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Using the quadruple helix to design strategies for the green economy

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ABSTRACT

This paper introduces green sustainable resources to the traditional triple helix of industry, academia and government, revealing the impact of geographical clusters and factor endowments on green competitiveness in the global economy. More specifically, this paper evaluates how water-intensive nations develop additional competitive advantages in a green economy. This analysis demonstrates that abundant water resources will not warrant economic growth per se but that incorporating a resource like water into a green quadruple helix will provide the framework needed to design and expand water-intelligent economies. This may result in a new generation of green products, services, and technologies capable of stimulating the world economy.

1. Introduction

In the fall of 2008, the "Global Green New Deal/Green Economy Initiative" was launched in the midst of one of the worst global economic crises in modern history. In the last two years, the concept of a green economy has moved into the mainstream of economic debates and has started to shape economic growth and development strategies around the globe. The four main issues driving the creation of a green economy are: a) increased pressure on finite natural resources; b) rising awareness of water and energy security; c) global climate change; and d) intergenerational justice [3,8,14,37,55,58,70]. Each category reveals the complicated social, political, legal, and economic problems that revolve around the allocation of natural resources. In order to effectively produce a sustainable green economy, it is clear that one must navigate the institutional and systemic concerns of a global green *political economy* as part of this process.

The world system is poised to encounter dramatic social, political, and economic shifts in the next three decades. According to recent forecasts of the world economy, given population growth and natural resource allocation trends, the global economy will encounter an economic boom of unprecedented magnitude in 2020, with a period of massive institutional changes regarding world leadership and global political priorities [60]. With an increased world population of 8.9 million by 2050 and a saturation value of the global economy of around 142 trillion adjusted USD, there is no feasible scenario where we "grow sustainably." Instead, those who are aware of these scenarios agree that a discourse of "sustainable prosperity" should become the geo-political paradigm necessary to confront a myriad of geo-political instability [73]. Instead of focusing on a handful of economic indicators that may eventually construct a future scenario (what one would commonly refer to as forecasting), scholars are increasingly incorporating conjectures about the future, called "backcasting." This consists of identifying a desirable future and from that point of departure, requires that one determines the elements that help achieve that scenario [93]. This form of analysis challenges scholars to imagine a set of institutional conditions that would make for a more sustainable society, working backwards with a set of tools needed to measure the circumstances that produce a more livable future. This study asserts that the emergence of a sustainable global economy is dependent upon a robust discourse on natural resource allocation, or rather, natural capital as one

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of the essential elements of a sustainable future. The increasing need to address natural capital (ecosystem and biodiversity) losses as well as the need to create jobs, and address global poverty issues frames this initiative. This new paradigm illustrates the nexus between climate change strategies and economic development. As the global economy becomes greener, the debate is no longer concerned about whether a green economy would emerge, but rather how the green economy is beginning to transform the global economy, resulting in a more efficient and sustainable utilization of the Earth's natural resources, lessening the impact on the planet's natural capital [9,11,63,67].

Technologies that disrupt conventional practices, incremental contributions to progressive technologies, and pure innovation will all play a vital role in supporting this green revolution. These transformational technological changes will determine how we build a green economy, and as a result, will guide the institutional changes needed to support innovation and growth. For example, new technological paradigms will also imply the development and design of new business models, that will lead to systemic innovations [6,12,52]. Green technologies and innovations will enhance the efficient utilization of natural resources and lower or eliminate the environmental impact of these innovations and technologies [18,42,59]. Once a technological breakthrough is introduced, one must contend with the way that businesses will respond to those breakthroughs. This includes the manner whereby learning races and competitive behavior generate relational or collaborative capabilities [88]. As a result, technological innovation will produce a broad range of systemic issues, mediated by both the private and public sectors. Hence, green technologies are directly related to green business and green governance, both of which build upon green consciousness among social networks. All components are necessary for the development of a sustainable green economy. These components deserve immediate attention herein.

The green economy initiative is already leading to massive investments across the global economy. For instance, clean energy has become one of the driving forces behind the global economic recovery. In the U.S. close to US$ 100 billion, out of the US$ 787 billion stimulus package was allocated to clean-tech investments and activities; China is expected to invest close to 440 billion in its clean energy self-sufficiency program. South Korea's “Green New Deal” is expected to demand US$ 84 billion in clean-technology investments [13].

