Challenges and Paths for Sustainable Development in China

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Abstract. With China announcing its dual carbon goals in 2020 and its promotion of sustainability policies in the 14th Five-Year Plan, sustainable development has become an increasingly important issue. In the context of sustainable development, China's society has some defects in science and technology, policy governance, environmental governance and economic development, and the technology is not perfect. There are scientific and technological challenges such as renewable energy development and utilization; governance challenges such as international cooperation over climate issues and domestic regulations. In terms of the environment, China's air, water resources, soil and physical pollution are still not optimistic. The economic problems in the context of sustainable development have different defects. Corresponding improvement measures to address such challenges have been suggested. For science and technology, developing and utilizing new energy through increasing the number of research and development (R&D) personnel and patents is important. Furthermore, completing the innovation of clean technology through updating technology and policy support is also a big issue. For political governance challenges, some analysts pointed that a shared knowledge platform helps with international cooperation, and non-state actors such as non-governmental organizations (NGOs) and businesses could contribute to domestic regulations. For environmental governance, air pollution is controlled through the development of carbon capture, utilization and storage (CCUS) technology, the control of soil pollution is achieved through ex-situ remediation and in-situ repair technology, the control of water pollution is achieved by developing microorganisms and other methods. For economic development, innovation, policy support, and financial framework are vital.

Keywords: Sustainable development; technology; policy; environment; economic.

1. Introduction

With China announcing dual carbon goals in 2020, there has been a wave of political and economic efforts at the local and state levels to achieve environmental and ultimately sustainable development goals. The goals of sustainability come with complex challenges and barriers from technical, economic, and political areas. Addressing these challenges requires a diverse combination of scientific expertise, policies, and practices. To date, however, there hasn't been enough theoretical groundwork developed in this field to support the system-level change China needs to achieve sustainability.

China's path to sustainable development is not a single, unchanging one; it is diverse, open and evolving. As such, China's efforts to achieve sustainable development are also extremely challenging. At present, the existing literature only analyses China's sustainable development from a certain perspective. However, as the context of the times and the world landscape is constantly changing, China's sustainable development program should be multi-perspective, holistic and constantly evolving and optimized. In terms of the general direction of China's sustainable development, there are a number of problems or shortcomings in science and technology, policy governance, ecological management and economic development that need to be addressed to some extent.

The main purpose of this paper is to come up with suggestions for sustainable development in China. The paper first classifies those problems into technology, governance, environment and economy. Then analyzes the causes. Corresponding suggestions for improvements in the future are presented at the end of the paper.

2. Challenges of Sustainable Development

2.1. Science and Technology

2.1.1. Renewable energy development and utilization

The energy technology in China is still lagging behind developed economies such as the US, EU, Japan and Korea, which have more control of many core technologies. For example, the practice of enhanced geothermal demonstration experiments, which has been conducted in European countries and the US 30 years ago, has entered the theoretical and simulation research phase in China [1, 2]. This greatly influences the efficiency and cost of energy supply. Besides, the energy supply of China relies heavily on equipment with core technology controlled by other countries such as solar photovoltaic technology, solar photovoltaic hot spots, and lithium-ion battery separators, and import charges also cost a lot. These add more burden to the energy supply, which leads to a closed domestic market and a lack of competitiveness in the international market [1, 2].

2.1.2. Green technology

Green technology innovation is also very important. However, most of China's research and development levels fluctuate greatly, and can only complete the research and development of marginal aspects. Thus, it is difficult to achieve a breakthrough in core technology. This has led to the difficulty for enterprises to improve their technical strength, complete R&D independently, and carry out technological innovation [3].

The development of green technology requires the coordination of economy, society, and ecology. Thus, enterprises should meet higher requirements, such as more investment. Yet that can also bring greater risks. In addition, the current laws, regulations, policies and incentive mechanisms are also not sound enough for an enabling environment for companies. Besides, long technology development cycle and low return rate make it difficult for enterprises, for whom the maximum profits are what counts most, to invest much time and energy in green technology in the competitive market, despite the possible comprehensive benefits and great potential in it. Without interests serving as a driving force, the innovation of green energy is not promising [3].

