

# Analysis of Cooperative Approaches and Sustainable Development Mechanism: Fundamental Contents and Implementation Framework

Huangwei DENG

Tongji University <https://orcid.org/0000-0002-8738-737X>

Ying SU

Tongji University

Zhenliang LIAO (✉ [zl\\_liao@tongji.edu.cn](mailto:zl_liao@tongji.edu.cn))

Xinjiang University

Jiang WU

Tongji University

---

## Research

**Keywords:** Cooperative analysis, Sustainable development mechanism, Fundamental contents, Implementation framework, Comparative analysis

**Posted Date:** December 28th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-132171/v1>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

# Abstract

## Background

To slow down climate warming and achieve sustainable development, the Paris Agreement establishes Cooperative Approaches (CAs) and Sustainable Development Mechanism (SDM) for carbon trading. However, deficiencies in implementation exist due to a lack of systematic execution regulations and an integrated management system. The study's primary purpose is to propose a proposal of effective implementation of CAs and SDM for alleviating global warming. Based on international regime theory in global climate change and the nine elements of the market mechanism, the article analyzes the type of mechanism, coverage of the system, operational framework, and governance framework of CAs and SDM. The paper combines the operational framework with the governance framework to form an implementation framework of CAs and SDM, developing the nine elements of the market mechanism.

## Results

CAs are considered as project-based and quota-/ credit-based carbon market mechanisms. Under CAs, trading units should be authorized at the international-regional/ sub-regional level. CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, SF<sub>6</sub>, and NF<sub>3</sub> shall be covered and function as subject matters. The unit of CO<sub>2</sub>-eq shall account for them. CAs can transfer verified ITMOs through bilateral/ multilateral cooperation agreements or ITMOs information disclosure platform. The governance of CAs shall keep up with both international and regional/ sub-regional rules and regulations.

SDM is an industry-based and credit-based carbon market framework. Under SDM, trading units should be authorized at the international level. CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and PFCs work in SDM as subject matters. The unit of gases shall be CO<sub>2</sub>-eq. SDM is designed to transfer carbon reductions via an industry-level platform. A fully-centralized scenario is suggested as the governance model of SDM.

## Conclusions

This study proposes the rules and implementation framework of CAs and SDM, which can work as a guideline for the early implementation stage of CAs and SDM. The implementation framework of CAs ought to follow three stages: project preparation, project submission & auditing, and Internationally Transferred Mitigation Outcomes (ITMOs) transfer. The implementation framework of SDM ought to contain three phases: project development & review, project implementation & monitoring, and project acceptance & unit transfer.

# Background

Global warming makes a significant impact on global social, economic, environmental, and biological health[i]. The continuous emission of carbon emissions has been a great concern worldwide[ii][iii]. The Paris Agreement is the third landmark international legal text after the United Nations Framework

Convention on Climate Change (UNFCCC) and the Kyoto Protocol in humankind's history to deal with climate change<sup>[iv]</sup>. It aims to keep global warming within 1.5°C and pursue a more comfortable and healthier life for people and the 2030 Agenda<sup>[v]</sup>. Carbon emissions of each area shall be controlled at the same time<sup>[vi]</sup>. Countries should take distinguished responsibility to achieve the goal<sup>[vii]</sup>. The Paris Agreement was finally signed by about 200 Parties in the 21<sup>st</sup> Conference of the Parties (COP21) to deal with critical problems including the alleviation, adaptation, and implementation of climate change<sup>[viii]</sup>. With Biden coming to power, the United States will also rejoin the Paris Agreement, promoting global carbon emission reductions to some degree. Intended Nationally Determined Contributions (INDCs) is accepted in the Paris Agreement<sup>[ix]</sup>. Until June 2020, 186 Parties have submitted their first INDCs, and 4 Parties have submitted their second INDCs to the UNFCCC<sup>[x]</sup>. Among them, 146 INDCs listed in *Additional file 1* are actual effective records. In the current situation, greenhouse gases (GHGs) in 2030 will be reduced by about 5.5% compared with 2015, significantly lower than committed emission reductions in INDCs. New efforts and high execution must proceed<sup>[xi]</sup>.

Since the European Union's Emissions Trading Scheme (EU-ETS) establishment, the carbon trading mechanism plays an important and internationally recognized role in carbon reduction<sup>[xii]</sup>. Since the signing of the Kyoto Protocol, Joint Implementation (JI), Clean Development Mechanism (CDM), and International Emission Trading (IET) have worked a lot for carbon reduction. Lu and Liu<sup>[xiii]</sup> researched the economic rationality of JI, CDM, and IET and give a result that carbon trading not only helps increase cost-effectiveness but also strengthens economic development. For developing countries, emission trading may be the right way for green economic growth<sup>[xiv]</sup>. Blum<sup>[xv]</sup> examines the legitimization of carbon markets by interviewing 37 market stakeholders. The majority of the interviewees believe that carbon markets function well in alleviating climate change.

However, the practice of international carbon markets established since the Kyoto Protocol has faced severe troubles, such as unclear emission reduction effects, imperfect market regulation, obstacles to market integration, and difficulties in international coordination<sup>[xvi]</sup>. COP16 starts to discuss the international carbon market under the Paris Agreement<sup>[xvii]</sup>. New domestic and international carbon markets such as Framework for Various Approaches (FVA), New Market Mechanism (NMM), and improved Kyoto mechanisms require carbon markets after 2020<sup>[xviii]</sup>. Cooperative Approaches (CAs) and Sustainable Development Mechanism (SDM) are then advanced in the Paris Agreement (in Article 6)<sup>[xix]</sup>.

In the usual sense, CAs allow mechanisms established and operated by governments, non-governmental, or private sector organizations to transfer and account for international emission reduction units through Internationally Transferred Mitigation Outcomes (ITMOs)<sup>[xx]</sup>. SDM is considered an upgraded CDM, which owns broader international decisions and aims to promote GHGs mitigation and sustainable development. It enables an indirect connection between emission reductions and regional/ sub-regional or national trading systems<sup>[xxi]</sup>. The two mechanisms can be justified more hope for global carbon trading with grand ambitions<sup>[xxii]</sup>. Unfortunately, no specific details are contained in any documents for the two mechanisms, and no systematic framework has been formed for implementation yet. Lacking unified regulations brings about obstacles to successful coordination<sup>[xxiii]</sup>. The article aims to analyze

fundamental contents and provide a feasible implementation framework for CAs and SDM, which gives a chance to stimulus management enhancement. The international regime theory, nine elements of the market mechanism, and comparative analysis are employed in the article.

Understanding and analyzing international climate change mechanism helps a lot in grasping the essential requirements of carbon market mechanisms. Krasner established the international regime theory in 1983. The theory has been applied in international climate negotiations and the formation of regulations and rules since the 1990s[xxiv]. The theory contains a series of principles, norms, rules, and decision-making procedures, which provide a basic theoretical guideline for carbon trading flexible mechanisms' contents and principles[xxv]. The theory of nine elements of the market mechanism was proposed by Bolscher while preparing a design selection and implementation report for the EU[xxvi]. The comparative analysis enables appropriate systematic comparison and judgments between opposing interpretations[xxvii]. It has been widely used in the negotiation and evaluation of law enforcement.

The article first explains how to apply the international regime theory, nine elements of the market mechanism, and comparative analysis into the study. Secondly, according to the principles and purposes of CAs and SDM, it provides a result on the type of mechanism, coverage of the system, operational framework, and governance framework of the two mechanisms. The implementation framework is covered, as well. Thirdly, it demonstrates the rationality of the results. Finally, the article gives conclusions.

## Methods

### **The international regime theory in the field of global climate change**

The international regime theory includes four elements, principles, norms, rules, and decision-making procedures, divided into two layers: principles layer and rules layer<sup>24</sup>, displayed in Fig. 1. Principles of CAs and SDM are the Paris Agreement and the UNFCCC. This article focuses on the rules layer to set concrete implementation requirements for CAs and SDM.

### **The nine elements of a market mechanism**

The nine elements of market mechanism put forward by Bolscher include the type of mechanism, coverage of the system, sector target or crediting threshold, operational framework, requirements for data collection and MRV (monitoring, reporting, and verification), compliance framework and penalties, governance framework, ways of managing the transition from CDM to the NMM, and financing of the mechanism<sup>26</sup>.

According to the international regime theory, the article categorizes the nine elements in three parts: principles, basic framework layer, and supplement and improvement layer, as Fig. 2 shows. The contents involved in the supplement and improvement layer include technical and financial issues, which need complex and thorough analysis and are not essential at the beginning of mechanism construction<sup>[i]</sup>. This article focuses on the basic framework layer (except ways of managing the transition from CDM to the NMM) of CAs and SDM. Elements contained in the supplement and improvement layer will be determined in further study. In the nine elements of market mechanisms, operational framework and governance framework are two separate units. As a matter of fact, during the implementation of carbon market mechanisms, the operation and governance shall be conducted to make the execution more manageable and effective. The article merges the operational framework with the governance framework and forms the implementation framework.

\* It is a long process for managing the transition from CDM to the NMM because of the more complicated processes. Therefore, in this paper, this element is mainly considered as an influencing factor. The specific content of managing the transition from CDM to the NMM belongs to the supplement and improvement layer. The article will not discuss this element.

