



THE GREEN JOBS ADVANTAGE: HOW CLIMATE-FRIENDLY INVESTMENTS ARE BETTER JOB CREATORS

JOEL JAEGER, GINETTE WALLS, ELLA CLARKE, JUAN CARLOS ALTAMIRANO, ARYA HARSONO, HELEN MOUNTFORD, SHARAN BURROW, SAMANTHA SMITH, AND ALISON TATE

EXECUTIVE SUMMARY

Highlights

- As part of their COVID-19 recovery efforts, many governments continue to fund unsustainable infrastructure, even though this ignores the urgency of addressing climate change and will not secure long-term stability for workers.
- Our analysis of studies from around the world finds that green investments generally create more jobs per US\$1 million than unsustainable investments. We compare near-term job effects from clean energy versus fossil fuels, public transportation versus roads, electric vehicles versus internal combustion engine vehicles, and nature-based solutions versus fossil fuels.
- Green investments can create quality jobs, but this is not guaranteed. In developing countries, green jobs can provide avenues out of poverty, but too many are informal and temporary, limiting access to work security, safety, or social protections. In developed countries, new green jobs may have wages and benefits that aren't as high as those in traditional sectors where, in many cases, workers have been able to fight for job quality through decades of collective action.
- Government investment should come with conditions that ensure fair wages and benefits, work security, safe working conditions, opportunities for training and advancement, the right to organize, and accessibility to all.

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Suggested Citation: Jaeger, J., G. Walls, E. Clarke, J.C. Altamirano, A. Harsono, H. Mountford, S. Burrow, S. Smith, and A. Tate. 2021. "The Green Jobs Advantage: How Climate-Friendly Investments are Better Job Creators." Working Paper. Washington, DC: World Resources Institute. Available online at <https://doi.org/10.46830/wriwp.20.00142>.

Context

The COVID-19 pandemic has caused millions of jobs to be lost globally and has exacerbated inequality (ILO 2021c). The most vulnerable workers have been hit the hardest and existing social safety nets have often been inadequate. Economic recovery strategies must ensure that the right conditions are in place to deliver good quality jobs and make sure no one is left behind.

At the same time, addressing climate change is an urgent challenge. COVID recovery strategies must consider climate implications. Unsustainable infrastructure built today will lock in carbon emissions for decades to come and expose the world to further climate impacts.

Too many governments have provided stimulus to unsustainable sectors as part of their COVID responses even though it will not secure long-term stability for workers and will exacerbate climate change. Since the beginning of the pandemic, governments have spent US\$334 billion supporting fossil fuels, road construction, internal combustion engine vehicles, and other unsustainable investments compared with \$276 billion for renewable energy, energy efficiency, public transportation, electric vehicles, and other sustainable investments (EPT 2021).

About This Paper




We conducted a literature review to compare the number of jobs created per \$1 million in a variety of types of green infrastructure versus unsustainable infrastructure. Drawing on 12 studies that met

our criteria, we compared near-term job effects from clean energy versus fossil fuels, public transportation versus roads, electric vehicles versus internal combustion engine vehicles, and nature-based solutions versus fossil fuels. For each of these investment types we also investigated other literature on job quality, focusing on wages and benefits, work security, opportunities for growth, work safety, opportunities for social dialogue, and inclusivity of marginalized communities. Much of the research to date has focused on high-income countries and especially the United States; while we encountered this limitation, we also aimed to elevate studies and examples from developing and low-income countries.

Findings

Our analysis of the literature finds that \$1 million in green investments often creates more near-term jobs than an equivalent amount of unsustainable investments, and sometimes significantly more (see Figure ES-1 for results by investment type). The results vary by country and are preliminary given the limited literature. The studies in this analysis covered a range of countries for each clean energy investment type, but there were fewer studies for each investment type in sustainable transportation and nature-based solutions and they were predominantly U.S. focused, limiting the generalizability of the findings. Despite the limitations, this initial analysis suggests that, from a jobs perspective, green investments should generally take precedence over unsustainable investments when there is a choice between the two.

Figure ES-1 | Green Investments Can Create More Jobs in the Near Term than Unsustainable Investments

SECTOR	# COUNTRIES/ REGIONS ACROSS STUDIES	TYPE OF GREEN INVESTMENT	MEDIAN RATIO ACROSS STUDIES	COMPARISON TO UNSUSTAINABLE INVESTMENT
Energy 	7	Building efficiency creates...	2.8	...times as many jobs as fossil fuels per \$1 million
	7	Industrial efficiency creates...	1.8	
	6	Geothermal energy creates...	1.7	
	8	Solar photovoltaic energy creates...	1.5	
	7	Upgrades to existing grids create...	1.5	
	8	Wind energy creates...	1.2	
	7	Hydropower creates...	1.2	
	1	New grids create...	1.1	
	1	Reducing methane emissions creates...	0.8	
	1	Carbon capture, utilization, and storage creates...	0.5	
Public and non-motorized transport 	1	Pedestrian-only infrastructure creates...	1.3	...times as many jobs as road construction per \$1 million
	1	Bicycle-only infrastructure creates...	1.4	
	1	Roads with pedestrian and cycling infrastructure create...	1.1	
	2	Mass transit creates...	1.4	
	2	Railways create...	0.8	
Vehicles 	2	Electric vehicle manufacturing creates...	0.9	...times as many jobs as internal combustion engine vehicle manufacturing per \$1 million
	1	Battery cell manufacturing creates...	1.2	
	1	Electric vehicle charging infrastructure creates	2.0	
Nature 	1	Ecosystem restoration creates...	3.7	...times as many jobs as oil and gas production per \$1 million

Note: A ratio >1 (colored in green) means that green investments create more jobs than an equivalent amount of unsustainable investments. A ratio <1 (colored in red) means that green investments create fewer jobs than an equivalent amount of unsustainable investments.

Source: WRI analysis of 12 studies: IEA (2020), UNIDO and GGGI (2015), Chen (2019), Garrett-Peltier (2017), SGA (2011), Heintz et al. (2009), Ianchovichina et al. (2013), Garrett-Peltier (2011), Schwartz et al. (2009), Freedman et al. (2017), Soni (2020), and Peltier (2020).

Renewable energy and energy efficiency investments generally create more near-term jobs than fossil fuel investments, but efforts are needed to strengthen job quality. It is labor intensive to retrofit a home with energy-efficient technologies or to install solar panels. By contrast, the fossil fuel industry is highly automated. In developing countries, formal clean energy jobs are well paid and can provide avenues out of poverty, but too many jobs are informal and temporary. In developed countries, clean energy supports middle-class jobs, including for workers with less formal education, but there are concerns that the wages aren't as high as those for fossil fuel jobs (E2 2020; NABTU 2020). Governments can design clean energy projects with agreements that mandate high wages and benefits comparable to union work, promote work training, and target disadvantaged workers for hiring (Zabin 2020). Putting in place strong labor standards for clean energy workers could have only a minimal effect on the cost and speed of reaching net-zero emissions (Mayfield and Jenkins 2021).

Investments in mass transit, walking infrastructure, and cycling infrastructure generally create more jobs than investments in roads, and increase the productivity and inclusivity of the economy. Government investment needs to shift from building new roads to maintaining existing roads while expanding public and non-motorized transportation options. In addition to creating near-term jobs, public transportation investments have a long-term positive impact on jobs for everyone in the economy by lowering travel costs, reducing traffic, and improving job accessibility (APTA 2020). Rail investments may create relatively fewer near-term jobs per unit of investment, at least in the United States where more data are available, but railways and mass transit both create more long-term operations and maintenance jobs than roads do (Freedman et al. 2017; Austin 2017). Strong labor standards, unions, and training can increase the quality of construction jobs.

The transition to electric vehicles (EVs) will lead to net job gains in the overall economy, but jobs are expected to be lost in the manufacturing sector. EVs create jobs in the electricity sector, which is more labor intensive than the oil sector. Because EV owners save money on gasoline, they inject the savings into the overall economy, which is also more labor intensive than the oil sector (Melaina et al. 2016; Pek et al. 2018; UNECE and ILO 2020). Investments in EV charging infrastructure could also be a strong job creator (IEA 2020). However, investing in EVs is expected to create fewer manufacturing

and maintenance jobs than investing in internal combustion engine vehicles because EVs are made up of fewer and less complex parts (IEA 2020; Soni 2020). Much of the domestic jobs effect of an EV investment depends on whether a country has an established manufacturing base. Increased automation and industrial efficiency have already been impacting job quality in the automotive sector, and there are concerns that new EV manufacturers entering the market will continue this trend with poor standards and working conditions (Walter et al. 2020). Efforts should be made to promote quality jobs and retrain and employ workers from the traditional auto industry.

Nature-based solutions like ecosystem restoration and sustainable agriculture can create many more jobs than investments in fossil fuels, reduce emissions, improve resilience to climate impacts, and benefit marginalized communities—but the jobs are often informal. Most jobs needed for restoration and nature-based solutions require little training and provide an opportunity to quickly hire low-skilled workers. However, these types of jobs are often lower paid and temporary (ILO 2021a). In developing countries, a large proportion of people work in the informal sector. There are some effective models for improving job quality by allowing shifts from short-term to long-term contracts, creating opportunities to professionalize the sector, increasing skills, and prioritizing the hiring of women (Norton et al. 2020; Bek et al. 2017).

Recommendations

Green investments should be a core part of stimulus spending and longer-term economic strategies. They are necessary to meet climate goals and are often effective job creators compared with unsustainable alternatives. Note that aiming for a green recovery does not mean that 100 percent of investments need to be in green sectors. Investments in the care economy, public health, education, and other priority areas will be foundational in building a healthy and skilled workforce and increasing resilience.

With the right policies, it is possible to improve job quality in climate-friendly sectors and the wider economy and enable a just transition. Governments should work with unions and employers to advance policies and practices that ensure fair wages and working conditions and target hiring of excluded social groups as conditions for public investment and procurement. They should invest in job training to help current workers build new skills and apprenticeship programs

to ensure workers can move up the training and career ladder. They should invest in and help renew communities going through job transition or displacement. Governments should support job quality across the entire economy by implementing regulations like minimum wages and labor standards; strengthening social safety nets to support workers when emergencies like COVID-19 arise; and investing in the care economy, public health, and education to build a healthy and skilled workforce.

1. INTRODUCTION

1.1 Green Recovery

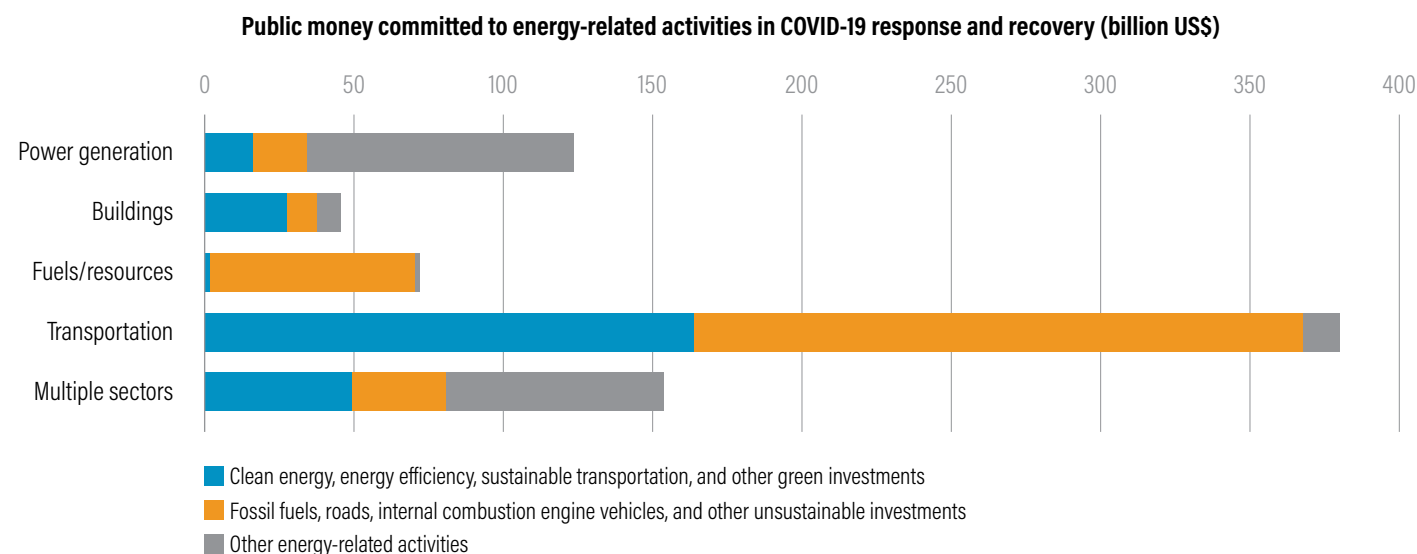
The COVID-19 pandemic and resulting economic recession have upended people’s lives and livelihoods around the world. In 2020, 255 million full-time jobs were lost and global labor income fell US\$3.7 trillion before taking into account income support measures (ILO 2021c). In 2021, employment has partially recovered, but between 1.3 and 4.6 percent of total working hours are still expected to be lost (ILO 2021c). Youth, the self-employed, low- and medium-skilled workers, people of color, and working mothers have been particularly impacted by job and wage losses (ILO 2021c; Inequality.org 2021).

There is increasing evidence that green investments can be an important part of recovery packages, lead to job creation and positive economic outcomes, and help

address climate change (Pollitt 2020; IFC 2021; C40 CCLG 2020; IEA 2020). However, the overall picture of COVID stimulus spending is not green. Governments have spent \$276 billion on clean energy, sustainable transport, and other green investments, but this is outweighed by \$334 billion supporting fossil fuels, roads, internal combustion engine (ICE) vehicles, and other unsustainable investments (EPT 2021; see Figure 1). This goes beyond what was strictly needed to prevent an economic crisis. Government rescue spending in the first few months of the pandemic was especially likely to bail out traditional fossil fuel-based industries, but as the crisis goes on there has been a shift toward more climate-friendly investments (Vivid Economics 2021).

As stimulus is disbursed and new investments are made, more countries can take advantage of the job and economic opportunities offered by green investments. Even once the COVID crisis is over, green investments will still be essential to transform the economy and reach net-zero emissions, and can therefore support jobs on an ongoing basis. Long-term employment opportunities should be coupled with strengthened social safety net spending to ensure no one is left behind in the COVID-19 recovery.

