-in portion highlights countries with smaller relative changes, where PA coverage and nearby population less than doubled between 2000 and 2020.

3.4 Share of PA Coverage and Population Near PAs in 2020

Figures 3 displays the relationship between the percentage of national land designated as protected areas and the percentage of the population residing within 10 km of these areas in 2020. Each point represents a country, with country codes labeled on the graph and a corresponding key provided below. The size of the points reflects the total national population.

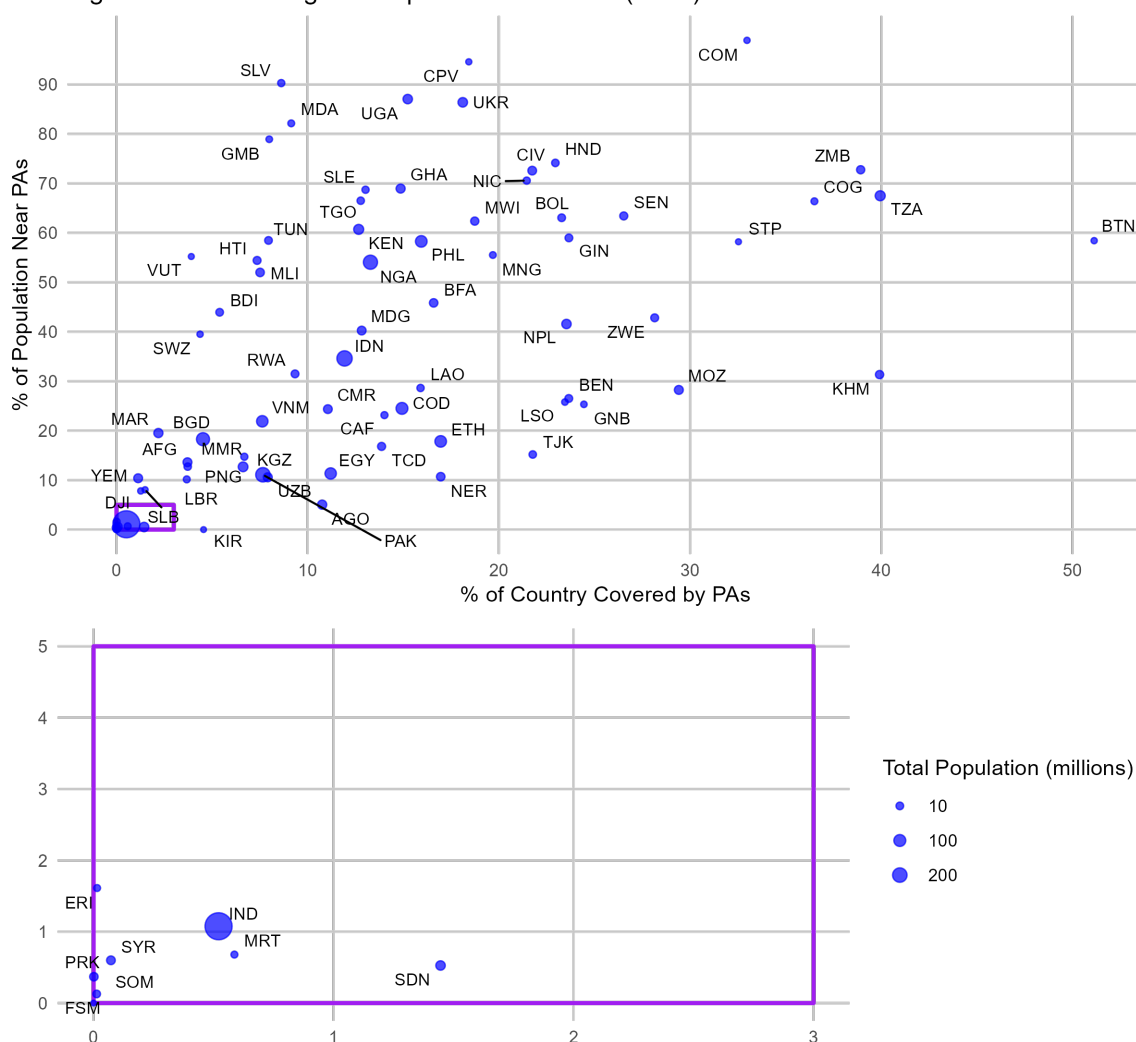Figure 3: PA Coverage vs Population Near PAs (2020)