Several green technologies are also expected to experience significant growth in the next few years. For instance, biofuels are expected to grow into a US$ 112.5 billion industry by 2019; wind power is expected to expand into a US$ 114.5 billion industry; and the solar photovoltaic industry will expand into a US$ 116.5 billion industry by 2019 [13]. This is consistent with new shifts in technological advancements that are indicative of system-wide paradigm shifts. For example, the development of auxiliary power units that are no longer based on similar technologies to primary units (i.e. biofuel to hydrogen; electric to wind-powered) have demonstrated a fundamental shift in the way that resources are viewed [2]. Thus, many of these innovations in the usage and diversification of natural resources have created economies of agglomeration that have spurned growth with each sector [79].

The green industrial, service, and agriculture economy will require the development of new skills, resulting in a need for job training and educational training. Restructuring toward a green economy will also require a large scale redistribution of jobs across industries and inside industries. Increasingly, new and reshaped jobs will change the demand for labor in a given economy. Green jobs will be created to deliver goods and services, demanding new training and qualifications. Thus, certification and regulation of goods and services must be anticipated. It is also expected that vocational employment will also increase. Moreover, green companies that use traditional supply chains will also add another impetus to the “traditional” global economy [14,23,45,83].

For instance, in 2010 the U.S. announced the distribution of additional funds for training of American workers for careers in green industries [80]. The U.S. has identified six main green strategies and initiatives that have the potential to generate green jobs. For instance: a) building retrofitting, b) mass-transit, c) energy-efficient automobiles, d) wind power, e) solar power, and f) cellulosic biomass fuels [69]. Assessing the development of the green economy is however, not as simple. Some providers of green services, technologies, and products are more easily identified than others. Many times, these companies are found in the same industrial categories as traditional industries, making them hard to identify. The U.S. Department of Commerce Report [92] measured the size of the U.S. green economy to be around 1%–2% of the total private business, and accounting for 1.8–2.4 million jobs. Thus, there is a substantial room for growth in the U.S. economy, pointing to a significant capacity for growth and a rapid growth projection for the green economy in the U.S.

In terms of green governance, the enactment of the state of California's “Global Warming Solutions Act” has also advanced the discussion of green public policies and green technologies and innovation aiming at enhancing natural capital and economic growth [42]. This initiative is expected to generate a US$ 74 billion increase in California's GDP and create 89,000 new jobs [50]. This is indicative of a gradual alignment between the public and private sectors on the systemic features needed to develop a green economy.

The increasing awareness that companies have a substantial impact on the globe's natural capital is leading companies to design business models, technologies and innovations to lessen their impact. These “meta-externalities”, encompassing toxins and non-biodegradable wastes, are driving the introduction of green business practices, technologies, and innovations [36]. For instance, companies like Philips are developing energy-saving lighting solutions. Lighting accounts for 19% of the world's electricity needs, and close to 75% of it relied on passé, less sustainable technologies such as incandescent light bulbs. New lighting technologies such as LED, CFL, or CCFL lights could save the equivalent of 1800 million oil barrels every year [52].

Countries and companies are increasingly transforming their mindset and operational strategies to cope with the challenges and opportunities presented by the dawn of the global green economy [86]. The United Nations' “Technology Needs Assessment” initiative is fostering the development of innovations and technologies for mitigating and addressing climate change challenges and opportunities. In addition, the economy-wide utilization of green technologies, innovations and practices has the potential to reinvigorate traditional industries and create new niches in these traditional markets. These elements have an enormous

influence over the production of a global economic consciousness; they have encouraged the public sphere to increasingly become aware of the need for green technologies. Fundamentally, these rapid and complex interactions between public and private institutions and the development of sophisticated economies of agglomeration have required that knowledge-based economies address the need to keep up with developments in the discourse on green living. Cluster management is an example of the kind of initiatives being proposed to adequately address the need to train managers to deal with the development of innovative practices derived from multiple institutional interests [40,82,101]. In this case, the changing social consciousness of people to live a green lifestyle has become one of those institutional interests.