If enterprises fail to recognize the importance of developing green technology, they will be unable to achieve revenue growth and sustainable development brought by the green technology. Benefits-driven companies may ignore the quality of their products, the affordability of the environment, their social obligations and their duty to green energy innovation [3].

2.2. Governance

The ways to govern and direct the path toward sustainable development has long been a critical component of the sustainability dialogue. This section examines the challenges and opportunities that international and domestic governance present for the future of sustainable development in China.

2.2.1. International governance

Over the years, China has become increasingly involved with the international cooperation over climate action. However, international climate cooperation has been an international governance challenge, for its very long times lags, often decades of time, between mitigation measures and environmental effects [4]. When the time lags are too long, it becomes quite difficult to evaluate the effectiveness of climate measures and initiatives. This lack of climate decision-making tools has obstructed collective fast-pacing action toward climate goals, and therefore the cooperation between

China and other countries over climate issues. The limited impact that the Kyoto Protocol has had on curbing carbon emissions demonstrated this problem [5].

2.2.2. Domestic governance

China's last four decades of rapid economic development and resource consumption has generated many environmental challenges and socioeconomic consequences. There are various measures to been taken by regulators, government, investors and industrial leaders to mitigate and adapt to climate change. Problems has surfaced that a lack of regulatory instruments and industrial standards are impeding the implementation of these measures. For example, with the development of green finance, there has been a growing concern of greenwashing which describes misleading claims about environmental practices, performance, or products. It is urgent that regulation catches up with the development of these climate solutions.

2.3. Environment

2.3.1. Air pollution

In China, the current situation of air pollution is not optimistic. The proportion of days that with good air quality in 339 prefecture-level cities and above is 86.8%. Among contaminants, the average concentrations of PM2.5 and SO_2 are basically unchanged; the average concentrations of PM10, NO_2 and CO are decreased; the average concentration of O_3 has an upward trend (Fig. 1). It reflects that in the context of the sustainable development policy, although the air quality has been improved to some extent, it still needs attention.

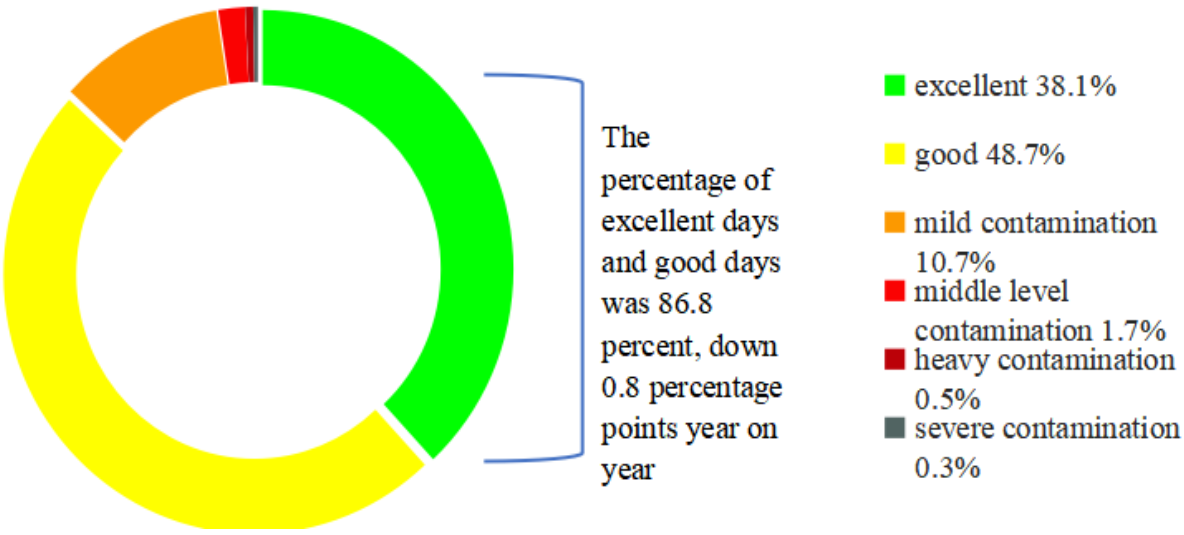


Fig 1. Proportion of days at all levels in 339 prefecture-level and above cities in China from January to November 2022 [6].

