Effects of the Policy and Human Intervention on the Infrastructure-Environment Nexus in China

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Abstract: With the outstanding investment in infrastructure during the past decades, the evaluation of the infrastructure-environment nexus is highly required to achieve the sustainable development of economy, resources and environment, as well as human being. This study analyzes the supply-chain-wide blue water withdrawal occurred in China for global infrastructure development, and one step further, the potential effects of policy and human intervention on future infrastructure-related environmental performances. Our results showed that the blue water withdrawal in China was main for the domestic infrastructure construction because of its rapid-growing investment, coupled with that in the United States, Japan, and India. Energy-related products (e.g., “Electricity by coal”) and primary materials (e.g., “Basic iron and steel”), highly required for the construction of infrastructure, have played relatively great roles in China’s blue water withdrawal. For the future sustainable development of infrastructure, we also addressed that efficiency improvement and nonconventional water resource utilization could cover half of the blue water gap between the current development trend and the sustainable one. In light of the synergies among infrastructure development, environmental sustainability and socioeconomic intervention, it is vital to uphold economic and environmental efficiency in the decision-making of infrastructure development.

Keywords: infrastructure-environment nexus; policy analysis; human intervention; structure decomposition analysis; sustainable development

1. Introduction

Infrastructure, e.g., roads and railways or wastewater and sanitation services or communication networks, enables daily commercial production, facilitates government operation and shelters and transports the population [1,2]. Constructing, utilizing and maintaining infrastructure require significant capital investment, at approximately USD $2.3 trillion per year around the world, which plays a major role in economic growth and is generally resource-demanding, especially during early stages of development [3–5]. In a period of unprecedented economic growth, China increased its share of world gross domestic product (GDP) from less than 2% in 1990 to nearly 15% in 2015 [6]. A prominent feature of China’s economic growth has been credited to the investment-led domestic savings, particularly the large-scale investment in physical infrastructure [7,8]. As a consequence, huge environmental pressures (e.g., energy use, water consumption, greenhouse gas emissions and metal ore extractions) were appropriated in China for its infrastructure development.
The World Bank pointed out the concept of infrastructure-environment nexus in 2007, which aimed to reach the optimized balance of meeting the demand of infrastructure services, while maintaining or improving the quality of the environment [9]. The quantity of studies has grown recently. Davis et al. [10] revealed that the CO₂ emission around the world would be mainly contributed by infrastructure between 2010 to 2060. Considering the influences of capital stock on the environmental impacts, Chen et al. [11] developed a dynamic model that involved the capital stock and found out that the model address more differently for fast-developing countries. Researchers also tempted to reduce the environmental impact by optimizing the operation and construction of infrastructure. Zhang et al. [12] optimized the logistics infrastructure investment (e.g., freight transportation) and green subsidies to reduce carbon emission. Li et al. [13] integrated multi-objective optimization and life cycle assessment to optimize the rainwater harvesting infrastructure in Beijing, and found the green infrastructure like green lands could bring the most socioeconomic benefits, but the least environmental impacts. However, a limited number of studies have looked into the supply-chain-wide infrastructure-water nexus [14,15], and there is little knowledge about the effects of national policies and human intervention on the environmental consequences of infrastructure development.

Policies by governments or decisions by stakeholders, although mainly focusing on the results, are always influencing the environmental performances of economic production and daily lives [16,17]. However, the actual transitions according to the policies and decisions, e.g., technological adoptions or economic structure changes, as well as their future effects on the pathways of sustainable development are not well known. Particularly for the water in China, policies restrictions on the maximal water withdrawal and the water efficiency played a great role in decelerating the national water use during the past two decades [18]. While the future water use and the associated water stress in those main water-exporting provinces (e.g., Xinjiang, Heilongjiang, and Inner Mongolia) are also highly depended on the full implementation of policy initiatives relating to water use and economic development [19]. Given the high proportion of infrastructure investment in China’s GDP, the assessment of the infrastructure-water nexus and its future performance under the current policies are critical to understanding the interdependencies of infrastructure development and the associated environmental consequences.

