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Editorial

Introduction to Sustainability Journal Special Edition "Global Warming and Sustainability Issues"

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Sustainability, in its multiple facets, is nothing if not interdisciplinary. In research circles, the current challenges to defining an alternative balance among global financial, economic, and environmental sustainabilities in global environments now produce almost constant reconsiderations, even upheavals, in what and how we can be said "to know"—including how to discern our best strategies for achieving sustainability. In this charged atmosphere, the boundaries between and among academic disciplines constantly undergo recontextualizing gestures in the search for more refined research paradigms, paradigms whose research metrics increasingly need to be constructed from across disciplinary research methods, models, and versions of validity. This same feature of current research methods is also a driving agent for the re-definition and re-inscription of disciplines driven by more specialized, more discipline-specific forms of modeling in academic institutions. Across our discursive sphere, we seem to need to have it both ways: on the one hand, we need disciplinary forms of research in order to enable more precise interdisciplinary modeling; on the other hand, we need to push disciplinary research methods into forms of overt and often less-than-predictable, sometimes underestimated and understated, collusion in order to break through the limitations of the more discrete, disciplinary development and application of models.

The essays included in this special edition attempt to place these tensions into new and emerging contextual "workings" within and against one another—among financial/economic determinants and environmental imperatives; across science, social science, and humanities disciplinary boundaries; and in reconfiguring qualitative and quantitative research methodologies and findings, to propose new directions for the constellation of financial/economic, political/social, and human/environmental patterns for achieving sustainability, if, by "sustainability", we mean the horizon of intelligibility bequeathed that word by the *Brundtland Report* (*Our Common Future*) [1]. The essays in the current edition of *Sustainability* all take the *Brundtland Report* as a starting point only, however; whereas the authors of the Brundtland Report never intended to develop knowledge that has specific applications in delimited social, geographic, and socio-economic policy recommendations and contexts, the authors of the current essays do take the difficult steps to integrate the wider vision of the Brundtland Report with the (often) context-specific application of their findings in their regional situatedness.

Like many strong collections that appear as a result of specific, multiple pressures, emerging as moments in the history of developing and/or emerging concepts and practices, this collection of essays provides a sample of developing strategies in agricultural processes and practices; identifies needs for the local and global development of modeling and paradigms; and, broadly speaking, construes findings that could benefit many regions across the globe. Similarly, these studies offer multiple combinations of disciplinary assumptions, research strategies, and assumptions of validity. Taken together, ultimately, this collection produces a cross-pollination of models and emerging research directions that represent secure steps for governments revising their research approaches to create more resilient conditions for their citizens as for their ability to "sustain" specified levels of living conditions for their current (and projected) populations. Across the globe, we are only in the beginning stages of the deliberate application of many of the scientific findings evident in the collected essays; that is, the authors here identify specific problems in the current design of research approaches, and these essays rebuild knowledge as they contribute research-based findings to address shortcomings or oversights in the relationship between social policy, living conditions and situations, and scientific data. Thus, these essays gesture toward a Brundtlandian world in which scientifically based findings are integrated directly into policy considerations and design, and these considerations, in turn, are reflected in the ultimate needs of the people and planet. The studies in this special edition of *Sustainability*, then, gesture toward an overall approach that not only calls for an awareness of our impacts on the planet and our own resilience in a future life increasingly driven, and limited, by Green House Gas (GHG) emissions but will also, one day, protect as it builds upon current levels of environmental resources, the overall environmental health of ecosystems and, ultimately, through combinations of the research approaches on display here, foster rather than diminish the health of the planet.