Country codes: AFG: Afghanistan, AGO: Angola, BDI: Burundi, BEN: Benin, BFA: Burkina Faso, BGD: Bangladesh, BOL: Bolivia, BTN: Bhutan, CAF: Central African Republic, CIV: Côte d'Ivoire, CMR: Cameroon, COD: Congo, Dem. Rep., COG: Congo, Rep., COM: Comoros, CPV: Cabo Verde, DJI: Djibouti, EGY: Egypt, Arab Rep., ERI: Eritrea, ETH: Ethiopia, FSM: Micronesia, Fed. Sts., GHA: Ghana, GIN: Guinea, GMB: Gambia, The, GNB: Guinea-Bissau, HND: Honduras, HTI: Haiti, IDN: Indonesia, IND: India, KEN: Kenya, KGZ: Kyrgyz Republic, KHM: Cambodia, KIR: Kiribati, LAO: Lao PDR, LBR: Liberia, LSO: Lesotho, MAR: Morocco, MDA: Moldova, MDG: Madagascar, MLI: Mali, MMR: Myanmar, MNG: Mongolia, MOZ: Mozambique MRT: Mauritania, MWI: Malawi, NER: Niger, NGA: Nigeria, NIC: Nicaragua, NPL: Nepal, PAK: Pakistan, PHL: Philippines, PNG: Papua New Guinea, PRK: Korea, Dem. Rep., PSE: West Bank and Gaza, RWA: Rwanda, SDN: Sudan, SEN: Senegal, SLB: Solomon Islands, SLE: Sierra Leone, SLV: El Salvador, SOM: Somalia, STP: São Tomé and Príncipe, SWZ: Eswatini, SYR: Syrian Arab Republic, TCD: Chad, TGO: Togo, TJK: Tajikistan, TUN: Tunisia, TZA: Tanzania, UGA: Uganda, UKR: Ukraine, UZB: Uzbekistan, VNM: Viet Nam, VUT: Vanuatu, YEM: Yemen, Rep., ZMB: Zambia, ZWE: Zimbabwe

fig-alt="A scatter plot with, for 2020, the percent of spatial PA coverage as X and the percent of population within 10 km of PAs."}

Figure 3 highlights considerable variation across countries in both PA coverage and the proportion of people living near these areas. Some countries, such as Bhutan and Tanzania, have extensive PA networks. A cluster of countries with low PA coverage and limited nearby population presence can also be observed. Notably India falls in this section, and it has such a large population that it weighs heavily on the global averages drawn from these national statistics.

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3.5 Consistency between sources

Table 2 presents the SMDs between GHSL and WorldPop estimates for populations residing within and near protected areas in 2000 and 2020, with higher values indicating greater discrepancies.

Table 2: Standard Mean Differences Between GHSL and Worldpop Estimates

	2000	2020
Population within PAs	0.29	0.20
Population within 10km of PAs	0.09	0.08

There is no universal interpretation of SMD values, and we could not find guidelines directly applicable to the comparison of different sources trying to assess the same indicators. For the purpose of assessing if an intervention has a significant effect of an outcome of interest, Cohen suggested as a rule of thumb to consider a small effect if the SMD is beyond 0.2, a large effect if it is beyond 0.5 and large if it is beyond 0.8 (Cohen 1988) and this principle is often use to consider that a SMD inferior to 0.2 does not indicate a meaningful difference when it comes to assess effect sizes. Austin discusses this principle and proposes as a more conservative principle that two unit groups could be considered as comparable if their SMD was below 0.1 (Austin 2009). According to this principle, we could interpret from table 2 that GHSL and Worldpop are significantly inconsistent to estimate the population living within protected areas, whereas they present consistent results when it comes to estimate the population within 10km of PAs. As we will discuss below, GHSL has been assessed as more reliable source for very high and very low density settings (Chen, Yan, Liu, Du, and Yang 2020).

Figure 4 provides a more disagregated view of the discrepancies between GHSL and WorldPop estimates. Each segment represents the difference between the two sources for a given country, with black and blue points respectively indicating GHSL and WorldPop.

