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A Review of Human Development and Environmental Outcomes

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Abstract

As climate change and its impact on the physical environment become increasingly evident, its relationship with human development outcomes is becoming a key area of research. While numerous researchers have studied the ways in which the immediate environment affects human capital, literature on the impact of human capital on the environment remains scarce. Despite the heightened interest in understanding the linkages between human development outcomes and environmental factors, most studies of this relationship are theoretical, correlational, or observational, thus lacking causality. This paper surveys the literature and explores how evidence can be established for policies focusing on human development and environmental outcomes. The paper presents a conceptual framework incorporating direct and indirect pathways – including cognitive and noncognitive factors through which improved education can lead to better environmental behaviors. Of the 31 studies reviewed, a majority (27 studies) present observational findings, while only a few (four studies, or 13 percent) use a quasi-experimental design to establish causality. The few causal studies suggest that it is possible to change attitudes but more difficult to change environmental behaviors. The review raises the key question of whether policies aimed at improving climate change awareness through education can effectively produce long-lasting changes in pro-environmental behaviors. Much more work is needed to advance understanding of how human capital policy can help mitigate or promote adaptation to climate change.

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1. Introduction

Environmental conditions, such as those pertaining to natural resources and climate, are intrinsically linked to human development outcomes in numerous ways. For example, exposure to poor air and water quality among populations is linked to birth defects and cognitive deficits in children (Ferguson et al. 2013). Similarly, workers in mining industries are known to have lower life expectancy due to exposure to heavy metals and toxic environmental conditions, and children living in more polluted environments display higher levels of chronic absenteeism (MacNaughton et al. 2017; Bangay and Blum 2010). On the other hand, human development outcomes such as improved educational attainment in turn may be linked to better environmental outcomes through pathways such as increased awareness about environmental issues and improved access to resources to address them.

Is there a link between human development outcomes and environmental outcomes? If so, are there ways to establish a causal relationship? What is the impact of schooling on climate actions, including attitudes, behaviors, and outcomes? We answer these questions by first surveying the literature that investigates the impact of environmental changes on human development outcomes. Then, with more focus, we look at the impact of human development on environmental outcomes, while also assessing the strength of such associations. Despite the heightened interest in understanding the linkages between human development outcomes and environmental factors, most studies of this relationship are only theoretical, correlational, or observational, thus lacking causality. We look at causal estimates of the impact of educational interventions on different environmental outcomes. We explore how evidence can be established for policies focusing on human development and environmental outcomes. We find that there are ways to causally estimate the impact of education on climate outcomes and propose approaches.

The broader relationships between economic development and environmental outcomes have been a topic of enquiry for researchers for a long time. The seminal paper by Grossman and Krueger (1995) was among the first to study this relationship using a global dataset. Using panel data (1977-1990) on four environmental indicators (urban air pollution, the state of the oxygen regime in river basins, fecal contamination of river basins, and contamination of river basins by heavy metals), the authors find that environmental outcomes initially worsen with increasing per capita GDP but eventually witness a U-shaped recovery as incomes increase above a critical threshold. The authors suggest that as countries prosper economically, their citizens demand better environmental conditions, thus improving environmental standards. The study validated the presence of the Environmental Kuznets Curve and was followed by further research to replicate and extend the initial findings (see Goklany 1999; Panayotou 1995).

A later cross-sectional study by Jha and Murthy (2003) also highlights a similar relationship. The authors construct a composite environmental degradation index (EDI) for 174 countries using six indicators of environmental degradation or pollution and identify its relationship with the Human Development Index (HDI). The study suggests an inverted N-curve that indicates that countries with high levels of development and lower values of HDI rank contribute more to environmental degradation while mid-ranking countries have the least levels of environmental degradation. Similarly, the paper by Dogan and Inglesi-Lotz (2020) considers how changes in economic

structure from developing to developed countries in the European Union (EU) relate to carbon emissions. They find that carbon emissions increase initially as countries move from agriculture to manufacturing, but a rising share of the service sector and increasing per capita incomes leads to reduced emissions, thus confirming the U-shaped curve.

A more recent paper by Mrabet et al. (2021) uses panel data for 16 Middle Eastern and North African countries (period 1990–2016) to examine the relationship between Ecological Footprint and HDI. They find that improving HDI will harm the environment in the early stages of development by increasing the Ecological Footprint, but as the country develops, further increases in human development will result in lower levels of environmental degradation. These findings thus suggest that human development and political stability can have a positive effect on the environment through better education and health care systems. However, validating these mechanisms and establishing a causal relationship still requires further research.