## Comparative analysis

During the UN negotiation, comparative analysis has become an essential method for coordinating various countries' ideas and reaching a final agreement. The quality management of the Chinese Certificated Emission Reduction (CCER) in the pilot carbon markets is discussed via comparative analysis<sup>[i]</sup>. Kuiti<sup>[ii]</sup> conducts a comparative analysis of the cap-and-trade policy to identify the strategic decisions in green initiatives. When determining elements of CAs and SDM, a comparative analysis of existing options can be made as well. The specific contents can be obtained combined with the actual needs of the mechanism. According to Keppel's working steps<sup>[iii]</sup>, the article makes use of comparative analysis in four steps: describe and explain the existing options in an integrated and objective way, align options to ascertain comparability standard which offers preliminary comparison results, compare options based on actual requirements and finally reach conclusions, as Fig. 3 shows.

## Technology roadmap

Referring to the main questions to be solved for carbon market mechanisms concluded by Steen<sup>[i]</sup>, based on the international regime theory in the field of global change and the nine elements of the market mechanism, this article describes and proposes the fundamental contents of CAs and SDM, including the type of mechanism and coverage of the system. Moreover, the article designs and analyzes the operational framework and governance framework of CAs and SDM. The implementation framework is concluded by integrating the operational framework with the governance framework of CAs and SDM, respectively. Fig. 4 introduces the technology roadmap of our work.

# Results

## Fundamental contents

### Type of mechanism

According to the purposes of CAs and SDM, the authorization level of the trading unit of CAs should be at the international-regional/ sub-regional level. Trading units of SDM need to be authored at the international level. Considering the objective of CAs and SDM, both quota-based and credit-based carbon trading satisfy transaction requirements in CAs, but credit-based carbon trading will be more suitable in SDM. By analyzing 146 INDCs in *Additional file 1*, the article found that CAs ought to adopt a project-based model. An industry-based mode is suggested for SDM.

### Coverage of the system

Subject matters refer to the objects to which the rights and obligations of both Parties are directed [i]. Subject matters of carbon trading have characteristics of publicity, fictitiousness, and homogeneity [ii]. The Paris Agreement uses ITMOs to achieve NDCs, which indicates that to determine coverage of CAs is to determine contents of ITMOs which are used for Parties who have clear quantitative mitigation goals. Referring to 112 Parties with clear quantitative mitigation targets, CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, SF<sub>6</sub>, and NF<sub>3</sub> were chosen as subject matters in CAs. CO<sub>2</sub>-eq was suggested as the counting unit. Concerning CDM, cement production, steel, electricity, heat, construction, waste management, aluminum production, and forestry were chosen as pilot industries in the initial SDM implementation stage. Subject matters of SDM are relevant to selected industries, including CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and PFCs. The basic unit of gases was suggested to be CO<sub>2</sub>-eq. Carbon offsets shall be accepted in both CAs and SDM.

## Operational framework

### For CAs

As mentioned above, CAs should adopt international cooperation based on the project level. CAs may transfer generated and approved emission/ reduction results from one enterprise to another. The emission/ reduction results can be reflected in the INDCs of each country. By analyzing the difference between with and without bilateral/ multilateral cooperation agreements, different operational frameworks for Parties were designed, as Fig. 5 and Fig. 6 present. The operational framework of CAs should contain identification of transaction objects and transaction of emission/ reduction results that meet international standards.

## **For SDM**

The operational framework of SDM (expressed in Fig. 7) was described based on analyzing the implementation of carbon emission reductions at the various industry level. In SDM, industry associations may participate in carbon emission reduction activities by promoting technological improvements, which helps international emission reduction agencies better grasp the industry's sustainable development level. The operational framework of SDM ought to include project initiation and registration, project implementation and emission reduction generation, and verification of emission reduction results and completion of the transaction.

## **Design of governance framework**

### **For CAs**

A comparative analysis was made among four scenarios (fully decentralized, semi-decentralized, semi-centralized, and fully-centralized scenario) classified by the World Bank. The result refuses to use semi-decentralized or semi-centralized scenario to govern CAs. Fig. 8 demonstrates the governance framework of CAs. CAs may give regional/ sub-regional and national discretion. For Parties with bilateral/ multilateral cooperation agreements, ITMOs should satisfy international standards to insist on environmental integrity. Only emissions or reductions that meet the requirements can be put into the market. The COP may help during this process to avoid interference of political factors in various countries. Furthermore, an eligibility review of subject matters should be conducted by international third-party agencies. For Parties without individual cooperative partners, ITMOs information disclosure platform should work at the international level to meet carbon reduction goals, which indicates that the platform can be implemented and governed by agencies under the COP.

### **For SDM**

Since the primary purpose of SDM is to help Parties discover more emission reductions and pursue sustainability, a fully-centralized scenario with strong binding force may be the most suitable governance model for SDM, that is, verify and approve emission reduction results at the international level under internationally unified environmental standards<sup>14</sup>. The article referred to CDM's experience, classified and described functions of the agencies at the international level, namely international industry associations, third-party organizations, and the COP, and finally proposed governance framework of SDM, shown in Fig. 9.

## **Implementation framework**

As a development of the nine elements of the market mechanism, the article combined the operational framework and governance framework of the two mechanisms separately and formulated the implementation framework of CAs and SDM. The implementation framework of CAs (see *Additional file 3*) was proposed to contain three stages: project preparation, project submission & auditing, and ITMOs transfer. The implementation framework of SDM (see *Additional file 4*) should consist of three stages: project development & review, project implementation & monitoring, and project acceptance & unit transfer.

## Discussion

This section first analyzed rationalities of the chosen type of mechanism and coverage of the system according to the purposes and principles of CAs and SDM. Different fundamental contents of CAs and SDM have been compared. A couple of precautions while designing an operational framework were then explained to make the results more reasonable. After that, the chosen governance scenarios of CAs and SDM were illustrated through a comparative analysis of the four management scenarios classified by the World Bank, respectively. The coordination among different associations was also emphasized. Furthermore, the reasons to merge the operational framework and governance framework into the implementation framework were discussed. The procedures of the implementation framework of CAs and SDM were analyzed as well.

## Fundamental contents analysis

### Type of mechanism

Regarding the trading unit's authorization level, the global carbon trading mechanism is mainly formed and developed by the UNFCCC. Trading units are usually set according to the regional/ sub-regional and national standards, such as the EU carbon emissions trading system[i]. The trading units issued are authorized by the UNFCCC, such as JI and CDM.

The purpose of CAs is to help countries achieve INDCs through international cooperation. Due to the Paris Agreement's extensive participation, CAs break through the limitation of original mandatory emission reductions under the UNFCCC framework while adhering to the "common but differentiated" principle. CAs can make full use of regional/ sub-regional and bilateral/ multilateral agreements among countries to provide Parties with the most room for an independent decision. SDM adopts international harmonization coordination to select baselines, technology transfer, financial support, and verification of emission reduction results to help developing countries, tiny island countries, and very underdeveloped countries[ii]. As a result, CAs shall work under international- regional/ sub-regional level, and SDM shall work under international level authorization.

The quota-based carbon trading mechanism is used to mitigate planned carbon emissions to the type of subject matter. A credit-based carbon trading mechanism is used for long-term carbon reduction to promote sustainable development. In a disequilibrium economy, traders need to obtain quantitative information to adjust demand and supply based on market price. The specific form of quantity adjustment is a quota, and the transaction can be completed shortly<sup>[iii]</sup>. However, it is necessary to estimate the number of carbon reductions and transactions after the accounting of generated carbon reductions<sup>[iv]</sup>. In this case, for CAs both quota and credits can function well. SDM aims to promote long-term sustainable development, which indicates that the credit-based mechanism should be better.

Concerning the basic unit of the transaction, whether there are specific requirements or target restrictions on the industry level in various countries' performance targets shall be considered. At the G8 summit, a statement that establishing emission reduction plans for critical industries will help achieve GHGs reductions was mentioned<sup>[v]</sup>. Adding credit into the industry-based carbon market mechanism may help with the sustaining goal<sup>[vi]</sup>.

The comparison among submitted INDCs expressed that the emission reduction industries involved are mainly from the emission industries in the IPCC national GHGs emission inventory. It is inappropriate for CAs to set limits at the industry level. Inappropriate amounts of industries covered may increase Parties' pressure of technic improvement and carbon reduction arrangements' integrity. A project-based mechanism may work well for CAs.

SDM plays an essential role in sustainable development. Specific industries have great potential for carbon reduction, so the industry-based mechanism is more suitable for SDM. On the one hand, the industry-based approach may avoid the situation where cross-border investment fails to meet sustainable development requirements more effectively. On the other hand, it can help regulate carbon emission reductions within the industry and further promote low-carbon development.

## Coverage of the system

*Additional file 1* shows 146 countries' willingness and efforts on carbon reduction. CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O are contained in 43 INDCs, 15 INDCs control CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, and SF<sub>6</sub>, 20 INDCs emission targets of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, SF<sub>6</sub>, and NF<sub>3</sub>. Although the number of Parties that contain seven types of GHGs is less than that of three types of GHGs. Countries containing seven types of GHGs are mostly developed countries that account for a large degree of international carbon market participation. Therefore, the article believes that CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, SF<sub>6</sub>, and NF<sub>3</sub> shall be covered in CAs. In this case, a standard unit of measurement that unifies different GHGs is required. Global Warming Potential (GWP) was accepted in the *IPCC First Assessment Report* and has been broadly used since UNFCCC and the Kyoto Protocol<sup>[vii]</sup>. In NDCs of Parties, GHGs were measured by carbon dioxide equivalent (CO<sub>2</sub>-eq), which indicates the unit is suitable to be widely used in CAs.

According to NDCs of Parties, most countries make efforts to decrease carbon emissions from energy, industrial processes, and transportation. However, various industries emit GHGs in various amounts and types. To achieve mitigation goals, CAs do not need to limit types of emission industries. A transaction may conduct if carbon emission/ reduction satisfies the requirements of subject matters.

