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RESEARCH ARTICLE

Unpacking sustainability: A feminist political ecological analysis of global overshoot

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To advance sustainability globally and equitably, a holistic approach to investigating economic, environmental, and social systems is needed. We extend sustainability research by considering gender explicitly in these efforts, employing feminist political ecology to improve understanding of such complicated interrelationships and to analyze the drivers and impacts of global unequal ecological exchange, namely the ecological deficit of countries to support economic value elsewhere. We employ structural equation modeling to test hypotheses connecting gender equity, neoliberalism attributes (e.g., size of government, degree of regulation), and overshoot. Our findings reinforce aspects of existing theoretical frameworks, including clear support for strong sustainability theories, such as unequal ecological exchange, and complicate dominant development narratives that modernization increases gender equity. We demonstrate the empirical importance of including measures of gender equity in sustainability research and the theoretical importance of feminist political ecology's contribution to understanding gender and environment as linked oppressions not just for conceiving of new imaginaries but also enacting them.

Keywords: Feminist political ecology, Unequal ecological exchange, Overshoot, Sustainability, Gender inequity, World-systems

1. Introduction

Research on strong sustainability—or theories of sustainability that find the prevailing system of global capital inherently unsustainable—is key to developing and implementing just sustainable transitions globally (e.g., Bunker, 1984; Jorgenson and Clark, 2012; Givens et al., 2019). Yet, little research into strong sustainability has taken up gender equity: a crucial but missing dynamic through which the transnational economic system operates (York and Ergas, 2011). Although a handful of studies include gender in their analyses (e.g., Dunaway, 2001; McKinney, 2012; McKinney, 2014a; Jorgenson et al., 2018), the role of gender in shaping global social, economic, political, and environmental systems, along with questions of gender equity, continues to receive little attention. Overlooking the role gender plays in the global political economic system and its impact on the environment hinders global efforts toward equitable sustainability as articulated in the UN's Sustainable Development Goals (York and Ergas, 2011).

To address this gap in knowledge, we advance strong sustainability scholarship by employing both a feminist political ecology approach—characterized by applying a feminist theoretical framework with a focus on gendered dimensions of socio-ecological relations (e.g., Rocheleau et al., 2013; Voyles, 2018)—and structural equation modeling (SEM)—a quantitative analytic strategy that can identify direct and indirect relationships across observed and latent variables—to empirically analyze the drivers and impacts of global unequal ecological exchange (Bunker, 1984; Givens et al., 2019). In doing so, we theoretically and empirically specify the role of gender in intersecting social, economic, and environmental systems globally using quantitative methods that can enrich strong sustainability research through robust gender theorizing with real-world implications for just sustainable transitions (McKinney, 2012; McKinney, 2014b).

2. Literature review

2.1. Strong sustainability theories and overshoot

Strong sustainability approaches, including world-systems and unequal ecological exchange theories, consider the system of global capital to be inherently environmentally unsustainable (e.g., Hornborg, 1998; Jorgenson, 2003; Jorgenson and Burns, 2007; Hornborg and Martinez-Alier, 2016; Schor and Jorgenson, 2019; Moore, 2022). Strong sustainability theories provide crucial insights into the ways in which uneven development and socio-environmental inequalities are produced globally (Givens et al., 2019). World-systems theory premises that all nations are connected in the world economy, which

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organizes nations in a global division of production and labor composed of core (including the wealthiest and most powerful countries), semi-periphery (including nations focused on manufacturing), and periphery zones (including nations from which raw materials are extracted and exported; Wallerstein, 1974; Frank, 1979; Kick et al., 2011; Moore, 2015). The world-system leads to chronic development of underdevelopment, locking in the low value of raw materials and manufacturing relative to the high value of consumer–retail (Frank, 1967), which transfers surplus value from periphery countries to core countries (Wallerstein, 1979).

Building from world-system theory, unequal ecological exchange theory argues environmental change and patterns of resource use are driven by global economic and political relationships, in which environmental exploitation and degradation of countries in the periphery allow for the preservation of environments in the nations that make up the core (Bunker, 1984; Rice, 2007; Jorgenson and Clark, 2012; Moore, 2017). Core countries, through colonial rule, were effectively able to develop through the appropriation of resources from Asia, Africa, and the Americas (Chase-Dunn, 1975). Equally important to the working of the global economy is a global division of labor that relegates the least profitable and most environmentally damaging forms of production (e.g., natural resource extraction and high-polluting industries) to noncore zones, with negative developmental and environmental results accruing outside the core (Frank, 1969; Wallerstein, 1974; Frank, 1979; Bunker and Ciccantell, 2005; Moore, 2015). In doing so, unequal ecological exchange theory adopts a global perspective to understand what is commonly referred to as the environmental degradation or resource consumption paradox in which environmental degradation is geographically removed from the source of demand. Prior research has shown the effects of social, economic, and political arrangements on environmental degradation, such as greenhouse gas emissions, deforestation, ecological footprints, and biodiversity (Bunker, 1984; Bunker, 1985; York et al., 2003; McKinney et al., 2010; Austin and McKinney, 2016).

To put such demands in perspective, on average, high-income, core countries in the Global North require more than 8 times the amount of biocapacity per person than low-income countries in the Global South (Howell, 2007). Such unequal ecological exchange is underpinned by the global hegemony of free trade, free money, and deregulation advanced under neoliberal processes, policies, and ideologies (Howell, 2007). These dynamics are also fundamentally shaped by colonialist exploitation of "free" land and associated natural resources, which has underpinned a global system of under/development facilitated by the exploitation of slave labor and under-compensated im/migrant laborers globally (Bunker, 1985; Bunker and Ciccantell, 2005; Howell, 2007; Voyles, 2018; Moore, 2018). The cumulative result has been the growth of a core country lifestyle, which is contingent on resources, labor, and ecological sinks across semi-periphery and periphery countries (Wichterich, 2015).

Such insights have ramifications for sustainable transitions. The current global population makes the greatest demands on nature than ever before due to rapid growth and the need for fossil fuels—the energy source of choice for our global system of transportation and production of goods and services (Ewing et al., 2010; IPCC, 2022). Humankind's ever-increasing demands on nature leads to *overshoot*, or when collective human demand on nature exceeds nature's ability to replenish necessary resources (i.e., energy, raw materials, and habitat; Catton, 1980). In opposition to sustainability—or meeting the world's needs without compromising the ability of future generations to do the same (United Nations, 1987)—overshoot is the direct result of the current global economic, social, and environmental system. Although strong sustainability research has focused on individual forms of environmental degradation (i.e., CO_2 emissions, deforestation; e.g., Jorgenson, 2006; McKinney et al., 2010), fewer studies have investigated the mechanisms of unsustainability holistically, such as through analysis of global overshoot (McKinney, 2014a).