The remainder of the paper proceeds as follows. The next section presents a synthesis of literature to establish that climate change can indeed affect human development outcomes. It also presents an overview of the adaptation and mitigation measures that can reduce the negative impact of climate change. While some interventions, such as risk assessment of buildings and disaster management, can aid adaptation and reduce climate vulnerabilities, others, such as curriculum redesign and promoting research in universities, can enable mitigation. The last section then shifts focus to the literature on the linkages between education and climate change and presents a possible framework to study these linkages. The last part of that section also presents compulsory schooling laws as one instrument that can be used to establish causal linkages.

2. Impact of Climate on Human Development

The influence of our physical environment and climate on human development outcomes such as educational attainment and child mortality has been studied by researchers in different contexts and regions of the world. While weather changes can directly affect human development outcomes by disrupting access to infrastructure such as schools or hospitals, availability of staff (teachers, doctors and nurses, etc.), and increasing incidence of diseases, research in countries across the globe has shown that changes in weather patterns can also affect cognitive performance, rate of skill formation, work behavior, workforce migration, and labor market participation (see Deuster 2021; Das 2020; Li 2020; Zivin and Neidell 2014). Park et al. (2021) use data for 58 countries and 12,000 US school districts with detailed weather and academic calendar information to show that the rate of learning decreases with an increase in the number of hot school days. These negative effects are further compounded in poorer countries and can be up to three times higher for students from low-income groups. Zivin et al. (2018) in their study further show that even though the negative effect of long-term temperature changes may be reduced due to compensatory behavior, short-run changes can lead to statistically significant decreases in cognitive performance (also see Zivin et al. 2020).

A similar study by Cook (2021) using the difference-in-difference methodology to assess the impact of flooding on education outcomes and cognitive performance among school children in Canada finds that exposure to floods can reduce performance by up to 7 percent of a standard

deviation. However, the effects are less pronounced for students living in high-rise apartment buildings and newer construction areas that are less prone to flooding, thus suggesting that adaptive measures can play a role in reducing the impact of climate change on human development outcomes.

Similarly, research on health outcomes also indicates that negative environmental conditions can create long-term negative impact on health indicators of citizens. Researching the link between temperature inversion events and air pollution in Sweden, Jans et al. (2018) show that such events can increase air pollution (PM_{10} levels) by 25 percent and children's respiratory health problems by 5.5 percent with low-income children being the worse affected. Arceo et al. (2016) have previously shown that the effect of air pollution on infant mortality can be higher in developing countries as compared to developed countries.

Studying the impact of increasing oceanic acidity on early-childhood mortality and development, Armand and Taveras (2020) have gathered data on more than 1.5 million births taking place over the last 50 years in 36 developing countries. The study finds that in coastal areas, a 0.01 unit increase in acidity can lead to 2 additional neonatal deaths per 1,000 live births. Ebi and Hess (2020) further suggest that increased exposure to climate hazards has increased risks of deaths and injuries from extreme events, infectious diseases, and food and water insecurity in Europe. They propose simultaneous government policies and investments in social and health protections aimed at reducing inequities and investments in climate change mitigation and adaptation to reduce these health risks.

2.1. Adaptation and Mitigation Measures to Reduce the Impact of Climate Change

As highlighted above, human development outcomes are frequently affected by environmental conditions while interventions targeting human development can in turn affect environmental outcomes. Numerous studies have advanced the role that human development interventions can play in adapting to and mitigating climate change. Bangay and Blum (2010) argue that a robust education system can equip and empower people to deal with climate uncertainties. They also present a generalized sequential framework to identify education responses ranging from provision of adequate educational infrastructure in the short term (adaptation) to equipping learners with the requisite skills, knowledge, and attributes to deal with future challenges in the long term.

Adaptation measures can include a variety of interventions that improve resilience or direct human behavior towards adaptation strategies. Instances of such short-term interventions include disaster-proofing infrastructure, adapting to seasonality changes, and building disaster preparedness capacity to respond to climate emergencies. According to the World Bank's World Development Report (2010), tackling climate change will require the expansion of some measures such as insurance and social protection as well as innovation in the implementation of others such as urban and infrastructure planning. DFID's report on Education, Climate and Environment (Blum 2015) further emphasizes the role that education and educational infrastructure can play in building the resilience of communities (particularly poor and vulnerable population groups) to climate and environmental change, and the potential opportunities provided by low carbon technology and environmentally sensitive construction and design in that process.

Other adaptation measures include introducing innovative policies that can change human behaviors through nudges and increasing awareness. Li (2020), for example, highlights the role that job flexibility can play in shaping people's adaptation to extreme weather. The study finds that when their residential areas are affected by extreme weather, workers with the flexibility to work at home reduced work time at their workplace by as much as 45 minutes on average, primarily because they wanted to avoid exposure to adverse climate during travel. Without this flexibility, workers made no changes to their work hours, thus suggesting that job flexibility improves workers' welfare by providing the choice of location adaptation. The European Commission (2019) too has pushed for policies that harness existing complementarities between efficiency, innovation, human capital, job quality, fairness, and improved working conditions to improve productivity while ensuring environmental sustainability. It identifies childcare and long-term care, education and training, skills, mobility, and housing as key policy intervention areas which could enhance sustainability and speed up the convergence of Member States' socio-economic performance.