Figure 4: Comparison of Population Estimates from GHSL and WorldPop
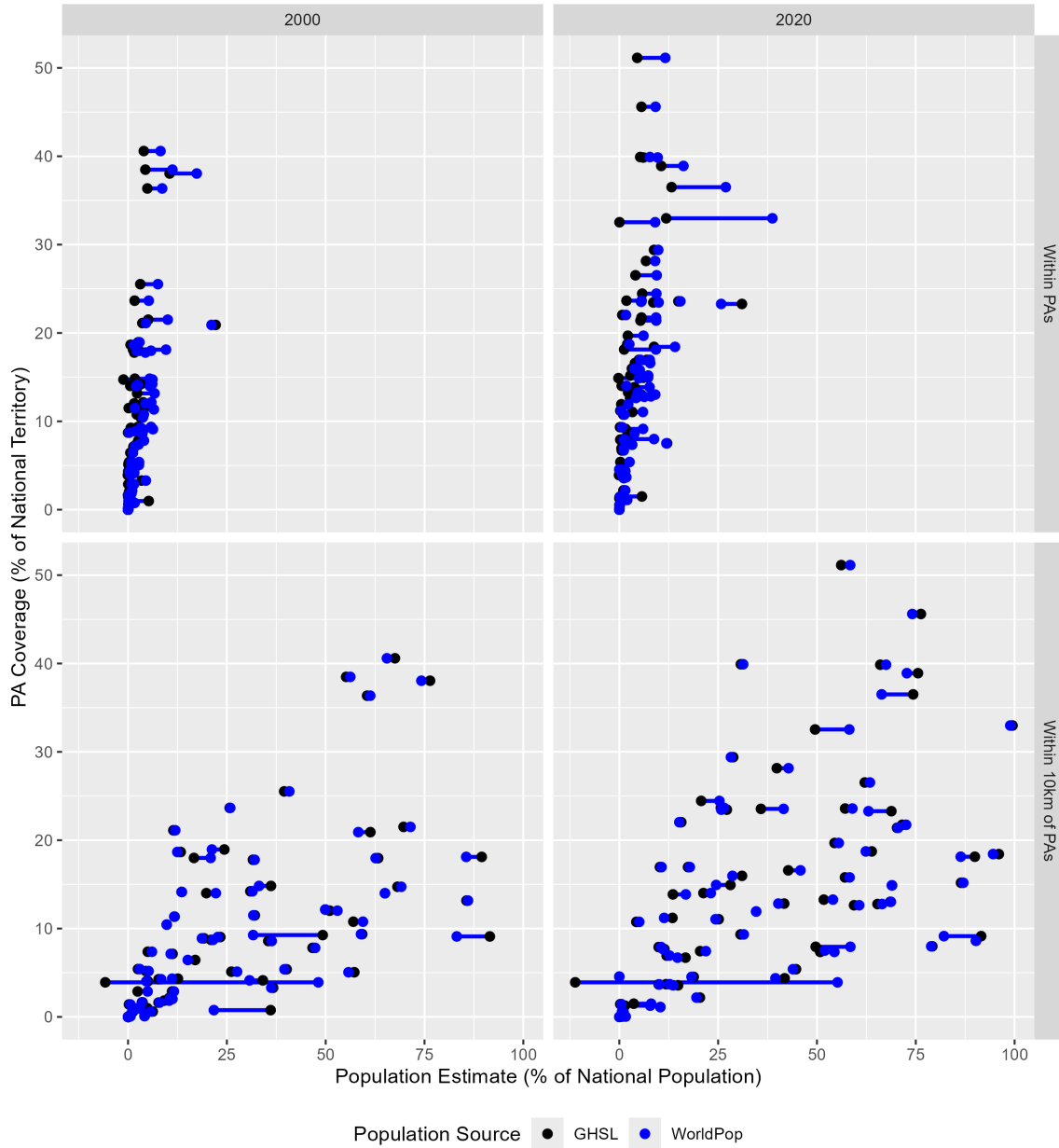
For most countries, GHSL and WorldPop estimates align closely, as indicated by the majority of blue dots overlapping or being nearly indistinguishable from black dots. However, some countries exhibit large discrepancies. Table S1 in the appendix details the 15 countries where GHSL and WorldPop estimates differ by more than 5 percentage points and by more than 10%. Notably, WorldPop estimates significantly exceed GHSL in countries such as Comoros, the Republic of Congo, and São Tomé and Príncipe, while GHSL reports higher population shares near PAs than WorldPop in countries such as Ukraine and Zambia. These variations may stem from differences in population allocation methodologies or underlying census data.

4 Discussion

4.1 A Relevant Parameter to Frame the Reflection on Conservation

This study has relatively modest theoretical claims and does not aim to establish a causal analysis for protected area expansion. Instead, we emphasize the value of a "mere description" (Gerring 2012) quantifying the magnitude of the population directly affected by protected areas in the developing world. To our knowledge, no other study has systematically estimated the number of people impacted by area-based conservation policies. Given the scale of the phenomenon described in this paper, addressing conservation challenges increasingly requires integrating socio-economic considerations.