Figure 1 | In COVID-19 Response and Recovery Packages, Unsustainable Spending Has Outweighed Green Spending So Far



Source: EPT (2021) as of August 25, 2021.

1.2 Defining Job Quality

Not all jobs are created equal. Past responses to economic crises have often focused on the number of jobs created without fully considering job quality. Job creation numbers are easier to understand, measure, and communicate, whereas estimating job quality requires taking a nuanced approach. Job quality is important in both the overall economy and in green sectors, especially as countries shift toward more sustainable low-carbon economies (UNEP et al. 2008; UNGA 2015; UNFCCC 2015).

In this paper we focus on the following six factors that affect job quality, building on definitions by the International Trade Union Confederation and the International Labour Organization:¹

- **Wages and benefits**—compensation that workers receive for their labor in terms of salary/wages and benefits such as retirement; health insurance; sick leave; paid time off; and maternity, paternity, and other care leave. Wages provide workers' livelihoods, while benefits contribute to safety nets and equal opportunity of employment. Providing parental leave, for example, ensures that parents have time to care for new children without fear of losing their jobs.
- **Work security**—job formality and contract length. Nonstandard forms of work, such as work in the informal sector, part-time work, and short-term contracts, are more precarious. Informal workers have lower wages and benefits, and less access to systems of social protection than do formal sector workers. Supporting work stability can reduce insecurity from possible loss of livelihood.
- **Opportunities for growth**—skills development, training, and career advancement. Making such opportunities open to workers of all skill levels is key for improving workers' livelihood opportunities and employability, especially as new technology continues to transform sectors and the labor force.
- **Safety at work**—the ability to be safe, secure, and healthy at work. This includes the prevention of on-the-job injuries and fatalities, diseases linked to specific occupations, exposure to extreme weather or contaminants, and mental health risks.
- **Opportunities for social dialogue**—whether workers are allowed to participate in and represent themselves in the decisions that affect them. This includes whether workers can collectively organize and the bargaining power and participation rates of unions. Social dialogue can promote other aspects of job quality including wages, benefits, and work security.
- **Inclusivity of marginalized communities**—the ability to be hired, access training resources, be promoted, fill leadership roles, and work in any industry or job type. This applies to historically excluded social groups along multiple dimensions such as gender, race, income, ethnicity, religious affiliation, disability, age, and sexual orientation. Enforcing policies that ban sexual harassment and discrimination based on social group membership also supports inclusion of and protection for historically marginalized groups.

In this paper, we focus on job quality in the context of public green investment, but the private sector also has a responsibility to address job quality issues.

1.3 Just Transition

No workers should be left behind in a green COVID recovery or in the vital low-carbon transition. Economic models find that with strong climate action, new jobs created in low-carbon sectors will outweigh the smaller number of jobs that will be phased out in high-carbon sectors (ILO 2018b; NCE 2018; IRENA 2020a). However, the new jobs may be created in different locations or require different skills than the jobs they are replacing, leaving workers without an easy solution. Communities that have been historically dependent on tax revenue from high-carbon industries will also be affected.

The labor movement has introduced the concept of “just transition” to manage these changes in a way that prioritizes workers. Just transition is both a process and an outcome. The process is ensuring that workers, unions, and civil society organizations are at the table when designing and delivering plans for climate action (ILO 2015b). The outcome is that these climate plans create decent jobs, include social protections, and support workers and communities that will be negatively impacted by a low-carbon transition. Just transition is based on principles of human rights, poverty eradication, equity, and inclusion (UNFCCC 2020; CJA 2019). It has been

enshrined as an imperative in the Paris Climate Agreement (UNFCCC 2015), and many countries have included it in their climate action plans.²

Emerging practices shed light on how to plan for and manage a just transition. For example, in 2020 South Africa established the Presidential Climate Commission—made up of stakeholders from government, the private sector, academia, traditional leadership, labor groups, nongovernmental organizations, and research institutions—to establish a framework for and facilitate a just transition to a low-carbon economy (SA News 2020; WRI 2021b). As another example, Spain reached a just transition agreement in 2018 to invest \$280 million in mining communities that would be impacted by the country's phaseout of coal, with options for early retirement, jobs in environmental restoration, and training for green industry (Nelsen 2018; Bouyé et al. 2019).

A just transition should also consider the many factors beyond climate mitigation that affect the global workforce. For example, automation and digitalization continue to transform the economy, impact jobs, and disrupt value chains (Hawksworth et al. 2018). Alternative, freelance, and platform (gig) economy jobs, which do not offer the same rights and benefits as traditional jobs, have been increasing in recent years (Katz and Krueger 2019a, 2019b). These trends may have been accelerated by COVID (Davinci Payments 2021).

Our analysis in this paper focuses on quality job creation from green investments, which is only one small part of the scope of a just transition. All of the just transition principles identified in this section should be considered part of a holistic government investment and climate strategy.

2. METHODOLOGY AND HIGH-LEVEL RESULTS

2.1 Methodology

Given that many governments are still allocating stimulus spending to fossil fuels and other unsustainable investments, it is useful to put sustainable and unsustainable investments head-to-head.

We conducted a literature review of studies from 2009 to 2020 to assess the number of jobs created per \$1 million from green investments versus unsustainable investments. We focused on three sectors: energy, transportation, and nature. For energy, we searched for studies with comparisons of job creation from clean energy investments versus fossil fuel investments. For transportation, we searched for studies with comparisons of job creation from public transportation investments versus road investments, as well as electric vehicle investments versus internal combustion engine vehicle investments. For nature, we searched for studies with comparisons of job creation from nature-based solutions versus carbon-intensive land sector activities but did not find any, so we instead compared nature-based-solution investments to oil and gas production and other activities.

We included only studies where the job creation comparisons used the same methodology, country/region, and timeframe for each type of investment. Ultimately, 12 studies met our criteria (Table 1). One of the studies (UNIDO and GGGI 2015) had results for five countries, so there were 16 total observations included in our data analysis. Seven of these observations were from the United States, while the rest were from a variety of countries and regions. For the energy sector, studies covered a range of countries/regions, but there were fewer studies for transportation and nature and they were biased toward the United States, limiting the generalizability of the findings.

We included as many relevant studies as possible, but this was not a systematic review so we may have missed some applicable research. We did not do a meta-analysis evaluating the quality of the studies' methodologies but have summarized the methodologies in Table 1.

Table 1 | **Studies Included in Analysis of Job Creation per \$1 Million in Green Investments versus Unsustainable Investments**

STUDY	GEOGRAPHICAL SCOPE	PEER-REVIEWED JOURNAL	RELEVANT SECTORS WITH JOBS PER \$1 MILLION ESTIMATES	METHODOLOGY	TYPES OF JOBS ^a
IEA (2020)	Global	No	<p>Energy: Solar photovoltaic (PV); wind; geothermal; hydro; building efficiency; industrial efficiency; existing grids; new grids; nuclear; carbon capture, utilization, and storage; reducing methane emissions; coal power; gas power</p> <p>Transportation: Electric vehicle (EV) manufacturing, battery manufacturing, internal combustion engine (ICE) vehicle manufacturing</p>	Developed employment multipliers for subsectors based on existing literature, industry engagement, surveys of government statistical accounts, and macroeconomic modeling.	Direct and indirect full-time equivalent (FTE) job-years. Construction and manufacturing jobs during the period of investment.
UNIDO and GGGI (2015)	Germany, South Korea, Brazil, South Africa, Indonesia	No	<p>Energy: Solar PV, wind, geothermal, hydropower, building efficiency, industrial efficiency, existing grids, coal production, oil and gas production</p>	Input-output (I-O) model derived from 2005 to 2008 national economic survey data. Some of the industries did not exist in national I-O tables, so the authors created "synthetic" industries weighted proportionally by existing industries based on cost data.	Direct and indirect FTE or part-time jobs during the period of investment.
Chen (2019)	China	Yes	<p>Energy: Solar PV, wind, coal production, oil and gas production</p>	I-O model derived from China's National Bureau of Statistics 2007 data. Clean energy and fossil fuel industries did not exist in these I-O tables at an aggregated level, so the authors created "synthetic" industries weighted proportionally by existing industries based on cost data.	Direct and indirect jobs during the period of investment. Distinguishes between formal and informal jobs.
Garrett-Peltier (2017)	United States	Yes	<p>Energy: Solar PV, wind, geothermal, hydropower, building efficiency, industrial efficiency, existing grids, coal production, oil and gas production</p>	I-O model derived from 2013 U.S. Bureau of Economic Analysis I-O tables. Clean energy industries did not exist in these I-O tables, so the authors created "synthetic" industries weighted proportionally by existing industries based on cost data.	Direct and indirect FTE jobs during the period of investment.
Schwartz et al. (2009)	Colombia	Yes	<p>Transportation: Bus rapid transit routes, roads</p>	Used available data from the World Bank's Bogota Urban Services Project documents and other assumptions to assign the share of investment spending going to labor and domestic and foreign content by subsector. Combined this with data on regional average wages to compute employment.	Direct jobs per year.

Table 1 | **Studies Included in Analysis of Job Creation per \$1 Million in Green Investments versus Unsustainable Investments, continued**

STUDY	GEOGRAPHICAL SCOPE	PEER-REVIEWED JOURNAL	RELEVANT SECTORS WITH JOBS PER \$1 MILLION ESTIMATES	METHODOLOGY	TYPES OF JOBS ^a
Garrett-Peltier (2011)	United States	No	Transportation: Pedestrian infrastructure, bicycle infrastructure, roads	Gathered cost data from 58 projects in 11 cities and mapped them to I-O model using state-specific 2008 data to estimate employment.	Direct, indirect, and induced FTE jobs during the period of investment in the U.S. state in which the project was undertaken.
SGA (2011)	United States	No	Transportation: Mass transit, highways	Ex-post analysis of data from 2009 American Recovery and Reinvestment Act for all 50 U.S. states published by the House Transportation and Infrastructure Committee as of May 31, 2010 (original data now unavailable).	Direct FTE job-hours.
Heintz et al. (2009)	United States	No	Transportation: Mass transit, railways, roads, and bridges	I-O model based on 2006 U.S. Bureau of Economic Analysis I-O tables.	Direct, indirect, and induced FTE jobs. Short-term jobs during the period of investment.
Ianchovichina et al. (2013)	Middle East/North Africa	Yes	Transportation: Railways, paved roads	Assigned share of investments going to various inputs and estimated regional average hourly wages based on the literature to calculate direct employment. Applied employment multipliers from Egyptian I-O table for indirect and induced employment.	Direct, indirect, and induced short-term jobs during the period of investment.
Freedman et al. (2017)	United States	No	Transportation: Railways, mass transit, highways	Allocated typical project investments into various types of costs based on expert consultations, industry benchmarks, and publicly available company reports. Used prevailing compensation rates by industry to estimate job creation at the sector level.	Direct and indirect FTE jobs. Distinguishes between temporary and sustained jobs.
Soni (2020)	United States	No	Transportation: EV and battery manufacturing, ICE vehicle manufacturing	I-O model in which sectors were distributed based on EV cost information available in the literature.	Direct, indirect, and induced FTE jobs during the period of investment.
Peltier (2020)	United States	No	Nature: Restoration and support activities for agriculture and forestry, forestry, conservation lands, environmental and other technical consulting, hunting Energy: Oil and gas production	I-O model using 2018 U.S. Bureau of Economic Analysis I-O tables.	Direct, indirect, and induced jobs during the period of investment.

Note: ^a Direct jobs are created in the sector where the money is spent. Indirect jobs are created in the supply chain. Induced jobs are created when the money paid to direct and indirect workers is re-spent in the rest of the economy.

Source: Compiled by authors.

These studies focus on near-term job effects, which are most relevant for an economic recovery situation. When it comes to green infrastructure investments, most jobs will be created early on in construction and manufacturing, but some permanent operations and maintenance jobs will be supported. Sustained investments over many years (which is required given the scale of the low-carbon transformation needed) will support construction and manufacturing jobs on an ongoing basis.

More than half of the studies use input-output (I-O) models to some extent. I-O models provide the industry-level breakdowns necessary for this kind of analysis, but they are suited only for short-term projections because they assume constant returns to scale and do not account for evolving economic structures or supply chain constraints. A few of the studies use other methods, such as ex-post surveys and employment multipliers, but they too are focused on jobs created in the near term.

All studies are looking at gross job effects of \$1 million in additional investment, not net effects. We use the terminology “job creation” but I-O models and other methods are often unable to distinguish between a new job created and continuing support for an existing job. When unemployment is high, investments are more likely to create new jobs.

We sorted the investment types included in the 12 studies into categories based on whether they were green or unsustainable (Table 2).

For each study that met our criteria, we calculated the ratio of jobs created per \$1 million from each green investment compared with \$1 million from the relevant unsustainable investment. For each type of green investment, we calculated the median across studies. See the Appendices for more details on the methodology and data.

2.2 High-Level Results

The overall takeaway from our analysis of these studies is that \$1 million in green investments generally creates more jobs than the same amount in unsustainable investments in the near term, and in some cases multiple times as many (Figure 2).

For example, investing \$1 million in building efficiency creates 2.8 times as many jobs as investing \$1 million in fossil fuels on average. Solar photovoltaic (PV) investment creates 1.5 times as many jobs as fossil fuels per \$1 million on average. Mass transit creates 1.4 times as many jobs as road construction per \$1 million on average, though railways create fewer jobs than roads on average. Electric vehicle (EV) charging infrastructure creates 2.0


Table 2 | **Categories of Investments in the 12 Studies Sorted by Green versus Unsustainable**

SECTOR	GREEN INVESTMENTS	UNSUSTAINABLE INVESTMENTS
Energy	Clean Energy	Fossil fuels
	Renewable energy (solar photovoltaic, wind, bioenergy, hydropower, geothermal)	Coal production, oil and gas production, coal power, gas power
	Energy efficiency (building efficiency, industrial efficiency)	
	Other low-carbon energy (nuclear; carbon capture, utilization, and storage)	
	Grid infrastructure (existing grids, new grids)	
	Reducing methane emissions from oil and gas operations	
Transportation	Sustainable transportation	Unsustainable transportation
	Public transportation (mass transit rail and/or buses, bus rapid transit routes, railways, pedestrian infrastructure, bicycle infrastructure)	Road construction (highways; roads; roads and bridges)
	Electric vehicles (electric vehicle manufacturing, battery cell manufacturing, electric vehicle charging infrastructure)	Internal combustion engine vehicle manufacturing
Nature	Nature-based solutions	Fossil fuels
	Ecosystem restoration	Oil and gas production

times as many jobs as ICE vehicle manufacturing per \$1 million, though EV manufacturing creates fewer jobs than ICE vehicle manufacturing on average. Ecosystem restoration creates 3.7 times as many jobs as fossil fuels per \$1 million.