Although the essays in the collection range across the globe in terms of applicability and insight, the majority of the studies included here begin by developing geographic specificity in the application of a scientific method to an existing or emerging problem that is at once social and atmospheric, economic and environmental, driven by both planetary and human systems. Although few of the authors explicitly pursue the destabilizing of existing models in climate change science, the assumptions here are governed by the need to develop models with what I will call “geographic transferability”: wider applicability globally in *specific* geographies and social systems, for increased accuracy or predictability in the ability to lower emissions to safer levels for all humans. The current challenge of this set of goals, of course, is to shift to low-carbon economies and modes of production without sacrificing human food and basic living necessities or securities; this necessity has emerged as the key challenge of our epoch. Each of the researchers gathered in this special edition understands that this challenge demands the redesign of climate impact modeling, both across the globe and regionally, in a strategy of geographic localization. The problem is, now, to develop the discussion of what these models actually mean in a world organized, or reorganized, by equality of access to resources rather than by a hinterland–metropolis power struggle for survival in conditions of dwindling resources in conditions of rapid climate warming.

For example, in “Mitigation of CO_2 and N_2O Emission from Cabbage Fields”, Hwang, Park et al. [2] pose the possibility of developing a strategy of mitigation through paying closer attention to the interaction of CO_2 and N_2O emissions via monitoring tillage depth and nitrogen levels in cabbage fields in Korea. They attempt to alter the current processes for strategic, socio-political decision-making in order to “incentivize the shift towards sustainable farming”. By developing the configuration of data differently—producing, through their study, advances in modeling—their insights lead quietly, if quickly, to a different configuration of “private” and “public” organization in society; they investigate a more sophisticated approach to developing low-carbon practices in farming, ultimately proposing the development of a gradated system of compensation for farmers who, in adopting low-carbon tillage practices, may thereby reduce their overall cabbage yields. While the emphasis of the study is, rightly, on developing more sophisticated modeling of the relationships among tillage depth, nitrogen fixation in the soil, and GHG emissions as a result of different levels adopted in the relationship between tillage depth and nitrogen fertilization, the study’s tentative conclusion gestures toward a revised social and agricultural system in South Korea’s (near) future. What these agricultural-social policies might become, however, is largely dependent on any given nation’s willingness to redesign, based on emerging scientific modeling, long-standing social, political, and economic assumptions, commitments, and paradigms.

The authors Glab and Sowiński [3], also investigating effective GHG mitigation strategies, turn their attention to the sustainable production of sweet sorghum as a bioenergy crop; however, they develop a model of the carbon footprint of sorghum production through the use of sewage sludge and digestate as a nutrient substitute. Their study takes place within the geopolitically “localized” context of the European Union but develops an additional mitigation opportunity that could further reduce the GHG impact of currently carbon-intensive agricultural practices. Thus, read these two studies together, applying the findings across the continuities of their localized parameters, suggests that the modeling strategies these authors' work may be combined most effectively into are as follows. A single strategy combining the findings of the two essays has the potential to reduce the percentage of subsidies proposed by Hwang and Park's study as necessary to meet GHG emissions goals—provided that these goals are defined clearly and, furthermore, that the GHG emissions goals are linked, through advanced modeling, to specific agricultural processes and practices that are measurable, attainable, and modifiable in atmospheric and other, more socio-politically determined, conditions in the future. This approach, exciting as it is, requires considerable additional study, the analysis of findings across sustained study parameters, and the development of resources as well as confidence in the methodological paradigm shift that both studies develop. As Glab and Sowiński note [3], the basic building blocks for such an approach require development: "little data are available on GHG emissions from sweet sorghum production under temperate climate. Similarly, information on the effect of bio-based waste products use on the carbon (C) footprint of sorghum cultivation is rare in the literature". The need to refocus analysis on the role of carbon—as well as the role of different methods for applying fertilizers in different locations and across differing farming practices—is also crucial to bear in mind, as Glab and Sowiński make clear: "Nitrogen application had the greatest impact on the external GHG emissions and it was responsible for 54% of these emissions".