This study aims to explore the nexus between the territorial blue water withdrawal in China and the global infrastructure development during the past two decades, by the environmentally extended multi-regional input-output (EEMRIO) model, as well as the potential effects of policy and human intervention on the nexus in near future. The concept of environmental “footprint” is referred to account the total environmental pressures, including direct and indirect throughout the entire supply and use chain, of the goods and services consumed in one certain region [20–22]. The historical key drivers for the infrastructure-related water withdrawal are revealed by structural decomposition analysis (SDA). Based on that, we further predict the future trend of water demand for infrastructure investment, through modelling the potential policy and human intervention based on the recently launched water-related policies in China (Table 1). Our results could provide stakeholders with scientific information for the strategies and policy making about water resource management in China and far beyond.
Table 1. Summary of recent water-related policies and plans in China.

| Policy/Planning                              | 2015          | 2020          | 2030          |
|----------------------------------------------|---------------|---------------|---------------|
| Water                                         |               |               |               |
| Water Withdrawal                              | 635 BCM       | 670 BCM       | 700 BCM       |
| Irrigation efficiency                         | 53%           | 55%           | 60%           |
| Water intensity of 1300 Euros (10,000 CNY) of industrial value added | 30% below 2010 figures | 65 m³ | 40 m³ |
| Water function zones achieving water quality standard more than | 60%           | 80%           | 95%           |
| National Water Resources Planning             |               |               |               |
| Water withdrawal for agriculture              | 420 BCM       |               |               |
| Irrigation                                    | 370 BCM       |               |               |
| Livestock                                     | 28 BCM        |               |               |
| Water withdrawal for industry                 | 172 BCM       |               |               |
| Water withdrawal for domestic                 | 102 BCM       |               |               |
| Urban                                         | 54 BCM        |               |               |
| Nonconventional water resources               | 16.6 BCM      |               |               |
| Water intensity of 1300 Euros (10,000 CNY) of value added | 120 m³ | 70 m³ |
| GDP                                           | 7.2 trillion Euros (56 trillion CNY) | 8 trillion Euros (62 trillion CNY) |
| Population                                    | 1.44 billion  | 1.5 billion   |               |
| Urban                                         | 0.8 billion   | 0.94 billion  |               |
| General                                       |               |               |               |
| China’s 13th Five-Year Plan                   |               |               |               |
| Water intensity of 1300 Euros (10,000 CNY) of industrial value added | -23% * |

Notes: BCM: billion cubic meters; CNY: Chinese Yuan; * compared with the corresponding figure in 2015.

2. Methods

2.1. China’s Situations

2.1.1. Gross Capital Formation in China

Data about the investment in infrastructure is not available in annual national account, whereas there is another economic term as gross capital formation (GCF) which is the investment of capital assets and mostly for infrastructure, e.g., roads, bridges, power plants, or communication networks [2]. The GCF (Figure 1), including the investment in domestic China and exported to other countries, has increased rapidly over the period 1995–2016, from 205 billion Euros to 3953 billion Euros with an average annual growth rate of 15% [23,24]. The share of GCF in total final demand (i.e., final expenditure of households, government, non-profit organization and GCF) illustrated a trend of decreasing before 2000 whereas increasing after 2000, accounting for around 32% of in recent years.

The overall increasing of GCF was primarily a result of the growing investment in infrastructure construction. In particular, 89% of the investment throughout the study period was for domestic infrastructure construction, such as the China Railway High-Speed network (gross investment more than 1.5 trillion Euros by the end of 2010), real estate booms (approximately 31,000 km² of floor space, or 22 m² per capita per year, were added during 2003–2014), and emerging internet communications (e.g., 4G/5G network facilities). Between 2007 and 2015, China accounted for almost 30% of all global infrastructure investment [2]. Although the growing trend of GCF slows down recently, it still occupies almost half of the GDP in China [6]; in contrast, GCF in the Organisation for Economic Co-operation and Development (OECD) countries is on average 21% of GDP.
2. Methods

2.1. China’s Situations

2.1.1. Gross Capital Formation in China

The overall increasing of GCF was primarily a result of the growing investment in infrastructure. The share of GCF in total final demand (i.e., final expenditure of households, government and non-profit organizations) illustrated a trend of decreasing before annual growth rate of 15% [23,24]. The share of GCF in total final demand (i.e., final expenditure of households, government and non-profit organizations) to other countries; “Dom. GCF”: domestic gross capital formation; “Exp. GCF”: exported gross capital formation to other countries. Results in the figure are calculated based on Exiobase 3.6 [24].