2.3.2. Water pollution

China's water resources have serious water pollution, water shortage, frequent floods and other problems. The main problem of pollution in China's rivers and lakes is organic pollution, including COD, BOD_5, total nitrogen, total phosphorus and other detection indicators. The main problems of groundwater pollution are the monitoring of total nitrogen and total phosphorus and the improvement of remediation technology.

2.3.3. Soil pollution

At present, the problems of soil pollution in China focus on the soil quality of cultivated land and the soil environment of industrial and mining wasteland. The cultivated land soil in former China was polluted by non-machine, machine and compound pollution points; industrial and mining waste soil is mainly polluted by heavy metals and organic substances.

2.3.4. Physical pollution

Physical pollution includes noise pollution, radioactive pollution, vibration pollution, electromagnetic pollution, light pollution, heat pollution, etc. At present, noise pollution is the most studied in China. The main pollution characteristics of physical pollution are local and non-residual. The main hazard of physical pollution is to interfere with the normal work and life of residents.

2.4. Economy

2.4.1. Green finance

At present, the main problems faced by China in the field of green finance are mainly in the areas of green financial innovation, market construction, improvement of pricing mechanisms, policy support and opening up to the outside world, all of which need to be optimized.

2.4.2. Circular economy

The circular economy is a green development model that emphasizes resource-saving and environmental-friendly quality development by minimizing waste emissions, maximizing resource recycling, and lowering the environmental burden through reduction, reuse, and recycle. The main issues facing China in the circular economy are the balance between energy consumption and economic efficiency, the breakthrough of key technologies, policy support and the improvement of the evaluation system.

2.4.3. Low Carbon economy

At present, China faces many problems in the low carbon economy (especially in international trade) as follows. The large energy consumption of products and the lack of foreign trade discourse. The low carbon economy has given rise to new green barriers. The lack of low carbon technology. The lack of international competitiveness of foreign export products and the lack of knowledge of international low carbon standards and related regulations, etc. [7].

3. Sustainability Improvement Measures

3.1. Science and Technology

3.1.1. Renewable energy development and utilization

The development and utilization of renewable energy sources have high requirements for both investment and technological innovation, such as increased investment, the number of researchers and patents in related fields can all be helpful [8].

As a technology-intensive industry, renewable energy can achieve significant advancement with more personnel involved. As for regions with low performance evaluation of renewable energy development and utilization (REDU), moderately accelerating the growth rate of installation capacity of renewable energy can effectively improve their REDU. For regions with poor overall performance, the overall performance of REDU can be increased by increasing the consumption of renewable energy and the share of renewable energy in primary consumption [8].

3.1.2. Green technologies

The quick growth of the green eco-economy is strongly dependent on technological progress which requires innovation. Today, the conflict between economic development and environmental pollution is more intense than ever before, highlighting the need to develop green energy. Yet the environmental problems arising from the innovation process cannot be ignored, so environmental factors should be taken into consideration along with technological innovation.

For small enterprises, the innovation efficiency benefited from advanced foreign technology coupled with some industry-academia research collaboration is greater than that from the government fund. While for large enterprises, building on the great support from foreign technology and industry-

academia research collaboration, government fund can better improve the efficiency of the development of green technology.

The patents on green energy and technology incubation, especially for original technology, is particularly important. On the one hand, the government should provide more financial support toward these original technologies. For example, qualified energy-consuming industries should be allowed to apply for financial support. On the other hand, the training of research personnel for greater basic knowledge and innovative consciousness should be emphasized. And certain incentive mechanisms can also encourage the enthusiasm of the staff for innovation.

It is also important to optimize resource allocation. This means that investment should be allocated according to the nature, features and needs of industries. For instance, for industries with low R&D efficiency, the ratio of capital investment and talent should be designed accordingly. To be more specific, more international talents should be introduced and the fund should go to areas that can achieve innovation by imitating current innovative achievements. For industries with low conversion rate of results, the priority is to increase the economic and environmental benefits of the results of conversion.