In another exciting study in this special edition, Yang, Long et al. [4] attempt to develop models that map the environmental cost of a "typical" citrus-producing county in China. They find, too, that the "production and utilization" of nitrogen fertilizer is a significant object of study: nitrogen fertilizer "accounted for more than 95% of the total environmental costs" of citrus production in the areas that formed the basis for the study. Their findings are stunning: based on 155 farmers' data, "the high yield and nitrogen use efficiency orchard group with younger and better educated owners, achieved a higher citrus yield and N use fertilizer efficiency with less fertilizer input and lower environmental costs" (1). The intervention these authors suggest sounds practical, relatively simple to implement, and achievable across diverse cultural, political, and scientific contexts globally. We would do well to pause on this finding and attempt to replicate the authors' study methods, inroads to more sophisticated modeling, and overall findings in other areas of the globe: as the authors note, "citrus is the top fruit crop with the largest cultivation area and highest production in the world". The object of study, the relationship between citrus yields and productivity assumptions in the current, widely adopted regimes of fertilizer application, is remarkably strategic, not merely for China's adaptability and resilience in the face of global climate change but for all nations attempting to provide for the current generations' needs without compromising the ability of future generations to meet their needs. As the authors note, "optimum nutrient management based on the local field recommendation in the citrus-producing areas is crucial for achieving a win-win target of productivity and environmental sustainability in China and other, similar countries".

While their work points to exciting insights that lie just beyond our own more nation-based decision-making paradigms, the study moves toward developing models that provide the capacity to extrapolate across multiple environmental, social, and political conditions the findings expressed there. However, due to the relative lack of development, in the current conditions for producing knowledge, for producing widely accepted pairings of scientifically-based knowledge, the development of specifically interdisciplinary-informed models, with socio-political policy and decision-making, the authors' inroads into alternative modeling methodologies can compel only a tantalizing horizon of possibilities for future study, suggest the development of an emerging global awareness of interdisciplinary modeling, and hint at a paradigm of equality—of more balanced access, stability, and security, for all. As they note, "although many aspects of environmental costs in cereal and annual crop production have already been investigated, the life cycle assessment (LCA) of environmental indicators in perennial fruit crops is still rare, mainly due to lack of methodological standardization". In part, this limitation in the studies is driven by significant differences across geographic regions: soil types, climate conditions, management practices, language, and other cultural barriers, etc. However, "methodological standardization" should not be the "crucial" determining factor in our inability to make inroads to sustainability. To eliminate this false barrier to change, the quantification of environmental sustainability continues to be a singular challenge.

The movement toward a more aggrandizing perspective is made by Wu, Huang et al. in "Net Greenhouse Gas Emissions from Agriculture in China" [5]. The authors of the study take "21 sources of agricultural GHG emissions into consideration", linking the "emission" and "absorption" of GHGs in a single model—in this case, focusing on emissions in 30 provinces in China between 2007 and 2016. The study analyzes the spatial correlation and convergence of net GHG emissions in China's agricultural production. They find that, in the "agricultural GHG emission structure of China" across that period, as we might expect, there are fluctuating patterns of net emissions across provinces; however, across their findings, the rate of "absorption was much lower than emissions". Thus, their findings are multiple, but one key finding is that, in the results of the convergence tests of 30 provinces' GHG emission scenarios across the period under study, there is no nationwide convergence, which suggests that emissions will not decline by natural means. The development of effective reduction measures is a crucial finding of the study, and furthermore, the data showed that strong possibilities exist for regional cooperation in the sharing of low-carbon technologies. For its future, China should "attach importance to the development of the technologies and techniques" of low-carbon technologies (and non-technological strategies), applying these "as soon as possible". Furthermore, the authors find that "at present, low-carbon technology is relatively insufficient for agriculture in China". These findings diverge from current studies conducted in China, in that the authors widen the modeling inputs from 6 to 21 sources of GHG emissions. This, of course, is a significant rethinking in the design of GHG modeling in agricultural applications, and we would do well outside of China to pattern additional studies based on the model developed by these researchers.