2.1.2. Future Investment of China

Under current trends, China’s infrastructure investment is forecast to be slightly over 24 trillion Euros, or 1.0 trillion Euros per year by 2040 [2,25]. Based on China’s recent performance on infrastructure investment, relatively small growth in investment is required for China to match the performance of its top performing peers. Therefore, the infrastructure need is forecast just 7% higher than under current trends [2]. The road and electricity sectors would account for a large proportion of China’s future spending need. The proportion of investment in rail and road infrastructure could increase in future, while electricity may account for a slightly smaller share of investment than in the past. Together they account for 16.5 trillion Euros out of the 24 trillion total spending forecast under current trends. Rail also plays an unusually prominent role within the Chinese infrastructure market as the country continues to develop a network of high-speed lines (CRH) to link its major cities. Under current trends, 5 trillion Euros of investment in rail infrastructure is expected between 2016 and 2040. Moreover, the “China–Pakistan Economic Corridor”—announced in 2015 as part of the Belt and Road Initiative, which aims to establish a regional cooperative framework from east to west—involves 57 billion Euros of Chinese investment, which is more than the investment in infrastructure has occurred since the creation of the state of Pakistan [26].

2.1.3. National Policies for Water in China

China’s water shortage has increased to 40 BCM in recent years, and about half of the population face a certain degree of water scarcity [27–29]. In this study, we summarized two water-related, and one general policies to set the targets of water use by 2030, as well as 2050 for a long-term analysis (Table 1). The “Three Red Lines” water policy, regarded as China’s strictest water resource management policy in history, targeted: (1) the national water withdrawal (maximum of 670 BCM in 2020, and 700 BCM in 2030); (2) the improvement of irrigation efficiency to 55% in 2020 and 60% in 2030; (3) the water intensity of economic output (65 m³ per 1300 Euros of industrial value added in 2020, and 40
m$^3$ in 2030); and (4) the reduction of water pollution. Furthermore, the National Water Resources Planning provides the water withdrawal for detailed sectors and household, as well as the potential non-conventional water resource (e.g., rainwater or wastewater) by 2030.

2.2. Environmental Extended Multi-Regional Input-Output (EEMRIO) Modelling

Wassily Leontief developed the input-output (IO) model as an analytical framework of monetary input for production and output of sectors in the United States in the late 1930s [30]. The international trade inherent in globalization has proved the territorial resource use not only benefiting the domestic consumption of goods and services, but also the human needs in other countries [20,31]. In this study, we adopted the transformed IO table, i.e., EEMRIO table [21,22,32,33], to analyze the supply-chain-wide environmental pressures in China of global infrastructure investment. We use the version 3.6 of the EXIOBASE database for further calculation [24], which includes the EEMRIO tables for 44 countries and 5 aggregated regions with a 200-product resolution during 1995–2016. The final demands consist of final expenditure by households, government and non-profit organizations, and gross capital formation (GCF). The balance of production for sector $i$ will be presented as Equation (1):

$$X_r^i = \sum_s \sum_j x_{ij}^{rs} + \sum_s \sum_k F_{ik}^{rs}$$

where $X_r^i$ is the total output of sector $i$ in region $r$; $x_{ij}^{rs}$ is the intermediate input of sector $i$ in region $r$ to sector $j$ in region $s$; $F_{ik}^{rs}$ is the final demand of category $k$ in region $s$ from sector $i$ in region $r$.