Taken together, strong sustainability research has shown the incompatibility of uneven patterns of consumption, extraction, and degradation with global sustainability (Rice, 2007). In doing so, such research has advanced an important counter narrative to eco-modernization theory, which argues that economic development and environmental welfare are mutually supportive, a consequence of which is the promotion of a singular, capitalist path toward global sustainability (Mol and Spaargaren, 2000; Lidskog and Elander, 2012). Yet, gender equity is one area frequently overlooked in strong sustainability research.

2.2. Feminist political ecology: An opportunity to advance sustainability research

Feminist approaches have been generally neglected in strong sustainability research for several reasons including the divergent scales and methods with which the 2 communities of scholars tend to work—in which scholars using feminist approaches tend to work at local levels with qualitative methods and strong sustainability researchers tend to focus on quantitative approaches at global scales. Moreover, strong sustainability scholars have tended to focus on political economic forces, such as modernization and urbanization, at the expense of social dimensions such as gender. Yet, not only are feminist approaches and strong sustainability approaches not at odds but, in fact, they share many objectives. Both approaches focus on power relations (Voyles, 2018; Givens et al., 2019), and because gender as a microlevel process influences macro-level processes of the world-system, not only is a gender analysis complementary to strong sustainability theories, it is critical for advancing the field (e.g., Dunaway, 2001; York and Ergas, 2011; McKinney, 2014b; McKinney and Fulkerson, 2015; Austin and McKinney, 2016).

Although gender inequality and feminist perspectives have been more widely adopted within development literatures more broadly (e.g., Wickramasinghe, 2003; Cornwall et al., 2006; Hansen and Coenen, 2015; Stock and

Birkenholtz, 2020), there is a noticeable lack of engagement within strong sustainability research (i.e., world-systems and unequal ecological exchange theories). While some strong sustainability research has indicated how social inequities generally facilitate unequal ecological exchange in producing and reifying power differentials that are exploited to sustain the extraction of resources and exploitation of labor (Howell, 2007), the lack of consideration for gender equity is particularly notable in discussions of global sustainability given the linkages across the 3 pillars (social, economic, and environmental) of sustainability (Purvis et al., 2019). This gap is far from inconsequential. Gender inequity can facilitate unequal ecological exchange through the exploitation of women's labor as well as through their limited access to rights the world over and increased responsibilities (including for families' and communities' health and well-being) conditioned by gender (Rocheleau et al., 2013). Failure to include gender inequality in macro-comparative world-systems analyses can confound quantitative findings of global drivers of unsustainability by failing to include relevant explanatory factors (York and Ergas, 2011).

Empirical assessment of such relationships between gender and sustainability have been particularly lacking, potentially due to divergent methodological approaches (York and Ergas, 2011; McKinney, 2014b; Austin and McKinney, 2016). Limited quantitative evidence does support a negative association between environmental degradation and gender equity, in which women's economic status significantly increases disaster vulnerability and increased economic status of women improves the health resources of a country in a cross-national sample (McKinney, 2014b; Austin and McKinney, 2016). Such research points to interrelationships among economic, political, and ecological conditions that shape the extent and distribution of disaster harm, concluding that increasing women's status could help to mitigate disaster impacts in direct and indirect ways. In turn, Ergas and York (2012) show that high political status of women corresponds to lower carbon dioxide emissions, even controlling for relevant political and economic covariates. Together, this empirical research supports feminist political ecology findings that gender and the environment are linked (e.g., Rocheleau et al., 2013; Nirmal and Rocheleau, 2019; Sultana, 2020). Integration of feminist theory into comparative environmental research is needed regarding the mechanisms by which these relationships play out (Austin and McKinney, 2016).

Feminist political ecology provides a clear platform and impetus for advancing scholarship in considering drivers of environmental and social unsustainability by providing a theoretical grounding to the economic, social, and environmental consequences of such a system. Feminist political ecology considers the gendered dimensions to political ecology's concerns related to environmental degradation, capitalist accumulation, and access and control over resources (Elmhirst, 2011; Rocheleau et al., 2013). Research across feminist political ecology, particularly drawing on work from the Global South, has greatly contributed to our understanding of such unsustainable dynamics, illustrating the multitude of ways by which gender inequity and environmental degradation co-constitute oppressions perpetuated by intertwined systems of heteropatriarchy, racism, colonialism, capitalism, and neoliberalism, all underpinned by shared logics of domination (Mollett and Faria, 2013; Bigger et al., 2018; Voyles, 2018; Sultana, 2020). Moreover, feminist political ecology can help us to better understand the context-specific factors for gendered implications of environmental relationships, particularly across the Global South by paying attention to race, caste, ethnicity, and regional ethnicism (Mollett and Faria, 2013, p. 116), which in turn can help us to understand that the Global South context is not separate from our own—tied together, in part, through colonial racialization and environmental-economic practices (Mollett and Faria, 2013, p. 118).

Across the globe, due to women's manufactured role of social reproduction, women are particularly vulnerable to the effects of environmental degradation (Rocheleau et al., 2013; Harcourt and Nelson, 2015). Such effects include deforestation (Epule et al., 2012; Mishra and Mishra, 2012; Osborne, 2015), water contamination (Sultana, 2009; Sultana, 2021a), and disasters (Neumayer and Plümper, 2007; Dhungel and Ojha, 2012; Rahman, 2013; Sultana, 2021b). But these very same roles also make women critical to adaptation and mitigation efforts (Neumayer and Plümper, 2007; Austin and McKinney, 2016). Thus, environmental degradation reinforces gender inequities and vice versa (McKinney, 2014b; Austin and McKinney, 2016). Gendered divisions of labor are not solely responsible for these conjunctures. Acts of domination and "power over" maintain hierarchical relations between gender and nature/society binaries, and shocks in one set of relations often spill over into the other (Voyles, 2018).