Many of these themes, challenges, and inroads into modeling on global scales are developed, albeit with a different emphasis, by Jensen, Domínguez et al. ("Economic Impacts of a Low Carbon Economy on Global Architecture: The Bumpy Road to Paris") [6]. Taking a similar pathway in arguing for increased accuracy in modeling a, or the, global carbon economy, the authors call for an "integrated modeling framework". The study gathers considerable data from across multiple existing disciplinary frameworks; for example, "first, the macroeconomic impacts of moving into a global low carbon economy are analyzed" by applying different carbon taxes in a general equilibrium modeling framework". Emission mitigation technologies are then quantified and applied through the Aglink–Cosimo model to assess agricultural markets' responses compatible with emissions scenarios mirroring the 2 °C threshold of the Paris agreement. While the authors underscore the need to create substantial reductions in GHG emissions and foster the transition to a climate-friendly, low-carbon economy, their findings also express the need for caution in the development of a successful set of GHG mitigation strategies. As they word their conclusion, "transition to a lower carbon intensive economy has large implications from both regional and global perspectives". An environmental modeling of successful strategies or clear policies must take into account, equally, economic, environmental, and societal impacts. Only then will the transmission of these strategies directly into (local and global) agricultural market policy be "fair" in assessing the long-, medium-, and short-term effects of changes in the global agricultural market systems. Their analysis indicates that "for the net mitigation of global agricultural emissions", policies need to target carefully specified interventions in current policy and practice decisions. Policy and other considerations for emerging geospatial emission intensities, or addressing measurable "hotspots" of CO_2 production in localized areas, differ between developing and developed countries, for example. More sophisticated and differentiated policy approaches are needed in the agricultural sector, and this, in turn, could be driven more effectively by movement to an updated version of the Aglink–Cosimo model, measuring agricultural productivity in numerous regions of the globe, the dimensions of which the authors develop and extend to readers of the work. In the end, the revised modeling scenario developed by the authors can fuel technological development in correlating carbon tax scenarios to more differentiated, context-specific environmental, societal, and political conditions—suggesting not only the interdisciplinarity of the authors' research and modeling but also the need for additional, similar studies able to tackle the design of a methodology capable of a global scale of "localizable" applicability.

The final two essays in the edition address aspects of the increasingly arid conditions in many regions, brought about by emerging and predicted climate change patterns in the precipitation and aspiration of rainfall due to increasing aridity in many regions across the globe. Like the other studies in the collection, these authors situate their work in the latest predictions emerging from sources such as the Intergovernmental Panel on Climate Change (IPCC) as well as other experts, whose thinking has formed a largely accepted set of framework ideas for addressing the mitigation of, adaptation to, and reversal of the detrimental impacts of climate change on human (and other) populations. As Yi Li, Xie et al. note [7], "climate change has altered the existing pattern of precipitation and has an impact on the resistance and adaptability of desert plants". Studying life on the antipodes of human adaptability is an emerging strategy for testing the limit cases of adaptability and mitigation in life forms already adapted to the stress of what, for humans, are largely inhospitable climatic conditions.

The authors position their work in an emerging paradigm of climate change study: as climate change increases dramatically, impacts on precipitation are expected to alter landscapes differentially, if simultaneously, across multiple regions globally: "the time and intensity of precipitation may change". Here, too, the study of specific climatic changes is a key feature of the study parameters the authors construct: although in the semi-arid and arid regions of northwestern China, precipitation is projected to increase from 30 to 100 mm in the next 100 years, this increase will be accompanied by a "trend of increasing precipitation intervals, decreasing small precipitation events and increasing extreme precipitation events". The character of precipitation events across many additional areas of the globe is expected to undergo these forms of geo-spatial differentiation—a diffusion of current climate into regional "aridities" characterized by vastly different precipitation events than those we see in current climatology. Climatologists expect flash flooding accompanied, paradoxically, by increasing aridity over time. The authors underscore the reach of their study; although the authors limit their object of study to a specific region and set of climatic conditions in northern China, "globally, the proportion of land surface under extreme drought is predicted to increase from 1–3% currently to 30% by the end of 2090". Underscoring the urgency of studies of arid conditions is the fact that this percentage of change in arid regions globally is likely to be underestimated in current modeling scenarios, simply because the complexity of the data continues to be a challenge to the development of an adequate model; in the absence of clear, more comprehensive collection and analysis of data for arid regions, models of this kind of climate change have long remained on the conservative side in the predication of projections across longer temporal spans. At stake is a more comprehensive knowledge of impacts we might expect—or be able to mitigate more effectively—in the destabilization of ecological successions of species forced to adapt beyond current morphological processes and, more rapidly, to conditions of drought and less frequent, more intense patterns of precipitation. As the authors note, the interactive impacts, as well as the central characteristics of the changes in precipitation amounts and frequency in desert ecological conditions, are "unclear" (1). The study is an attempt to contribute baseline data for additional study in an area of knowledge production currently not well known or understood.