We explain these results in detail and sector by sector in the following sections. The findings vary by country and are preliminary given the limited state of the literature. Very few of these studies include job quality considerations, but not all jobs created will be the same, so for each sector we also reviewed other literature on job quality.

Figure 2 | Analysis of 12 Studies of Job Creation from Green Investments Compared with Unsustainable Investments

SECTOR	# COUNTRIES/ REGIONS ACROSS STUDIES	TYPE OF GREEN INVESTMENT	MEDIAN RATIO ACROSS STUDIES	COMPARISON TO UNSUSTAINABLE INVESTMENT
Energy 	7	Building efficiency creates...	2.8	...times as many jobs as fossil fuels per \$1 million
	7	Industrial efficiency creates...	1.8	
	6	Geothermal energy creates...	1.7	
	8	Solar photovoltaic energy creates...	1.5	
	7	Upgrades to existing grids create...	1.5	
	8	Wind energy creates...	1.2	
	7	Hydropower creates...	1.2	
	1	New grids create...	1.1	
	1	Reducing methane emissions creates...	0.8	
	1	Carbon capture, utilization, and storage creates...	0.5	
Public and non-motorized transport 	1	Pedestrian-only infrastructure creates...	1.3	...times as many jobs as road construction per \$1 million
	1	Bicycle-only infrastructure creates...	1.4	
	1	Roads with pedestrian and cycling infrastructure create...	1.1	
	2	Mass transit creates...	1.4	
	2	Railways create...	0.8	
Vehicles 	2	Electric vehicle manufacturing creates...	0.9	...times as many jobs as internal combustion engine vehicle manufacturing per \$1 million
	1	Battery cell manufacturing creates...	1.2	
	1	Electric vehicle charging infrastructure creates	2.0	
Nature 	1	Ecosystem restoration creates...	3.7	...times as many jobs as oil and gas production per \$1 million

Note: A ratio >1 (colored in green) means that green investments create more jobs than an equivalent amount of unsustainable investments. A ratio <1 (colored in red) means that green investments create fewer jobs than an equivalent amount of unsustainable investments.

Source: WRI analysis of 12 studies: IEA (2020), UNIDO and GGGI (2015), Chen (2019), Garrett-Peltier (2017), SGA (2011), Heintz et al. (2009), Ianchovichina et al. (2013), Garrett-Peltier (2011), Schwartz et al. (2009), Freedman et al. (2017), Soni (2020), and Peltier (2020).

When there is a choice between a green investment and an unsustainable investment to create jobs in the near term, this analysis shows that the green one should take precedence. But aiming for a green recovery does not mean that 100 percent of investments should be in green sectors. Investments in the care economy, public health, education, and services will be foundational in building a healthy and skilled workforce and increasing resilience. For example, studies from both developed and developing countries find that increased spending in and better wages for the care economy would create jobs, enable women who have left the workforce during the pandemic to return, and make it possible for countries to deliver on United Nations Sustainable Development Goal targets for health and education (ILO 2018c; De Henau and Himmelweit 2020; ITUC 2017).

2.3 Why Some Investments Create More Jobs than Others

There are multiple reasons why some investments create more jobs domestically in the near term per additional \$1 million (Garrett-Peltier 2017). First is labor intensity. For some industries, more of the \$1 million goes to paying workers while for other industries more is spent on machinery, buildings, land, and other capital inputs.³ Second, if a sector pays lower wages it will create more jobs per \$1 million when holding labor intensity constant.⁴ However, real world dynamics are complex; in the macroeconomy, labor intensity is not constant and raising wages has been found to have only a small effect on employment levels (Cengiz et al. 2019; Manning 2021).

A complementary question to how many jobs would be created is where those jobs would be created: If more of the industry content were produced and supplied domestically, more of the jobs would be created at home rather than abroad, independently of the net result of job creation.

The impacts from investments go beyond the number of jobs created in an individual sector. Economic systems contain complex interactions among sectors and spillovers throughout the economy. This becomes even more complex when considering how the pandemic will impact the ongoing structural transformation going on in many economies. Assessing these issues is beyond our scope but we recognize the high levels of uncertainty. The final effects may be complicated, but from the evidence we reviewed, we know the general direction is that green measures will create jobs, which may provide fertile ground for other sectors to bloom.

3. CLEAN ENERGY

3.1 Context

Since the beginning of the COVID crisis, governments have announced more than \$15 billion for clean energy in the power sector and \$27 billion for clean energy and energy efficiency in the building sector (EPT 2021). However, they have also announced at least \$27 billion supporting fossil fuels in the power and building sector, plus \$68 billion for fossil fuel supply (EPT 2021).

Among the positive examples, South Korea's Green New Deal committed \$8 billion for renewable energy, \$5.5 billion for zero-energy buildings, and \$1.8 billion for smart grid technology, expected by the government to create 300,000 jobs (KMEF 2020). Nigeria is investing \$630 million to promote solar home systems and mini-grids; the government expects the investment program to reach five million households and create 250,000 jobs (NESC 2020). France, Germany, and Denmark have announced major green building retrofitting programs (O'Callaghan and Murdock 2021; EPT 2021).

A range of global modeling studies have outlined the substantial jobs potential of clean energy investments (IEA 2020; IRENA 2020b; IFC 2021). One study finds that global public and private spending of \$1 trillion per year on clean energy over the next three years would add 1.1 percent to global economic growth a year compared with a scenario without the investment; support about nine million jobs each year; and make 2019 the definitive peak in global emissions (IEA 2020). Experience from the global financial crisis is also encouraging: Economies that announced the most green stimulus in 2008–09, including China, the European Union, South Korea, and the United States, successfully created near-term jobs and built up new industries (Jaeger et al. 2020).

3.2 Results of Our Analysis

Our literature review and analysis found that investing in various types of clean energy generally creates more jobs than investing in fossil fuels (Figure 3). Investments in building efficiency have the highest employment multipliers, creating 2.8 times as many jobs as fossil fuels per \$1 million on average in the near term. Solar PV creates 1.5 times as many jobs as fossil fuels and wind creates 1.2 times as many jobs as fossil fuels per \$1 million on average. Other clean energy investments like upgrades to existing grids, hydropower, geothermal energy, and industrial efficiency also create more jobs than fossil fuel investments. These estimates are the median from a range

Figure 3 | Analysis of Four Studies of Job Creation from Clean Energy Investments Compared with Fossil Fuel Investments



Notes: All studies cover direct jobs in manufacturing and construction and indirect jobs in the supply chain.

For UNIDO and GGGI (2015), Chen (2019), and Garrett-Peltier (2017), fossil fuels are the average of coal production and oil and gas production. For IEA (2020), fossil fuels are the average of coal power and gas power.

CCUS = carbon capture, utilization, and storage.

A ratio >1 means that clean energy investments create more jobs than an equivalent amount of fossil fuel investments. A ratio <1 means that clean energy investments create fewer jobs than an equivalent amount of fossil fuel investments.

of studies and data points, covering Brazil, China, Indonesia, Germany, South Africa, South Korea, the United States, and the world as a whole (UNIDO and GGGI 2015; Chen 2019; Garrett-Peltier 2017; IEA 2020). About 90 percent of the study observations found that various types of clean energy investment create more jobs than fossil fuel investments. Investments in nuclear energy; reducing methane emissions; and carbon capture, utilization, and storage (CCUS) were covered in only one study, but are estimated to create fewer jobs globally per \$1 million than investments in fossil fuels (IEA 2020).

Clean energy industries are labor intensive. Activities like installing solar panels or retrofitting homes to be more energy efficient are difficult to automate or outsource. By contrast, the fossil fuel industry is highly automated. In the United States, for example, the number of coal workers needed per ton of coal has fallen to one-fifth what it

was 60 years ago (Kolstad 2017). Clean energy industries are also experiencing automation and labor efficiency gains, but as of yet not to the same extent as fossil fuel industries.⁵

While most jobs from clean energy investment are created in the short term during manufacturing and construction, there are also a smaller number of jobs in clean energy operations and maintenance (O&M) that can last for decades. Compared with fossil fuel plants, rooftop solar creates three times as many O&M jobs per unit of investment, utility-scale solar creates about the same number of O&M jobs, and wind creates fewer O&M jobs (IEA 2020).

3.3 Job Quality

Strong efforts are needed to ensure that clean energy jobs are quality jobs. Policymakers need to make sure the industry avoids a “race to the bottom” where the fall-

ing costs of clean energy are achieved by cutting wages; reducing workplace safety or job security; or worsening working conditions (ACTU 2020). We look first at developing countries drawing on studies of India, Nigeria, and Kenya, and then to the United States, where more data are available.

Developing countries

In developing countries, the biggest challenge of addressing job quality is that most employment is informal. For example, in the distributed renewable energy sector in India, Nigeria, and Kenya, 60–70 percent of the direct jobs are informal (Power for All 2019). This is not a problem unique to renewable energy, and in fact renewable energy may be more formalized than other sectors: The overall economies of both India and Nigeria are around 90 percent informal (ILO 2018a).

Formal clean energy jobs are a good way to make a living. In the distributed renewable energy sectors in Kenya and Nigeria, wages for non-managerial formal employment fall within the national middle-income range. However, informal workers earn about one-tenth to one-quarter as much as formal workers. The average formal job lasts almost three years while the average informal job lasts one year or less, likely causing job insecurity (Shirley et al. 2019). In India, there is a select group of skilled renewable energy workers who move around between grid-based projects and receive a steady income, but most workers are unskilled and on short-term contracts. The work offers an alternative to subsistence farming, but the jobs have few benefits or career advancement opportunities (Jairaj et al. 2017). Across countries, efforts are needed to create opportunities for skills development and career progression and to formalize the workforce, for example, by developing pathways to certify skilled technicians without credentials (Shirley et al. 2019).

United States

In the United States, the median hourly wages of clean energy workers in 2019 were 25 percent higher than the median hourly wages for workers overall, but 8 percent lower than those of workers in fossil fuel jobs (E2 2020). Construction workers perceive the wages, benefits, and skills development opportunities in the oil and gas sector to be better than those for renewable energy jobs (NABTU 2020). U.S. fossil fuel workers spent decades fighting (sometimes literally) for unionization, higher wages, and better labor standards and were able to improve what

were originally dismal working conditions into good jobs (Green 2015; Gershon 2015). On the other hand, the clean energy industry is new and evolving, and doing so in the context of declining worker leverage in all sectors. Even so, clean energy investment does create many good jobs that are widely accessible to workers with various levels of education (Muro et al. 2019).

Modeling has found that \$1 million invested in clean energy would be expected to create more high-paying jobs than \$1 million invested in fossil fuels; this is because clean energy investments create more jobs than fossil fuels at all pay levels—for higher-paying as well as lower-paying jobs (Pollin et al. 2009). It is also worth noting that oil and gas jobs are subject to the volatility of fuel prices and production cycles while the clean energy industry is generally steadier (Raimi et al. 2019).

Better labor standards need to be in place to ensure that renewable energy workers have family-supporting wages and opportunities to advance in their careers. In California, for example, almost all utility-scale renewable generation projects have been constructed with project-labor agreements, which mandate high wages and benefits comparable to union work and promote apprenticeships to advance worker skills and careers. Some have been constructed with community workforce agreements, which focus on hiring people from marginalized communities (Zabin 2020).

Moreover, putting in place stronger labor standards that raise wages for U.S. solar and wind workers could have only a small influence on wind and solar PV costs or the cost and speed of net-zero transitions, according to a new study (Mayfield and Jenkins 2021). Increasing wages by 20 percent for solar and wind workers could increase installed capital costs by only 2–4 percent and O&M costs by 3–6 percent across technologies. These small cost increases could be offset by increases in labor productivity because worksite productivity is 14–33 percent higher in states with prevailing wage laws (Mayfield and Jenkins 2021).⁶ Higher wages may also generate more locally induced jobs as workers spend their wages, contributing to wider community economic growth (Bauer et al. 2018).

Global issues

Globally, women make up about 32 percent of the renewable energy workforce, which is higher than the 22 percent share in the oil and gas sector (IRENA 2019). However,

individual renewable technologies may differ in the share represented, and the energy sector as a whole is male dominated compared with other economic sectors (IRENA 2020c). A majority of the jobs created from clean energy stimulus investment are construction and manufacturing jobs, which are taken mostly by men. Women are more likely to work in administrative and consumer-facing jobs and less likely to work in infrastructure or science, technology, engineering, and mathematics (STEM) jobs (IRENA 2019; Pearl-Martinez and Stephens 2017). This is often driven by cultural and social perceptions: 75 percent of female clean energy workers perceive the existence of gender-related barriers, while only 40 percent of men think it is a problem (IRENA 2019). Barriers to female participation can be addressed through training and audits to raise awareness, supportive networks and mentorships for women in the field, gender targets and quotas, provision of childcare, and policies against sexual harassment and gender-based violence (IRENA 2019; WRI 2021a).

Clean energy jobs are generally much safer than fossil fuel jobs. Lung disease kills thousands of coal miners per year. Tradespeople perceive that renewables projects are slightly safer than oil and natural gas projects (NABTU 2020). Yet clean energy features its own hazards, such as solar PV workers dealing with potentially toxic materials or technicians climbing tall wind turbines, so stringent safety measures are still required.