3.2. Governance

3.2.1. International governance

To promote intergovernmental cooperation and collective action among states, there are a few measures to consider. First, establishing a science-based knowledge platform as a basis for international cooperation is beneficial. As most empirical studies have found, a science-based knowledge platform often facilitates negotiations by bringing the parties to a common ground first. The agreement and plans for action reached by these negotiations are also more ambitious [9]. In practice, cooperation in knowledge building often precedes the establishment of many international environmental regimes.

Second, major actors such as China and the European Union could work as global or regional leaders to pull action in the sustainable direction. A recent “follower” assessment survey of possible global leaders on climate change shows China, the United States and the European Union as the three candidates, with 49%, 43%, and 51% support respectively. Major actors like China, US, and the EU can exert global or at least regional leadership on climate issues, considering they are responsible for more than 50% of global greenhouse gas (GHG) emissions [10]. They can collaborate on climate issues to steer action in a sustainable direction.

3.2.2. Domestic governance

Since China declared the dual carbon goals in 2020, non-state actors (NSA) and networks have mobilized to develop solutions at a subnational level. Many NSAs such as non-governmental organizations and businesses have engaged in private climate change governance. They have contributed to setting regional and industrial standards and regulations, which could later on be developed into operation certification programs and other market-oriented regulations. The private sector had produced a synergy with state regulations and improved domestic governance. In sustainability science, the process of diverse actors working together toward sustainability goals is known as co-production. An extensive review of 100 empirical studies involving co-production processes revealed that co-production fosters performers’ creativity and self-reflection [11].

3.3. Environment

3.3.1. Remediation of soil pollution

According to different pollutants, different sites and different methods of soil repairing, physical, chemical, biological and other methods and principles are used. According to different polluted sites, soil remediation can be divided into in-situ remediation and ectopic remediation. The process of soil remediation mainly includes: investigation and evaluation of contaminated sites; repairing plan and preparation; implementing of repairing works; repairing acceptance and post-management (Fig. 2).