All of these issues will have a direct impact on the development and sustainability of the green economy. Policy instruments can be used to foster progress toward a green economy. First, institutions and markets within the economy must determine an accurate price; assessing a value to natural resources, and penalizing environmental "bads." Second, stakeholders within an economy must provide incentives for government and private investments on infrastructure and on natural capital. Third, an economy must implement ecological tax schemes, where one taxes factors such as pollution. Fourth, an economy must support environmentally sound technologies and innovations. Fifth, it must emphasize investments in the foundations for a self-sustained social and environmentally sound economic growth [29].

1.1. Methodology

The current concerns with the green economy do not reconcile the desire to live in a green environment with institutionally intelligent systems in the global economy. Consequently, more attention must be paid to methods that engender an institutional or systemic perspective. Studies of the environment in relation to business have engaged the concept of the stakeholder as being the unit of analysis that bears institutional interests [19,46]. This move from the interests of shareholders to stakeholders, the shift from business interests rendered internally to those rendered externally, are indicative of an epistemic shift in approaching the concept of the business model and its interests as having a larger role in a given economy. In other words, consumers are institutionalizing their behavior as they increasingly learn how to relate to a green economy. Consumers will not think along the same lines as technological innovators, and neither will view their interests entirely similar to those of producers within a given industry. It is how all these interests interact and influence each other that explain how a green economy will evolve. This is consistent with the concept of the "triple helix," which has become central to these institutional methodologies. Ref. [56] presented in their seminal work on the triple helix the assertion that markets within an economy are developed in relation to a constellation of distinct interests and that mapping these interests by academia, industry and government is essential in understanding the trajectory of a given economy. Government policy can't merely be understood in relation to business practices. It may be that, for example, government policy is indirectly mediated by its support of academic institutions for research and development. As these organizational networks cross-pollinate, new institutions are likely to develop [49]. Thus, the body of literature regarding the triple-helix has evolved to account for "polities," larger, systemic models that analyze how policy and consensus are driven by multiple ethical, social, and political matrices. In order to understand how institutions regulate corporate behavior, one must understand how those institutions interact with each other in relation to newly developed economic or business concepts. Contemporary scholarship has applied the triple helix as a way to understand the evolution of knowledge-based economies. Henning and Schiller, for example, suggest that the dramatic emergence of Chinese enterprise is dependent upon an intense collaboration between public–private collaborations [102]. This supports a broad range of case-studies from all parts of the world which view the systemic features of a triple-helix as an essential way of understanding the concept of innovation from a national and global perspective [10,21,57,89].

To summarize, triple helix studies, are methodologically driven by institutional analysis — systemic renderings of values and agendas that are compared with one another to determine the general trajectory of a particular economy. A green economy, which implies questions of ethics, sustainability, and planetary urgency, demonstrates an added dimension which this study will construct and add to the concept of a "triple-helix." Recently, scholars of innovation and knowledge-based economies have acknowledged the need for increased attention to the geographical elements of innovative practices [33]. Factor endowments, for example, have become increasingly macroeconomic, and systemically, the role that natural resources play in the decision making processes of the academy, the public sector, and the private sector, has been characterized as a systemic problem [4,31]. This follows a small, but under-expressed element of the relationship between the public and private sectors which asserts that green economies must necessarily view geographic factors as its own category of analysis, because geography itself institutionalizes economic and political behaviors [29]. Thus, a quadruple-helix more adequately confronts the systemic features of emerging green economies, and helps us to understand how we will innovate in relation to our natural resources in the next century.

As a methodology, an institutional analysis can take many forms. For example, formal experimentation or historical reviews are two methods that can help one understand the circumstances that produce a given phenomenon. However, case studies are capable of being both descriptive and explanatory when complex social and political relationships are well beyond the control of researchers [96–100]. According to Yin, case studies are a useful alternative to other empirical research models when a) the type of question requires answers at a topographic, macro scale, b) the extent of control one has over actual behavioral events is minimal; and c) the degree of focus on contemporary rather than historical events is a central feature of the research question. Questions regarding institutions largely fit within these conditions [99,100]. Any attempt to answer questions about the green economy as it relates to a larger system of actors fulfills these criteria, and according to [24,25], they are constitutive of a unit of analysis (one case that explains a particular systemic behavior) that is obvious in theory, but difficult to penetrate beyond the institutional level. Applying the research of Eisenhardt and Yin, this study builds on these constructs through the concept of a

water helix, which can be understood as a case study that provides multiple sources of evidence that consumption has an institutional effect that has a similar value to other major institutional forces (e.g. the other components of the triple helix). Consequently, this study is able to validate theoretical claims because it has properly framed the case as a specific manifestation of that claim (the water helix as a form of systemic consumption). This allows the research to explain and describe systemic behavior while also qualifying the status of evidentiary claims. This is consistent with several important critiques of case study methods which place importance on having a well-designed theoretical apparatus that will allow information to undergo proper analytic scrutiny rather than just letting a case "speak for itself" [41,84].