4. SUSTAINABLE TRANSPORT

4.1 Context

Since the start of the pandemic, governments have announced at least \$163 billion for sustainable transport investments like mass transit, railways, and electric vehicles, but have also announced at least \$204 billion for unsustainable transport investments like road building, internal combustion engine vehicle subsidies and bailouts, and airline bailouts (EPT 2021). Among the most positive examples, Germany's stimulus includes \$18 billion in investment in climate-friendly transport, from EV infrastructure to money for buses and trucks, rail, and low-carbon shipping and aviation (Chazan 2020; Euractiv and Reuters 2020). France is investing \$13 billion in railways, mass transit, cycling, and electric bikes, while halting road projects unless there is a critical need and no alternative

(GoF 2020; L. Thomas 2020). China and Korea have introduced or extended EV subsidies (Vivid Economics 2021; O'Callaghan and Murdock 2021).

Investing in sustainable transportation is an effective way to create jobs and expand economic opportunities. In 21 emerging markets, \$2.7 trillion invested in green urban transport could create 53.4 million jobs from 2020 to 2030 (IFC 2021). In addition, sustainable transportation investments expand access to employment, decrease travel costs, improve road safety, and reduce deaths and illnesses from air pollution, all of which have a long-term positive effect on the economy (APTA 2020; CUT 2019).

4.2 Results of Our Analysis

Public transportation

Our literature review and analysis found that investing in multiple types of public and non-motorized transportation generally creates more jobs than investing in roads (Figure 4). Three out of four relevant studies found that investing in mass transit creates more near-term jobs than investing in roads, with a median of 1.4 times as many per \$1 million (Schwartz et al. 2009; SGA 2011; Heintz et al. 2009; Freedman et al. 2017). A study of projects in 11 U.S. cities found that investing in cycling infrastructure creates 1.5 times more jobs than roads and investing in walking infrastructure creates 1.3 times more jobs than roads per \$1 million (Garrett-Peltier 2011). Two out of three studies found that investing in railways creates fewer near-term jobs per \$1 million than investing in roads (Ianchovichina et al. 2013; Heintz et al. 2009; Freedman et al. 2017). This is a small number of studies, and a disproportionate number are focused on the United States, limiting the generalizability of these findings. When building public transportation in a middle- or low-income country, labor intensity, costs, and skills may be vastly different. Note that the only two studies that focus on middle- and low-income economies—Schwartz et al. (2009) covering bus rapid transit routes in Colombia and Ianchovichina et al. (2013) covering railways in the Middle East and North Africa—find positive jobs effects compared with roads.

For the initial construction of public transportation, a relatively higher share of the investment may be used to employ planners, designers, and construction workers, while for roads a higher share may be spent on materials like asphalt and stone products (Garrett-Peltier 2011). An

exception is that rail investments may not be very labor intensive in the near term, at least directly, if most of the money is going to purchasing rail cars and construction materials. However, railways and mass transit both create more long-term operations and maintenance jobs than roads do (Freedman et al. 2017).

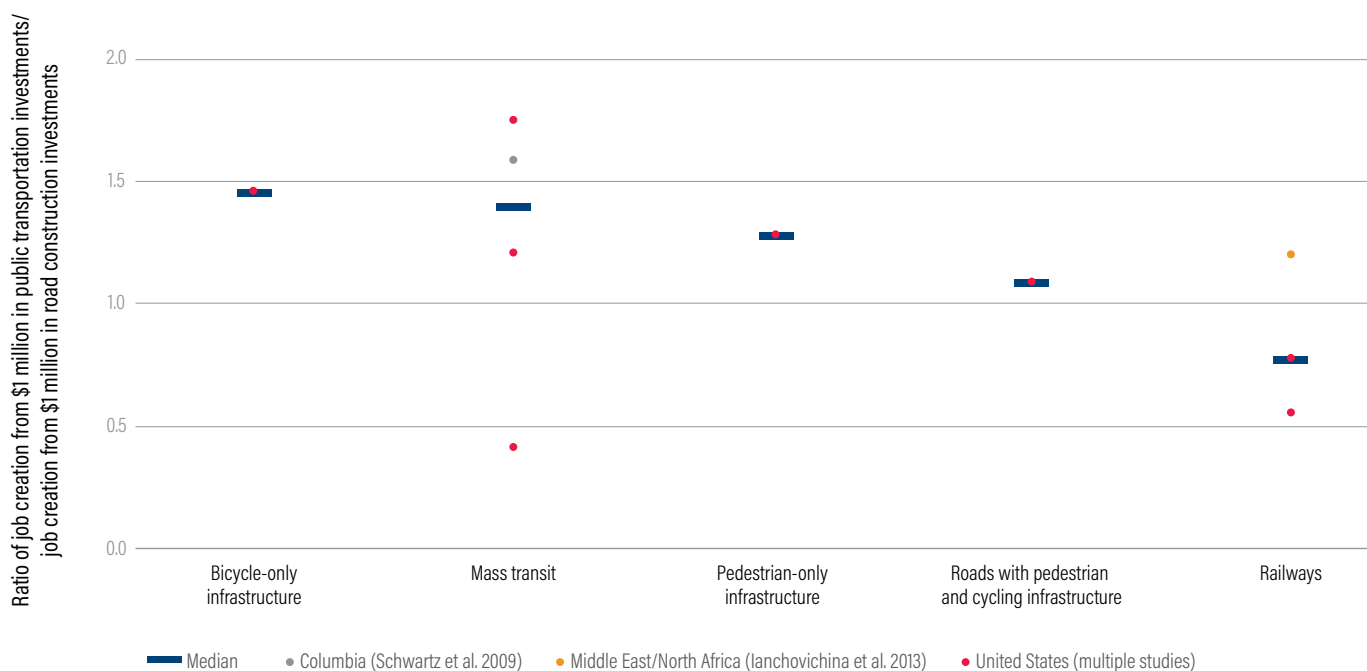
Our comparison of public transportation versus roads is not to say that no road investments are necessary, especially given that sustainable transportation options like buses, bicycles, and EVs use roads too—but the current approach needs to shift from building new roads to maintaining existing roads while expanding public transportation options. There is evidence that repairing roads and bridges creates more jobs per \$1 million than building new roads and bridges (Heintz et al. 2009).

Electric vehicles

Various studies have found that the transition toward EVs will lead to net job gains in the overall economy (Melaina et al. 2016; Pek et al. 2018; UNECE and ILO 2020). First, EV owners spend their money on electricity rather than gasoline, and the electric utility sector is more labor intensive than the oil sector. Second, EV owners spend less on electricity than they would on gas each year, injecting the savings back into the overall economy, which is more labor intensive than the oil sector (Melaina et al. 2016).

While the net jobs effect will be positive, some jobs will be lost. Investing in EV manufacturing is expected to create fewer jobs than investing the same amount in ICE vehicle manufacturing because EVs are made up of fewer and less

Figure 4 | Analysis of Six Studies Covering Job Creation from Public Transit Investments Compared with Road Construction Investments



Sources: Included in the chart for Colombia and the Middle East/North Africa. U.S. sources: U.S. bicycle and pedestrian data points: Garrett-Peltier (2011); U.S. mass transit: SGA (2011); U.S. mass transit and railways: Freedman et al. (2017) and Heintz et al. (2009).

Notes: SGA (2011) and Schwartz et al. (2009) look at direct jobs, while Garrett-Peltier (2011), Heintz et al. (2009), and Freedman et al. (2017) look at direct, indirect, and induced jobs.

A ratio >1 means that public transportation investments create more jobs than an equivalent amount of road construction investments. A ratio <1 means that public transportation investments create fewer jobs than an equivalent amount of road construction investments.

complex parts (Figure 5). A global study found that EV manufacturing will create 0.9 times as many direct and indirect jobs per \$1 million as ICE vehicle manufacturing (IEA 2020). A range of other studies don't present a direct comparison of jobs per \$1 million but also find that the transition to EVs over the long term will lead to manufacturing job losses (Herrman et al. 2020; FTI Consulting 2018). On the other hand, there is one U.S. study that finds that \$1 million invested in EV manufacturing will create essentially the same number of direct, indirect, and induced jobs as \$1 million in ICE vehicle manufacturing, with potentially more jobs from EV investment if battery prices drop further (Soni 2020). Note that all of these effects are expected to be small in comparison to the effects of advanced production techniques, digitalization, and artificial intelligence, which are poised to cause big reductions in the number of auto manufacturing workers needed for any type of vehicle (ILO 2021b).

In addition to the job creation effects of EVs, there may also be job redistribution across countries and regions. Much of the domestic jobs effect of EV investment depends on whether a country has an established auto manufacturing base; even if it does, it matters whether

the batteries are manufactured domestically or abroad. More than 70 percent of lithium-ion batteries are made in China currently, though there are opportunities for other countries to increase their involvement (BMI 2020; UNU-INRA 2019). There are trade-offs for policymakers to consider because manufacturing EVs and batteries locally may increase costs, making it hard to compete in the global market or making EVs unaffordable for low-income consumers.

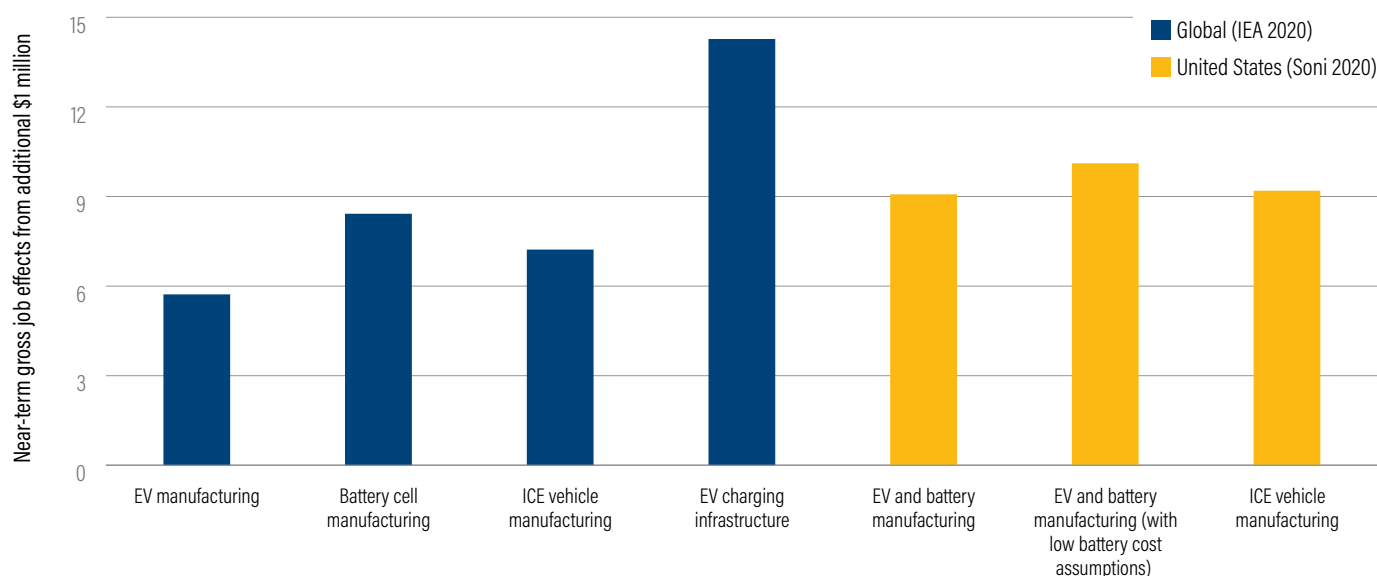
Finally, building EV charging infrastructure will be a job creator given the immense needs worldwide. EV charging infrastructure construction requires about twice as many direct and indirect jobs per \$1 million as ICE vehicle manufacturing (IEA 2020).⁷

4.3 Job Quality

Public transportation and construction

In this section we discuss job quality in the construction sector, which is relevant for public transportation, and highlight the small amount of research specific to public transportation. More research is needed, particularly in developing countries.

Figure 5 | **Two Studies of Job Creation from EV Investments Compared with Internal Combustion Engine Vehicle Manufacturing**



Notes: IEA (2020) includes direct and indirect jobs while Soni (2020) includes direct, indirect, and induced jobs.

EV = electric vehicles; ICE = internal combustion engine.

Jobs in the construction sector provide opportunities for those with less formal education to earn competitive wages (Kane and Puentes 2015). Construction wages are lower than the national average in many countries (ILO 2021a), though in the United States median annual wages were 21 percent higher for construction than the average in 2017 (Torpey 2018). Putting in place strong prevailing wage laws can help all construction workers increase their earnings. In U.S. states where prevailing wage laws were average or strong, workers' incomes averaged almost \$12,000 more each year from 2004 to 2013 than in states where they were weak or nonexistent (Manzo et al. 2016). There is little research on public transportation wages in particular, but one U.S. study shows that investments in mass transit and rail create jobs with higher median salaries than investments in highways or bridges (Freedman et al. 2017).

Formal apprenticeships and on-the-job training can fill skills gaps, increase pay, and promote safe working conditions (Walter 2019). Participation in registered apprenticeship programs in Illinois resulted in a \$120,000 boost in lifetime earnings (Bruno and Manzo 2016). Workers must be trained for and protected from workplace hazards; globally, there are 60,000 fatal construction accidents each year (ILO 2015a) and construction workers can be exposed to excess heat as well as disease-causing substances like mold and toxic chemicals (CSC 2012; Echt et al. 2020). In addition, nonstandard (informal, part-time, contractual) work is a major challenge. Data from 10 developing countries show that more than three-quarters of construction jobs were informal in 2005–2010. (ILO 2013; Mella and Savage 2018). Even in developed countries, a portion of companies often pay wages far below industry standards and misclassify their workers as independent contractors, going against workplace laws (Walter et al. 2020). Informal workers may experience lower or unpaid wages, be discouraged from seeking medical attention when injured, and lack access to social services or formal benefits.

Globally, the construction industry is predominantly male (ILO 2020; Bivens 2014). In 2014, women accounted for only 9.5 percent of construction workers worldwide (Mella and Savage 2018). However, the construction industry can provide opportunities for other historically marginalized communities. For example, Latino men represented almost a third of the construction workforce in the United States in 2020 (BLS 2020). Investment in mass transit offers both employment and opportunity benefits. An assessment of 12 U.S. infrastructure proposals found that

transit-focused proposals performed better in terms of job distribution to communities of color than other options (Austin 2017).