As the difference of carbon emission and mitigation abilities among various industries, in the early stage of the implementation of SDM, only part of industries should be included. In annual reports of the International Energy Agency (IEA)[\[viii\]](#)[\[ix\]](#)[\[x\]](#)[\[xi\]](#), statistics on carbon emissions emitted by energy combustion activities indicates that the primary carbon emission industries were concentrated in power, heat, processing and manufacturing, construction and transportation industries. The Emissions Database for Global Atmospheric Research (EDGAR) shows that cement production emissions account for 80% of category 2A[\[xii\]](#). It has been found that steel, copper, and aluminum contribute most to carbon footprint through life cycle analysis[\[xiii\]](#). Blok[\[xiv\]](#) assesses emission reduction potential for agriculture, construction, energy, forestry, and other land use, industry, and transportation. The result presents that the energy industry has the most enormous carbon emission reduction potential (12.2 GtCO<sub>2</sub>e by 2030), approximately one-third of the global total reduction potential. Projects registered in CDM focuses on energy, waste management, and manufacturing[\[xv\]](#). Dong[\[xvi\]](#) comes to a result that electricity production generates the highest carbon emissions and has the highest carbon reduction potentials. Combining the above records with the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, it turns out that cement production, steel, electricity, heat, construction, waste management, aluminum production, and forestry can represent most carbon emission industries and own considerable potential for carbon reduction.

The subject matter of SDM is emitted by relevant industries, indicating that the most gas emission types of subject industries in SDM shall be the subject matter. Table 1 shows the most gas emission types of the subject industries contained in SDM[\[xvii\]](#)[\[xviii\]](#). As a result, CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and PFCs shall work as the subject matters in SDM. Similar to CAs, CO<sub>2</sub>-eq should be used as an accounting unit.

**Table 1.** Industries Covered in SDM and Related Gas Emission Types

Industry	Gas Types
Cement production	CO <sub>2</sub>
Steel	CO <sub>2</sub>
Electricity	CO <sub>2</sub>
Heat	CO <sub>2</sub>
Construction	CO <sub>2</sub>
Waste management	CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O
Aluminum production	CO <sub>2</sub> , PFCs

*Additional file 2* concludes the basic characteristics of CAs and SDM. When it comes to transaction contents, CAs should transfer carbon emissions and reductions, but SDM should only transfer carbon reductions. Only countries with clear carbon reduction goals can transfer carbon reductions to ITMOs and then function in the market under CAs. SDM is available to Parties who voluntarily participated in the international market mechanism. Therefore, the subject matters of SDM can be included in ITMOs of CAs.

What's more, as the corresponding emission reduction results generated by the industry and gas types in SDM have been recognized at the international level, the emission reduction results generated can directly enter into the transaction and connect with CAs without re-accounting, thereby reducing transaction costs and streamline processes. Carbon offsets can compensate GHGs emissions through energy transfer, higher energy effectiveness, and forestry, which is regarded as an essential way in carbon mitigation and promoting sustainable development. It is a possible measure for carbon mitigation in CAs and SDM.

## Explanation of the operational framework

### For CAs

While designing the operational framework of CAs, it should be noted that: (⊗) the enterprise is the implementation body of various emission reduction activities, so the ignition of all projects, the start and end of emission/ reduction units should come from the enterprise; (⊗) CAs help Parties to achieve mitigation goals clearly defined in their INDCs. Therefore, participants must establish relevant departments responsible for registering emission/ reduction units; (⊗) whether the emission/ reduction units obey environmental integrity needs to meet the responsible agency's standards at the Paris Agreement[xix].

For Parties with bilateral/ multilateral cooperation agreements, ITMOs of the seller can be transferred to the buyer after verification by the institution set under the Paris Agreement. Compared to Parties with bilateral/ multilateral cooperation agreements, ITMOs information disclosure platform may allow interested Parties without bilateral/ multilateral cooperation agreements to register themselves in the system and then make carbon transaction inside the relevant system, like the carbon trading operational framework in the pilot phase of China's carbon market.

## For SDM

Different from CAs, SDM ought to only transfer carbon emission reduction results. SDM can be invested by enterprises that want to obtain emission reduction credits and achieve certain technologies. Local enterprises shall submit applications to the government of the country first. Then, the applications shall be audited and reviewed by the agency set under the Paris Agreement. If meet the requirements, the project's approved emission reductions will be issued to the country's government where the Party locates, and then the government will release funds to the investor's enterprise.

The investing country's government should be included in the carbon emission reduction contribution of the investment enterprises. However, SDM should not be limited to foreign investment by developed countries. It shall have new stimuli and restrictions at the industry level, which is stricter than CDM. Industry associations shall be built to strengthen technical development for carbon emission and participate in carbon trading.

## Summary of operation framework

For CAs, the verified ITMOs can be transferred from the sellers of the selling country to the buying country buyers through bilateral/ multilateral cooperation agreements or ITMOs information disclosure platform. For SDM, carbon reductions may be conducted through the industry-level platform between the host country and the investor country.

## Coordination in the governance framework

### For CAs

The World Bank classifies four scenarios of management for carbon market mechanism, namely fully decentralized (without any global standards), semi-decentralized (some minimal environmental standards provided by an international body as guidance), semi-centralized (must observe environmental standards but no approval required), and fully-centralized (global environmental standards must be observed, compliance under the Paris Agreement) scenario[xx]. Considering the requirements of ITMOs results in CAs, the article did not accept the suggestion put forward by the World Bank. Multi-level

organizations and governance may be helpful for better function of carbon trading mechanisms<sup>[xxi]</sup>. The unit review should be carried out at the international level to ensure environmental integrity. However, other contents can be managed by regional/ sub-regional or domestic relevant agencies.

For Parties with bilateral/ multilateral cooperation agreements, there are two ways to measure the environmental integrity of selected ITMOs. The agency reviews one under the Paris Agreement, and a third-party agency reviews the other at the international level, which has been selected in this article. The former agency reviews subject matters submitted by the buyer's country's government following compliance requirements approved by the COP. The latter has been used in CDM. A total of 30 designated operating entities with rich experiences have conducted CDM project verification at present<sup>[xxii]</sup>. To meet the Paris Agreement's new standards, the third-party agencies only need to train for rules and characteristic standard requirements for emission reduction results in CAs. Compared to the former, the Paris Agreement only requires rulemaking at the international level and does not require specific review. For Parties interested in CAs without bilateral/ multilateral cooperation agreements, the ITMOs information disclosure platform should help them participate in carbon transactions. So, it is unnecessary to verify the business itself.

## For SDM

SDM aims to discover more emission reductions and to promote sustainable development. As it has been proposed that SDM functions at the international level and the transaction units are authorized at the international level, the governance framework of SDM should adopt international uniform environmental standards. The emission reduction results shall be verified and approved at the international level as well. So, it is rational to choose a fully-centralized scenario as the governance model for SDM.

Similar to CAs, environmental integrity shall be enhanced and maintained in SDM. The critical issue of SDM is the coordination among the executive committee, industry associations, and third-party verification agencies at the international level to keep integrity and synchronicity<sup>[xxiii]</sup>. The industry associations at the international level should be composed of enterprises, non-governmental organizations, and individuals. Third-party organizations should function as the third-party organizations under CDM who assess carbon reduction results and post relevant reports<sup>[xxiv]</sup>. The COP needs to develop institutional rules and uniform sustainable environmental standards at the international level for Parties to comply. Furthermore, a unique agency under the Paris Agreement shall be established to manage SDM, responsible for reviewing and approving national proposals and the release of emission reductions during mechanism operation.

## Summary of governance

Both CAs and SDM shall establish an independent agency to supervise carbon emissions and reductions<sup>[xxv]</sup>. The governance of CAs shall contain two-level: international auditing and regional/ sub-

regional organization. The governance of SDM shall follow a fully-centralized scenario. At the international level, the executive committee, industry associations, and third-party verification agencies must work in high coordination to ensure carbon transaction validity.

## Explanation of Implementation framework

While implementation, the operational framework and governance framework of carbon market flexible mechanisms shall ensure carbon transfer's effectiveness and rationality. To make the mechanisms more practical, it is beneficial to combine the operational framework with the governance framework. Thus, the article proposed an implementation framework for CAs and SDM, respectively, which develops the nine elements of the market mechanism to some extent.

### For CAs

Under CAs, participating companies must come from Parties that have quantified emission reduction targets. Once the emission reduction results were approved, they shall be completely transferred from the seller to the buyer's government and used by the companies who bought. The implementation framework of CAs contains three stages (see *Additional file 3*):

The first stage: project preparation. Enterprises that intend to take part in CAs deliver emission reduction results to third-party for review. A compliance report of reduction results will then be issued to explain environmental integrity. Enterprises identify trade objects through bilateral/ multilateral cooperation agreements or ITMOs information disclosure platform.

The second stage: project submission & auditing. The compliance reports of ITMOs shall be delivered to the local government or the International Executive Committee for review. All information on transaction projects shall be announced to the public for questions.

The third stage: ITMOs transfer. After the government of both Parties and the International Executive Committee review, the two governments shall register the confirmed ITMOs on INDCs. Then the transaction can be done.

### For SDM

Unlike CAs, the primary purpose of SDM is guiding and promoting sustainable development. Thus, whether or not the Party has proposed clear mitigation goals in INDCs, it can participate in carbon trading. Investors of different projects can obtain corresponding emission reduction credits after completing the project and calculate emission reduction units by the third-party agency. Accordingly, if the reduction credits are included in the host country's independent contribution, they should also be recorded and should not be counted as the host country's emission reductions. This rule is formed to

prevent double accounting. The implementation framework of SDM was proposed to include three stages (see *Additional file 4*):

The first stage: project development & review. Enterprises of investing country first communicate with enterprises of the host country for local information and data. A project investment plan shall then be composed and assessed by a qualified third-party agency to ensure feasibility and compliance. After that, relevant reports may be posted to the local government. The project's host country shall submit all reports and project applications to the International Executive Committee for auditing and registering.