2. Designing the green quadruple helix

It is clear that given the complicated negotiations that take place in the evolution of a given economy, the global green economy must contend with myriad institutional concerns. One effective way to characterize these relationships is through the development of clusters, or groups of geographically related components that mobilize in a particular way as an economy agglomerates. The global green economy will promote and demand the creation of green quadruple helix clusters that will encompass the activities that take place along the whole length of the green economy's value chain. From research and development investments, commercialization, distribution, adaptation and installation and final use, the creation and introduction of green helixes will play a key role in fostering the global green economy and green companies' competitiveness [65,71].

These helixes will play a pivotal role in creating green competitive advantages for nations and companies linked to them. Thus, nations and companies that are aiming at developing and gaining an additional competitive edge in the green economy will have to understand how they participate and navigate through these complex economic categories.

As demand increases for green products, services, technologies, and innovations, so too does demand increase for suppliers, distributors and related service providers, creating a green multiplier effect across several layers of national economies; and will expand the impacts on national and global backward and forward linkages [47,48].

An accurate global/national green economy quadruple helix should include the following elements: a) epistemic communities such as universities and research institutions or producers of green technologies and innovation, b) providers of green products and services, c) green consumers, which include the consumer as the foundation of a public institution that identifies itself in relation to a green economy, and last but not least d) the public sector and institutions that regulate or mediate green products and services.

The green economy will rely on producers of green technologies and innovations. The symbiotic relationship between universities, research institutions, end users, and government will be of extreme importance to keep on feeding the green economy with renewed impetus. Governments will also play a critical role by investing in emerging technologies and innovations, through universities and related research institutions. Additionally, government green standards will foster the development of new technologies, innovations, products, and services. Moreover, government policy can also induce the adoption of green related technologies, innovations, products, and services.

Consumers also play a very meaningful role in shaping the government's standards, policies, and incentives. Consumer preferences will shape green providers of green products and services, and will influence design, applications, and offerings in the marketplace. In the last few years, consumers and consumer groups have become strong advocates for greener products, services, and technologies. This includes increased awareness of business practices and the impact of those practices on the natural economy. However, more than ever, consumers will have to embrace a new green paradigm of consumption behavior, replacing self-interest and adherence to the old economy. Consumers, by definition, formulate a great part of their identity in relation to what they consume. As a result, the way that we mediate our social consciousness is directly related to the emergence of new communities that identify themselves as "green." Understanding this relationship is tantamount to the development of the cultural institution needed for a green economy to succeed. The government can provide incentive and disincentives for these changes in consumer preferences and behavior via carbon pricing and taxation [53]. However, future studies must also effectively capture the manner whereby consumers develop the horizontal kinship to "green-ness" needed to create significant capacity within an economy for growth.

The quadruple helix cluster (represented in Fig. 1) describes the internal economic synergies that will in return create additional multiplier effects and backward and forward linkages. For instance, each technology, innovation, product, and service will generate their own value chain network that in return will reinvigorate the cluster, eventually affecting the whole economy. It is important to note that these quadruple green helixes can have local, national, and global linkages, promoting green joint-ventures and alliances. This serves as a robust analytic framework whereby stakeholders in both the public and private sectors can both measure the emergence of a green economy and navigate initiatives that can effectively generate a green economy.

3. Water as a source of international competitiveness in the green economy

The 2012 UN Conference on Sustainable Development (UNCSD) or Rio+20 is organized with the following objectives: a) secure national and corporate political commitment for a greener economy, b) discuss new and emerging challenges to the development of a green economy, and c) assess progress toward global goals on sustainable development. The 2010 Summit also addressed two related themes: a) how a green economy will impact the eradication of poverty eradication and will promote sustainable development, and b) how to design an institutional framework for sustainable development.