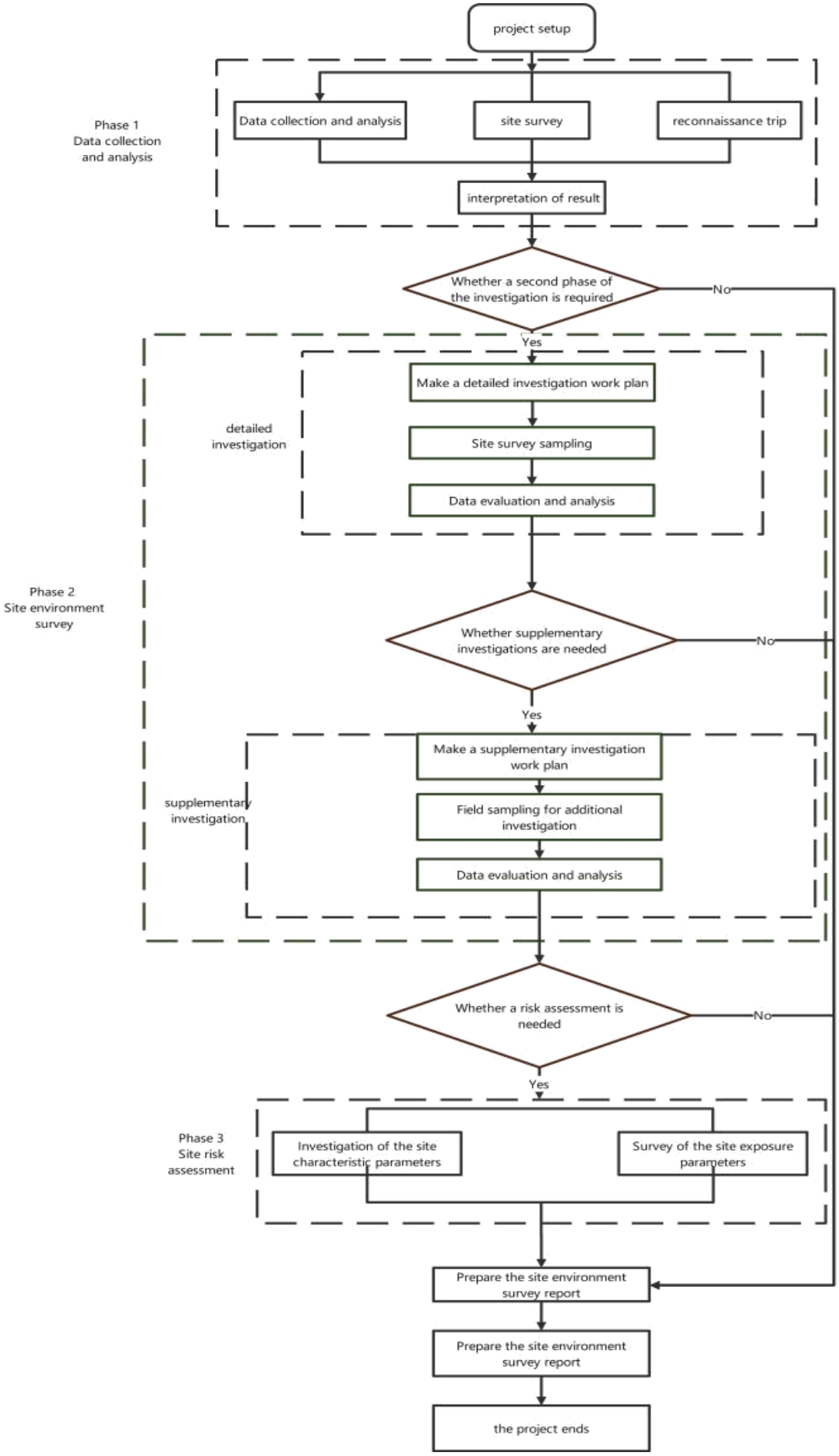


Fig 2. Technology roadmap for site investigation and risk assessment.

3.3.2. Air pollution control

In addition to traditional air pollution control methods, CCUS technology is currently the most promising technology for carbon neutralization and carbon peak. CCUS technology refers to separating CO_2 from emission sources and transporting it to a certain place for use or storage [12]. Industrial engineering to achieve CO_2 emission reduction, including key links such as CO_2 capture, transmission, storage and utilization. Fig. 3 is the technical road map of CCUS and the development status of CCUS in China. First, CO_2 was captured from an industrial emission source, then transported by pipeline or ship. Finally, CO_2 was injected into sub-seabed geological reservoirs. The process contributes to the isolation of CO_2 from the atmosphere [13].