The direct input coefficient ($a_{ij}^{rs}$) is defined as the direct input from sector $i$ in region $r$ for increasing unit output of sector $j$ in region $s$ [34], calculated by Equation (2):

$$a_{ij}^{rs} = \frac{x_{ij}^{rs}}{X_j^s}$$

Then, Equation (1) could be rewritten as (3):

$$X_r^i = \sum_s \sum_j a_{ij}^{rs}X_j^s + \sum_s \sum_k F_{ik}^{rs}$$

Equation (3) could also be transferred into matrix formats as Equation (4) or Equation (5):

$$x = Ax + y$$

$$x = (I - A)^{-1}y = Ly$$

where $x$ is the total output vector; $A$ is the technical coefficient matrix, with elements of $a_{ij}^{rs}$; $I$ is the identity matrix; $y$ is the finial demand matrix; $L$ is the Leontief inverse matrix, defined as the total inputs from sector $i$ in region $r$ for increasing one monetary unit output of sector $j$ in region $s$.

The environmental pressure ($ef$) embedded in final demand could be calculated by:

$$ef = fLy$$

where $f$ is the environmental coefficient vector indicating environmental intensity of each sector.

2.3. Structural Decomposition Analysis (SDA)

To apply the SDA into a standard MRIO modelling, we further decompose the GCF ($yk$) into:

$$yk = Mp$$
where $M$ is the per-capita GCF mix matrix, representing the per-capita GCF from each sector; $p$ is population in a scalar quantity. Equation (6) is therefore converted into Equation (8):

$$ef = fLMp$$

(8)

The structural decomposition form of Equation (3) is shown in:

$$\Delta ef = \Delta fLMp + f\Delta LMp + fL\Delta Mp + fLM\Delta p$$

(9)

The notation $\Delta ef$ indicates the change in total environmental pressure. The right side indicates the change in total environmental pressure driven by the change in environmental coefficient $\Delta f$, production structure $\Delta L$, GCF mix $\Delta M$, and population $\Delta p$. Because there will be $n!$ kinds of decomposition forms if the number of decomposed factors is $n$, we use the average of all possible decomposition forms to address this problem [35,36].

2.4. Wedge Approach

A framework of “wedges”, following reference [37], is applied to examine the corresponding effect of policies and human intervention on the reduction of blue water withdrawal of infrastructure investment, compared with a business-as-usual (BAU) scenario (a continuously rising resource demand) to an alternative future with stabilize water requirements. The minimal water withdrawal is set by the policy control in the “Three Red Lines” policy by 2020 and 2030. We assume that the annual increasing rate of blue water withdrawal after 2030 is equal to the annual average increasing rate between 2020 and 2030, referred into a national policy control (NPC) scenario.

According to the results of SDA as well as the water-related policy, we consider four interventions, i.e., lower-water-intensity production (including the improvement in irrigational efficiency), lower infrastructure investment as much as the current level of OECD countries (an average of 21% of their GDPs), population control and nonconventional water resource utilization. We analyze the relative contribution of each intervention on covering the blue water gap between the BAU scenario and NPC scenario. The irrigational efficiency is targeted to 0.6 and 0.65 in 2030 and 2050, respectively, while the water intensity of industrial sectors is consistent with those targeted in the “Three Red Line” policy and assumed identical after 2030. The population is predicted to reach 1.40 billion in 2030 and 1.31 billion in 2050 under the high challenging shared socio-economic pathway (SSP) for the BAU scenario, whereas it is predicted to be 1.36 billion in 2030 and 1.22 billion in 2050 under the low challenging SSP for a sustainable pathway [38]. The utilization volume of nonconventional water resources is targeted to 16.6 BCM in 2030 in National Water Resources Planning (2010–2030), with an annual average increasing rate of 8%. Change in each factor is represented by the associated change in each element of Equation (8). The economic technical coefficient matrix ($A$) is adjusted by the RAS technique [39,40], according to the predicted GDP in 2050 [41].