Higher unionization rates can improve workers' wages as well as increase the gender balance within the labor force. In the United States, the median weekly earnings of construction sector union members were \$334 more than nonunion workers (BLS 2021). Lower levels of union density are associated with elevated levels of nonstandard workers, and higher density is positively correlated with rates of women's participation (Mella and Savage 2018). In the United States, the median weekly earnings of construction sector union members were 34 percent more than those of nonunion workers in 2020 (BLS 2021).

Electric vehicles

In countries with established auto manufacturing industries, unionized workers generally enjoy high wages and good benefits. However, these industries have been experiencing increased automation and manufacturing efficiency, while simultaneously facing a trend over the past decade where new jobs created are more likely to be nonunion or temporary, which have lower wages and benefits. There are concerns that the transition to EVs could contribute to this trend (Walter et al. 2020). Since more of EV manufacturing will be focused on components like batteries and electronics rather than vehicle assembly, the industry will shift toward new companies rather than traditional vehicle manufacturing firms. As a pattern, these new companies are less likely to have strong job quality standards and can have worse working conditions (UAW 2020). Even with existing auto manufacturers, there are concerns; for example, wages at a proposed General Motors battery plant in Ohio would be lower than those at the previous ICE vehicle assembly plant (Boudette 2019).

Traditional vehicle manufacturing firms are expected to pay high wages in part because of hard-fought union representation and bargaining, but new companies and industries are less likely to have these established. In the United States, 13 percent of all motor vehicle jobs are unionized, whereas 9 percent of clean vehicle jobs are (NASEO and EFI 2020). When workers at the EV company Tesla tried to unionize, Tesla interfered with those efforts, a practice ruled illegal by the National Labor Relations Board (McFerran et al. 2021).

In countries that do not have strong auto manufacturing industries, it remains to be seen whether the growing EV industry will be a source of decent jobs. Major electronics

companies in China are reportedly competing for people to work in their new EV businesses, offering higher salaries compared with alternatives for highly skilled workers like engineers and software developers and also taking on workers with minimal experience. But EV start-up jobs can be precarious and rely on stock options instead of high wages in some cases, or may not pay wages on time (Ying and Zhang 2016; Ee 2020).

Where possible, government support for EVs should come with conditions that ensure workers receive fair wages and benefits, work in a safe environment, and have the right to join a union. To ensure a just transition, people who previously worked in the traditional auto industry and marginalized groups should receive preference for newly created EV jobs (Walter et al. 2020; UAW 2020). Employers should commit to building skills for new workers and retraining workers from the ICE auto industry.

Women are less likely to work in the auto industry because they are less likely to have STEM or digital backgrounds. Prevailing societal norms prevent women from pursuing those fields in the first place and many experience discrimination when they do. Efforts are needed to make STEM education and skills training more accessible to women, provide equal opportunities and parental leave, and put in place mechanisms to address workplace harassment and discrimination (ILO 2021b).

5. NATURE-BASED SOLUTIONS

5.1 Context

Nature-based solutions (NBS) are activities that sustainably protect, manage, and restore ecosystems to benefit biodiversity and human well-being (IUCN 2020a). NBS is a broad categorization that includes activities like ecosystem restoration (such as invasive species removal, land restoration and afforestation, or coastal zone management) and sustainable agriculture (such as silvopasture, agroforestry, and no-till farming).

Governments invest an estimated \$115 billion annually in NBS, with a third directed toward protection of biodiversity and landscapes, and the rest for ecosystem restoration, regenerative agriculture, pollution control, and other activities (UNEP 2021). Several governments have also included NBS in COVID stimulus packages. For example, Pakistan financed \$135 million in tree planting, plant care, and protection of natural forests that the government says created 85,000 daily wage jobs from March 2020 to February 2021 (Aslam Khan 2021). The Australian gov-

ernment has allocated \$47 million for conservation, tourism, and infrastructure upgrades at National and World Heritage sites, including restoration efforts for the Great Barrier Reef and land affected by bushfires (Australian Government 2020). On the other hand, during the pandemic at least 22 countries have rolled back conservation efforts and some are investing in agricultural expansion without consideration of sustainability (IUCN 2021).

NBS investments can quickly create jobs while simultaneously protecting nature and contributing to the increased resilience, health, and safety of society (WWF and ILO 2020). Ecosystem restoration and avoided land and ocean use expansion could create 11 million jobs and sustainable agriculture could create 62 million jobs by 2030 (WEF and AlphaBeta 2020). The small amount of evidence we have from prior experience with NBS stimulus also suggests that it can be an effective job creator. Investment in coastal ecosystem restoration under the American Recovery and Reinvestment Act of 2009 created about 15 jobs per \$1 million—higher than other studies have found for fossil fuels—along with longer-term economic benefits, including increased property values, future job creation from rebounded fisheries and ecotourism, and resilience to climate impacts (Samonte et al. 2017; Edwards et al. 2013). Additionally, such investments can avoid job loss for workers dependent on nature-based income, such as people working in agriculture, forestry, or fishing, whose livelihoods are at risk from ecosystem degradation (Brasser and Ferwerda 2015).

5.2 Results from Our Analysis

Studies on the job effects of NBS compared with those of other investments were limited and focused on the United States. One U.S. study found that \$1 million for restoration and forestry and agricultural support activities supports 31 direct, indirect, and induced jobs, compared with 23 jobs if the investment went to forestry, 20 jobs if it went to hunting and trapping, 17 jobs if it went to fishing, or 8 jobs if it went to oil and gas production (Figure 6).⁸ Another U.S. study found that investing in regenerative agriculture and ecosystem restoration would each create more than 23 direct, indirect, and induced jobs per \$1 million, more than almost any other type of investment, including in school infrastructure, highways, public health, and electricity infrastructure, and second only to the care economy (of course, these other types of investments are important too) (Pollin and Chakraborty 2020). Other U.S. studies found high employment multipliers for investments in ecosystem restoration, ranging from

11 to 32 jobs per \$1 million, but did not compare them to the job creation potential of other types of investments (Samonte et al. 2017; C.C. Thomas et al. 2016; Nielsen-Pincus and Moseley 2013; Industrial Economics, Inc. 2012; Wagner and Shropshire 2009). There is a wide array of job opportunities under the umbrella of NBS and some projects create more jobs than others. More research is needed, especially for developing countries.

The reason NBS investments seem to create so many jobs is because each dollar goes almost entirely to wages for workers as opposed to capital. This would be especially true in developing countries where agriculture and nature-based activities use less heavy machinery (though this may change if the sector becomes more automated). In addition, NBS projects generally need to be done with local workers and can't be outsourced (WWF and ILO 2020; Bek et al. 2017; Wagner and Shropshire 2009).

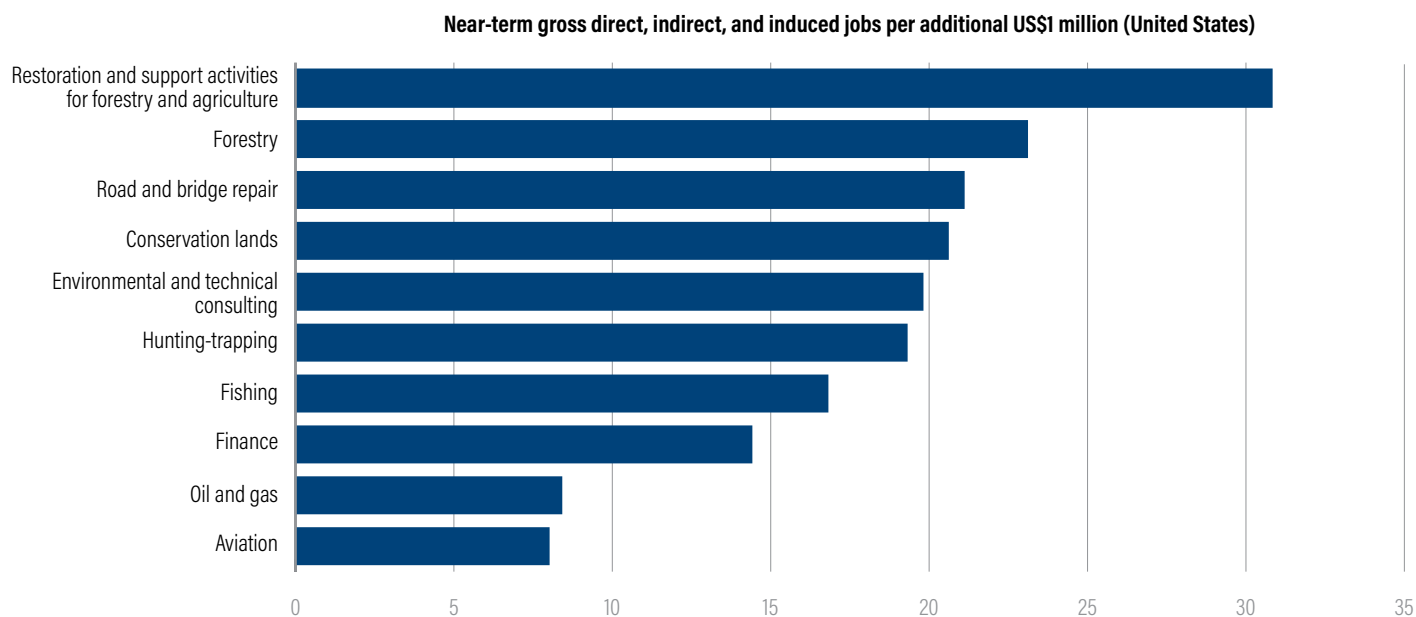
5.3 Job Quality

There is limited research on the quality of the jobs generated by investments in NBS. In this section we do a preliminary assessment of the topic, recognizing that job quality varies greatly depending on the sector, type of activity, and region.

Agriculture, fishing, and forestry are among the lowest paid economic sectors overall. In 59 of 64 countries, workers in these sectors received lower wages than the national median in 2018 (ILO 2021a). NBS jobs would theoretically follow this pattern, but there is little data available and in the few examples where we do have wage rates, they vary by country and type of activity. In Montana, part-time restoration jobs paid above average national wages and benefits (Wagner and Shropshire 2009). In Guatemala, community-owned forest enterprises created employment at twice the minimum wage (FAO 2018). Conversely, in South Africa and Mexico, government poverty reduction initiatives that include NBS jobs paid at or below the minimum wage (Bek et al. 2017; Norton et al. 2020).

A high proportion of NBS jobs are low skilled, labor intensive, and in the informal sector, limiting access to job security, safety, or social protections (Jarvis et al. 2011). This is consistent with agriculture, forestry, and fishing work overall. Ninety-four percent of agriculture workers worldwide are informal, more than any other sector (ILO 2018b). NBS jobs are also often seasonal and short term (Ellison et al. 2010). Some NBS programs have played a role in formalizing the work. For example, South Africa's Working for Water program allows for shifts from short-term contracts to longer-term ones that provide workers

Figure 6 | Study on Job Creation from Nature and Conservation Investments Compared with Other Investments



Source: Peltier 2020.

with increased stability, job security, satisfaction, and knowledge of future income. This allows them to invest more into skills development, equipment, and entrepreneurship (Bek et al. 2017).

More effort is still needed to improve opportunities for training and capacity building in NBS jobs. Nature-based production firms are generally not incentivized to reduce their low-skilled labor supply by developing worker skills (Rodriguez et al. 2009). At the individual level, conventional agricultural workers are either unaware of the benefits of sustainable alternatives or perceive the switching costs as unaffordable, though this is increasingly changing (Krishnaveni et al. 2019). Training programs in the United States are focusing on enabling new entry sustainable farmers to compete with existing agricultural firms (Carlisle et al. 2019)—an example that could be replicated.

For training and capacity building, NBS investment initiatives could learn from the example of certain national employment schemes (which support some green activities though they are not the main focus). For example, India's Mahatma Gandhi National Rural Employment Guarantee Scheme includes skill development efforts to enhance both the skillset of rural residents and the capacity of rural institutions to make informed selections of infrastructure projects. Ethiopia's Productive Safety Net Programme directly involves communities in choosing which public works projects to invest in their communities and who takes part, thus building community agency (Norton et al. 2020).

NBS jobs are often in settings with occupational and health hazards, including extreme weather conditions. Because the workers are informal they may receive inadequate protections (Jarvis et al. 2011). In the United States, only California and Washington offer farmworkers protections from heat-related illnesses (Smith 2019). NBS initiatives can and should increase worker agency and capacity to call for job safety mechanisms (Bulkeley 2020). In some cases, the attributes of NBS may make them safer than unsustainable alternatives. For example, farmers in India who adopted organic practices that reduced pesticide and chemical use were found to be significantly healthier than their traditional farming counterparts (Krishnaveni et al. 2019). Reduced chemical use eliminated the need for protective gear necessary under conventional agriculture that many farmers are unaware of or unable to afford.

Finally, inclusivity of the most vulnerable is a crucial consideration. Any NBS project must account for the natural, cultural, socioeconomic, and policy contexts and be considerate of impacts on historically excluded and Indigenous groups (IUCN 2020b). Agriculture is the largest employment sector for 60 percent of women in South Asia, sub-Saharan Africa, and Oceania, yet women still lack access to resources and decision-making processes (Huyer 2016). Again, national employment schemes provide a useful template for incorporating diversity, even though they're not specifically focused on NBS. India's rural employment guarantee scheme sets a minimum threshold of 33 percent women in the program and pays them wage rates equal to those for men with the intention of transforming gender norms around employment (Norton et al. 2020). In South Africa, 52 percent of the Working for Water's labor force consists of women, and the program is aiming to recruit more women (a target of 60 percent), youth (20 percent), and disabled people (5 percent) in the future (RSA n.d.).

Overall, more research needs to be done on this topic. Governments must implement policies to make sure NBS investments provide living wages, create more stable and equitable employment, and protect workers' safety.

6. JOB IMPACTS OF CLIMATE ACTION AND GREEN INVESTMENTS ACROSS ECONOMIC SECTORS

The previous sections analyze jobs impacts in specific sectors, but there are also national modeling studies that evaluate the job impacts of climate action and green investments across multiple sectors. Some examples include the following:

Brazil: Modeling from WRI Brasil shows scenarios where transitioning to a more efficient and resilient economy could deliver a net increase of more than two million jobs compared with business as usual. This is accomplished by investing in quality infrastructure, promoting new low-carbon technologies, and transitioning to sustainable agriculture. Restoration of degraded pasturelands would allow deforestation-free expansion of agriculture while contributing to reductions in greenhouse gas emissions, depending on how the restored land is used. Investing in low-carbon public transport such as electric buses would reduce air pollution, which causes approximately 20,000 premature deaths per year (Romeiro et al. 2020).