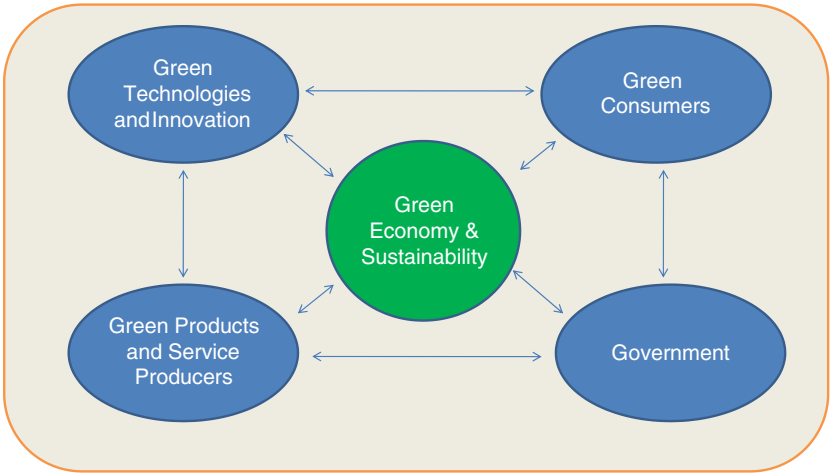

Fig. 1. The quadruple green helix.

The global economy and community are facing a number of pressing and interrelated problems. Therefore, it is more important than ever to introduce a pathway toward sustainable development that incorporates both economic growth and development. Several challenges currently threaten this pathway; we could cite: a) food crisis, b) energy crisis, c) water scarcity, d) biodiversity and ecosystem loss, e) climate security, and f) desertification [26,27,30,39,51,54].

Water, particularly potable water, is considered the "oil" of the 21st century, increasingly expensive and scarce, overwhelmed by a global growing demand. Unlike oil, however, water has no substitute and is finite, posing an increased threat to people, nations, and companies worldwide [35,62,68,81].

Globally, aquifers are falling below historical limits, glaciers are diminishing at record speeds, and rivers are showing consistently lower levels of water flow. The message is very clear: water is getting scarce and is getting scarcer at a geometric rate. In several countries, from India, China to the United States, demand is exceeding supply, leading to withdraws that exceed annual recharge [34,43].

Several issues contribute to an increasing water shortage: a) growing populations that are increasingly interconnected, and by extension, expand food preferences that demand more water; b) the green revolution has expanded the size of irrigation land increasing demand for water, that accounts for close to 70% of world's water withdraws; c) increasing industry needs, that account for 22% of world's water withdraws, d) increasing urbanization trends across the world, accounting for close to 8% of global water demand, and e) global climate change, that affects rain patterns all over the planet threatening to exacerbate water issues [20,22,35].

The increasing scarcity of water, amplified by global climate changes is increasingly imposing a threat to global economies and global business environment. Still, very few companies have taken a proactive approach to the long-term issues common to all markets within the global economy. Consequently, the large majority of businesses have ignored the financial and sustainable threats posed by this problem [15,71,85].

Aside from the inimitable role that water plays in our physical survival, water plays a vital role in the global economy, permeating every single dimension of the global business environment. It fosters and drives every single industry from agriculture to silicon chip manufacturing. The increased use of water has increased the cost of doing business in every industry in every sector of the global economy. In addition, safety and security issues are also emerging within the water business environment. These four dimensions of the water conundrum have forced nations to implement a number of policies and guidelines aimed at reducing the impact of business on water resources and reduce their water footprint [61,72,74,76]. However, by mediating water issues as a national problem, future solutions that are derived globally will face additional challenges, because national interests may disrupt practices that are commensurate with global sustainability.

The following measures will enable us to begin long term evaluations of water usage: a) changes in the allocation of water allotments; b) full-cost water pricing strategies; c) higher water quality regulations; d) increasing demand for more transparent water usage information by industries, and e) restrictions on investments and expansions by water-intensive companies, and f) the cost of translating water values beyond national interests.