Mitigation measures on the other hand may include updating curriculum and assessments, teacher education reforms, orientation towards new 'low carbon' technologies and sustainable futures, which can have a positive impact on environmental outcomes in the longer term. For example, research by Yao et al. (2020) has shown that advanced human capital, in the form of additional tertiary schooling, is associated with a reduction in CO_2 emissions between 50 and 65 percent. The findings of the paper suggest that the social benefits of investing in advanced human capital offer a promising avenue for addressing climate change without impeding economic growth. Another possible avenue to promote mitigating measures is through increased investments in research and development activities. Recent IEA estimates suggest that achieving global energy and climate change ambitions consistent with a 50 percent reduction of energy-related CO_2 emissions in 2050 (with respect to 2007 levels) would require a two to fivefold increase in public R&D spending (Dechezleprêtre et al. 2016). OECD too, in its report titled 'Promoting Technological Innovation to Address Climate Change' (2011) highlights the need to formulate flexible yet predictable, long-term policies that can incentivize innovations in a broad portfolio of complementary fields, and not just energy, "climate-friendly" or 'environmental' R&D. It also emphasizes enabling international collaboration between emerging countries and small OECD economies to enable easier transfer of knowledge and technologies.

It is thus quite evident that the education sector can play an increasingly important role in adapting to as well as mitigating climate change. While studies have explored numerous possible interventions such as building resilient infrastructure and improving educational attainment, considerable research is still required on the pathways through which these interventions can impact climate change. The following section presents an overview of current literature addressing this aspect.

3. Impact of Schooling on Climate

We now turn to the question of the impact of schooling on climate actions, including attitudes, behaviors, and outcomes. While numerous adaptation and mitigation measures have been proposed by policy makers and think tanks, empirical evidence on the causal effect of education on climate

literacy and pro-environmental behaviors remains scarce. Moreover, most of the research that does exist is theoretical, correlational, or observational (see, for example, Torgler and Garcia-Valinas 2007; McCright and Dunlap 2011; Kahan et al. 2012; Lee et al. 2015; O'Neill et al. 2020) or small-scale experiments that focused on the impact of specially designed education about the causes and consequences of global warming on public understanding of climate change risks of a nonrepresentative sample (Ranney and Clark 2016; Rumore et al. 2016).

The studies have used a variety of outcomes, including waste generation and recycling, purchase of organic foods, water saving behavior, demand for eco-labeling, attitudes toward sustainability, environmental concern, energy use, willingness to pay premium for green electricity, and contributions and actions regarding the environment and studied their relationship to educational attainment (Meyer 2015). Most of these observational studies find positive effects (for example, Bellows et al. 2008; Blend and van Ravenswaay 1999; Brecard et al. 2009; Callan and Thomas 2006; De Silva and Pownall 2014; Duggal et al. 1991; Ek and Soderholm 2008; Ferrara and Missios 2005; Gilg and Barr 2006; Klineberg et al. 1998; Kriström and Kiran 2014; Monier et al; Reschovsky and Stone 1994; Rowlands et al. 2003; Smith 1995; Teisl et al. 2008; Torgler and García-Valiñas 2007; Xiao et al. 2013). A few find negative effects (Grafton 2014; Johnston et al. 2001; Poortinga et al. 2004; Thompson and Kidwell 1998) or no effects (Berk et al. 1993; Millock and Nauges 2014; Wessells et al. 1999). Table 1 presents a summary of the key findings from these studies, while an overview of all the studies included has been provided as Appendix A. A broader systematic review by Ardoin, Bowers and Gaillard (2020) on the research on environmental education's contributions to conservation and environmental quality outcomes resulted in the analysis of 105 studies. The study documented strongly positive environmental education outcomes overall. However, their quality checks looked for studies that could document impact, but it is not clear if the studies were randomized or causal.