Precisely because women, namely women of color in the Global South, have been stereotypically used to represent these unsustainable dynamics and assigned the role of "sexual stewards" with the responsibility to address overshoot (Sasser, 2018), gender is particularly important to consider. Social construction of gender mediates human relationships with the environment, surfacing differences in the experiences of responsibilities for and responses to environmental degradation with far reaching consequences (Rocheleau et al., 2013; Nirmal and Rocheleau, 2019). But women's status itself is conditioned by these same factors (McKinney, 2014b; McKinney and Fulkerson, 2015; Austin and McKinney, 2016). Feminist political ecology can offer conceptual and empirical tools for including social equity, generally, and gender equity, more specifically, in conceptual and empirical analysis of sustainability globally.

2.3. Gender inequity and the Washington consensus

This potential contribution is well observed when it comes to analyzing the global political economic system and its environmental impacts. For example, research suggests that reducing gender disparities set out by the United Nations Millennium Development Goals—a precursor to today's Sustainable Development Goals—led to an increase in gross domestic product (GDP) per capita, on average, of up to 15% (Abu-Ghaida and Klasen, 2004). Although such relationships may point to an underlying logic of compatibility between the Washington consensus—or neoliberal approaches to government and economies characterized by deregulation, reduction in taxes, privatization, and trade liberalization (Stiglitz, 2004; 2017)—and feminism (Prügl, 2017), increasingly, feminist scholars have critiqued this assumption, noting a convergence with respect to valuing choice while surfacing a predominant tendency of neoliberal reforms to reinforce rather than disrupt patriarchal social structures (Cornwall et al., 2008). Modernization—industrialization processes associated with a country's development—is also often assumed to advance gender parity, but these linkages are similarly subject to critique. Capitalism necessitates exploitation of women's unpaid labor, resulting in development initiatives disproportionately benefiting men, and raising tensions between pursuit of economic growth and the potential for increased gender inequities (Prügl, 2017).

More than 2 decades of research has continued to find evidence pointing in a variety of different directions when it comes to gender equity and economic growth, with evidence to support both a positive and negative effect, and conclusions that vary depending on both the level of analysis considered and the metrics of gender (in)equity employed (Kabeer and Natali, 2013; Prügl, 2017). Here, we posit that some of these inconsistencies, in part, may relate to the interplay of gender equity and modernization with world-systems position—namely, whether a country is in the core, semi-periphery, or periphery zones. These inconsistencies may also reflect the role of the Washington consensus or neoliberal policies—such as low regulation, reduced or eliminated barriers to free trade, and small government size—and their potentially differing outcomes related to biocapacity losses and overshoot within a nation's boundaries.

Prior research suggests the relationship among neoliberal economic drivers and gender inequality across the world-system is complicated and rife with contradictions. For instance, Austin and McKinney (2016) find that world-system position in combination with modernization influences women's status in a country, which in turn is suppressed by biocapacity losses and mediates the number of people affected by disasters. Yet, greater gender equity, at both the micro- and macro-levels, may foster economic growth (Prügl, 2017), which in turn is positively associated with overshoot (McKinney, 2012)—a counterproductive linkage. Investigation of such complications and contradictions has been limited by the lack of inclusion of gender in most empirical macro-comparative strong sustainability analysis. Here, leveraging the flexibility of SEM—a statistical approach that can identify direct and indirect effects across both observed and latent variables—we tackle such ambiguities to advance understanding of the complex relationships among unequal ecological exchange, gender equity, the Washington consensus, and overshoot.

2.4. Hypotheses

Based on the extant literature reviewed above, we developed the following hypotheses integrating a strong sustainability framework with a specific focus on unequal ecological exchange and gender inequity.

1. Given the assertion within feminist political ecology theory of fundamental linkages between ecological and gender oppression detailed above (e.g., Voyles, 2018), we expect that gender equity and overshoot will be inversely related such that greater gender equity will be associated with reduced overshoot.
2. Given the significant negative relationship between biocapacity losses and women's economic status found by Austin and McKinney (2016) and other findings connecting resource scarcity with patriarchal violence/domination (Mies, 1998; Dunaway and Macabuac, 2007), we expect to observe a positive relationship between biocapacity and gender equity.
3. Noting that neoliberalism tends to increase inequity of all forms (Klein, 2007), we anticipate a negative relationship between neoliberalism and gender equity when accounting for differing effects of neoliberal attributes on countries with different world-system positions.
4. In keeping with existing unequal ecological exchange research (Bunker and Ciccantell, 2005), we highlight the unequal benefits reaped in core versus peripheral countries, and the proliferation of neoliberal attributes across the core, indicating a positive relationship between modernization and neoliberalism as is predicted under world-system approaches to sustainability.

3. Data and methods

This article employs SEM to test the above hypotheses. SEM is a statistical approach to conduct hypothesis-based testing of structural theories that can deepen our understanding of them through a more granular approach than ordinary least squares (OLS) regression (Byrne, 2016, p. 3). In SEM, all variables in the hypothesized model are analyzed simultaneously to determine the extent to which the model is consistent with the data (Hoyle, 2012). SEM explicitly accommodates latent variables, thereby allowing for the testing of a theoretical model of the relationships between key concepts (i.e., neoliberalism, modernization) rather than just among indicators of those concepts and the dependent variable (i.e., overshoot). Unlike multiple regression, SEM also explicitly models the residual terms or errors as variables, allowing them to be independent or correlated with other variables. This feature allows for the specification of interdependence, or clustered errors, such as between world-system position and biocapacity (see **Figure 1**).

Based on these characteristics, SEM is well suited to testing theoretical propositions with nonexperimental data, providing a unique opportunity for empirical