The second stage: project implementation & monitoring. Enterprises in the investing country need to regularly appoint a third-party agency to monitor emission reduction results during project implementation. The third-party agency shall measure and calculate actual emission reduction results according to the methods and standards of the sustainable verification of emission reduction results under the Paris Agreement. The host government and the Executive Committee shall record monitoring results and promptly indicate any problems.

The third stage: project acceptance & unit transfer. Based on the second stage, the project's actual emission reduction results shall faithfully comply with a report on the calculation of emission reduction results. The Executive Committee ought to issue corresponding emission reduction units to the investing country. Once the government of both transaction sides registered INDCs, enterprises in the investing country should obtain corresponding emission reduction units. Then the transaction can be done.

## **Summary of the implementation framework**

By integrating the operational framework with the governance framework of CAs and SDM, the study analyzed the two mechanisms' implementation framework. The implementation framework of CAs ought to consist of project preparation, project submission & auditing, and ITMOs transfer. The implementation framework of SDM should be composed of project development & review, project implementation & monitoring, and project acceptance & unit transfer.

## **Conclusions**

To fulfill the systematic execution regulations and an integrated management system of carbon market mechanisms, the article combined the international regime theory with the nine elements of the market mechanism and took the comparative analysis to propose a reference guideline of CAs' and SDM's fundamental contents and implementation framework based on the Paris Agreement and the UNFCCC. The details are as follows.

1. CAs ought to work as a project-based trading mechanism and transfer international- regional/ sub-regional authorized quotas/ credits, which consist of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, SF<sub>6</sub>, and NF<sub>3</sub> to achieve INDCs. SDM should work as an industry-based mechanism and transfer international

authorized credits including CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and PFCs produced in cement production, steel, electricity, heat, construction, and waste management, aluminum production, and forestry. Both mechanisms shall use CO<sub>2</sub>-eq as the unit of covered GHGs.

2. The operation of CAs may function in two different circumstances: Parties with bilateral/ multilateral agreement can transfer internationally approved ITMOs; Parties without bilateral/ multilateral agreement shall learn about ITMOs through ITMOs information disclosure platform to identify transaction object and complete the trading under CAs. SDM can transfer carbon reduction from the host country to the investor country via an industry-level platform.
3. The international-level standards and regional/ sub-regional requirements shall govern CAs together. For SDM, a fully-centralized scenario is suggested for the governance framework.
4. The implementation framework of CAs ought to contain three stages: project preparation, project submission & auditing, and ITMOs transfer. The implementation framework of SDM should include three stages: project development & review, project implementation & monitoring, and project acceptance & unit transfer.

The study provides a proposal for the construction and implementation of the basic framework of CAs and SDM, enriches the system construction of the two mechanisms, and provides support for carbon reduction and mitigating global warming. In the later period, we will continue to discuss the supplement and improvement layer elements.

## Abbreviations

CAs Cooperative Approaches

CCER Chinese Certificated Emission Reduction

CDM Clean Development Mechanism

CH<sub>4</sub> Methane

CO<sub>2</sub> Carbon dioxide

CO<sub>2</sub>-eq Carbon dioxide equivalent

COP Conference of the Parties

EDGAR the Emissions Database for Global Atmospheric Research

EU-ETS the European Union's Emissions Trading Scheme

FVA Framework for Various Approaches

GHGs Greenhouse gases

GWP Global Warming Potential

HFCs Hydrofluorocarbons

IEA International Energy Agency

IET International Emission Trading

INDCs Intended Nationally Determined Contributions

ITMOs Internationally Transferred Mitigation Outcomes

JI Joint Implementation

NF<sub>3</sub> Nitrogen trifluoride

NMM New Market Mechanism

N<sub>2</sub>O Nitrous oxide

MRV Monitoring, reporting, and verification

PFCs Perfluoro octane sulfonate

SDM Sustainable Development Mechanism

SF<sub>6</sub> Sulfur hexafluoride

UNFCCC United Nations Framework Convention on Climate Change

## Declarations

## Additional files

The article supplies four additional files for a better understanding of the fundamental contents and implementation framework of CAs and SDM:

- Additional file The Parties' NDCs comparison table (until June 2020\*);
- Additional file 2. Proposed type of mechanism and coverage of CAs, SDM;
- Additional file 3. Proposed implementation framework of CAs;
- Additional file 4. Proposed implementation framework of SDM.

## Availability of data and materials

The data sources of the article are shown in 'Reference'. The countries' INDCs were downloaded from the website of the UNFCCC.

## Author's contributions

**Huangwei Deng:** Conceptualization, Methodology, Formal analysis, writing- original draft, Visualization.

**Ying Su:** Conceptualization, Methodology, Formal analysis, Resources.

**Zhenliang Liao:** Conceptualization, Methodology, Resources, Supervision.

**Jiang Wu:** Conceptualization, Methodology, Resources, Supervision.

## Competing interest

None.

## Funding and acknowledgments

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

## References

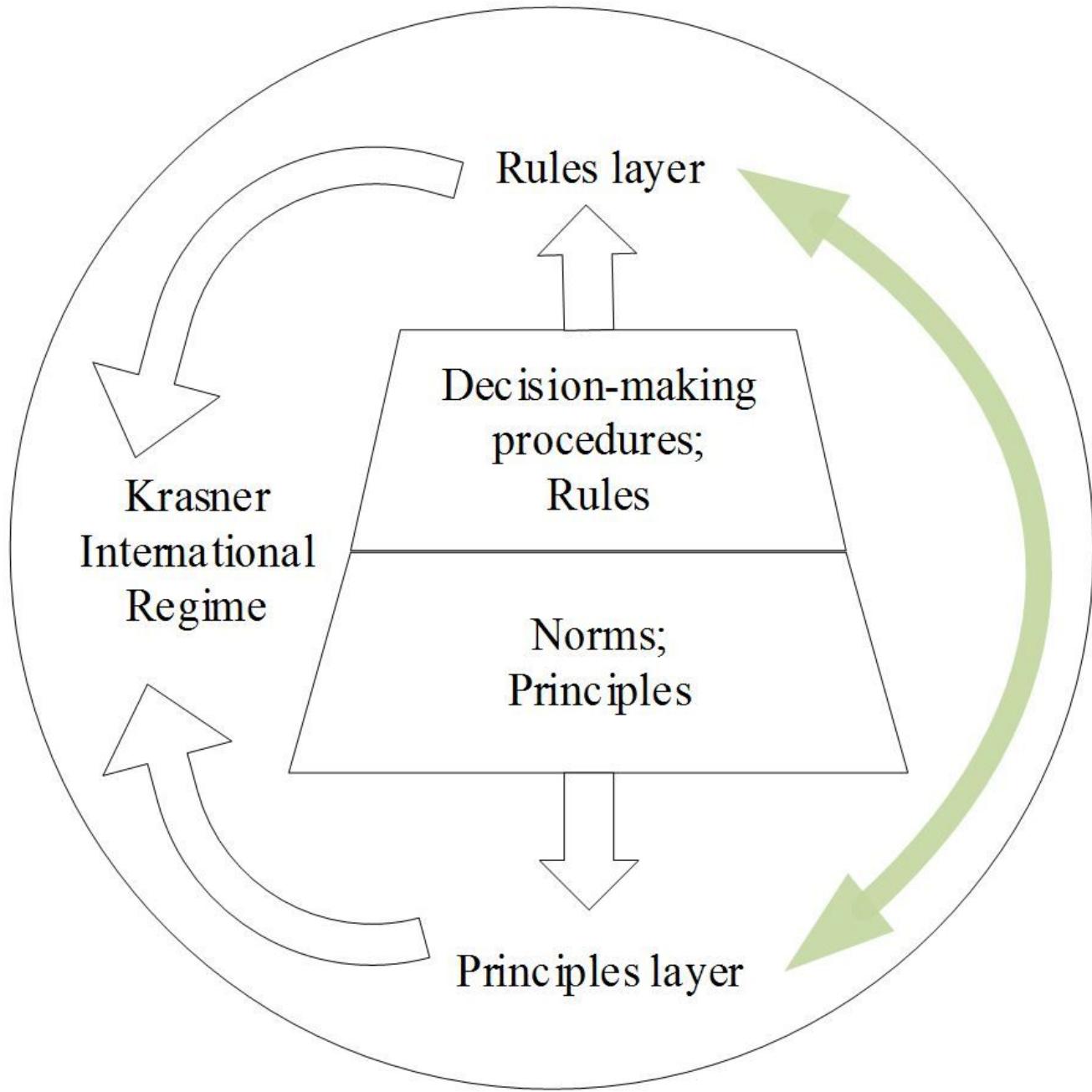
1. Huang S-L, Liu S-G, Liu J-X, Dahal D, Young C, Davis B, et al. Projecting the spatiotemporal carbon dynamics of the Greater Yellowstone Ecosystem from 2006 to 2050. *Carbon Balance and Management*. 2015;10:7.
2. Yue T, Zhao M, Zhang X. A high-accuracy method for filling voids on remotely sensed  $\text{XCO}_2$  surfaces and its verification. *Journal of Cleaner Production*. 2015; doi: 10.1016/j.jclepro.2014.08.080.
3. Huisingsh D, Zhang Z, Moore JC, Qian Q, Li Q. Recent advances in carbon emissions reduction: policies, technologies, monitoring, assessment and modeling. *Journal of Cleaner Production*. 2015; doi: 10.1016/j.jclepro.2015.04.098.
4. Li J-F, Chai Q-M, Ma C-M, Wang J-J, Zhou Z-Y, Wang T. China's Climate Policy and Market Outlook in Post-Paris Era. *Energy of China*. 2016; 38:1 (in Chinese).
5. Sustainable development through climate action. *Clim. Chang.* 2019; doi: 10.1038/s41558-019-0528-3.
6. Tamaki T, Nozawa W, Managi S. Controlling  $\text{CO}_2$  emissions for each area in a region: the case of Japan. *Carbon Balance and Management*. 2019; 14:19.