Table 1: Summary of findings of studies on relationship between education and pro-environmental behaviors

Aspects of environmental behavior	**Nature of relationship with educational factors**	**Studies included**
Resource (water and energy) conservation	Studies find a weak or insignificant relationship with total years of education or highest level of education	Berk et al. 1993 Ek and Soderholm 2008 Gilg and Barr 2006 Grafton 2014 Kriström and Kiran 2014 Poortinga et al. 2004 Rowlands et al. 2003
Waste reduction and recycling	Studies found a positive relationship with the level of education achieved	Callan and Thomas 2006 Duggal et al. 1991 Ferrara and Missios 2005 Reschovsky and Stone 1994
Sustainable food purchases	Most studies find a positive relationship with total years of education; some studies find a negative relationship with level of education	Bellows et al. 2008 Blend and van Ravenswaay 1999 Brecard et al. 2009 Johnston et al. 2001 Millock and Nauges 2014 Monier et al. 2009 Thompson and Kidwell 1998 Wessells et al. 1999

Aspects of environmental behavior	Nature of relationship with educational factors	Studies included
		Zepeda and Li 2007
Environmental awareness and concern	Studies find a positive relationship with total years of education as well as level of education	De Silva and Pownall 2014 Klineberg et al. 1998 Smith 1995 Teisl et al. 2008 Torgler and García-Valiñas 2007 Xiao et al. 2013

Hence, it remains inconclusive whether differences in climate literacy across education groups are the direct result of education affecting people's attitudes towards climate change, or whether these differences are due to other factors that may or may not be directly observable such as differences in early life experiences, family background, political ideologies, and inborn predispositions (Powdthavee 2021). Therefore, while previous evidence suggests a positive correlation between education and environmental behavior, unobserved characteristics that might cause individuals to attain more education and cause individuals to be environmentally conscious make it difficult to infer causality from this evidence. It is thus essential to introduce mechanisms of exogenous variations in schooling such as compulsory schooling legislations to overcome the endogeneity issue and establish causality.

3.1. The Linkages between Education and Climate Change: Toward a Conceptual Framework

Establishing the impact of schooling on climate also requires understanding the pathways that could lead from increased educational attainment to improved environmental outcomes. Authors have previously established the role that increased schooling can play in changing an individual's cognitive skills (e.g., Pekkala Kerr 2013). Dahmann (2017) further suggests that cognitive skills, which includes innate abilities to reason and process information as well as learned knowledge or behavior, can improve through increased instructional time and a multiplier-effect on the skills gained during the early years. Other authors such as Mcguire (2015) and Powdthavee (2021) have suggested that improved cognitive skills, especially attitudes and behaviors gained through schooling can equip individuals to process information on climate change better and faster thus providing one pathway from schooling to pro-environmental behavior.

While improved cognitive skills provides one direct pathway, there are other indirect pathways that may be at play as well. Hwang et al. (2000) in their study based at the Kwang-Reung Arboretum in the Republic of Korea suggest that in addition to cognitive factors, there are affective and situational factors that play a role in ensuring responsible environmental behavior. Affective factors include feelings and emotions whereas situational factors include economic conditions and access to information or resources. The study finds that an individual's belief in their ability to bring about change plays a critical role in determining their actions and hence education should focus on building critical thinking and action skills that can enable individuals to take their own decisions. Levy et al. (2016) in their study with approximately 3,000 adults in Israel further analyze

how different dimensions of cognitive and affective factors relate to environmental behavior. The study finds that affective factors (environmental concern and a willingness to act) are the strongest predictors followed by cognitive aspects such as action-related knowledge and social knowledge.

Besides the cognitive and affective factors, the role of situational factors has also been studied in some detail. Chankrajang and Muttarak (2017) suggest that better education results in better earnings, improved access to information, and increased access to resources that can enable individuals to take mitigating action. For example, higher earning households have command over resources such as installing renewable energy sources at home or willingness to pay carbon taxes. Also, knowing where to get information on how to reduce emissions or what adaptations to take can allow individuals to change behavior appropriately. With the causal effect of education on income previously well established in literature (see Heckman et al. 2016) this establishes an indirect pathway from education to improved environmental behavior (Figure 1).