As the authors characterize their contributions, given that the main change in precipitation is in the "intensity, frequency, and duration" of precipitation events, more research is necessary for predictive and mitigation efforts across these specific variables; similarly, few scholars compare "frequency and interactive impacts on individual plant growth". Thus, their study highlights the interactive properties of rainfall by placing into contiguity, for example, precipitation amount and precipitation frequency. Their findings, as well as their study design, have significant implications for developing more knowledge of emerging semi-arid and intensified arid regions' conditions for sustaining climate, creating refuge conditions or areas in semi-arid and arid regions, and the development of collection and dispersal methods for these emerging patterns of rainfall in regions long perceived to be "wastelands" or un- or under-productive geo-climatic resources. The authors unarticulated insight, that studying existing semi-arid and arid regions through simulated rainfall and frequency conditions will accrue predictive and adaptive value, is directly applicable now. Shifting the perception of arid regions now can produce a more informed, longer-term set of strategies for building human resilience in areas predicted to become arid with rapid changes in climate in this century.

Kamali, Abbaspour et al.'s work [8]—"A Quantitative Analysis of Socio-Economic Determinants Influencing Crop Drought Vulnerability in Sub-Saharan Africa"—in some senses, reverses the parameters of the above study, although these two studies, taken together, offer a glimpse of the potential for exacerbated aridity posed by unabated atmospheric conditions in the emergent patterns of climate change. Population studies have long predicted that the world population will increase significantly by 2100, with estimates often predicting an increase of 2 billion people (from 7 billion to 9 billion) in that relatively brief time span. Pressures on food and water security are expected to increase significantly across the century, with the greatest vulnerabilities expected in South Asia and in Sub-Saharan Africa. Combining social science research modes with scientific data, the authors assert, rightly, that the social infrastructures in these regions not only produce significant impacts on levels of human adaptability but also may contribute negatively to drought resilience. The study combines the use of the crop drought vulnerability index (CDVI), the application of data from the Environmental Policy Integrated Climate model (EPIC), and the identification and quantification of socio-economic variables in regressive analysis techniques.

Their results circle back to where we began the collection of essays: "the level of fertilizer use" is a highly influential factor in understanding, and measuring, vulnerability. For most of us, of course, fertilizer is the "forgotten" element of food production, environmental sustainability, and climate change. However, as multiple studies in the collection of essays point out, "fertilizer" is the "forgotten element" that may turn out to have the most significant impacts on land, ocean, and atmospheric health, simply because this is a key, readily available, easily understood point of widescale, global intervention. Understanding more precisely the interaction of these systems of human assumptions, agricultural processes, or practices, and the earth's responsiveness to changes in both, is a fundamental pathway to resilience, mitigation, and, in many cases, survival, as climate change's impacts become increasingly difficult to avoid. The unvoiced hope of these studies, of this collection's contributions to sustainability *as* adaptability, is that the interdisciplinarity and analytic rigor of the work of these scholars contributes, quite literally, not only to a better future but also to a more secure set of pathways to ensure greater equality of access to survival itself.

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