China: By pursuing the climate action needed to meet its 2060 carbon neutrality goal, China could generate almost ¥6.5 trillion (\$1 trillion) in net social and economic benefits by 2050. In the Yangtze River Delta region alone, compared with business as usual, a green economic strategy could create nearly 3.8 million additional jobs by 2025. The modeling shows that this could be achieved by increasing incorporation of renewables and moving away from coal, improving energy efficiency within the industrial sector, electrifying transportation, and removing carbon from the atmosphere (WRI China 2020).

European Union: Public and private investment of €200 billion (\$235 billion) in 1,000 short-term, shovel-ready green projects in the European Union (EU) (focused on energy, building efficiency, land use, industry, and transport) has the potential to support 2.8 million jobs over the two-year timeframe of the projects. These projects represent only 10 percent of total green projects under development in the EU (EY & Associés 2020).

Indonesia: Modeling by the Indonesian Ministry of National Development Planning shows that a low-carbon development path in Indonesia could deliver 15.3 million additional greener and better-paid jobs by 2045 compared with business as usual. Such a path would also decrease poverty rates and close regional and gender opportunity gaps. This could be achieved by increasing energy efficiency and the use of renewables, protecting and restoring forests and wetlands, and increasing agricultural productivity. Transitioning away from coal could improve air quality and avoid 40,000 deaths each year (BAPPENAS 2019).

South Africa: Modeling of COVID-19 recovery options shows that implementing green policies— including subsidies for clean energy, early decommissioning of coal plants, and financing for the power sector—would return gross domestic product to what it would have been sans the pandemic as well as generate positive net effects on employment greater than conventional policies alone. Job losses in the coal sector would be offset by new jobs in the renewables supply chain, but support is needed for coal workers and their communities for a just transition (Kiss-Dobrony et al. 2021).

United Kingdom: Clean recovery investments in the United Kingdom worth £85 billion (\$118 billion) could create 1.24 million jobs over the next two years. The projects with the highest job creation potential include building new social housing and retrofitting existing social housing (500,000 jobs), expanding and upgrading railroads (120,000 new jobs), and investing in the electrification of transport (59,000 jobs) (TUC 2020).

United States: One study found that investing \$320 billion per year in clean energy and agriculture programs over 10 years would create 4.5 million gross jobs per year over that period (Beachy et al. 2020). Another study found that achieving total electrification of the economy by investing about \$300 billion per year for 10 years, mostly through loans, would support up to 25 million good-paying jobs per year over the next 15 years and 5 million sustained jobs by mid-century (Griffith et al. 2020).

7. CONCLUSION AND RECOMMENDATIONS

A robust green economic recovery is an opportunity to create a just and equitable transition to a future that is climate resilient and inclusive.

Green investments should be a core part of stimulus spending and longer-term economic strategies. They are necessary to meet climate goals and, as this paper shows, often effective job creators compared with unsustainable alternatives. Yet governments continue to invest heavily in unsustainable sectors in their COVID responses, beyond what is strictly needed. Investments need to shift decisively to green sectors to take advantage of job opportunities and set the world on course for emissions reductions and climate-resilient societies. This should be paired with macroeconomic and industrial policies to fast track a green structural transformation.

Stepping up green investments is only part of the picture. Governments need to increase their investments in the care economy, public health, education, and services. These are foundational to improve the health and skills of workers, create jobs, allow parents and other caregivers to return to the workforce, and increase the resilience of the economy. Governments also need to strengthen social safety nets to respond to COVID and protect vulnerable people from future crises.

Governments need to work with unions and employers to ensure that green investment strategies enhance job quality and contribute to the empowerment of both workers and communities. Public investments involving large-scale construction projects like renewable energy installations or public transit should set wages and benefits at family-supporting levels. Incentive programs like subsidies for building efficiency retrofits should also ensure fair wages and benefits, compliance with labor laws, minimum skill standards, and health and safety standards. Funding should support and incentivize industry-led training programs and apprenticeship programs to allow for career advancement and opportunities to shift to longer-term contracts. Governments should ensure that members of historically excluded communities, and especially women, are benefitting from such investment and support.

Measures to improve job quality should not be limited to green sectors. Governments need to put in place broader policies to enhance job quality for the entire economy, addressing minimum wages, labor rights, occupational health and safety, and decent working hours.

Future research should continue to explore green job multipliers, particularly for developing countries and for less studied investment types like sustainable transportation and nature-based solutions. A greater variety of methods beyond input-output analysis is needed, including more ex-post analysis. Future job quality research should further consider the levers needed to improve green job quality.

APPENDIX A. EXPLAINING JOBS TERMINOLOGY AND MODELS

Researchers and policymakers are often interested in estimating the number of jobs that a policy intervention will create, or if it has already been implemented in demonstrating or verifying the job creation from the policy. This is not an easy task, as efforts to report job creation can show a wide variety of results depending on the definitions and methods used to produce them.

This section presents common terminology and methodologies to evaluate job impacts.

A. Basic concepts

The crucial concept to define when talking about employment is what we mean by “a job.” There are different definitions and it is helpful to define what we are interested in measuring. Here are some widely used definitions of jobs:

- **Job-year:** “a metric that is equivalent to the resources required to employ 1 person for 12 months (or 2 people for 6 months each, or 3 people for 4 months each), which can be full or part time” (Bell and Barrett 2014).
- **Full-time equivalent (FTE):** “FTE employees equal the number of employees on full-time schedules plus the number of employees on part-time schedules converted to a full-time basis. The number of full-time equivalent employees in each industry is the product of the total number of employees and the ratio of average weekly hours per employee for all employees to average weekly hours per employee on full-time schedules. An industry’s full-time equivalent employment will be less than the number of its employees on full- and part-time schedules, unless it has no part-time employees” (BEA 2007).
- **The International Labour Organization’s (ILO’s) “employment” definition:** “... all those employed above a specified age who during a specified brief period, either one week or one day, were in the following categories: i) paid employment; ii) employers and self-employed; iii) unpaid family workers; unpaid family workers at work should be considered as being self-employed irrespective of the number of hours worked during the reference period” (OECD n.d.).
- **A job headcount indicator** proposed by the UK’s Department for International Development (now the Foreign, Commonwealth & Development Office) considers a job to be when a person is “... 1) Working at least 20 hours/week for at least 26 weeks/year; 2) In conditions that comply with the 8 ILO Core Conventions and 3) earning at least the ‘living wage’...” (Fowler and Markel 2014).

Many stakeholders, especially governments, are interested in knowing the precise impact that policies have on employment. They want to know how many more people get a job as a result of a program or policy intervention. This is a tricky question to answer because, when using the aforementioned definitions, this is not totally evident. For instance, using a job-year or an FTE measure does not reveal the number of individuals benefitting from additional jobs; they merely measure the total resources to employ someone (job-years) or the total quantity of work created (FTE) (Fowler and Markel

2014). ILO’s definition also does not entirely reflect the real impact of a policy, as a one-hour-per-week job counts the same as a 40-hours-per-week job, and using a “living wage” may leave out many underpaid jobs.

There is no universally accepted definition of what is counted as a job. The definition and how to measure jobs are context specific and highly dependent on the level of employment/unemployment in a region or country. Sometimes, an FTE-based measure is more suitable for policies that are expected to create significant amounts of new work. A headcount approach may be more appropriate for policies targeted to populations fully employed in low-productive tasks or rural areas with significant informal sector employment levels (Fowler and Markel 2014).

Once a definition of employment has been chosen, many economic analyses distinguish three types of jobs (Bell et al. 2015):

- **Direct jobs:** Jobs generated within one sector from the policy change or investment that creates increased economic activity
- **Indirect jobs:** Jobs generated in the supply chain and supporting sectors that are directly impacted by the increased economic activity or investment
- **Induced jobs:** Jobs generated by the re-spending of income earned by direct and indirect workers

Another important distinction is between gross and net employment. By “gross,” we mean the number of jobs created due to the policy intervention, whereas “net” subtracts all other jobs that were substituted or shut down. The net effect is a result of “job substitution, in which new jobs are taken by people previously employed elsewhere. For example, new employees in a processing factory may have previously worked as agricultural workers” (Fowler and Markel 2014). Often, the net effect of a policy in employment is lower than the total number of jobs created. If the economy is functioning close to full employment or with labor shortages, “a new job is more likely to pull a worker from another job, with no aggregate effect on employment” (Fowler and Markel 2014).

Finally, it is helpful to differentiate between total and additional jobs. Total jobs reflect the total number created whereas additional jobs are those created relative to a counterfactual—i.e., relative to the situation in which the policy was not enacted.

Bell et al. (2015) identify two main types of methods to assess employment effects:

- **Bottom-up methods** “use head counts and/or database verification to count direct jobs.” These methods “may be able to capture direct and perhaps indirect job creation in the implementation phase, but they cannot capture induced jobs from investments.”
- **Top-down approaches** “use an economic impact analysis tool” such as input–output, computable general equilibrium (CGE) or macroeconomic models. “Economists designed these models to predict job creation impacts rather than to count them, and using predictive tools for retrospective verification may provide inadequate evidence of real-world impacts.”

Many of the studies included in our literature analysis in Section 2 use input-output (I-O) models, based on national I-O tables that show how changes in final demand have affected the economy. I-O tables are a snapshot in time and the models do not consider evolving industrial structures so are best suited for short-term projections rather than long-term forecasts. They assume constant returns to scale and do not take account of potential supply constraints, and therefore are likely accurate if investment is increased a slight amount but may not be if investment is multiplied many times. Most of these estimates are from I-O models that generate estimates as though everything is happening at one fixed point in time, and thus do not provide insight into the length and quality of the jobs (UNIDO and GGGI 2015; NREL 2021).

Additional modeling approaches include CGE and macroeconomic approaches.⁹ CGE models reproduce economies' structures and transactions among economic agents (economic sectors, households, government, trade) as a system of interdependent components. External shocks create ripple effects throughout the economic system and produce impacts in variables such as government surplus, wage rates, labor supply and demand, income, tax revenues, and consumption. The advantages of these models are their ability to capture the economy-wide effects of policies (e.g., distributive effects of restoration) as well as to reflect gains or losses in aggregated variables (e.g., welfare, income, employment, taxes), making them more suitable for analyses of the medium- or long-term effects of policies. The main limitations of CGE models are that the results are not precise measures of effects but rather represent their direction and distribution. They are therefore not appropriate for short-term analysis or analyzing small sectors or regions.

Macroeconometric models estimate the main macroeconomic variables (e.g., economic growth, employment) using historical data. They represent the economies' short-run structures through these variables and the outcomes are determined by demand. They also comprise a long-run structure that follows a supply-side analysis following standard macroeconomic growth approaches. The main model outputs are government surplus, wage rates, labor supply and demand, income, tax revenues, and consumption. They can evaluate a broad range of policies as the structure is flexible and consistent with the national accounts. These models can simultaneously evaluate changes in policy instruments and can generate short- and long-term forecasts while maintaining consistency between sectors and national accounts. Macroeconometric model estimates, however, are difficult to interpret from a policy perspective because changes in policy may invalidate some of the estimated relationships that were based on historical data. Additionally, forecasting may be difficult as models need to generate future values for exogenous variables.

APPENDIX B. METHODOLOGY AND FULL DATA FOR JOBS PER \$1 MILLION; LITERATURE REVIEW AND ANALYSIS

We performed a literature review to assess the number of jobs created per \$1 million from green investments versus unsustainable investments in the three sectors that are the focus of this paper: energy, transportation, and nature. A full systematic review and meta-analysis for each sector is out of the scope of this paper, but we included as many relevant studies as possible.

Study criteria

We included only studies that did the following:

- **Provided estimates of the number of jobs created per unit of investment**—most frequently jobs per \$1 million, but sometimes with another amount that we converted to jobs per \$1 million. There is another set of literature that looks at job creation from energy investments per megawatt of electricity generation, but given that jobs per unit of investment is more applicable when considering stimulus spending, we focused only on the studies with analysis by unit of investment.
- **Included multiple investment types to provide comparisons between green investments and unsustainable investments.** For energy, we searched for studies with comparisons of job creation from clean energy investments versus fossil fuel investments. For transportation, we searched for studies with comparisons of job creation from public transportation investments versus road investments and electric vehicle investments versus internal combustion engine vehicle investments. For nature, we searched for studies with comparisons of job creation from nature-based climate solutions versus carbon-intensive nature-based activities, but this was limited so we also searched for studies comparing nature-based climate solutions versus any other investment types.
- **Compared the number of jobs per \$1 million with an unsustainable investment within that same study using the same geographical scope, timeframe, and methodology.** It is difficult to compare one jobs study to the next since they use different countries/regions, time periods, and methodologies. One million dollars spent in a developing country will create significantly more jobs than \$1 million spent in a developed country, no matter what sector it is, due to lower wages, less automation, and other factors. One million dollars spent today will create a different number of jobs than \$1 million spent 10 years ago because of inflation and changes in wages and technology prices. Different economic models have vastly different assumptions. Some studies look at only direct jobs while others also include indirect and induced jobs. This means that citing the number of jobs per \$1 million in a green project from one study and comparing it to the number of jobs per \$1 million from another study is usually an apples-to-oranges comparison.

- **Focused on the impacts of investments, not of other policies like market-based mechanisms or regulations.**
- **Were published in 2009 or later.** This allowed us to capture studies investigating the job impacts of stimulus investments after the global financial crisis and other green investments in the ensuing decade.