In fact, several key-industries are already facing these water risks and threats [1,15,23,75]:

a) Countries that depend heavily on hydropower for their electricity will suffer energy issues as a result of drought-induced water shortages. For instance, in 2007, drought in Atlanta, Georgia, reduced hydropower generation by 51%.
b) Most of the world's 14 semiconductor manufacturers are in the Asia-Pacific region, where water scarcity is bound to be higher. For instance, both Intel and Texas Instruments Inc. use on average close to 11 billion gallons of water/year to produce silicon chips.
c) Beverage industry: large beverage companies such as PepsiCo and Coca-Cola are facing increasing opposition to their investments in water-poor countries such as India. Nestle is also facing similar opposition in California.

d) Agriculture: climate change is already affecting crop productions all over the planet, causing major supply disruptions and increasing prices. The 2009 drought in California costs farmer an estimated US$ 644 million and close to 24,000 in a state already burdened by the global recession.
e) Biofuels: it is estimated that for every gallon of ethanol, 4 gal of water are used. Increasingly, in the U.S.'s Midwest region, water conflicts are growing as a result of increasing demands of water by ethanol producers.

Recently several companies have introduced new technologies, innovations, and products to better manage water resources. From new drought-resistant genetically modified seeds, to dual-flush lavatories, an increased awareness for water saving has occurred and continues to develop among various stakeholders [87,90]. Increasingly, companies will have to take a number of steps to address these pressing water issues: a) a comprehensive measure of the company's water footprint, including its entire supply chain; b) a comprehensive assessment of all business related risks involved, such as regulatory and reputational risks; c) comprehensive analysis and integration of water related risks into the company's strategic planning.

Several companies are already proactively implementing "water footprint" reducing strategies — increasing their global water competitiveness, by reducing their water footprint:

a) Unilever has implemented the "Medusa" project that cuts its total water usage by 8%.
b) SAB Miller is introducing changes in its production processes that will save 25% of all the water they consume to produce beer.
c) Nestle has cut its water consumption by 1/3 since 2000.
d) Cisco is increasingly dependent on the use of recycled water.
e) Pinnacle West Capital Corp. discloses water discharges from its facilities, using treated wastewater to cool its Palo Alto nuclear reactor.
f) General Motors de Mexico uses water and wastewater treatment and recycling techniques that conserves water.

In a recent survey by [16], 73% of the companies surveyed showed some exposure to lower water supplies. It seems that companies are still not assessing this exposure seriously. Additionally, nations are increasingly concerned about multinationals impact on their water resources, including the lack of authority to encourage companies to respond to this exposure in a significant manner.

As shown in Fig. 2, the green water helix-knowledge intensive economy will have to acknowledge the four dimensions of water resources: a) availability, b) safety, c) quality, and security. Thus, the implementation of a green economy will also have to pay heed to these four dimensions of water resources, each dimension requiring the development of sustainable technologies and innovations to keep the green water helix in balance [38,91,94,95].

The simple availability of water resources will not be a "sine qua non" condition for water-intensive nations to benefit from the availability of water resources. Issues, like safety, quality and security of water resources will play a very meaningful role as well. Thus, it is very important to stress the interactions between the "quadruple helix" and the water helix. The interactions and synergies between the two will provide the framework needed for these companies and nations to gain additional competitive advantages from the existence of water resources.

The conjunction of a domestic quadruple green helix with the water helix will optimize the utilization of water resources and created synergies for the development of additional products, services, technologies and innovations (see Fig. 3).

4. Reshaping global trade and investment: the water quadruple triple helix

In an increasingly water-starved planet, economies and companies will face dramatic changes and water-related social, economic, and business choices. This is bound to create a major inflection point in the reallocation of economic power and business activities around the planet [5,64,66,77].

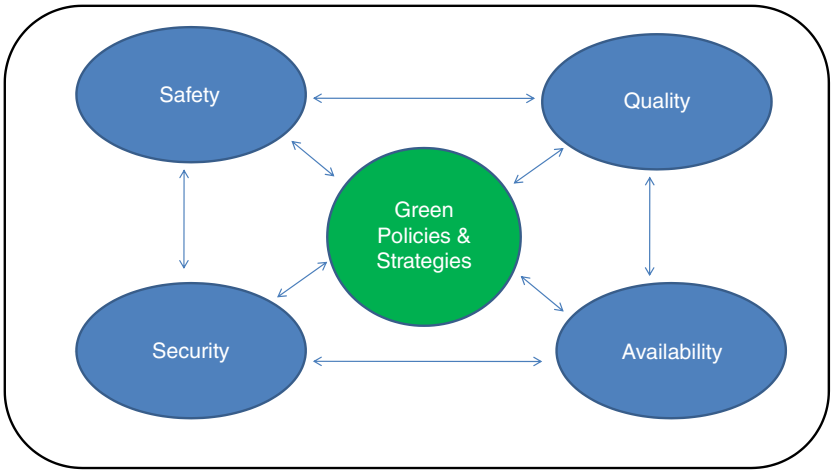

Fig. 2. Green water helix.