The demographic dynamics around protected areas have been a subject of debate in the literature. Wittemyer et al. (2008) reported accelerated population growth near existing PAs, suggesting an attraction effect, while Joppa, Loarie, and Pimm (2009) argued that such cases were isolated and that population growth near PAs was not disproportionately high overall. Our analysis aligns with the latter, as we find no evidence of increased neighboring population growth in areas where PA coverage has remained stable. Instead, our results indicate that the observed rise in populations near PAs in some countries is primarily driven by the expansion of PA coverage itself. In the cases where population growth outpaces PA expansion, this can be attributed to the selection of denser areas for new PAs. Additionally, a geometric effect may also play a role: as smaller and more irregularly shaped PAs are added to enhance connectivity (Saura et al. 2019) or accommodate political and ecological constraints, the relative extent of surrounding buffer zones increases compared to the total protected area (Schauman et al. 2024).

4.2 The Least Inaccurate Method Available

Our estimation of the share of people living within and around protected areas is derived from WorldPop, and the reliability of our analysis depends on the accuracy of this data product. Several studies have attempted to assess Worldpop's accuracy, but they all face a key challenge: census data are only available at the administrative unit level, and no alternative dataset provides fine-grained "ground truth" population estimates at low resolution to benchmark such gridded datasets. Consequently, most assessments compare gridded datasets aggregated to administrative units with official census counts or evaluate the spatial consistency between different gridded population datasets. The most comprehensive comparative studies we identified is Chen, Yan, Liu, Du, and Yang (2020), which evaluated four global gridded datasets – WorldPop, HYDE (Goldewijk et al. 2017), GPWv4 (Center for International Earth Science Information Network-CIESIN-Columbia University 2018), and GHSL (Freire et al. 2016) – across four countries with diverse population distribution patterns: United Kingdom, Argentina, Sri Lanka, and Tibet. When aggregating estimates at administrative levels, GPWv4 and GHSL were closer to official census totals and WorldPop exhibited larger deviations. However, WorldPop showed the highest pairwise spatial consistency with other datasets, suggesting that its population allocation model aligns well with the relative distribution patterns in other datasets.

In principle, household surveys such as the Demographic and Health Surveys (DHS) could complement or validate these gridded estimates. naidoo2019 used DHS data from 34 developing coun-

tries (2001–2011) to compare households near and far from PAs in assessing conservation impacts. While their objective was not to estimate the proportion of the population near PAs, their supplementary materials report the number of surveyed households located in proximity to PAs. Direct comparisons between our estimates and household survey data are not straightforward, but a rough approximation using data extracted from Naidoo, Gerkey, Hole, Pfaff, Ellis, Golden, Herrera, Johnson, Mulligan, Ricketts, and Fisher (2019)'s appendix provides a useful reference point. Summing the total number of surveyed households and the number located within 10 km of a PA, we estimate that approximately 22% of households in the DHS sample reside within 10 km buffers, which is broadly in line with our estimates.

However, several factors prevent a direct comparison. 1. DHS estimates require inverse probability weighting to be population-representative, which cannot be applied using Naidoo, Gerkey, Hole, Pfaff, Ellis, Golden, Herrera, Johnson, Mulligan, Ricketts, and Fisher (2019)'s appendix data. 2. DHS GPS coordinates represent the centroid of the enumeration area, not individual household locations. 3. Additionally, DHS relies on a two-stage cluster sampling approach, meaning that the survey covers only a limited number of sampled locations (typically a few hundred per country), reducing spatial representativity at a fine scale. 4. DHS also reports household counts, not individual population estimates, meaning that differences in household size could affect comparability. 5. DHS geolocations are intentionally displaced, with rural clusters randomly shifted by up to 10 km, introducing uncertainty in proximity assessments (Skiles et al. 2013). Processing to the raw DHS data would allow to tackle the issues 1., 4., and update this analysis with more surveys. However, obtaining DHS data also involves a vetting procedure with a USAID contractor and, at the time of writing, the foreign assistance programs have been indefinitely suspended and it is unknown when or if it will be resumed.

5 Conclusion

Our analysis provides an assessment of the population living within or in the immediate surroundings of protected areas following their expansion in low- and lower-middle-income countries. Between 2000 and 2020, PA coverage in these countries grew from 9.3% to 12.9%, while the share of people living within 10 km of a PA increased from 16.4% to 21.8%. This global trend is strongly influenced by India, where limited PA expansion and a large population shape the overall figures. Excluding India, PA coverage rose from 10.2% to 14.1%, and the proportion of the population near PAs increased from 26.5% to 33.5%. These figures highlight the extent to which conservation policies affect human populations and the need to address their socio-economic implications. Balancing ecological goals with the well-being and rights of nearby communities will become ever more critical as governments pursue accelerated PA expansion to meet global 30% targets.

Although our data and method have inherent limitations, it relies on the most consistent and scalable approach currently available for estimating demographic exposure to conservation policies. Future improvements in population mapping and survey integration could refine these estimates, but we believe that our findings represent a useful first step in quantifying the human dimensions of PA expansion at a global level.

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