7. Rajamani L. Ambition and Differentiation in the 2015 Paris Agreement: Interpretive Possibilities and Underlying Politics. *International and Comparative Law Quarterly*. 2016; 65:2.
8. Savaresi A. The Paris Agreement: a new beginning?. *Journal of Energy & Natural Resources Law*. 2016; 34:1.
9. Schneider L, Theuer SLH, Howard A, Kizzier K, Cames M. Outside in? Using international carbon markets for mitigation not covered by nationally determined contributions (NDCs) under the Paris Agreement. *Clim. Policy*. 2020; doi: 1080/14693062.2019.1674628.
10. UNFCCC: NDC Registry. <https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx>. Accessed 20 Jun 2020.
11. Roelfsema M, Harmsen M, Bertram C, Krey V, Kriegler E, Luderer G, et al. Taking stock of national climate policies to evaluate implementation of the Paris Agreement. *Nat. Commun.* 2020; 11:2096.
12. Yang W-J, Zhao R-Q, Chuai X-W, Xiao L-G, Cao L-H, Zhang Z-P, et al. China's pathway to a low carbon economy. *Carbon Balance and Management*. 2019; 14:14.
13. Lu C-Y, Liu D-S. An Economic Analysis of Kyoto Mechanisms for Mitigating Global Climate Change. *The Journal of World Economy*. 2002. p. 71-77 (in Chinese).
14. van Renssen S. Carbon market rescue. *Nat. Clim. Chang.* 2015; doi: 10.1038/nclimate2588.
15. Blum M. The legitimization of contested carbon markets after Paris - empirical insights from market stakeholders. *Journal of Environmental Policy & Planning*. 2019; 2:22.
16. Liu H, Tang J. Development and problems of the carbon market since the Kyoto Protocol. *International Study Reference*. 2014. p. 12-17 (in Chinese).
17. Gao S, Li M, Duan M, Wang C. International carbon markets under the Paris Agreement: Basic form and development prospects. *Advances in Clim. Change Research*. 2019. p. 21-29.
18. Redmond L, Convery F. The global carbon market-mechanism landscape: pre and post 2020 perspectives. *Clim. Policy*. p. 647-669.
19. UNFCCC: Paris Agreement. 2015. [https://unfccc.int/sites/default/files/english\\_paris\\_agreement.pdf](https://unfccc.int/sites/default/files/english_paris_agreement.pdf). Accessed 20 Jun 2020.
20. Schneider L, Kollmuss A, Theuer SLH. SEI policy brief: Ensuring the environmental integrity of market mechanisms under the Paris Agreement. 2016. <https://www.sei.org/publications/integrity-market-mechanisms/>. Accessed 20 Jun 2020.
21. Stavins RN, Stowe RC. Belfer Center for Science and International Affairs: Market Mechanisms and the Paris Agreement. 2017.
22. Heitzig J, Kornek U. Bottom-up linking of carbon markets under far-sighted cap coordination and reversibility. *Nat. Clim Chang.* 2018; doi: 1038/s41558-018-0079-z.
23. Green J, Sterner T, Wagner G. A balance of bottom-up and top-down in linking climate policies. *Nat. Clim Chang.* 2014; doi: 1038/nclimate2429.
24. Chen Y. Evolution of the international climate regime and analysis of China's negotiating position. *World Economics and Politics*. 2007. p. 52-53 (in Chinese).

25. Krasner SD. International Regimes. Cornell Univ. Press, Ithaca and London. 1983.
26. Bolscher H, Laan J, Slingerland S, Sijm J. Design options for sectoral carbon market mechanisms and their implications for the EU ETS. Ecorys, 2012.  
[http://ec.europa.eu/clima/news/articles/news\\_2012111402\\_en](http://ec.europa.eu/clima/news/articles/news_2012111402_en). Accessed 20 Jun 2020.
27. Lijphart A. Comparative Politics and the Comparative Method. American Political Science Review. 1971. p. 681-693.
28. Yu X, Lo AY. Carbon finance and the carbon market in China. Nat. Clim. Chang. p. 15-16.
29. Zhou Y, Gu A, Deng M. Voluntary emission reduction market in China: development, management status and future supply. Chinese Journal of Population Resources and Environment. 2019; 17 (in Chinese).
30. Kuiti MR, Ghosh D, Basu P, Bisi A. Do cap-and-trade policies drive environmental and social goals in supply chains: Strategic decisions, collaboration, and contract choices. International Journal of Production Economics. 2020;
31. Keppel Comparative Method in Education. Studies in Philosophy and Education. 1965. p. 43-51.
32. Steen A M. Implementation of Article 6 of the Paris Agreement – status and pathways to COP24. IEA/ IETA/ EPRI. 2017. [https://iea.blob.core.windows.net/assets/imports/events/17/4.1\\_Steen.pdf](https://iea.blob.core.windows.net/assets/imports/events/17/4.1_Steen.pdf). Accessed 20 Jun 2020.
33. Feng Z. Financial derivatives and risk management. Air Finance. 2009. p. 68-90.
34. Energy Research Institute of National Development and Reform Commission. The nature and institutional framework of carbon trading. 2015.  
[http://www.tanpaifang.com/tanguwen/2015/1118/49044\\_2.html](http://www.tanpaifang.com/tanguwen/2015/1118/49044_2.html). Accessed 20 Jun 2020.
35. Technical synthesis on the Framework for Various Approaches. Technical paper (FCCC/TP/2013/5). 2013. <https://unfccc.int/resource/docs/2013/tp/05.pdf>. Accessed 20 Jun 2020.
36. Winkler H, Vorster S, Marquard A. Who picks up the remainder? Mitigation in developed and developing countries. Clim. Policy. 2009; doi: 3763/cpol.2009.0664.
37. Li Y. Plan Quotas and Market Mechanisms. Economic Theory and Business Management. 1991. p. 2-8 (in Chinese).
38. Zhai X. Can the EU's Carbon Credit System for Electric Vehicles Attain Three Aims?. The World of Inverters. 2017. p. 43-44 (in Chinese).
39. Ward M, Streck C, Winkler H, Jung M, Hagemann M, Sullivan RO, et al. The Role of Sector No-lose Targets in Scaling up Finance for Climate Change Mitigation Activities in Developing Countries. Ecofys, GtripleC and ClimateFocus; 2008.
40. Baron R, Buchner B, Ellis J. Sectoral Approaches and the Carbon Market. OCDE; 2009.
41. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC; 2014.
42. CO<sub>2</sub> emissions from fuel combustion Highlights 2014 Edition. IEA; 2014.
43. CO<sub>2</sub> emissions from fuel combustion Highlights 2015 Edition. IEA; 2015.