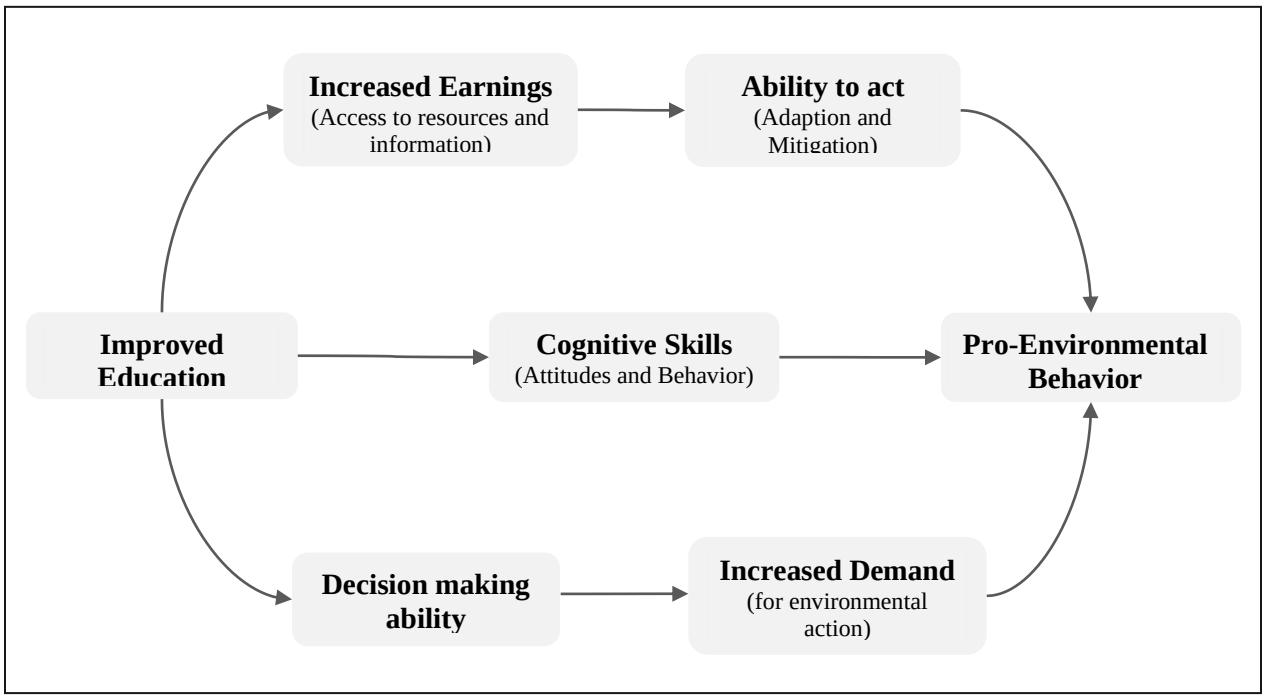

Figure 1: Direct and Indirect pathways from improved education to pro-environmental behavior

While the model provides a possible framework to establish the role that education can play in addressing climate change, determining direction of causality requires more evidence from large-scale studies in an analytical model with variations in educational attainment where environmental behavior is an outcome variable and might lead to improved environmental outcomes.[2]

[2] For example, increased willingness to pay for green electricity can lead to faster decarbonization, resulting in improved air quality and mitigation of climate change. The linkages between changes in behavior and environmental outcomes need to be further examined.

3.2. Establishing Causality in Educational Research

Establishing causal relationships between education and later life outcomes such as incomes, employability, and even voting behavior has been of interest for many decades. While there is overwhelming evidence for the positive impact that schooling can have, researchers have been cautious in drawing strong inferences about the causal effect of schooling especially in the absence of experimental evidence.

However, the emergence of large-scale microeconomic datasets such as OECD's Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), and Progress in International Reading Literacy Study (PIRLS) has provided researchers with more tools to study these relationships. It is now possible to deploy econometric methods such as instrumental variables, regression-discontinuity, propensity score matching, difference-in-difference, and different sorts of fixed-effects specifications to establish causality. Cordero and Cristóbal (2017) provide a comprehensive overview of literature that uses such quasi-experimental techniques. The authors also provide examples of studies that have used such techniques to establish the impact of various school education policies. Particularly, the difference-in-difference approach and instrument variables strategy have been most frequently used for comparison between public and private schools, or to study the effects of class size, tracking, instructional time, teaching methods, school entry age, etc. The authors further suggest creating longitudinal datasets to further causal research in the sector. Schlotter et al. (2011) provide further examples for the applications of these causal methods and the issues faced in aggregation of relevant data.

Other techniques that have been suggested include using co-twin control designs on many monozygotic twin pairs to understand the impact of schooling on factors such as political knowledge (Weinschenk and Dawes 2019), wages (Bingley et al. 2009), and health (Fujiwara and Kawachi 2009). Heckman et al. (2016) and Card (1999) further present theoretical models that build on variations of the simple static models presented by Becker (1964) to estimate the private returns to education. However, estimating the social returns using these models remains a limitation.

Thus, while numerous methods have been advanced to causally estimate the ex-post returns for education, the lack of large-scale panel data limits generalizability of these results. Using compulsory schooling laws as a source of exogenous variation is thus one possible way to overcome this limitation especially because many countries have historically introduced or made changes to their compulsory schooling laws at different times. The next sub-section presents an overview of some studies that make use of these laws to establish causality.

3.3. Compulsory Schooling as an Instrument and Its Use in Climate Research

Numerous studies have used changes in compulsory schooling laws, where some individuals are randomly forced to stay in school longer than their peers, as a natural experiment to research the effect of educational attainment on various aspects of human development. For example, Angrist and Krueger (1991), using longitudinal data from the U.S. Censuses of 1960, 1970, and 1980 for men show that compulsory school attendance laws can have a positive effect on schooling and earnings (see also Domnisoru 2021). The authors further suggest that compulsory schooling laws

can improve educational attainment and thus have an associated effect on other social and environmental factors. This is further confirmed by Lleras-Muney (2002; see also Grenet 2013) who shows that legally requiring children to attend school for one more year increased educational attainment by about 5 percent. Furthermore, the study uses data from the 1960, 1970, and 1980 U.S. censuses in conjunction with changes in compulsory schooling between 1915 to 1939 to establish that each year of additional schooling can reduce mortality by 3-6 percent.