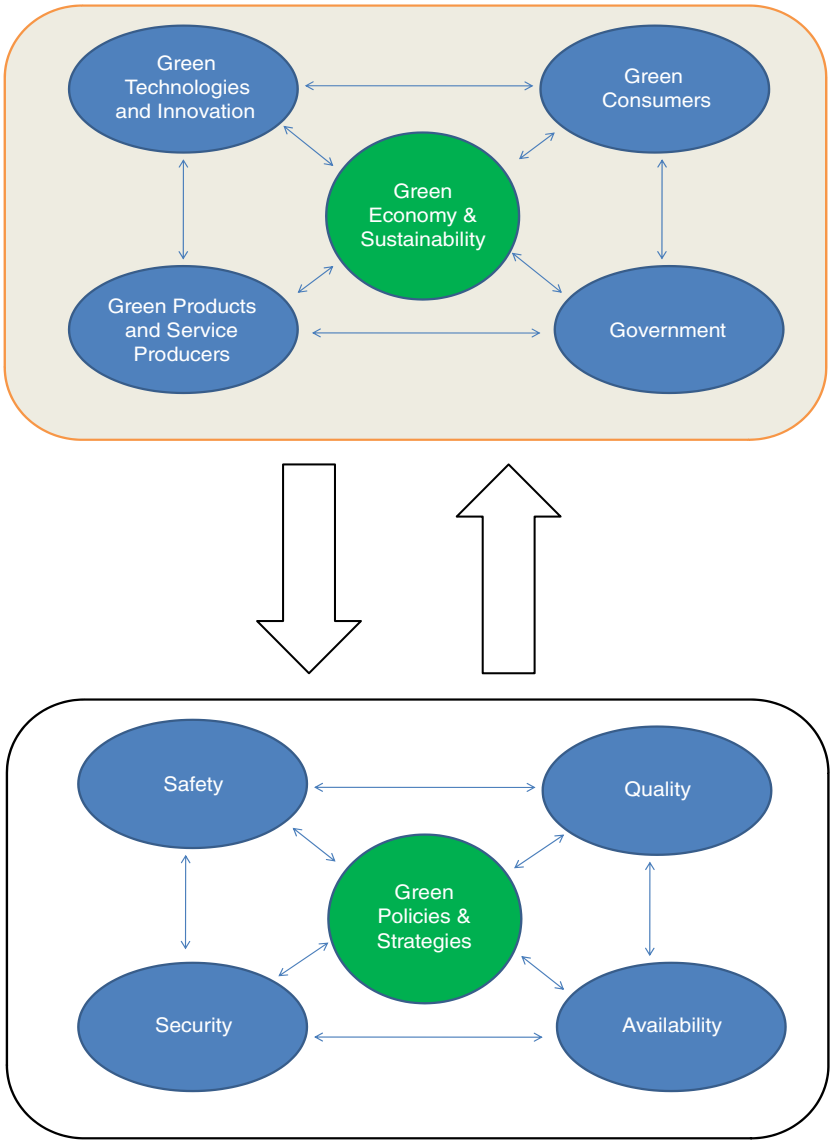

Fig. 3. Water cluster.

Moreover, water-related policy changes and guidelines, coupled with an increasing global climate change are bound to deeply affect the geography and landscape of global manufacturing and global trade.

Thus, water intensive products and water intensive agriculture will slowly gravitate toward water-intensive nations and regions, promoting a radical reallocation of business activities on a global basis. Countries like China and India that have specialized in water-intensive manufacturing will increasingly face domestic pressures to move these manufacturing activities offshore to water-rich nations. Additionally, they will be compelled to aggressively engage in the development and implementation of water-saving technologies and innovations, including the implementation of green water management policies and guidelines [34,44].