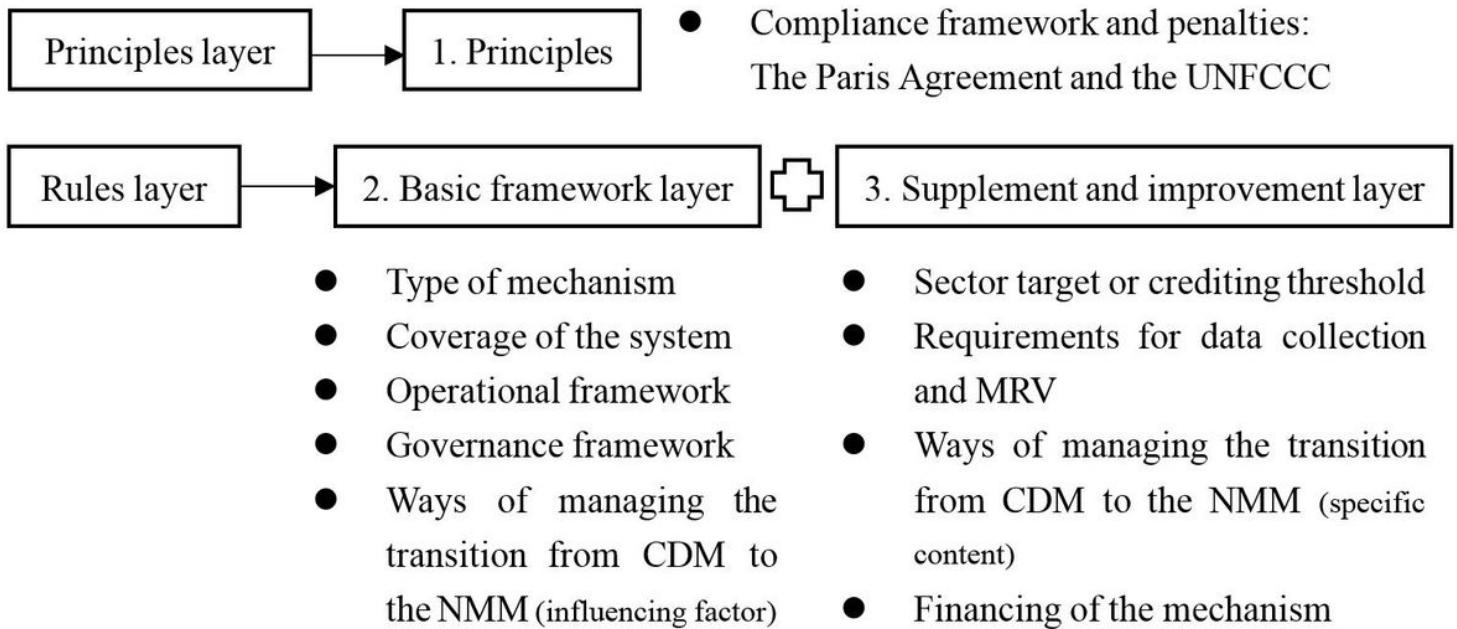
44. CO<sub>2</sub> emissions from fuel combustion Highlights 2016 Edition. IEA; 2016.
45. CO<sub>2</sub> emissions from fuel combustion Highlights 2017 Edition. IEA; 2017.
46. Olivier J, Janssens-Maenhout G, Muntean M, Peters J. Trends in global CO<sub>2</sub> emissions: 2016 Report. JRC and PBL; 2016.
47. Ochoa GV, Prada G, Duarte-Forero J. Carbon footprint analysis and advanced exergo-environmental modeling of a waste heat recovery system based on a recuperative organic Rankine cycle. *Journal of Cleaner Production*. 2020; doi: 1016/j.jclepro.2020.122838.
48. Blok K, Afanador A, Hoorn I, Berg T, Edelenbosch OY, Vuuren DP. Assessment of sectoral greenhouse gas emission reduction potentials in 2030. *Energies*. 2017; doi: 10.3390/en13040943.
49. CDM Project Search. UNFCCC. 2019; <http://cdm.unfccc.int/Projects/projsearch.html>. Accessed 20 Jun 2020.
50. Dong H-J, Dai H-C, Geng Y, Fujita T, Liu Z, Xie Y, et al. Exploring impact of carbon tax on China's CO<sub>2</sub> reductions and provincial disparities. *Renewable and Sustainable Energy Reviews*. 2017. p. 596-603.
51. 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 2 Chapter 2, Volume 3 Chapter 2, Chapter 4, Volume 5), National Greenhouse Gas Inventory Plan Preparation. Institute for Global Environmental Strategy; 2006.
52. 2018 Global Status Report: towards a zero-emission, efficient and resilient buildings and construction sector. IEA & UNEP; 2018.
53. Schneider L, Theuer SLH. Environmental integrity of international carbon market mechanisms under the Paris Agreement. *Clim. Policy*. 2019; doi: 1080/14693062.2018.1521332.
54. The Networked Carbon Markets Initiative. World Bank Group; 2015.  
<http://pubdocs.worldbank.org/en/162841457735232763/NCM-initiative-pitchbook.pdf>. Accessed 20 Jun 2020.
55. Vivek NM, Stavros A, Jouni P, Andrew JD, Lindsay CS. Experiences of host communities with carbon market projects: towards multilevel climate justice. *Clim. Policy*. 2014; doi: 1080/14693062.2013.861728.
56. CDM List of DOEs. UNFCCC; 2019. <https://cdm.unfccc.int/DOE/list/index.html>. Accessed 20 Jun 2020.
57. Cement Sustainability Initiative – Sectoral Approach briefing note. World Business Council for Sustainable Development; 2009.
58. Bakker S, Haug C, Asselt HV, Gupta J, Saidi R. The future of the CDM: same same, but differentiated? *Clim. Policy*. 2011; doi: 3763/cpol.2009.0035.
59. Liu Z, Guan D-B, Moore S, Lee H, Su J, Zhang Q. Climate policy: Steps to China's carbon peak. *Nature Climate Change*. 2014. p. 1017-1023.

## Figures



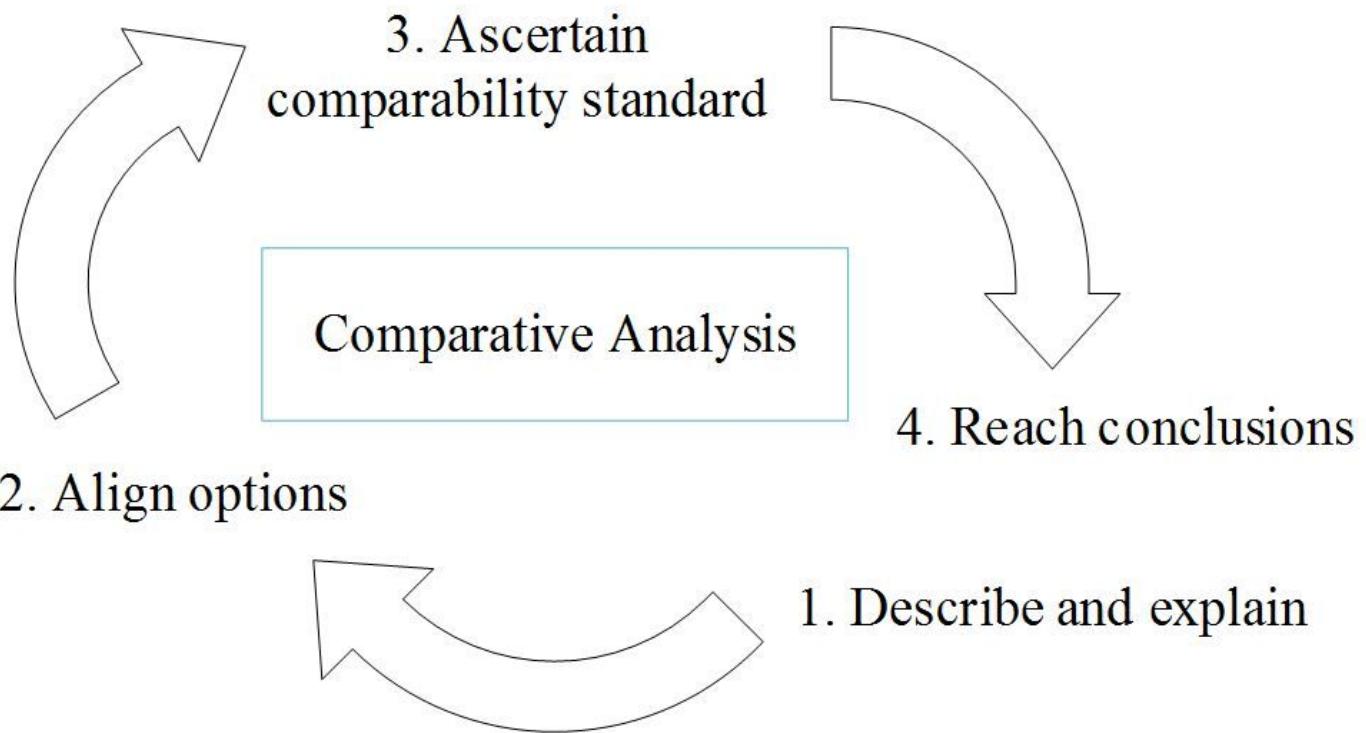
**Figure 1**

The divided layers of the international regime theory



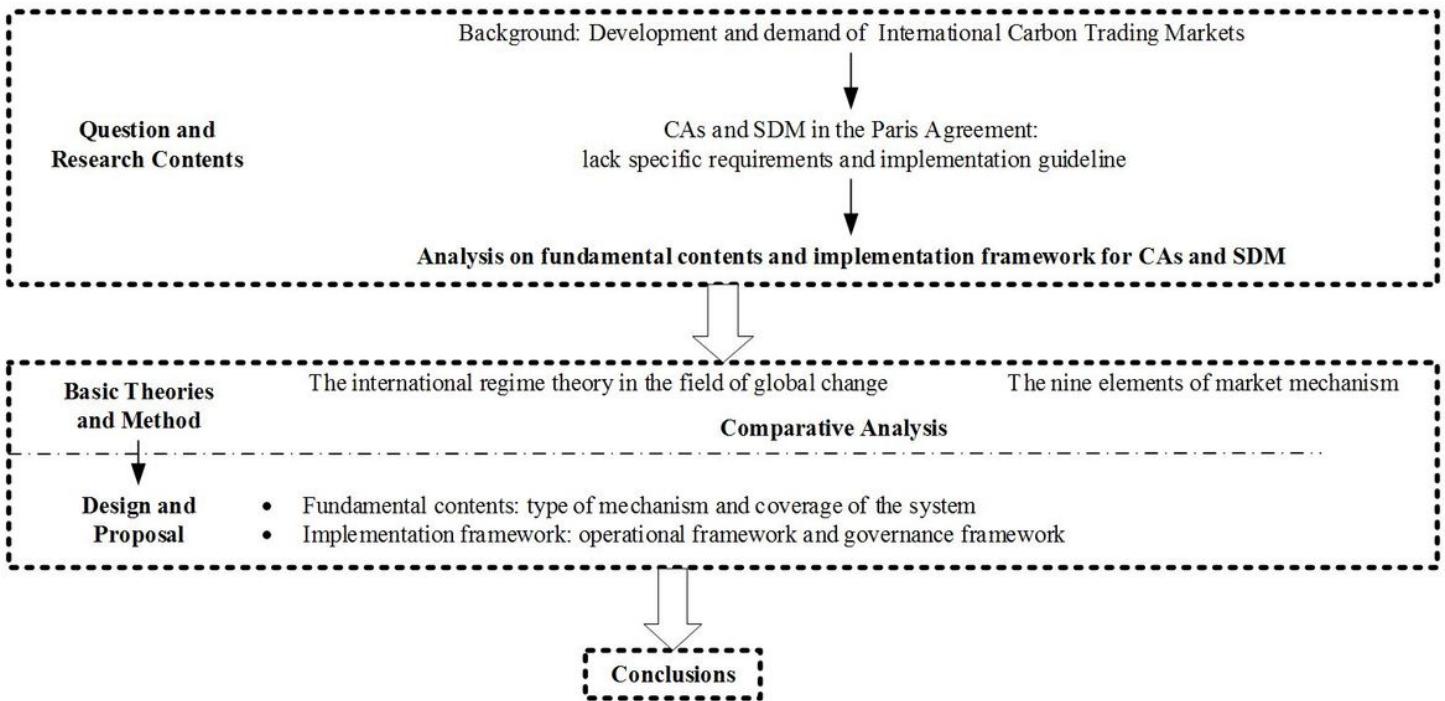
**Figure 2**

Elements of the market mechanism.