Study selection

We used Google Scholar, Google, and EBSCO Discovery Service for a top-down search of relevant studies. Keywords included “jobs,” “employment,” or “jobs per \$1 million” paired with “infrastructure” or a variety of sector-specific keywords including “energy,” “clean energy,” “renewable energy,” “energy efficiency,” “fossil fuels,” “transportation,” “transit,” “railways,” “roads,” “electric vehicles,” “ICE vehicles,” “gas vehicles,” “nature,” “restoration,” and “sustainable agriculture.” We also added studies that we were already aware of based on our knowledge of the field and studies we came across in the references of other sources. We asked experts if they were aware of other relevant studies. There is a possibility for bias in that we may be more likely to be aware of studies or be provided studies by our contacts that have findings that are more favorable to green investments. We included only English language studies, which is part of the reason for the geographical bias described in Section 2. We included both peer-reviewed journal articles and gray literature. Our results should be seen as preliminary considering the non-systematic nature of our literature review and the limitations of the existing literature.

Section 2 of this paper provides details on each study included in the analysis including the country/region covered, peer-review status, methodology, and definitions of jobs used.

Four of the 12 studies were from peer-reviewed journals while the rest were published by international institutions, universities, and research organizations. Several were published or sponsored by institutions that could have a predisposition to want to promote green investments, introducing a potential source of bias. We have made the publishers/sponsors clear in Table A1. Six of the studies were done by scholars affiliated with or formerly affiliated with the Political Economy Research Institute at the University of Massachusetts Amherst, so in Table A1 we have also indicated what these studies are to make clear they are coming from a similar source and should not be seen as entirely independent from each other.

Energy

In the category of energy, we found four studies that met our criteria and compared the number of jobs created per \$1 million in clean energy investments to those created per \$1 million in fossil fuel investments. We were able to find studies that covered a range of countries and regions. The UNIDO and GGGI (2015) study included five countries, each of which we treated as a separate observation. This means that five of the nine data points for clean energy rely on this one study. Several older U.S.-focused studies by Heidi Garrett-Peltier and her colleagues met our criteria but were removed because Garrett-Peltier (2017) was a more recent update in a peer-reviewed journal using a similar methodology as before.

Table A1 | Study Publishers

STUDY	PUBLISHER	AUTHORS AFFILIATED WITH POLITICAL ECONOMY RESEARCH INSTITUTE AT UNIVERSITY OF MASSACHUSETTS AMHERST
IEA (2020)	International Energy Agency	No
UNIDO and GGGI (2015)	United Nations Industrial Development Organization and Global Green Growth Institute	Yes
Chen (2019)	<i>International Review of Applied Economics</i>	Yes
Garrett-Peltier (2017)	<i>Economic Modelling</i>	Yes
Schwartz et al. (2009)	World Bank/ <i>Journal of Infrastructure Development</i>	No
Garrett-Peltier (2011)	Political Economy Research Institute, University of Massachusetts Amherst	Yes
SGA (2011)	Smart Growth America	No
Heintz et al. (2009)	Alliance for American Manufacturing	Yes
Ianchovichina et al. (2013)	World Bank/ <i>World Development</i>	No
Freedman et al. (2017)	Boston Consulting Group and CG/LA Infrastructure	No
Soni (2020)	Georgia Institute of Technology (dissertation)	No
Peltier (2020)	Boston University	Yes

Table A2 | Energy Near-Term Gross Direct and Indirect Jobs Created per \$1 Million

	TYPE OF INVESTMENT	IEA (2020)	UNIDO AND GGGI (2015)					CHEN (2019)	GARRETT-PELTIER (2017)
		Global	Germany	South Korea	Brazil	South Africa	Indonesia	China	United States
Clean energy	Solar PV	12.1	8.8 (7.9)	11.0 (9.9)	25.7 (25.1)	55.6 (52.4)	63.4 (60.8)	100.1	7.24
	Wind	1.7	8.4 (7.5)	12.4 (11.3)	29.2 (28.6)	60.5 (56.9)	79.7 (77.3)	100.1	7.52
	Geothermal		9.7 (7.9)	14.3 (12.9)	28.7 (28.4)	69.5 (67.2)	64.7 (62.9)		7.4
	Hydro	1.6	8.8 (7.5)	15.2 (14.3)	25.5 (25.2)	61.6 (59.3)	75.9 (70.2)		7.53
	Building efficiency	15	11.8 (11.5)	13.9 (13.2)	46.2 (46.0)	94.0 (92.1)	97.9 (96.3)		7.77
	Industrial efficiency	9.9	8.6 (7.7)	12.3 (11.1)	25.1 (23.9)	60.5 (57.2)	59.6 (57.3)		7.41
	Upgrades to existing grids	7.2	8.1 (7.3)	12.0 (10.9)	26.2 (25.1)	55.9 (52.7)	62.2 (59.6)		6.76

Table A2 | Energy Near-Term Gross Direct and Indirect Jobs Created per \$1 Million, continued

	TYPE OF INVESTMENT	IEA (2020)	UNIDO AND GGGI (2015)					CHEN (2019)	GARRETT-PELTIER (2017)
		Global	Germany	South Korea	Brazil	South Africa	Indonesia	China	United States
Clean energy	Nuclear	1.5							
	CCUS	2.5							
	New grids	5.5							
	Reducing methane emissions	3.8							
Fossil fuels	Coal	5.5	10	14.1	22.4	29.4	40.6	111.6	3.1
	Gas	4.4							
	Oil and gas		5.3	13.1	20	36.8	3.5	81.7	2.2
	FOSSIL FUEL AVERAGE	5.0	7.7	13.6	21.2	33.1	22.1	96.7	2.7

Note: For UNIDO and GGGI (2015), the sensitivity analysis in parentheses is a scenario where domestic content declines 20 percent for tradeable activities.

PV = photovoltaic; CCUS = carbon capture, utilization, and storage.

Table A2 presents the number of jobs created per \$1 million in various types of clean energy and fossil fuel investments from each of the studies that met our criteria. It also calculates the average (mean) for fossil fuels across the fossil fuel technologies included in each study. The fossil fuel average is used as the comparator for clean energy going forward.

Table A3 | Ratio of Direct and Indirect Jobs Created in Clean Energy Compared with Fossil Fuel Average per \$1 Million

TYPE OF INVESTMENT	IEA (2020)	UNIDO AND GGGI (2015)					CHEN (2019)	GARRETT-PELTIER (2017)	MEDIAN
	Global	Germany	South Korea	Brazil	South Africa	Indonesia	China	United States	
Solar PV	2.44	1.15	0.81	1.21	1.68	2.88	1.04	2.73	1.45
Wind	0.34	1.09	0.91	1.38	1.83	3.61	1.04	2.84	1.24
Geothermal		1.27	1.05	1.35	1.10	2.93		2.79	1.73
Hydro	0.32	1.15	1.12	1.20	1.86	3.44		2.84	1.20
Building efficiency	3.03	1.54	1.02	2.18	2.84	4.44		2.93	2.84
Industrial efficiency	2.00	1.12	0.90	1.18	1.83	2.70		2.80	1.83
Upgrades to existing grids	1.45	1.06	0.88	1.24	1.69	2.82		2.55	1.45
Nuclear	0.3								0.3
CCUS	0.5								0.5
New grids	1.11								1.11
Reducing methane emissions	0.76								0.76

Notes: Ratios >1 indicate that clean energy investments create more jobs than fossil fuel investments. Ratios <1 indicate that clean energy investments create fewer jobs than fossil fuel investments. The ratios shown here may not match exactly those of Table A2 due to rounding.

PV = photovoltaic; CCUS = carbon capture, utilization, and storage.

In some countries, \$1 million invested creates far more jobs than in other countries, no matter what the investment is in, because of the national context. Therefore, we normalized the results by taking the ratio of jobs from one investment type to another for each country. Table A3 compares the ratio of jobs created in each clean energy category compared with the average of fossil fuels per \$1 million in investment (i.e., number of clean energy jobs/number of fossil fuel jobs). For example, in the first row, first column, the 2.44 means that according to IEA (2020), investing \$1 million in solar photovoltaic (PV) globally creates 2.44 times as many jobs as investing \$1 million in fossil fuels.

The number of jobs created from clean energy versus fossil fuel investments varies depending on the country/region considered. For example, investing in solar PV creates far more jobs per \$1 million than fossil fuels in Indonesia, the United States, and South Africa. It creates a moderately higher number of jobs per \$1 million than fossil fuels in Brazil, Germany, and China. However, in South Korea, solar PV creates fewer jobs than fossil fuels per \$1 million. This pattern holds true across other clean energy technologies, with clean energy creating more jobs than fossil fuels in most countries, with only a few exceptions.

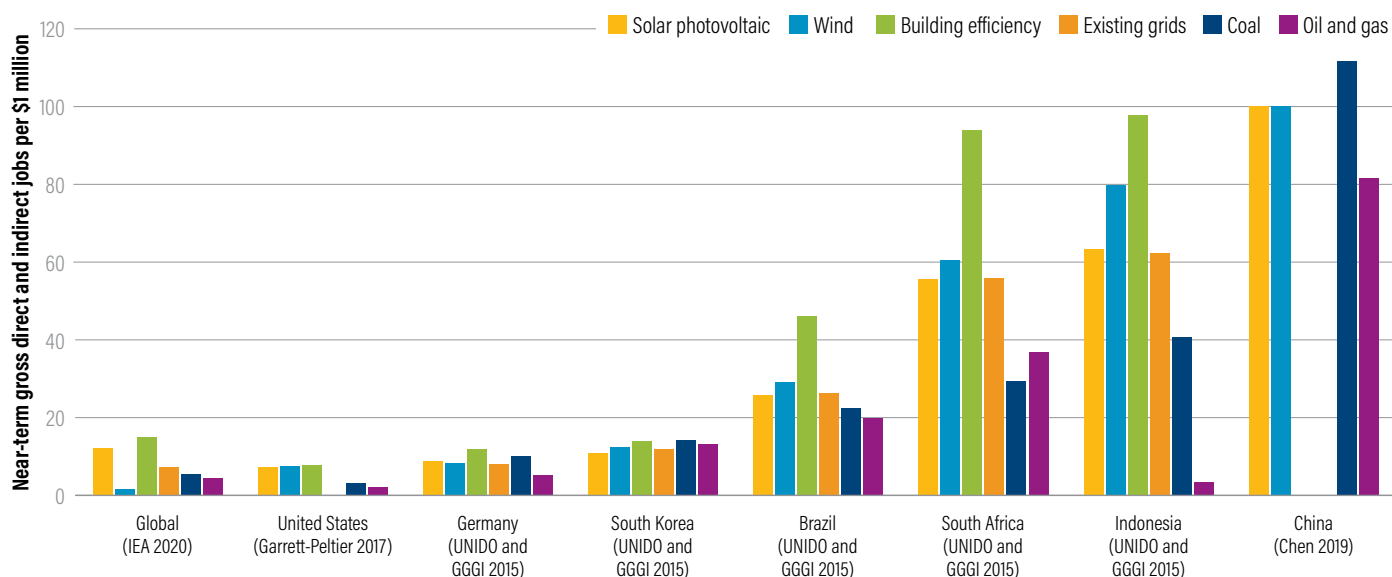
A final note is that while we compared clean energy investments to the average of the fossil fuel investments, the comparison is sometimes more or less favorable if it is made with individual types of fossil fuels such as coal or oil and gas. Figure A1 presents comparisons for a few select technologies and studies. For example, in China, investing \$1 million in solar or wind creates more jobs than investing the same amount in oil and gas, but fewer jobs than investing the same amount in coal (Chen 2019). Note that Chen (2019) used 2007 data to arrive at her results but in the following years the labor productivity of coal in China increased faster than the labor productivity of solar and wind, so coal may no longer be the largest job creator per \$1 million.

Sustainable Transportation

In the category of sustainable transportation, we split the comparisons into two: observations where job creation from investments in mass transit, railways, and pedestrian and cycling infrastructure was compared with investments in roads, and where job creation from investments in electric vehicles (EVs) was compared with investments in internal combustion engine (ICE) vehicle manufacturing.

Table A4 and Figure A2 present the number of jobs created per \$1 million in various types of public transportation and road investments from each of the studies that met our criteria.

Figure A1 | **Jobs per \$1 Million in Clean Energy versus Coal and Oil & Gas**



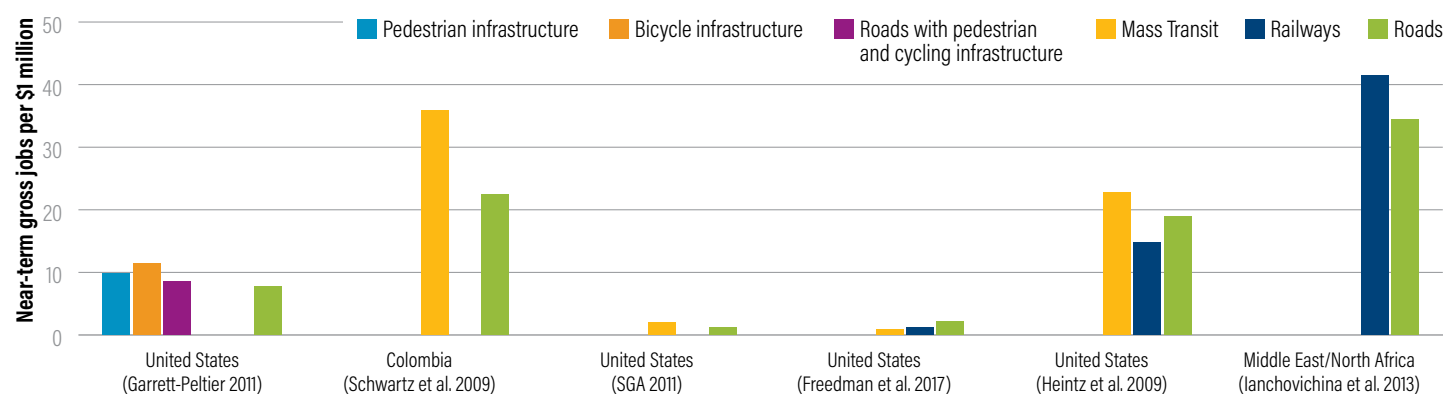
Notes: For all but one study "coal" and "oil and gas" refer to production. For IEA (2020), "coal" refers to coal power and "oil and gas" refers to gas power.