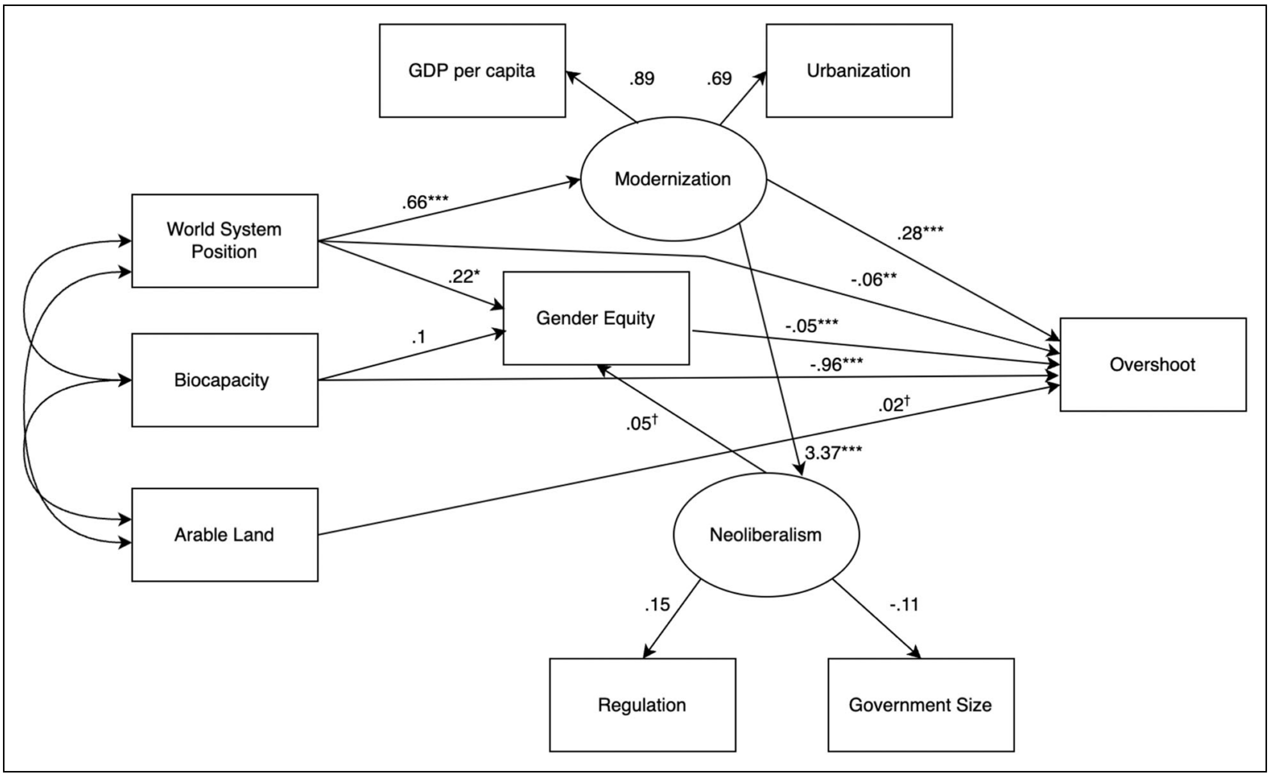

Figure 1. Structural equation model of overshoot, measured as the difference in biocapacity and demands on nature. $N = 128$; Model fit: $\chi^2 = 27.52$ (not significant), $df = 19$, RMSEA = .059, NFI = .962, RFI = .928, CFI = .988, TLI = .977, IFI = .988. $^{\dagger}P < 0.1$, $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$. DOI: https://doi.org/10.1525/elementa.2022.00038.f1

assessment of the rich theoretical propositions well established in strong sustainability research. Moreover, based on these flexibilities, SEM, while an unusual approach for feminist political ecology research, is well positioned to advance the integration of feminist scholarship and global political economy research, which as previously noted, tend to diverge in the methods they utilize. By combining the 3 pillars of sustainability into one quantitative analysis, our approach advances our goal of understanding of how world-systems are gendered (McKinney and Fulkerson, 2015).

To test our research hypotheses, we analyze data for 128 countries (see Appendix B). This includes all countries for which data are available in order to reveal global processes related to gender equity, neoliberalism attributes, and overshoot and to maximally generalize the results. Data are drawn from a variety of sources for the year 2014 except for overshoot data, which are taken from 2016. Following prior research (see McKinney, 2014b), and in order for the model to make conceptual sense, the independent variables must represent a snapshot in time that precedes the dependent variable. Data sources and measures are elaborated below. Appendix A displays descriptive statistics for each model term.

3.1. Dependent variable

3.1.1. Overshoot

These data come from the Global Footprint Network (Lin et al., 2019). Overshoot measures discrepancies between productive resources and consumption for each nation by subtracting national biocapacity from national ecological footprint, both of which and the resulting overshoot indicator are measured in global hectares per person (i.e., an aggregate measure of agricultural, livestock, fishery/aquaculture, timber, and CO_2 emission production). Larger, positive numbers mean more overshoot. Negative numbers indicate that a country has not reached overshoot and holds biological reserves.

3.2. Independent variables

3.2.1. Neoliberalism

Indicator variables used to construct the neoliberalism latent variable come from the Fraser Institute's Economic Freedom Data (Gwartney et al., 2019). These include indexed scores for the size of government, which are inversely scored (i.e., higher scores mean smaller government) and the degree of regulation, which is also scored inversely (i.e., high scores reflect countries that limit business, labor, and credit market regulations), that the Fraser Institute compiles based on a total of 42 government policies.

3.2.2. Modernization

Following McKinney's (2014b) analysis of gender, democracy, and overshoot and in line with much of the literature on the ecological modernization theory (e.g., Mol and Spaargaren, 2000), we employ 2 indicator variables to represent the latent variable, modernization. The first is per capita GDP, measured in U.S. dollars, and percentage of urbanization, the percentage of the total population living in urban areas as defined by national statistical offices, both accessed from the World Bank open data portal.

3.2.3. Gender equity

The national gender equity data used in this article come from the Global Gender Gap data from the World Economic Forum (2020). Unlike many other gender-related indices, the Global Gender Gap index, which is a scale from 0 to 100, measures gender equity rather than women's empowerment or discrimination. The index is comprised of 4 dimensions, economic participation (i.e., labor force participation rate), educational attainment (i.e., percentage of literacy rate), health and survival (i.e., healthy life expectancy), and political empowerment (i.e., percentage of women in parliament), and made up of 14 different indicators. Given its established and tested nature (Jütting et al., 2008; Choe et al., 2017), the index is included as an observed variable rather than as a latent variable. Higher values represent greater gender equity.

3.2.4. World-system position

World-system position is based on the index developed by Kick et al. (2011), which employed a network analysis of 4 different types of linkages between countries: military/arms transfers, co-membership in organizations, trade, and embassy sponsorship. System positions are reverse coded for ease of interpretation so that larger numbers (i.e., 10 being the highest) represent core countries and lower numbers (i.e., 1 being the lowest) represent countries more on the periphery.

3.2.5. Arable land

The arable land indicator is included as a control variable and is taken from the World Bank open data portal. Arable land is defined by the Food and Agriculture Organization of the United Nations (2020) as "land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded."