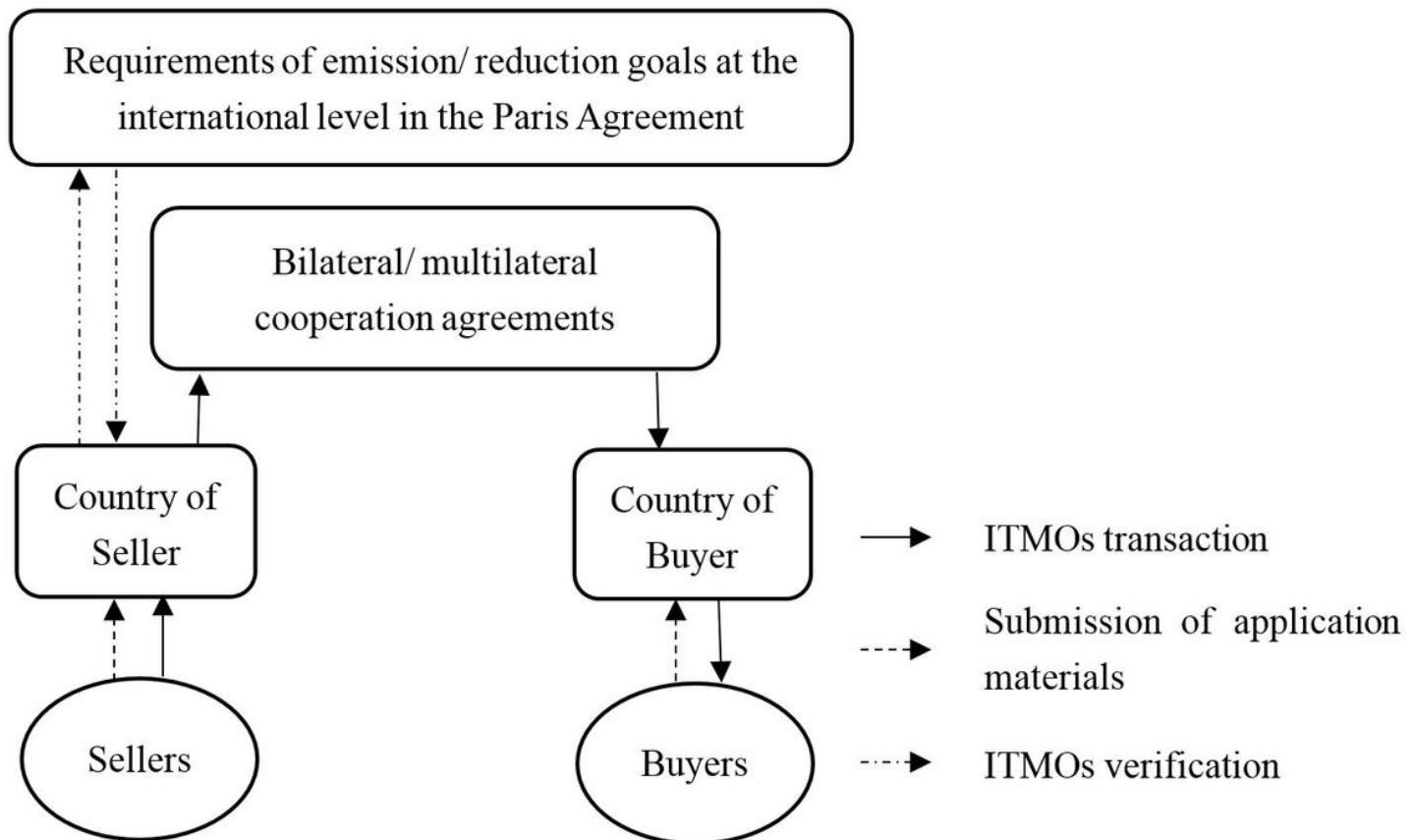
**Figure 3**

Working steps of comparative analysis.



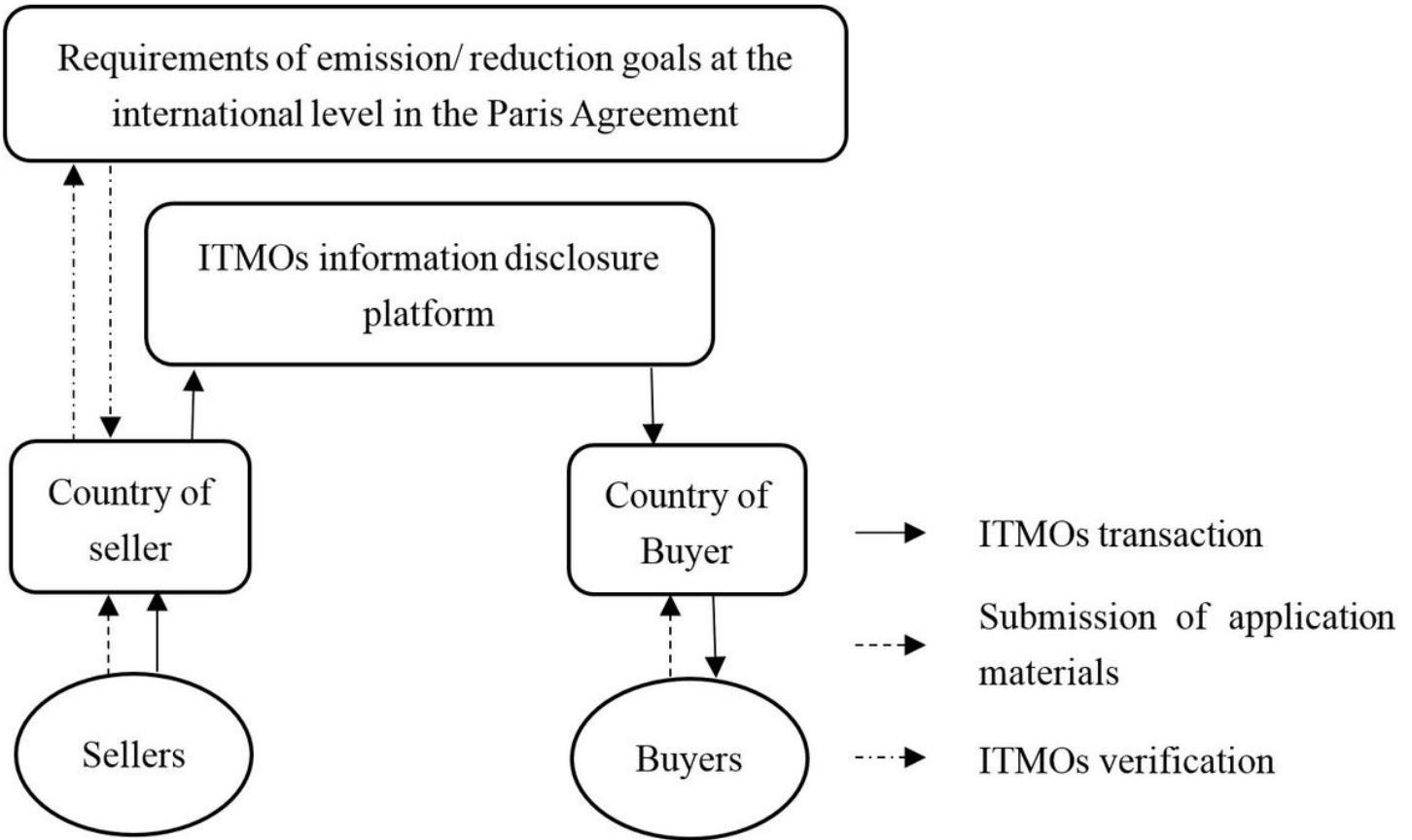
**Figure 4**

Technology roadmap.