Other researchers have used the onset of compulsory schooling law changes to estimate the returns to schooling in the República Bolivariana de Venezuela (Patrinos and Sakellariou 2005), the Netherlands (Levin and Plug 1999), Australia (Leigh and Ryan 2008), Sweden (Card 2001), Ireland (Callan and Harmon 1999), Türkiye (Patrinos, Psacharopoulos and Tansel 2021), the United States (Harmon and Walker 1995), for example. In Europe, Brunello, Fort and Weber (2009), using data from 12 European countries show that compulsory school reforms significantly affect educational attainment, especially among individuals belonging to the lowest quantiles of the distribution of ability. There is also evidence that additional education reduces conditional wage inequality, and that education and ability are substitutes in the earnings function. Aparicio and Kuehn (2017) use data from 31 European countries to find that educational attainment is a key factor for understanding why some individuals migrate and others do not. The authors suggest that individuals moving from low to medium part of the education distribution are less likely to migrate across countries for employment. Other uses of compulsory schooling laws to obtain causal estimates have been used in mortality studies (e.g., Albouy and Lequien 2009; Gathmann et al. 2015), health (e.g., Kemptner et al. 2011), crime (e.g., Bell et al. 2016), religion (e.g., Hungerman 2014), preferences (e.g., Yang 2021), and immigration (e.g., Cavaille and Marshall 2018).

3.4. Use of Compulsory Schooling Laws to Study the Impact on Environmental Behaviors

There has recently been some interest in using regression discontinuity design with changes in compulsory schooling laws to analyze whether more schooling improves climate change literacy and pro-environmental attitudes and behaviors later in life. Using the raising of school leaving age (ROSLA) law from September 1972 which increased school leaving age from 15 to 16 years in England as a natural experiment, Powdthavee (2021) shows that remaining in school because of the reform causally reduces people's unwillingness to change their behaviors for the environment and their perception that climate change is too far in the future to worry. However, Powdthavee finds little evidence that more education improves the pro-environmental behaviors of those who were affected by the reform. This raises an important question of whether policies aimed at improving climate change awareness through education can effectively produce long-lasting changes in pro-environmental behaviors.

For Europe as a region, using a regression discontinuity design to instrument for educational attainment, Meyer (2015) uses changes in compulsory education laws in the 20th century as a source of exogenous variation. Meyer finds strong evidence of a positive average treatment effect of increased education on pro-environmental behavior. Using two waves of Eurobarometer surveys, he finds a positive local average treatment effect for 7 of 8 pro-environmental behaviors. An analysis of related questions on the survey supports the notion that education causes individuals to be more concerned with social welfare and to accordingly behave in a more environmentally friendly manner (Meyer 2015). However, the study is restricted to 14 European countries where

majority of the educational reforms increased the minimum schooling level to 9 or 10 thus limiting the findings to the lower end of schooling distribution. A wider sample incorporating a larger number of countries with reforms encompassing both primary and secondary schooling may provide more generalizable results.

The few studies that focus on developing countries unearth different results. For example, Chankrajang and Muttarak (2017) adopt an instrument variable strategy with self-reported pro-environmental behaviors as the dependent variable and supply of education (number of teachers per 1,000 children) as an instrument in Thailand. They find that improving education levels can have a positive impact on knowledge-based environmentally friendly actions but may not have the same effect on cost-saving pro-environmental actions such as minimizing use of electricity and water, or willingness to pay environmental taxes. Similar research in Philippines by Hoffman and Muttarak (2020) using Propensity Score Matching finds that additional year of schooling significantly increases the probability of pro-environmental actions by 3.3 percent. However, the study uses cross-sectional non-experimental data thus lacking causality. These studies further highlight the need for further research on the linkages between human development and environmental outcomes in a representative sample of countries using long-range panel data and changes in compulsory schooling laws to establish causality. The various studies using compulsory schooling laws as instruments to study the impact on human development outcomes are summarized in Table 2.