3.2.6. Biocapacity

Finally, biocapacity data come from the Global Footprint Network (Lin et al., 2019). It is calculated as the summed total of biocapacity from crop land, grazing land, forest land, fishing grounds, and built-up lands. The measure is standardized across countries as global hectares per person. This measure is used to control for potential effects of available biological resources on overshoot.

3.3. SEM: Specified relationships

Key relationships among relevant social, economic, political, and ecological factors and overshoot, however, are assessed using the SEM presented in **Figure 1**, which shows the standardized coefficients of the best fitted model. In the hypothesized model, we specify that world-system position has both a direct and indirect effect on overshoot through both its direct effect on gender equity and its direct effect on the latent variable representing modernization, which is made up of observed indicators, GDP per capita, and percentage urban. The ecological control variable, arable land, is specified to have a direct effect on overshoot. Following SEM standard practices and earlier theorizations on associations among world-system position and ecological variables (i.e., biocapacity per capita and arable land), we covary all exogenous variables (Bollen, 1989; Grace and Bollen, 2008). Neoliberalism attributes (i.e., decreased regulation and government size) are specified to indirectly affect overshoot through indirect effects on the gender equity gap and the latent variable of modernization. Biocapacity per capita directly affects overshoot and indirectly affects overshoot through gender equity.

4. Results

4.1. Data overview

Before diving into the results of the SEM, it is worth noting a few expected and unexpected trends in the data (see Appendix A for descriptive statistics). Not surprisingly given research into gender and economic development of nation-states (e.g., Amin et al., 2015; Jayachandran, 2015; Falk and Hermle, 2018), core countries have greater gender equity as measured by the Global Gender Gap index. Core countries also unsurprisingly limit regulation more than semi-periphery or periphery countries. Notably, when it comes to size of government, one of the 2 indicators we use for neoliberalism, 2 semi-peripheral countries—Honduras and Guatemala—top the list and 2 semi-peripheral countries—Algeria and Oman—fall at the bottom of the group.

The correlation matrix and descriptive statistics, presented in **Table 1**, indicate no distinguishable pattern of multicollinearity among variables included in the latent variables. Additional analyses (e.g., collinearity statistics, such as Variance Inflation Factor [VIF] and tolerance) were conducted and reaffirmed there was no concerning multicollinearity among measures.

4.2. SEM: Indirect and direct relationships

For this model, fit statistics indicate an excellent fit based on the nonsignificant χ^2 test statistic, desirable in SEM analysis, because it tests for whether the predicted model and observed data are equal, the low root mean square error of approximation value, which is a parsimony-adjusted index, in which values closer to 0 represent a good fit, and values approximating unity for each of the fit indices (e.g., comparative fit index, incremental fix index, and normed fit index; Byrne, 2016).

In this section, we discuss the statistically significant relationships for the indirect and direct effects across the SEM and whether they support the research hypotheses elaborated above. Our analysis supports Hypothesis 1 that suggests enhanced gender equity is inversely associated with overshoot. This result supports previous research that has similarly found increased environmental degradation (i.e., disaster vulnerability) increases gender inequity (i.e., lack of access to health resources; Austin and McKinney,

Table 1. Descriptive statistics and bivariate correlation matrix. DOI: https://doi.org/10.1525/elementa.2022.00038.t1

Variable	Mean	*SD*	1	2	3	4	5	6	7	8	9
1. Total biocapacity per capita	3.855	9.997	1.00								
2. World-system position	4.914	2.775	−0.053	1.00							
3. Arable land	0.236	0.292	0.211*	0.105	1.00						
4. Per capita GDP	15,538.6	19,927.91	0.022	0.594**	0.059	1.00					
5. % Urban	60.485	22.687	0.044	0.462**	0.078	0.617**	1.00				
6. Regulation subindex	7.075	0.997	0.028	0.307**	0.057	0.456**	0.291**	1.00			
7. Government size subindex	6.475	1.17	−0.085	−0.209*	0.01	−0.289**	−0.18*	0.093	1.00		
8. Gender equity	0.692	0.057	0.078	0.343**	0.195*	0.433**	0.161	0.299**	−0.026	1.00	
9. Overshoot	−0.294	9.873	−0.969**	0.157	−0.178*	0.169	0.166	0.087	0.012	−0.028	1.00

GDP = gross domestic product.

*$P < 0.05$; **$P < 0.01$.

2016). Countries with greater biocapacity per capita also have increased gender equity providing support for Hypothesis 2. As such, not only is biocapacity significantly negatively associated with overshoot, meaning that the more biocapacity a country has, the less that country exacerbates global overshoot (i.e., the more resources a nation starts with, the greater ecological buffer that nation has before reaching overshoot), biocapacity also has an indirect, negative relationship with overshoot via gender equity. This finding supports prior research reviewed above in which gender equity, particularly the representation of women in parliament, can lessen negative environmental outcomes (e.g., McKinney, 2014b).

We find support for Hypothesis 4 drawn from extant sustainability research that modernization drives neoliberal attributes (e.g., Bunker and Ciccantell, 2005). Furthermore, countries exhibiting neoliberal attributes have an indirect effect on overshoot through gender equity, in which core countries evidence greater gender equity, and gender equity has a slight ameliorating effect on overshoot. This finding supports prior research that has similarly found that women's status can lead to improved environmental outcomes (McKinney, 2014b; Austin and McKinney, 2016). SEM is a helpful analytic strategy given the ability to covary exogenous variables, yet these data are difficult to distill given their complexity. We note the enlarged coefficient likely represents some multicollinearity which indeed corresponds with our understanding about the relationship between the 2 variables.

Notably, the model does not support Hypothesis 3, that countries with greater neoliberal or Washington consensus attributes have decreased gender equity, indicating instead a positive relationship between neoliberalism and gender equity. This result does not support some prior research (e.g., Klein, 2007) into the inequitable impacts from neoliberalism but does support gender and development literature more broadly on the links between modernization and gender equity (e.g., Stock and Birkenholtz, 2020). Given this unexpected relationship, we further investigate the finding below.