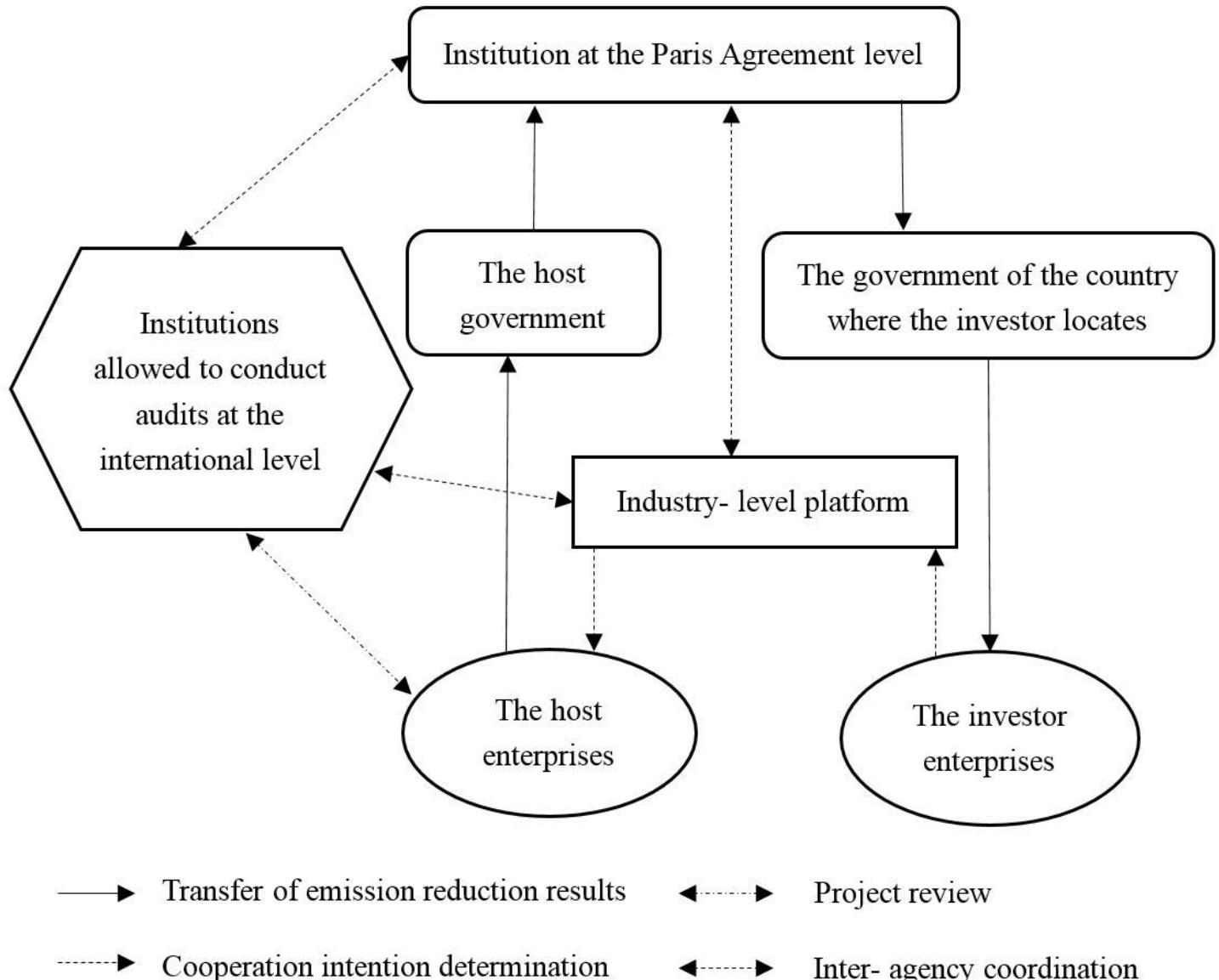
**Figure 5**

The operational framework of CAs (with bilateral/ multilateral cooperation agreements).



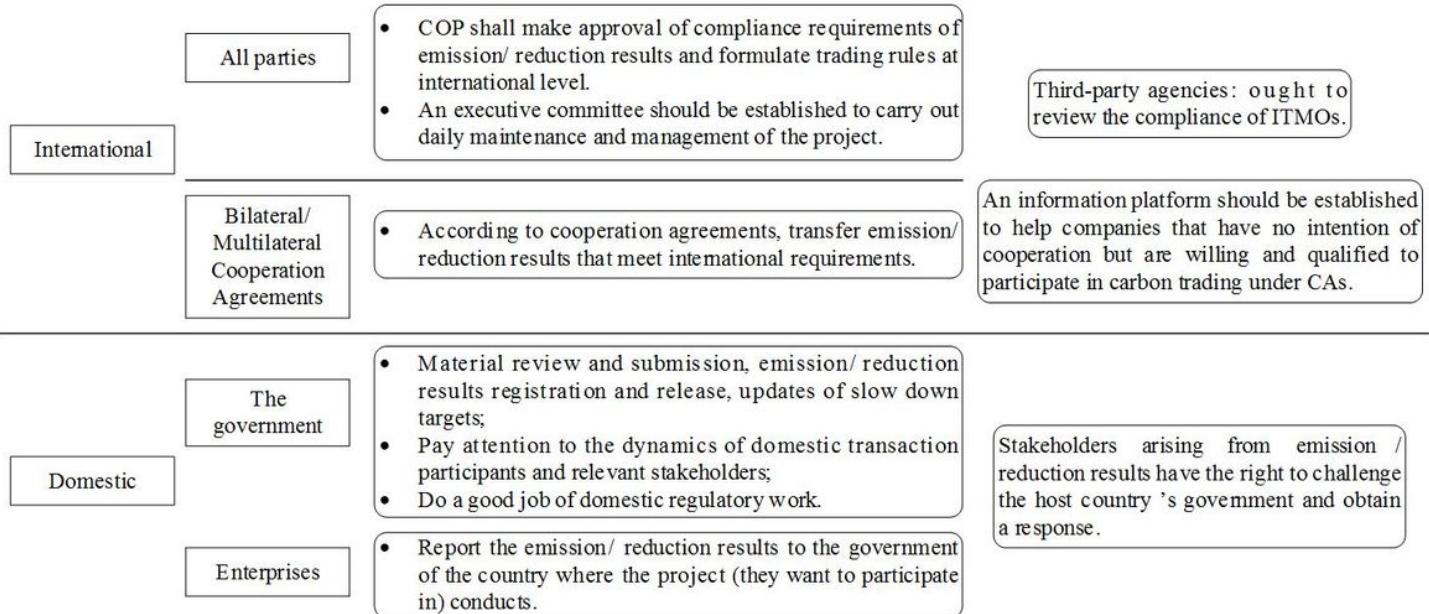
**Figure 6**

The operational framework of CAs (without bilateral/ multilateral cooperation agreements).



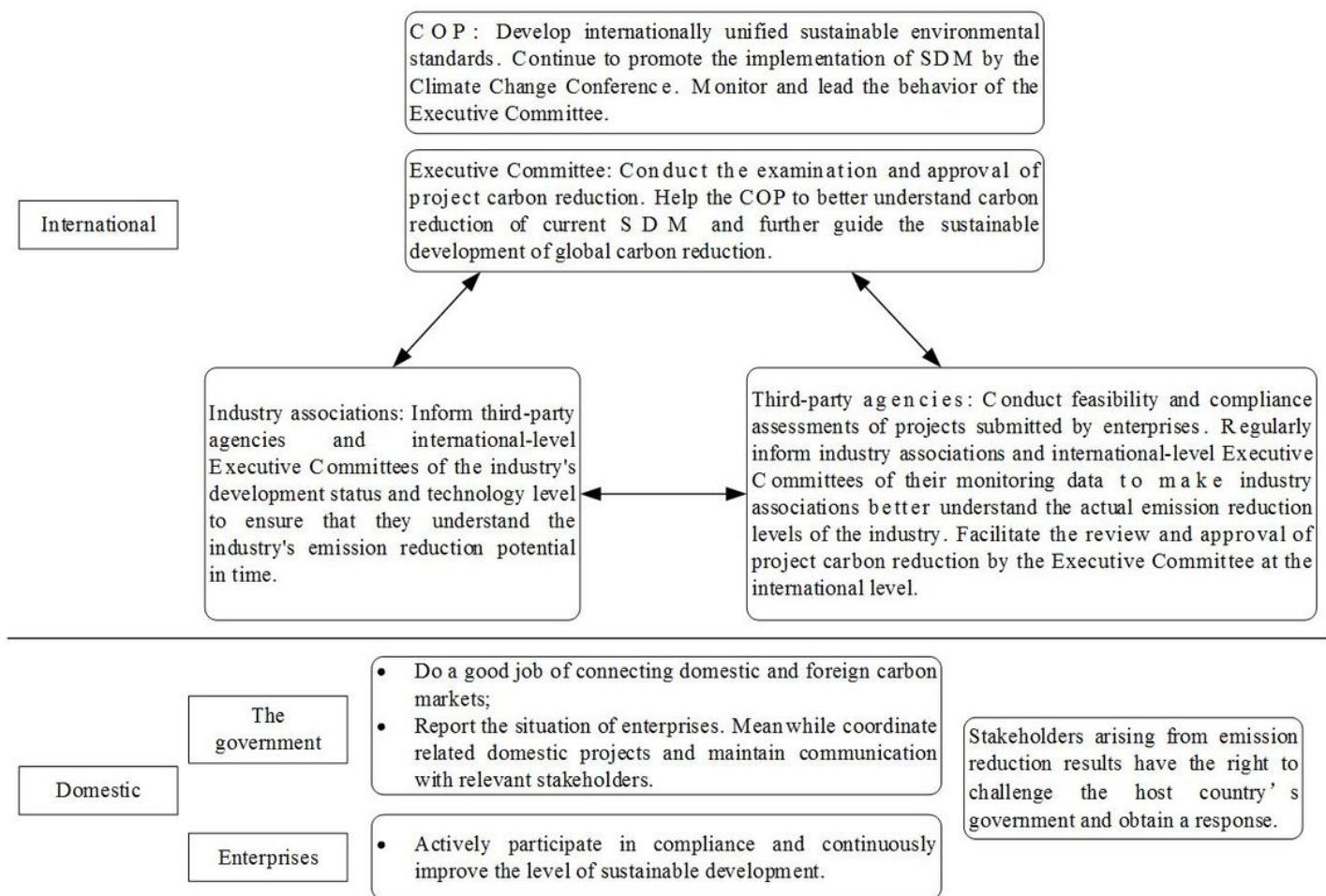
**Figure 7**

The operational framework of SDM.



**Figure 8**

The governance framework of CAs.



**Figure 9**

The governance framework of SDM.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Additionalfile1.ThePartiesNDCscomparationtable.docx
- Additionalfile2.Proposedtypeofmechanismandcoverage.docx
- Additionalfile3.ProposedimplementationframeworkofCAs.docx
- Additionalfile4.ProposedimplementationframeworkofSDM.docx