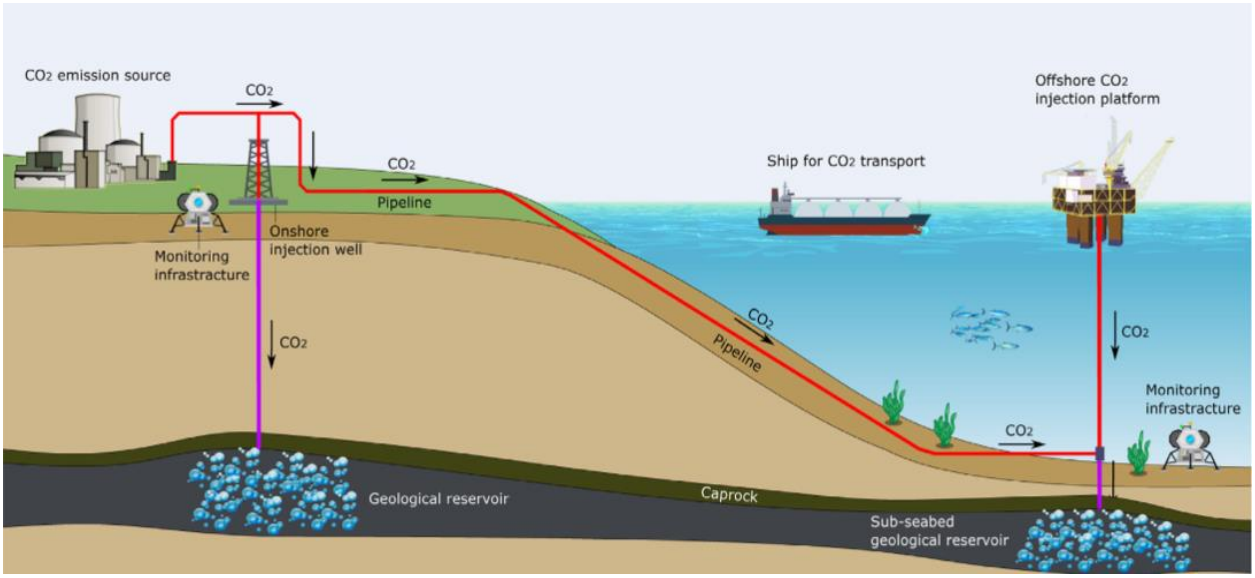


Fig 3. Key elements and processes in offshore CCUS [13].

3.3.3. Water pollution control technology

At present, the main control technology is the construction of water plants and the setting of drainage networks. The technology is relatively mature. At present, the main development direction is the treatment of microbial technology. Looking forward to the future, compared with traditional physical and chemical methods for sewage treatment, due to the development of genetic engineering technology and the gradual maturity of microbial cultivation technology, changing microbial genes and cultivating suitable microbial species for sewage treatment have become the main means of development.

3.3.4. Physical pollution control engineering

Due to the characteristics of physical pollution, pollution would not last for a long period. For example, if the noise disappears, the pollution stops. Therefore, the recovery income is low. Thus, the main control measures are the development and prevention of new materials and the issuance and planning of policies.

3.4. Economy

3.4.1. Green finance

Innovation is the key to promoting China's development in the field of green finance. Green financial innovation aims to promote the construction of green financial markets, encourage the research and development of green financial product design, promote deeper reform of trading platforms, and strengthen the improvement of relevant operational mechanisms, and regulation of relevant laws and regulations. China's green financial development insists on fairness and openness, green innovation, and strives for domestic innovation and international cooperation.

In terms of market construction, establish a primary, secondary and tertiary green financial product trading market. Primary green market (e.g. forest land and wetlands) maintains property rights trading at the commodity spot level. Secondary trial securitization trading (e.g. conversion of carbon rights into equity, debt and options) includes policy innovation for green industry listing channels. Tertiary futures and options trade with green financial derivatives as the mainstay, thereby improving the liquidity of green financial products and the hedging of risks in the green financial transaction process to meet the needs of different investors or consumers [14]. In terms of the pricing mechanism, a complete pricing and evaluation system should be built to unify the design, evaluation and credit-granting of green finance. In terms of policy innovation, green finance policy innovation directly affects the development of related green industries and the mechanism innovation of green financial product markets. In terms of internationalization, the green industry should implement an open policy of internal linkage and international cooperation to bring the green industry out of the country and into the world; at the same time, the quality inspection standards of green financial products strive to be in line with international standards.

3.4.2. Circular economy

The development of a circular economy is the primary way to achieve sustainable economic development and the dual carbon goals in terms of energy consumption, resource use, and demand, as well as responding to green development trends and environmental and climate change.

Firstly, financial and policy support should be strengthened. A circular economy is essential for constructing a resource-saving and environmental-friendly society, and it serves as a critical pivot point for balancing energy consumption and economic development. Secondly, a universal green financial standard should be established. Green finance is mainly intended to solve the problem of insufficient green financing due to market failure, a problem that can be rectified to a certain extent. Thirdly, the innovation of green technology should also be encouraged, including the innovation of green product and green process. Green product innovation refers to the incorporation of environmental concepts into the selection of raw materials, product design, product packaging and product production [15, 16]. Green process innovation refers to the improvement of a company's environmental management processes, such as energy saving, pollution prevention, waste recycling and other benefits associated with green innovation, green process innovation can realize a company's vision of environmental sustainability and stimulate its eco-efficiency potential [17, 18]. It often consists of end-of-pipe governance and cleaner production technology innovations with the intention of lowering hazardous substance output and raising energy efficiency.

There are five common measures of green process innovation as follows. Low energy consumption in the production process is done by reducing the use of energy, such as water, electricity, coal and oil. Adopt cleaner production technologies, thus saving energy and preventing the production of pollutants. Recycle, reuse and remanufacture materials. Effectively reduce harmful substances and waste emissions in the production process. Effectively reduce the consumption of raw materials in the production process [19]. China should simultaneously boost the research and development of green products, expand the innovation of green technology, and enhance the necessary legal and regulatory framework.