4.3. Exploring unexpected findings with additional analyses

To further unpack the unexpected relationships between world-system position and overshoot, and neoliberalism and gender equity, we ran a series linear regressions including interactive effects—which account for both the simultaneous effect of 2 independent variables on a dependent variable and their joint effect—to identify any potential confounding relationships. Our theoretical model expected that world-system position would increase overshoot since wealthier, more powerful core countries consume more goods and services, thus drawing on more environmental resources, than periphery countries (Bunker, 1984; Roberts, 2003; Givens et al., 2019). Instead, we found the opposite—that world-system position was negatively associated with overshoot. One possible explanation for this could be that the association, found in the SEM model, between world-system position and overshoot is contingent on modernization, in other words, whether the extent of modernization moderates this relationship. We tested this possibility by including an interaction term between world-system position and modernization (using the per capita GDP indicator)[1] in an OLS regression including all of the connected terms from the SEM.

The results, presented in **Table 2**, suggest that this interaction is present and significant (at $P < 0.01$).

1. Removing the interaction term, the regression results mirror the SEM findings with respect to effect and standard error magnitude and direction.

Table 2. Interaction terms in asynchronous regressions with coefficients followed by standard errors in parenthesis. DOI: https://doi.org/10.1525/elementa.2022.00038.t2

Independent Variables	Dependent Variable: Overshoot	Dependent Variable: Gender Equity
GDP per capita	0.0002* (0.00002)	
World-system position (WSP)	0.176* (0.063)	–0.03** (0.013)
GDP per capita × WSP	–0.00001* (0.0000)	
Neoliberalism (regulation)		–0.008 (0.009)
Neoliberalism (regulation) × WSP		0.005* (0.002)
Gender equity	–5.514*** (2.425)	
Biocapacity per capita	–0.965* (0.012)	0.0005 (0.0005)
Arable land	0.883*** (0.422)	
Constant	3.863** (1.664)	0.717* (0.064)
Observations	130	130
R^2	0.982	0.23
Adjusted R^2	0.981	0.205
Residual standard error	1.334 ($df = 123$)	0.051 ($df = 125$)
F Statistic	1,138.873* ($df = 6$; 123)	9.316* ($df = 4$; 125)

GDP = gross domestic product.

*$P < 0.01$; **$P < 0.05$; ***$P < 0.1$.

Independently, both world-system position and per capita GDP are positively associated with overshoot, as presented in **Figure 2**. But these relationships are contingent such that for those countries with a per capita GDP of less than $12,500, more core countries have higher overshoot than their more peripheral counterparts. Yet, the positive association with increasing per capita GDP on overshoot is more moderate than for peripheral countries for whom increasing per capita GDP is associated with a more marked increase in overshoot. Among countries with a per capita GDP of more than $12,500 in turn, more peripheral countries have higher overshoot compared to core countries with the same rates of change (more positive association between per capita GDP and overshoot for more peripheral countries).

Similarly, based on the extant literature, we hypothesized that an increase in neoliberalism policies (i.e., reduced regulation and government size) would decrease gender equity since neoliberalism has been shown to reduce social equity generally, of which gender equity is a part (e.g., Howell, 2007; Klein, 2007; Voyles, 2018). Our SEM model showed the opposite—that increasing neoliberalism increases gender equity. Much like in the case of modernization and world-system position, we suspected that some of the explanation here may also lie with understanding this relationship as contingent on world-system position. Specifying another OLS model to reflect this relationship employing the regulation indicator as a neoliberal attribute, we once again find a significant interaction term between the two, presented in **Figure 2**. Independently decreasing regulation and increasing world-system position are associated with decreasing gender equity, but understanding these influences in the world-system requires us to understand their implications in combination. For countries with a regulation index of less than 6 indicating somewhat high levels of regulation, lower world-system position rank is associated with more gender equity, whereas more core countries at these levels of regulation have less gender equity. After crossing this threshold, however, the 2 groups swap places with more core countries associated with more gender equity.

These results show that world-system position and modernization "duel" for explanatory power of the outcome, overshoot. The 2 measures differ in that world-system position is an index of 4 kinds of linkages between countries across military/arms transfers, co-membership in organizations, trade, and embassy sponsorship, while modernization is measured as GDP per capita. The implication of this finding is that wealthier countries make up more of the core, and as such, the specificity around power that is captured in world-system position loses out to the singular fact of GDP per capita, a frequently used measure of wealth. The implication of this for strong sustainability research is then, not for every country to develop in the same way and to the same degree as core nations as advocated by ecological modernization theorists (e.g., Mol and Spaargaren, 2000), but that without buy-in and leadership from core countries there is little hope for global sustainability. As beneficiaries of the current global system to produce and accumulate wealth, it is incumbent upon core countries to lead efforts globally across not just technology transfer, to assist semi-periphery and periphery countries in reducing their contributions to overshoot, but also in losses and damages, in acknowledging the impacts from climate change that will occur because of the core's past and current draw down in order to achieve a just sustainable transition. Such implications can and should guide core nations as they work with all countries to achieve the 17 Sustainable Development Goals (United Nations, 2022).

5. Discussion

This study advances our understanding of sustainability across the world-system by investigating the ways gender equity relates to power via world-system position, modernization, neoliberal attributes, and environmental outcomes cross-nationally (Dunaway, 2001; Ergas and York, 2012; Austin and McKinney, 2016). Doing so provides a quantitative analysis that includes gender indicators along with environmental data to advance research into