3. Results

3.1. Territorial Blue Water Withdrawal of Global Infrastructure Investment

The territorial blue water withdrawal in China for global infrastructure investment showed an overall growing trend during the past two decades (Figure 2A), from 39 BCM in 1995 to 121 BCM in 2016. Blue water was mainly abstracted to meet the domestic infrastructure investment (accounting for 77% in 2016), followed by ROW Asia and Pacific (6%) and the United States (5%). Geographical distance would be the major factor, which directly influences the transportation cost of traded products [42], for those Asian countries and regions (i.e., Japan, India and ROW Asia) listed in the top five regions/countries for China’s blue water exporting. The blue water exported to ROW Middle East illustrated a 16-fold increase over the period of 1995-2016, with an average increasing rate of 14% per year, and particularly up to 19% between 2013–2014. The Belt and Road Initiative from east
to west, as mentioned in the section Future investment of China, can explain this rapid increase. It will unprecedentedly enhance the economic activities and resource sharing among China, the Middle East, Africa and Europe.

![Figure 2. Territorial pressures in China for global infrastructure development: blue water withdrawal from the perspective of exporting destination (A) and sectoral contributions (B). "RoW": rest of world; "RoP": rest of products; BCM: billion cubic meters.](image)

We also note that the decrease of territorial blue water pressures before 2000 and in 2008 contradicted the overall trend. The decrease before 2000 was mainly due to the reduction of the requirements of water-intensity products, such as “Electricity by coal”, “Basic iron and steel and of ferro-alloys and first products” and “Plastic, basic” shown in Figure 2B. The depression of the territorial blue water pressures in 2008 was driven by multiple factors, mainly for the blue water reduction for the global production arising from the financial crisis. Furthermore, the product category of “Electricity by coal” played the most significant role in the territorial blue water pressures, which is quite different from the case that agricultural products (e.g., “Cereal gains”) dominate the blue water pressures of total final demand (i.e., including both Non-GCF and GCF). This could be explained by the high requirement of energy for infrastructure construction and the coal-dominated energy structure in China (accounting for 69% of annual energy use).

### 3.2. Key Drivers for the Infrastructure-Related Blue Water Withdrawal in China

Our results reveal that the changes in water coefficient is the key driver to reduce the blue water withdrawal of infrastructure, whereas per-capital GCF and population are the main factors to increase the water withdrawal during the period of 1995–2015 (Figure 3). For details, per-capital GCF and population made a 138 BCM and 10 BCM contribution on the increase of water withdrawal since 1995, respectively, if other factors remain constant. The increase of per-capital GCF represents the rapid growth of infrastructure investment recently (details see section Gross capital formation in China), especially in domestic China with a 124 BCM contribution of the total 138 BCM increase of blue water withdrawal. It should also be noted that its effect has been shrinking obviously in recent years, while with the largest contribution during the period 2005–2010 (for a gross 58 BCM increase). The effect of population growth on blue water withdrawal is conservative in this historical trend analysis. This could be explained by the relatively low growth rate of population (5%) before 2015, after which the center government of China launched the “Open Second Child” policy. The growth rate of China’s population could increase in near future, and its effect in both economic development and environmental impacts could intensify.
Figure 3. Contribution of each driver to the change in total blue water withdrawal of infrastructure development during the period of 1995–2015.

The changes in water coefficient—namely the changes in water intensity which is highly related to the technology improvement—contributed a substantial 86 BCM decrease of blue water withdrawal during the study period, if other factors remain constant. Technology improvement, particularly in those water-intensive sectors like food manufacturing, paper printing manufacturing and chemical product manufacturing, which are also listed in the main products that require the most water withdrawal of infrastructure in Figure 2B, is the key factor for the reduction of blue water withdrawal. Moreover, the water intensity of industrial value added has been set in the “Three Red Line” policy (Table 1), which implies that stakeholders or policy makers also believe this could be an efficient method to decline the water requirement for economic production. Last but not least, the production structure contributed the least 0.5 BCM increase in blue water withdrawal. It should also be noted that it did not show a consistent effect on the changes in blue water withdrawal, with positive effects during the periods of 2000–2005 and 2010–2015, whereas negative effects were shown during the periods of 1995–2000 and 2005–2010.

3.3. Policy and Human Intervention on the Infrastructure-Environmental Nexus

Based on the major drivers for the infrastructure-related water withdrawal as well as the associated policies in China, we analyze four potential strategies, i.e., lower-water-intensity production (including the improvement in irrigational efficiency), lower infrastructure investment, population control and nonconventional water resource utilization, to determine the relative efforts by each wedge to reduce blue water withdrawal into a sustainability level (Figure 4).