Table 2: Summary of Studies using Compulsory Schooling Laws as Instruments to Study Impact on Climate Outcomes

Country, year	Data	Dependent variable	Education variable	Controls	Methods	Result	Reference
England, Wales 2012, 2014	Cross-section	Climate change literacy; pro-environmental behaviors	Education level	Month of birth, sex	Causal: RD - compulsory schooling laws	(+) willingness to change behavior for environment; no effect on behaviors	Powdthavee 2021
Europe 2007, 2011	Cross-section	Pro-environmental behaviors	Education level	Age, country fixed effects	Causal: RD - compulsory schooling laws	(+) pro-environmental behaviors	Meyer 2015
Thailand 2013	Cross-section	Environmental attitudes; willingness to pay for environmental tax	Education level	Age, Occupation, Wage, Sex	Causal: IV - compulsory schooling, teachers per 1000 students	(+) knowledge based pro-environmental actions; no cost-saving action; no impact on concern for global warming; no impact on pay	Chankrajang and Muttarak 2017
Philippines 2015		Pro-environmental behaviors	Education level		Non-Causal: PSM	(+) increased knowledge; some effect on behavior	Hoffmann and Muttarak 2020

4. Conclusion

Human development and environmental outcomes are intrinsically linked and affect each other in numerous ways. While there is vast literature on the role that environmental conditions can play in human development outcomes, the role of human development interventions in environmental outcomes is far more difficult to ascertain. Researchers have often linked economic growth with human development and suggested that as economies develop, they initially witness a period of increased environmental degradation followed by a U-shaped recovery. The nature of this relationship suggests that there may be certain human development factors such as education and per capita income at play in determining the relationship between economic growth and environmental outcomes.

Human development interventions have also been a way to address environmental degradation. Numerous adaptive and mitigative measures ranging from risk assessment of key infrastructure to redesigning curriculums and promoting research in universities have been suggested by policy practitioners and thinktanks over the years. While the type of interventions suggested are broadly based on the rationale that educated individuals are likely to be more environmentally conscious, a causal relationship has proven to be quite elusive.

The paper synthesizes the vast literature on the interlinkages between human development interventions and environmental outcomes. While most of these studies have documented a positive correlation between education and environmental behavior, unobserved characteristics make it difficult to infer causality because there may well be omitted variables that cause individuals to attain more education and cause individuals to be environmentally conscious.

We assess compulsory schooling laws as a possible instrument to determine causality. Changes in compulsory schooling laws over the years have been used by researchers as a natural experiment in a regression discontinuity design to study the effect of educational attainment on factors ranging from returns to schooling to migration. While authors have used the methodology to study the effect of education on pro-environmental behaviors, evidence on whether policies aimed at improving climate change awareness through education can effectively produce long-lasting changes in pro-environmental behaviors remains inconclusive. Thus, creating a broader dataset incorporating education law changes over a longer time-period along with other confounding variables for a representative sample of developing and developed countries might provide robust results and help design better human development policies in the future.

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Appendix A: Summary of Observational Studies on Relationship between Schooling and Climate Attitudes and Behavior

Dependent variable	Education variable	Controls	Methods	Result	Reference
Waste generation	Not specified	Not specified	Not specified	No relationship	Ayalon et al. 2014
Frequency of purchasing organic foods	Not specified	Shopping engagement, political affiliation, age, food production knowledge	Bivariate associations and OLS	(+) for both bivariate and multivariate models	Bellows et al. 2008
Water saving behavior	Years of education	Social desirability index, LA indicator, income, occupation, children at home, own dwelling, have pool, have lawn or garden	Quasi-MLE Poisson regression	(+) but statistically insignificant	Berk et al. 1993
Intention to purchase eco-labeled apples	Years of completed education	Price, type of eco-labeling, grocery vs. supermarket, frequency of buying organic apples, income, household size, age, gender	Contingent choice, Cragg Double-Hurdle Model, Tobit Model	(+) for probability of eco-labeled purchase, insignificant for quantity of eco-labeled purchase	Blend and van Ravenswaay 1999
Desire for eco-labeling of fish	Proxied with professional situation	Environmental attitudes, seaside frequentation, age, gender, marital status, country effects, localization of habitat	Ordered probit regression	(+) for intellectual profession	Brecard et al. 2009
Municipal solid waste, municipal recycling	Percentage of town with baccalaureate education	Population, income per capita, median age, housing density, price of waste disposal, frequency of collections, recycling grants	Simultaneous equations, 3SLS	(+) quadratic relationship between education and municipal recycling	Callan and Thomas 2006
4 attitudes toward sustainability (1 to 10 scale)	High school, college indicators	Gender, mortgage owner, age, no. of children, income, regional/city controls	OLS, matching estimation	(+) for college education in 3 of 4 attitudes. (+) for high school education in 1 attitude	De Silva and Pownall 2014
Newspaper and glass recycling	Percent population over 25 with 4 or more years of college	Family median income, availability of curbside pickup	OLS	(+) in most of the models	Duggal et al. 1991
WTP for green electricity	Indicator for university degree	Electricity price, electric heating, self-image controls, perception of green benefits, gender, age, presence of social norm	Probit regression	(+) in 1 of 3 reported models	Ek and Soderholm 2008
Recycling participation (7 categories)	Highest education level attained	Price, weekly recycling, free units, unit limit, mandatory recycling, home ownership, income, household size, age	Ordered probit regression	(+) for post-grad in 4 of 7 recycling categories, several other education levels (+) for some recycling categories	Ferrara and Missios 2005
Water saving behavior	Level of formal education	None	Cluster analysis	Significant differences in education levels across clusters	Gilg and Barr 2006