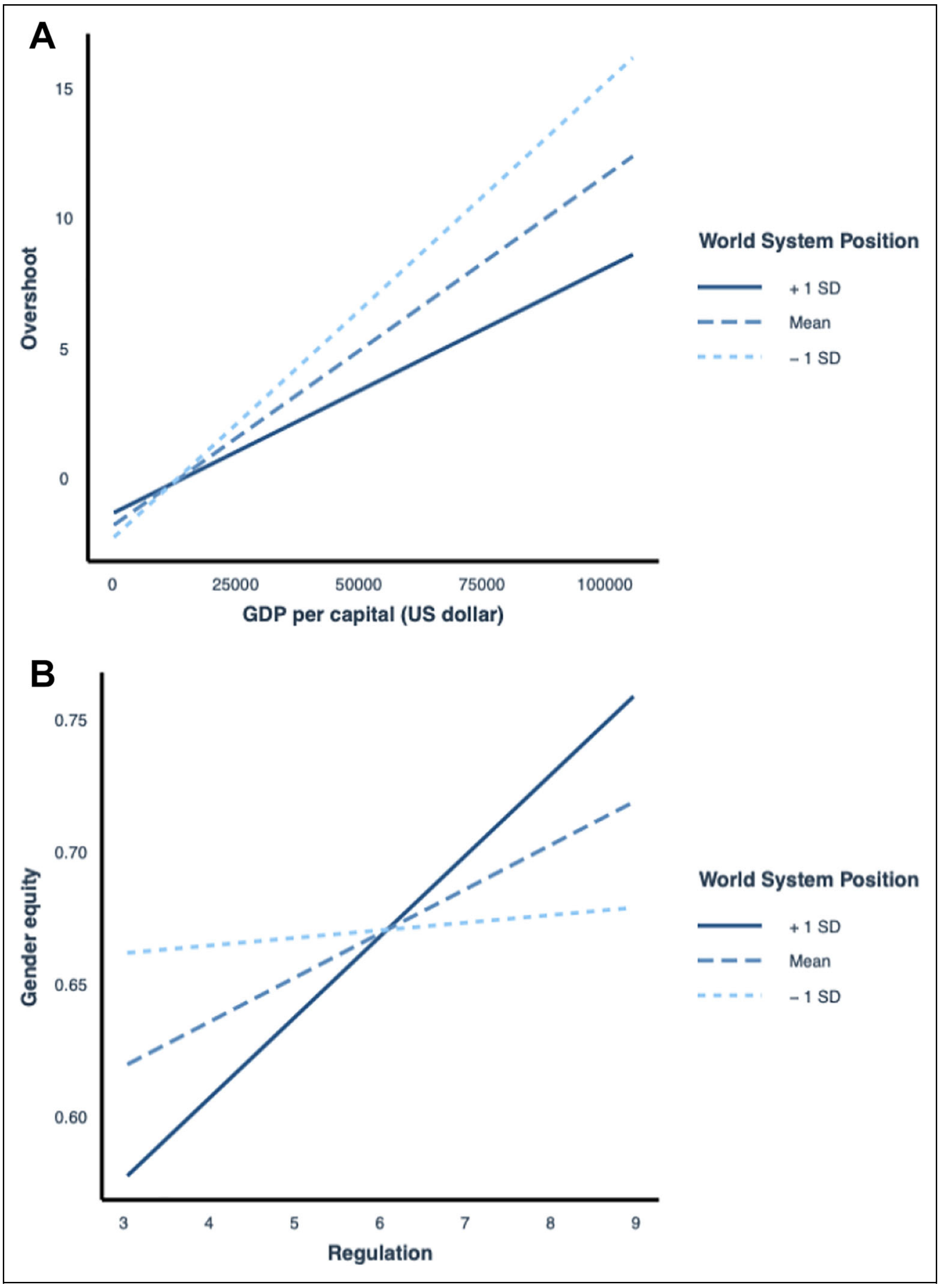

Figure 2. (A) shows the graphed interactive effects between world-system position and gross domestic product per capita and (B) shows the interactive effect between world-system position and regulation. DOI: https://doi.org/10.1525/elementa.2022.00038.f2

sustainability across social, economic, and environmental systems, which has been an underexplored area of strong sustainability research (see McKinney and Fulkerson, 2015; Austin and McKinney, 2016). Moreover, by bringing together feminist political ecology approaches to bear on theories of strong sustainability (i.e., unequal ecological exchange), we build up the theoretical and empirical capabilities to increase our understanding of the role gender plays across global political, economic, and environmental dynamics.

Our analysis suggests that modernization is the most robust driver of overshoot, supporting unequal ecological exchange theory that has similarly shown that development under the current system of capital accumulation is unsustainable (Bunker, 1984; Roberts and Grimes, 1997; Gould et al., 2004; Bonds and Downey, 2012; Ewing, 2017), and failing to support ecological modernization theories that argue global sustainability is achieved through development (e.g., Mol and Spaargaren, 2000; Mol, 2010). Considering the model holistically, we find support confirming strong sustainability theories (e.g., Gould et al., 2004; Howell, 2007; Jorgenson and Clark, 2012; McKinney, 2012) that modernization is a significant driver of overshoot. We also find support for unequal ecological exchange scholarship that has found world-system position is inversely related to biocapacity and that world-system position drives modernization (McKinney, 2012). Modernization's complicated effects across the model evidence its likely ineffectiveness at securing both gender equity and sustainable outcomes (i.e., reducing or eliminating overshoot) simultaneously. Thus, our study underscores the need for a holistic approach to studying and addressing such relationships that analyze positive and negative impacts on social, environmental, and economic outcomes.

This research also adds to our understanding of gendered dimensions of environmental outcomes generally (Ergas and York, 2012; McKinney, 2014b; Austin and McKinney, 2016)—namely that there is strong support for key associations among gender equity, the world-system, and neoliberal attributes cross-nationally. Such associations point to the need and opportunity for intervention in both theory and practice that can get at the coupled root causes of both gender inequity and overshoot. Feminist political ecology provides such theoretical grounding for understanding linkages across environmental, economic, and social dynamics. Given that increased gender equity is associated with decreased overshoot, our findings signal the twin systems of oppression of both women and the environment (Voyles, 2018; Sultana, 2020). As gender inequity increases, so does the drawing down of Earth's resources at a pace that far exceeds its ability to replenish.

Our findings suggest overshoot and gender oppression are mutually co-constituted such that current hierarchical arrangements of power across the world-system produce both, while doing so *is necessary to the functioning of the system*. Gender inequity is, then, baked into the system. We find empirical evidence that supports theoretical claims that women, including their labor and energy, is appropriated for creation and accumulation of capital across the world-system in similar ways as surplus value is extracted and transferred from the periphery to the core through the chronic development of underdevelopment (Moore, 2018). Both are maintained by patriarchy and capitalism, which reinforce each other across a set of power relations that subjugates women and nature (Mies, 1998; Rocheleau et al., 2013). Doing so is both necessary to support the current global capitalist system and potentially, in part, drives overshoot. Further, we argue that since shocks in one set of relations spills over into the other set (e.g., Voyles, 2018), similarly ameliorating effects may also spill over, signaling the importance of gender equity not just for equity but also for sustainability efforts.

At the same time, we find increased gender equity provides a positive environmental effect (i.e., the reduction in overshoot). Women due to their manufactured role as arbiters of social and ecological responsibility (Rocheleau et al., 2013; Harcourt and Nelson, 2015) have an important role to play for adapting societies to the effects wrought by overshoot (Austin and McKinney, 2016). Taken together, our research has sought to empirically test and provide theoretical support for what York and Ergas (2011) referred to as the "gendered world-system," which they assert and we agree, is a more accurate description, and one that is necessary for rising to the global sustainability challenges before us.