We find that the strategies with absolute effects to reduce blue water withdrawal (i.e., lower-water-intensity production and nonconventional water resource utilization) could make main contributions (33% and 23%, respectively) to cover the blue water gap between the BAU scenario and the NPC scenario. Economic production with lower water-intensity, which has been proved as the most powerful driver to reduce water withdrawal (Figure 3), could also play a great role in future blue water reduction. Particularly for irrigational efficiency, it was 0.48 in China of year 2008, which was generally lower that in the United States and Japan. It was specifically targeted in the “Three Red Line” that the irrigational efficiency is targeted into more than 0.55 by 2020, and more than 0.60 by 2030. A switch from flood irrigation to water-saving irrigation technologies (e.g., sprinkler or drip) or widely using cost-efficient mulching could help achieve this goal [43,44]. In addition, as we discussed before, the reduction in the water intensity of high-requirement products for infrastructure construction (Figure 2B) could also be a key factor for the reduction of blue water withdrawal. Non-conventional water resource utilization and management have been a hotspot in recent years in China, especially the “Sponge City” construction for rainwater harvesting, as well as reclaimed water reuse which
both obtain powerful supports from the government. Although the non-conventional water resource utilization and management require significant infrastructure investment and resource inputs in the future, it could potentially reduce 23% of the blue water withdrawal as an important benefit.

![Figure 4](image-url)

**Figure 4.** Effect of the policy and human intervention on China’s blue water withdrawal for global infrastructure construction by 2050. “Non-con. wat. res.” represents nonconventional water resource utilization.

Strategies with relative effects, which compared with that in the BAU scenario, also share a 33% contribution (18% and 15% by lower infrastructure investment and population control, respectively) to cover the blue water gap. Although the unprecedented growth of investment on infrastructure in China has been the most significant factor to increase the historical blue water withdrawal (Figure 3), the future prediction of China’s infrastructure investment would be slow (details see section Future investment of China). Compared with the BAU scenario with the historical investment pace (around 45% of its GDP), the lower investment on infrastructure in China, as much as the level of the OECD countries (an average of 21% of their GDPs), could make the second largest contribution (18%) to curve the blue water withdrawal to a sustainable pathway. Given the policy “Open Second Child” launched in 2015, we assume that there could be a new population boom in near future in China. If we could keep the population under the low challenging SSP for a sustainable growth, it could be a potential solution to cover the blue water gap (accounting for 15%). It should also be noted that the potential effect of the policy “Open Second Child” on birth rates is unknown, since the birth rate in China in 2017 was 1.680 per woman, 1.690 in 2018 and 1.693 in 2019, according to the United Nations Population Division [45]. Economic development is changing the birth and fertility rates in developed countries. Compared with the growth in the population, the migration of rural population to urban namely “urbanization” will play a more significant role in the environmental and economic development [46]. The rest around 10% of water gap could be covered by other measures, like the reduction of water waste by end-users, or the reduction of water loss in the supply pipelines and etc.

4. Discussion

Our research reveals the supply-chain-wide environmental pressures occurred in China for global infrastructure development, and one step further, the potential effects of policy and human intervention on future infrastructure-related environmental performances. Our results showed that the blue water withdrawal in China was predominated by domestic infrastructure construction (accounting for 68–84%), which was driven by China’s rapid-growing infrastructure investment, coupled with that in the United States, Japan, India, and other countries in Asia and the Middle East. Our results also shed lights on China’s strategies to reduce the environmental pressures for global infrastructure
development. We address that efficiency improvement and non-conventional water resource utilization, both being policy-oriented, could make great contributions (33% and 23%, respectively) to covering the blue water gap between the BAU scenario and the NPC scenario. Given the previous finding that the implementation of policy initiatives relating to water use and economic development has been significantly influencing the national water withdrawal and water stress situations in China [18,19], our study further strengthens this hypothesis from the perspective of infrastructure development and its environmental performances influenced by environmental policies and human intervention. Last but not least, due to the long life spans of infrastructure, future generations are locked into operating and maintaining historically-developed stocks and the specific use patterns of infrastructure, which may no longer meet future needs of resources efficiency and climate change mitigation [47,48]. This line of research is beyond the scope of this analysis but worth future explorations.