3.4.3. Low carbon economy

In order to promote the transformation and upgrading of high carbon emitting industries to zero and low carbon emissions, and to achieve a low carbon economy at an early date, the concept of "transition finance" has been proposed (Table 1).

Ben Caldecott argues that the established definition of transition finance is inappropriate and not agreed upon, and that a more precise and broader definition of transition finance should be financial products and services that aim to achieve environmental and social sustainability by enabling companies, governments or individuals to raise funds or obtain what they need to make the real economy in better shape [20]. In the EU Sustainable Finance Classification Scheme, sustainable finance is distinguished between green finance and transition finance, where transition finance is

defined as "financial support for the transition to low carbon and zero carbon emissions, in particular for traditionally carbon-intensive economic activities or market players, using a diversity of financial instruments to address the impacts of climate change" [21-23].

Table 1. Transition Finance Development [24].

Time	Important Events
December 2016	EU establishes high-level expert group on sustainable finance
March 2018	EU Action Plan on Financing for Sustainable Development
March 2019	OECD presents preliminary concept of transition finance
March 2020	The EU Sustainable Finance Classification Scheme report provides a clear definition of transition finance
June 2020	The EU Taxonomy standardises financial classification criteria and indicators
September 2020	CBI proposes initial framework and five principles for transition finance
October 2020	Japan Institute of Environmental Finance publishes "Guidelines for Transition Finance"
December 2020	ICMA publishes Handbook on Financing Climate Transition
March 2021	EU Sustainable Finance Platform publishes Transformative Finance Report
May 2021	Japan's multi-sectoral joint publication of the Essential Guide to Financing Climate Transition
November 2022	G20 Leaders' Summit unveils G20 Transformative Finance Framework

The establishment of a practical framework for transition finance is the basis and guarantee for the development of transition finance activities, and provides guidance for the development of transition finance. On the one hand, the EU Sustainable Finance Classification Scheme can be used as a reference to develop a clear and realistic catalog of transition activities based on China's national economic sectoral classification. On the other hand, the recommendations of the Climate Transition Finance Handbook can be used to improve the transition finance information disclosure mechanism, provide reference standards for the identification and assessment of transition activities in China's high carbon emission industries, and avoid the phenomenon of "greenwashing" in transition investment and financing by strengthening regulation. This will prevent the phenomenon of "greenwashing" in transition investment and financing. Moreover, the definition and scope of transition finance in China can be clarified in the form of documents, performance evaluation criteria can be set for transition finance activities and entities, and the incentive mechanism for transition can be improved at the same time. The financial system is a bridge between the supply and demand sides of transition finance activities. International exchanges and cooperation are crucial to jointly addressing global climate change. The development of transition finance can take the Paris Agreement's 2050 net-zero emissions as a target, and deepen international exchange and cooperation between enterprises, industries, governments and other levels.

4. Conclusion

Adopting sustainable development policies has become inevitable in a world with high energy consumption. China, however, as a later starter, still faces many problems in sustainable development. This paper analyzes these problems from science and technology, governance, environment and economy, and proposes practical solutions. The backwardness of core technology, heavy reliance on imported equipment with core technology and the lack of enabling environment and motivation for technological innovation have made it urgent to increase the investment in the development of core technology and to optimize the innovation environment. The lack of decision-making and regulatory tools and uniform standards in industries requires the government to establish a knowledge platform sharing scientific consensus and develop regulatory regulations. In terms of the environment, in order to deal with the difficulties in improving air condition, water shortage and serious soil pollution, soil restoration, CCUS and microbial technologies should be given major consideration. From the perspective of the economy, the problems rest on innovation and globalization issues, the imbalance between energy consumption of circular economy and benefits, little capacity in foreign trade, and the lack of competitiveness. In this respect, institutional innovation should be accelerated, a multi-

level trading market should be established, pricing mechanisms should be improved, and international financial exchange should be deepened to achieve sustainable development. These works are conducive to deep research and improvement for sustainable development. With these done, there is still much room for sustainable development in the future.

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