The current study informs important new directions for not just research and theory but also practice. Development research has long considered impacts and drivers related to gender and the environment (e.g., Abu-Ghaida and Klasen, 2004; Sinha et al., 2007). However, assumptions that increased gender equity will necessarily lead to more sustainable outcomes should be troubled to better enable us to broaden the tools we develop to ensure just transitions that are inclusive of social equity and sustainable environments. More specifically, the broad assumption that modernization is good for women may not be wholly reflective of the complicated realities of global, dynamic forces endemic to the world-system, including neoliberal logics and Western-oriented ideals of women's equality. Rather what feminist political ecologists, among others, provide us with is a theoretical framework to understand the connections between gender equity and strong sustainability. Doing so opens the door for greater opportunities for researchers, decision makers, and advocates to study, develop, and advocate for gender equity and environmental sustainability together. Practically, such chances can advance the political and social imagination, which is all too often constrained by global forces that have led to unsustainable approaches to development in the first place. Such reimagining through the meaningful participation and empowerment of those exploited by the current world-system, including women, periphery, and semi-periphery countries, can have profound impacts on how we design policy and implement governance, particularly in working to achieve the Sustainable Development Goals (United Nations, 2022), which seek to create and maintain an equitable and sustainable global world-system. The urgency for both an equitable and sustainable global world-system underscores the lack of progress made so far and the imperative to design and implement policies that reduce overshoot and achieve gender equity.

5.1. Limitations

There are limitations to the current research. First, gender equity is just one measure that can be used to analyze and understand how women affect and are affected by the world-system and overshoot. Future research should consider other measures of gender, particularly from organizations that are not themselves steeped in neoliberal practices such as the World Economic Forum, to advance our understanding of the relationships between gender and overshoot and their implications for just sustainability. There are always limits to the data that are available, and more work particularly needs to be done to secure more and better data on gender equity globally. We employ a unique analytic strategy to analyze widely available and frequently used data to add to the scant literature within strong sustainability research that includes gender. We suggest this as a starting place for additional research to draw from when considering gender in their own quantitative analyses. We also suggest future research should consider using qualitative approaches to identify how and why gender equity may be leveraged to ameliorate overshoot and vice versa and how efforts to advance global sustainability and just transitions may be leveraged to promote greater gender equity.

6. Conclusions

Our analysis demonstrated the importance empirically of including gender measures in strong sustainability research. Theoretically, our research has contributed a feminist political ecology approach to understanding strong sustainability, broadly, and unequal ecological exchange, more specifically, at a global level of analysis. Methodologically, we demonstrated the value of using SEM to identify key relationships across gender, world-systems, and the environment. We find doing so positions the field to better respond to the marshaling of gender and sustainability frameworks. As the world moves closer to the direst predictions of the unfolding global climate crisis, research such as this will only become more urgent as we look for ways of slowing overshoot while reducing inequities in creating just sustainable transitions. Such empirical and conceptual advances offered by this study therefore provides novel opportunities for practice by researchers, decision makers, and advocates to identify, assess, and promote gender equity and environmental sustainability together. We find it empirically imperative to include measures of gender equity in sustainability research and feminist political ecology's theoretical contribution of understanding gender and environment as linked is necessary for not only conceiving of new socio-ecological imaginaries but also enacting them.

Data accessibility statement

This study utilized the following publicly accessible data sets:

- The Global Footprint Network, data.footprintnetwork.org.
- Fraser Institute's Economic Freedom Data, https://www.fraserinstitute.org/studies/economic-freedom#:~:text=Economic%20Freedomz%20of%20the%20World%3A%202021%20Annual%20Report%20is%20the,of%20credit%2C%20labour%20and%20business.
- World Bank Open Data, https://data.worldbank.org/.
- World Economic Forum, https://reports.weforum.org/global-gender-gap-report-2020/dataexplorer/.
- World-system position, from Kick, EL, McKinney, LA, McDonald, S, Jorgenson, A. 2011. A multiple-network analysis of the world-system of nations, 1995–1999. *Sage handbook of social network analysis*. Los Angeles, CA: Sage: 311–327.

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The authors have declared that no competing interests exist.

Author contributions

Contributed equally to the manuscript: CEBC, KBD.

The co-authors contributed to this piece in the following manners:

Contributed to conception and design: CEBC.

Contributed to acquisition of data: KBD.

Contributed to analysis and interpretation of data: CEBC, KBD.

Drafted and revised the article: KBD, CEBC.

Approved the submitted version for publication: CEBC, KBD.

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Appendices

Appendix A. Descriptive statistics for model terms across entire sample

Model Term	Mean	Standard Deviation	Median	Minimum	Maximum
Overshoot	–0.2944	9.8733	0.7450	0.8493	1.8162
GDP per capita (modernization)	15,538.6032	19,927.9100	6,475.4557	11,763.8800	8,167.4420
World-system Position Rank	4.9141	2.7751	4.0000	4.7885	2.9652
Arable land	0.2363	0.2915	0.1550	0.1793	0.1348
Gender Gap Index	0.6915	0.0567	0.6931	0.6913	0.0525
Biocapacity per capita	3.8555	9.9965	1.3598	2.0341	1.2210
Regulation (neoliberalism)	7.0746	0.9968	7.1850	7.1526	0.8673
% Urbanized (modernization)	60.4847	22.6871	63.1865	11.7760	100.0000
Government size (neoliberalism)	6.4752	1.1712	6.3250	3.9800	9.4100

n = 128. GDP = gross domestic product.

Appendix B. List of countries included in the SEM analysis

The following countries are included in the structural equation modeling (SEM) analysis: Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belgium, Bhutan, Bolivia, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Canada, Chad, Chile, China, Colombia, Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Estonia, Eswatini, Ethiopia, Fiji, Finland, France, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guyana, Honduras, Hungary, India, Indonesia, Iran, Islamic Rep., Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Rep., Kuwait, Kyrgyz Republic, Lao PDR, Latvia, Lebanon, Lesotho, Liberia, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Nepal, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Rwanda, Saudi Arabia, Senegal, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Suriname, Sweden, Switzerland, Tajikistan, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Bolivarian Republic of, Vietnam, Zambia, Zimbabwe. Two additional cases are included in the linear model due to the reduced number of model terms, maintaining all cases without missing data.

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