Future policy-making needs pay more attention to the “quality” (resource-efficient and environmental friendly), rather than only “quantity” (more than USD 94 trillion predicted by 2040) of infrastructure development [2,25]. Infrastructure either directly or indirectly influences all 17 of the sustainable development goals (SDGs) [25], such as water supply and treatment plants (SDG 6, clean water and sanitation), power plants (SDG 7, affordable and clean energy), transport infrastructure (SDG 8, industry, innovation and infrastructure), as well as digital communication networks (SDG 11, sustainable cities and communities). The associated environmental pressures for infrastructure, including both internal-and-external/temporal-and-future, should be comprehensively considered. For instance, accounting for the temporal dynamics of greenhouse gas emitted during current infrastructure development and their attributions to future use can help make equitable carbon budgets at the national and global scales. As for developing countries like China, decreasing the net exports of major resources, like blue water, energy and raw materials, will be the priority in the following two decades. If the shift of resource demands and environmental pressures cannot be avoided within the international trade, policy-makers could establish more rational decisions to seek more sustainable development from a global scope, e.g., interventions for curbing consumption and advancing production technologies [49,50], or exporting (importing) highly resource-efficient commodities from relatively resource-deficient (sufficient) regions [51]. This requires international collaboration between governments, financial institutions, companies and others [52], based on an understanding of shared responsibility.

With the expansion of agricultural and manufacturing production from Asia to Africa, more and more capital investment will influx particularly on infrastructure construction. The total infrastructure investment forecast for Africa is projected more than USD 4.3 trillion up to 2040 [25]. Thus, the lessons from China infrastructure development and environmental challenges could provide more practical instructions for the infrastructure investment and environmental issues in Africa. These points include: (1) advanced technologies, especially for high resource-intensive sectors; (2) more investments in sustainable basic infrastructure. Infrastructure investments also commit future generations to the costs of operation and maintenance, which demand continuous resource consumption and capital inputs throughout their life spans; (3) optimizing economic structure. Economic development should depend more on services and emerging sectors instead of industry and agriculture. Fully taking the advantage of labor resources and land resources in Africa to produce cheaper and greener productions could make them more competitive in the international market, as well as for environmental tax debt.

Lastly, the limitation of this study could be described in three aspects: first is the environmental accounts from EXIOBASE: there are some data missing in the intermediate table and the environmental extended matrix, which make our results more sensitive to data availability, but not easy to expand for a long time-series analysis; second would be the gross capital formation here may not apply for all infrastructure construction, it could also be used for internet network updates and so on; the last limitation would be the parameter prediction in 2050, such as population in the wake of the current period of the COVID-19 pandemic, which will change a lot and also influence the birth and death rates in the following years. Further studies should be carried out for more reliable data sources or
multiple data sources to fill the missing data, and for the future scenarios formulation, and national policy should be considered sufficiently for a more practical scenario.

5. Conclusions

This study fills one current research gap about the supply-chain-wide environmental pressures of infrastructure development, and the potential effects of policy and human intervention on future infrastructure-related environmental performances. We selected China as the study area, due to the outstanding infrastructure investment pace and its great contribution in China’s national GDP. Our results showed that the rapid increase in China’s blue water withdrawal of global infrastructure development was predominated by its intensive investment pace, and suggested the potential strategies, e.g., environmental efficiency improvement and nonconventional water resource utilization, to curve China’s current water withdrawal pathway into a sustainable one. Based on our results, we also suggest that the future policy-making needs pay more attention to the “quality” (resource-efficient and environmental friendly to reduce the cost of operation and maintenance for the next generations), rather than only “quantity” of infrastructure development, not only in China, but also in other developing countries, especially Africa, with the current expansion of global commodity production from Asia to Africa due to the cheaper labor and land resources there. Regarding the limitations of our study, we also suggest potential studies that could rely on more reliable data sources or multiple data sources to fill the missing data, and consider the national policy sufficiently for the development of future scenarios.

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