Both India and China are facing water challenges that are worsening, and that threaten the fabric of their societies and economies. For instance, the Himalayan Gangotri glacier, which is the source for most of the river Ganges' water, is shrinking by at least 40 m per year. By 2030, it is expected that the glacier will disappear imposing a heavy impact on India's water supply. Moreover, the poor management of India's water resources aggravates the situation. Industrial and human wastes are rapidly contaminating India's water supply. International demand for India's cotton products is also putting additional stress on its water resources (www.textileworld.com, [17,32]). In 2010, China became the world's largest water consumer, accounting for close to 13% of the world's total water consumption. Chinese aquifers are dropping, rivers are drying up and becoming more polluted [7,78]. Water is China's most important and crucial issue, bar none. Water scarcity and pollution will shape the future of China's steel, textiles, paper, and forest products, among other sectors of the Chinese economy, such as agriculture.

Thus, the next wave of global flows of foreign direct investments (FDI) may be heavily influenced by water-related restrictions and incentives. Water-rich countries, like Brazil, will likely receive additional investments by companies located in nations that are bound to experience water shortages. Thus a new cycle of water-related foreign direct investments will be created. This cycle will also affect the manufacturing capabilities portfolio of nations, and the de-industrialization resulting from this global reallocation of foreign direct investment will also generate additional losses of economic activity, resulting in a substantial loss of jobs, due to the labor-intensive nature of these manufacturing industries, such as electronics, textiles, and automobiles. Another possibility is for these water-poor countries to subcontract water-rich countries to manufacture parts and components, assigning an "assembling–maquiladora" function to countries that were formerly vertical producers of water-intensive products. This shift is also bound to create additional economic disturbances in countries that will have to move from a vertical to a horizontal manufacturing process, deeply affecting domestic backward and forward linkages.

International trade flows will also be substantially affected by this new water economic paradigm. On the one hand, water-poor countries will develop the institutional intelligence necessary to contend with water disputes, a product that will be valued globally. On the other hand, relatively water-rich countries will have to adopt ways to contend with their resources that can accommodate the needs of trading partners with less water. Both of these problems create new business paradigms that will be mediated internationally among trading partners. Water has become a conduit for international trade. The level of water embedded in products and their related "virtual water" content, and its related water footprint will be the new paradigms for the reshaping of global trade flows. If the "virtual water" embedded in these manufacturing and agriculture products is properly compensated, water-rich nations will experience higher prices for their water-intensive products and commodities. In addition, these nations will also experience an additional diversification and expansion of their manufacturing and agricultural industries, toward more water-intensive economic activities. Thus, unfettered trade and investments policies will have to be implemented on a global scale in order to assure the optimum global reallocation of water-intensive economic activities toward water-rich countries.

5. Final remarks

The global economy and community are facing a number of pressing and interrelated economic and environmental problems. Therefore, it is more important than ever to introduce a sustainable development pathway that leads to global sustainable economic growth and development. Several challenges are currently threatening to derail this sustainable path, among them we could cite: a) food crisis, b) energy crisis, c) water scarcity, d) biodiversity and ecosystem loss, e) climate security, and f) desertification. It is becoming clear that the proposal to "green" the global economy could address a number of these concerns.

Future studies will benefit from understanding the way that a social consciousness emerges in relation to green technologies, particularly how we may identify the emergence of "imagined communities" that produce horizontal kinships toward a green economy. This type of study will help describe the evolution of both the green consumer and the green citizen within the global political economy. While most of these issues are mediated nationally and through international trade, it is clear that water and the development of a green economy is a global problem, and we must begin to distinguish the two in order to identify the cost of producing a universally applicable model commensurate with the needs of a global political economy.

This paper argues that the "green economy" will shape the global economy in the next decades, impacting the way nations and companies address their natural capital resources and constraints. This paper introduces the concept of a quadruple helix and of a water helix, proposing the interaction of both in order to create additional competitive advantages for water-rich countries. The creation of a quadruple helix coupled to a water helix, however, will demand a number of components and dimensions in order for a water cluster to flourish. Water is bound to permeate and affect international trade and foreign direct investments on a global level, deeply affecting the location and distribution of global supply chains. Water-intensive countries, in order to capitalize on their water endowments, however, should contemplate the establishments of water clusters in order to optimize the utilization of their water resources, and to create and gain additional competitive advantages.

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