Dependent variable	Education variable	Controls	Methods	Result	Reference
Several water saving behaviors	Years of post-secondary education	None	Correlation coefficient	(−) for plugging sink while washing dishes, recycling rainwater, taking shower instead of bath; no relationship for turn off water while brushing teeth, water garden in coolest part of day	Grafton 2014
Preferences for eco-labeled seafood	Indicator for at least a 4-yr degree	Member of environmental organization, frequency of consuming seafood, seafood budget, gender, age, income	Contingent choice, logit model	(−) for Norwegian households, insignificant for USA households	Johnston et al. 2001
4 measures of environmental concern	Years of education	Gender, age, ethnicity, size of town, income, political ideology, religiosity	Logistic, Poisson regressions	(+) for almost all specifications and measures of concern	Klineberg et al. 1998
WTP for green energy, electricity demand	Years of post-secondary education	Income, member of environmental organization, energy behavior index, index of concern for climate change, home size, household size, home type, years in residence, urban, age, gender, marital status, employment status	OLS, Tobit, Hurdle model, Exponential type II Tobit	(+) for WTP for green energy, no significant relationship for electricity demand	Kriström and Kiran 2014
Organic food consumption	Indicator for at least one-year post-high school education	Not reported	Not specified	No significant relationship	Millock and Nauges 2014
Purchase of organic eggs and milk	Not specified	Income, age, family size	Discrete choice, multivariate logit	(+) in increasing cross-complementarity between choices of organic products	Monier et al. 2009
Energy use	Level of education, units not specified	Age, income, household size, self-enhancement, environmental quality, self-direction, openness to change, maturity, family, health and safety, achievement, new environmental paradigm, concern about global warming	OLS	(−) for home energy use, (+) for transport energy use	Poortinga et al. 2004
5 household recycling behaviors	Indicators for level of education (beyond HS degree, bachelor's degree, and graduate or professional degree)	Measures for availability and knowledge of recycling programs, household size, marital status, gender, age, number of hours worked per week, income	Probit regression	Beyond HS degree (+) for 3 behaviors, bachelor's (+) for 4 behaviors, graduate (+) for 4 behaviors	Reschovsky and Stone 1994

Dependent variable	Education variable	Controls	Methods	Result	Reference
Willingness to pay premium for green electricity	Indicators for highest level achieved (high school or less, some college, bachelor's degree, graduate degree)	None	Spearman's correlation	(+) association	Rowlands et al. 2003
Contributing money to environmental groups, signing petition about environmental issues, recycling	Years of education, college major	Income, gender, age, race, support of environmental laws, science, and environmental knowledge	Probit regression	(+) for recycling, not statistically significant for other behaviors, majors mostly not significant	Smith 1995
Credibility of ecolabel information, perceived environmental friendliness of vehicle, importance of label information	Years of education	Gender, age, some environmental belief/concern measures	Simultaneous equations, Ordered probit	(+) for credibility and importance of ecolabel, (−) for perceived environmental friendliness	Teisl et al. 2008
Purchase of organic produce	Indicators for level of education (college degree and graduate or professional degree)	Cosmetic defects, price, income, age, number of children in household, gender, distance to grocery store	Random utility discrete choice model	(−) for graduate or professional degree	Thompson and Kidwell 1998
Willingness to prevent environmental damage	Formal education (age at which completed formal education), informal education (discussing politics)	Age, gender, marital status, employment status, trust, membership in environmental org., geographic identification, size of town, regional and time controls	Ordered probit regression	(+) for informal education (robust), (+) for formal education (not robust)	Torgler and García-Valiñas 2007
Preferences for eco-labeled seafood	Indicator for at least high school degree	frequency of fish purchases, weekly seafood budget, trust in certifying agencies, region, gender, principal shopper, member of environmental organization, subscription to environmental magazine, beliefs on overfishing	Contingent choice, logit model	No significant relationship	Wessells et al. 1999

Dependent variable	Education variable	Controls	Methods	Result	Reference
6 measures of environmental concern	Number of years of schooling	Gender, income, residence, age, non-admin job, admin job, Chinese Communist Party affiliation	Structural equation modeling (SEM)	(+) for composite environmental concern variable	Xiao et al. 2013
Purchase of organic food	Indicator for at least four years of college	Number of children, gender, age, race, religion, political identity, income, food expenditures, cooking controls, knowledge/familiarity variables, personal connection variables, intention to act variables, opportunity variables			Zepeda and Li 2007