Table A4 | **Public Transportation and Road Jobs Created per \$1 Million**

	GARRETT-PELTIER (2017)	SCHWARTZ ET AL. (2009)	SGA (2011)	FREEDMAN ET AL. (2017)	HEINTZ ET AL. (2009)	IANCHOVICHINA ET AL. (2013)
	United States	Columbia	United States	United States	United States	Middle East/North Africa
Types of jobs	Direct, indirect, induced	Direct	Direct	Direct, indirect, induced	Direct, indirect, induced	Direct, indirect, induced
Pedestrian-only infrastructure	9.9 (7.4–11.4, depending on city)					
Bicycle-only infrastructure	11.4 (8.5–14.4, depending on city)					
Roads with pedestrian and cycling infrastructure	8.5 (6.6–12.0, depending on city)					
Mass transit		35.8 (bus rapid transit routes)	4,200 job-hours (2.4 job-years)	0.9	22.8	
Railways				1.2	14.7	41.5 for high-income oil-exporting countries, 62.2 for developing oil exporters, and 124.4 for oil importers
Roads	7.8 (4.9–11.6, depending on city)	22.5	2,400 job-hours (1.3 job-years)	2.2	18.9 (roads and bridges)	34.5 for high-income oil-exporting countries, 51.8 for developing oil exporters, and 103.6 for oil importers

Notes: Ianchovichina et al. (2013) had options for both paved and unpaved roads. We looked only at paved to be conservative. We calculated indirect and induced jobs per \$1 million using the Type II multiplier they provided. For SGA (2011), job-hours were converted to job-years assuming the average U.S. working year of 1,778, which is the 2011 figure according to the Organisation for Economic Co-operation and Development.

Figure A2 | **Jobs per \$1 Million in Public Transportation versus Roads**



Notes: SGA (2011) and Schwartz et al. (2009) look at direct jobs, while Garrett-Peltier (2011), Heintz et al. (2009), and Freedman et al. (2017) look at direct, indirect, and induced jobs. For Ianchovichina et al. (2013), we present only the results for high-income oil-exporting countries. The study also examines developing oil-exporting countries and oil-importing countries, where the number of jobs created is higher but the ratio of railways to roads is the same.

Table A5 presents the ratio of jobs created per \$1 million in public transportation versus roads. For each observation, we calculated the ratio of the public transportation investment type/roads.

There were fewer comparable observations for public transportation than there were for clean energy. Therefore, we also present in Table A6 other studies we found that provide jobs multipliers for sustainable transportation but do not have something to compare it to, for reference.

Table A5 | **Ratio of Jobs Created in Public Transportation Compared with Roads per \$1 Million**

	GARRETT-PELTIER (2017)	SCHWARTZ ET AL. (2009)	SGA (2011)	FREEDMAN ET AL. (2017)	HEINTZ ET AL. (2009)	IANCHOVICHINA ET AL. (2013)	MEDIAN
	United States	Colombia	United States	United States	United States	Middle East/North Africa	
Pedestrian-only infrastructure	1.27						1.27
Bicycle-only infrastructure	1.46						1.37
Roads with pedestrian and cycling infrastructure	1.09						1.09
Mass transit		1.59	1.75	0.41	1.21		1.4
Railways				0.55	0.78	1.2	0.78

Notes: Ratios >1 indicate that public transportation investments create more jobs than road investments. Ratios <1 indicate that public transportation investments create fewer jobs than road investments. The ratios shown here may not match exactly those of Table A4 due to rounding.

Table A6 | **Other Studies with Jobs per \$1 Million for Sustainable Transportation That Do Not Allow for Comparisons with Unsustainable Transportation**

SOURCE	GEOGRAPHICAL SCOPE	SUSTAINABILITY SECTOR	JOBS CREATED PER \$1 MILLION
IEA (2020)	Global	Pedestrian and bike lanes	8.1–22.4
		Urban transport infrastructure	11.4
		Railways	4.6–8.9
Engel et al. (2020)	Europe/OECD	Bus rapid transit and urban rail	24–30
		Active transport infrastructure	24–30
Garrett-Peltier (2017)	United States	Mass transit and freight rail	
APTA (2020)	United States	Public transport capital and operations	17.9
Pollin et al. (2009)	United States	Mass transit and freight rail	22.3
Pollin and Chakraborty (2020)	United States	Railways	11.2

Note: OECD = Organisation for Economic Co-operation and Development.

Table A7 | **Ratio of Jobs Created in Electric Vehicles Compared with Internal Combustion Engine Vehicles per \$1 Million**

STUDY	GEOGRAPHICAL SCOPE	EV SECTOR	JOBS PER \$1 MILLION	ICE SECTOR	JOBS PER \$1 MILLION	RATIO OF EV JOBS/ ICE JOBS
Soni (2020)	United States	EV and battery manufacturing	9.05 (10.09 with low battery costs)	ICE vehicle manufacturing	9.17	0.98
IEA (2020)	Global	EV manufacturing	3.7-7.7 (midpoint 5.7)	ICE vehicle manufacturing	5.2-9.2 (midpoint 7.2)	0.79
		Battery cell manufacturing	5.3-11.5 (midpoint 8.4)	ICE vehicle manufacturing	5.2-9.2 (midpoint 7.2)	1.17
		EV charging infrastructure	7.3-21.2 (midpoint 14.25)	ICE vehicle manufacturing	7.2	1.98

Notes: Ratios >1 indicate that EV investments create more jobs than ICE investments. Ratios <1 indicate that EV investments create fewer jobs than ICE investments. The ratios shown here may not match exactly those of Table A6 due to rounding.

EV = electric vehicle; ICE = internal combustion engine.

There were only two applicable studies for job creation from EV investments versus ICE vehicle investments. Table A7 presents the jobs created per \$1 million and the ratios.

Nature-Based Solutions

For investments in nature-based solutions, we found one study (Peltier 2020) that compared job creation from investments in restoration and other forestry and agriculture support activities to investments in oil and gas. A previous estimate of restoration job creation compared with fossil fuel job creation from Garrett-Peltier and Pollin (2010) is often cited, but

we confirmed that the newer analysis from Peltier (2020) should be used instead. This is an appropriate comparison given that an alternate option to public land preservation and restoration would be to allow for oil and gas leasing and extraction on those lands. We hoped to find studies that compared job creation in nature-based solutions to job creation from traditional crop agriculture and livestock, logging, or other forms of traditional land use but were unable to find any observations where the comparison could be made within that same study using the same geographical scope, timeframe, and methodology.

In Table A8 we present data from Peltier (2020) plus six studies that provide data on jobs created per \$1 million but without comparisons to unsustainable investments. We caution against comparing these numbers

to job creation numbers from other studies that use different countries/regions, timeframes, or methodologies. All of these studies were conducted in the United States.

Table A8 | **Jobs per \$1 Million Invested in Nature-Based Solutions**

SOURCE	GEOGRAPHICAL SCOPE	JOB TYPES	TYPE OF NATURE-BASED CLIMATE SOLUTION	JOBS PER \$1 MILLION (RANGE)	COMPARISON
Peltier (2020)	United States	Direct, indirect, and induced	Restoration and other support activities for agriculture and forestry	30.8	8.4 jobs per \$1 million in oil and gas (3.67 times as many jobs in restoration versus oil and gas)
Samonte et al. (2017)	United States	Direct, indirect, induced	Coastal habitat restoration	15 (14–30)	N/A
C.C. Thomas et al. (2016)	United States	Direct, indirect, induced job-years	Various types of restoration	(12.9–32.1)	N/A
Nielsen-Pincus and Moseley (2013)	Oregon	Direct and indirect	Various types of restoration	16.3 (14.7–23.1)	N/A
Industrial Economics, Inc. (2012)	Massachusetts	Direct, indirect, induced	Various types of restoration	9.9–12.9	N/A
Wagner and Shropshire (2009)	Montana	Unclear, job-years	Mine-related pollution cleanup and creek restoration	31.5	N/A
Pollin and Chakraborty (2020)	United States	Direct, indirect, induced	Various types of restoration	(15.9–23)	Makes comparisons to other sectors of the economy but not unsustainable sectors
			Sustainable agriculture	(12.6–23.8)	Makes comparisons to other sectors of the economy but not unsustainable sectors

ENDNOTES

1. The International Trade Union Confederation defines a decent job as one that “ensures safe work, fair wages, respect for workers’ rights and social protection” (ITUC and Millennium Institute 2012). The International Labour Organization’s definition of decent work expands on this, noting that decent work is productive, provides workplace security, supports workers’ personal growth and social integration, ensures gender equality, and allows for labor organization and participation in decision-making that affects workers’ lives (ILO 2018b). Job quality can be measured objectively, for example, by looking at the level of pay and benefits provided, or subjectively, for example, by determining workers’ job satisfaction (Warhurst et al. 2017). We recognize that the six factors we present are not comprehensive, but they provide an overview of many of the challenges and draw on the existing literature.
2. As of August 2021, 14 countries plus the European Union have included just transition in their nationally determined contributions under the Paris Agreement, according to WRI analysis of the Climate Watch data platform. These include Argentina, Canada, Chile, Colombia, Costa Rica, Dominican Republic, the European Union, Kenya, Lebanon, Montenegro, Norway, the Philippines, South Africa, Suriname, and the United Kingdom. Other governments have integrated just transition into their national strategies (European Commission 2020, 2019; WRI 2021c).
3. Not considering the labor that went into constructing the machinery and buildings.
4. For example, imagine there is a \$1 million investment and 50 percent went to wages—\$500,000 in annual labor compensation split among workers making \$50,000 each would support 10 jobs for a year, while \$500,000 split among workers making \$25,000 each would support 20 jobs for a year.
5. Renewable energy firms are consistently increasing labor efficiency and automation, so as time goes on fewer workers have been needed for each project (Iaconangelo 2021). The amount of kilowatts installed per solar worker has tripled in the United States since 2011, including an acceleration due to COVID-19 as construction projects have continued to grow larger and more sales have moved online (TSF 2021).
6. Prevailing wage laws set wage and benefit floors in a given region based on local conditions and are often higher than minimum wages.
7. EV charging infrastructure construction jobs are quite different from ICE vehicle manufacturing jobs and may be located in different areas. A more appropriate comparison would be to compare EV charging infrastructure construction jobs with gas station jobs, but these comparisons were not available in the literature. Note: most gas station jobs are in food service and retail, so wouldn’t necessarily need to change in the transition to EVs.
8. As mentioned in Section 2, we originally planned to compare job creation from nature-based-solution investments to high-carbon nature-based activities, but were unable to find any so we searched for studies with comparisons with other investment types. In Peltier (2020), oil and gas production provides a useful comparison given that instead of preserving and restoring public lands an unsustainable alternative would be to allow for oil and gas leasing and extraction on those lands. The categories of forestry, hunting, and fishing can be sustainable or unsustainable depending on the context, but they also provide useful points of comparison.
9. For further details on the nature, advantages, and limitations of these models see EPA (2018).

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ACKNOWLEDGMENTS

We would like to thank our external reviewers for their helpful comments and suggestions: Bruce Wilson (RMIT University), Marek Harsdorff (International Labour Organization), Jean-Paul Adam (United Nations Economic Commission for Africa), Michael Renner (International Renewable Energy Agency), Sabrina Muller (London School of Economics), and Heidi Peltier (Boston University).

We would also like to thank our World Resources Institute internal reviewers: Aman Srivastava, Ayushi Trivedi, Benjamin Welle, David Waskow, Devashree Saha, Dow Martin, Erika Myers, Laura Malaguzzi Valeri, Leah Lazer, Liqing Peng, Pamli Deka, and Venkat Iyer.

We would like to thank Carlos Muñoz Pina, Emily Matthews, Emilia Suarez, and Renee Pineda from the WRI Research, Data, and Innovation team. We would also like to thank those who provided production, design, and editing support, including Romain Warnault, Rosie Ettenheim, Sarah DeLucia, and Jennifer Lockard; and communications and engagement support, including Molly Bergen, Christopher Ede-Calton, Madhavi Ganeshan, and Rhys Gerholdt.

ABOUT THE AUTHORS

World Resources Institute Authors

Joel Jaeger is a Research Associate II in the WRI Climate Program.

Ginette Walls is a Research Associate in the WRI Climate Program.

Ella Clarke was an intern for the New Climate Economy program.

Juan Carlos Altamirano is an Economist on the WRI Economics team.

Arya Harsono is a Research Associate for the New Climate Economy.

Helen Mountford is the Vice President for Climate and Economics at WRI.

International Trade Union Confederation Authors

Sharan Burrow is the General Secretary of the ITUC.

Samantha Smith is the Director of the Just Transition Centre, an initiative of the ITUC.

Alison Tate is the Director of Economic and Social Policy at the ITUC.

ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

Our Challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our Approach

COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.

ABOUT NCE

The New Climate Economy (NCE) is the flagship project of the Global Commission on the Economy and Climate, comprised of former heads of government and finance ministers and leaders in the fields of economics and business. Since 2013, NCE has built the evidence base to demonstrate that climate action is both complementary to and essential for economic development. The project is now focused on translating this narrative and analysis into specific and actionable plans for key emerging and developing countries to build back better from COVID-19.

NCE has released four major global reports, as well as a variety of country-focused reports, case studies and other research. NCE also supports the work of aligned platforms—including Food and Land Use Coalition (FOLU), the Coalition for Urban Transitions (CUT), the Platform for Accelerating the Circular Economy (PACE), and Partnering for Green Growth and the Global Goals 2030 (P4G)—to create impact that is greater than the sum of their parts.

ABOUT ITUC

The International Trade Union Confederation (ITUC) is the global voice of the world's working people. The ITUC represents 200 million workers in 163 countries and has 332 national affiliates.

The ITUC's primary mission is the promotion and defense of workers' rights and interests, through international cooperation between trade unions, global campaigning and advocacy within the major global institutions.

Its main areas of activity include the following: trade union and human rights; economy, society and the workplace; equality and non-discrimination; and international solidarity.

The ITUC adheres to the principles of trade union democracy and independence. It is governed by four-yearly world congresses, a General Council and an Executive Bureau.

The ITUC regional organisations are the Asia-Pacific Regional Organisation (ITUC-AP), the African Regional Organisation (ITUC-AF) and the American Regional Organisation (TUCA). It cooperates with the European Trade Union Confederation, including through the Pan-European Regional Council.

The ITUC has close relations with the Global Union Federations and the Trade Union Advisory Committee to the OECD (TUAC). It works closely with the International Labour Organization and with several other UN Specialised Agencies.



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