



Global INDCs Gap, Dilemma and Innovative Path of Carbon Sink Increase

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Abstract. Mitigating global warming is an urgent task facing all countries in the world, which requires the joint efforts of all countries. In the context of INDCs and the framework of the Paris Agreement, this paper estimates the gaps in CO₂ concentration, atmospheric temperature, and emission quantity with respect to global INDCs targets. Based on global carbon budget, the dilemma of global carbon emission is analysed and quantified in this paper. Furthermore, this paper reveals the huge potential of blue carbon system in the ocean to mitigate climate change, and proposes developing an innovative path to increase blue carbon sinks from China's point of view.

Keywords: Climate change · Carbon emission · INDCs · Blue carbon · Global warming

1 Introduction

Coping with climate warming is an urgent issue that all countries in the world must face together [1–5]. The Intended Nationally Determined Contributions (INDCs) are action targets in response to global climate change of each individual signatory country under “United Nations Framework Convention on Climate Change” in light of their own circumstances. Regarding the actual situation of individual signatory countries, scholars have carried out some studies on how to achieve the targets of INDCs [6–11]. China is currently the world's largest carbon emitter, and its policies, technologies and measures to deal with climate change have attracted extensive attention [12–14]. Many international researches by various scenario models of climate emission reduction have shown that, in terms of the INDCs emission reduction targets and the strength of climate governance policies of individual signatory countries, there is still a huge gap to meet the target of the Paris Agreement on climate change by 2030 and 2050. It is not enough to achieve the goal of keeping global temperature rises at 2 °C. In this paper, we make a systematical estimation on the actual difference in concentration, temperature and quantity of global INDCs targets, and discuss carbon emission dilemma with respect to global carbon budget. Furthermore, we reveal the potential of blue carbon sinks stored in the ocean to mitigate climate change, and propose an innovative path to increase blue carbon sinks.

2 Analysis of Global INDCs Gap

2.1 Concentration Gap of Global INDCs

The open data from Global Carbon Project (GCP) and Global Carbon Data from the Madrid Climate Conference in December 2019 have shown that, since the Industrial Revolution, the annual emissions of artificial CO₂ are approximately 2.37×10^{10} tCO₂e, and the cumulative CO₂ emissions of developed countries account for 70% of global CO₂ emissions in the same period. The data also indicated that global CO₂ concentration from 2016 to 2019 has reached the highest level in the past 80 million years, and the climate change risk is imminent, as shown in Fig. 1.

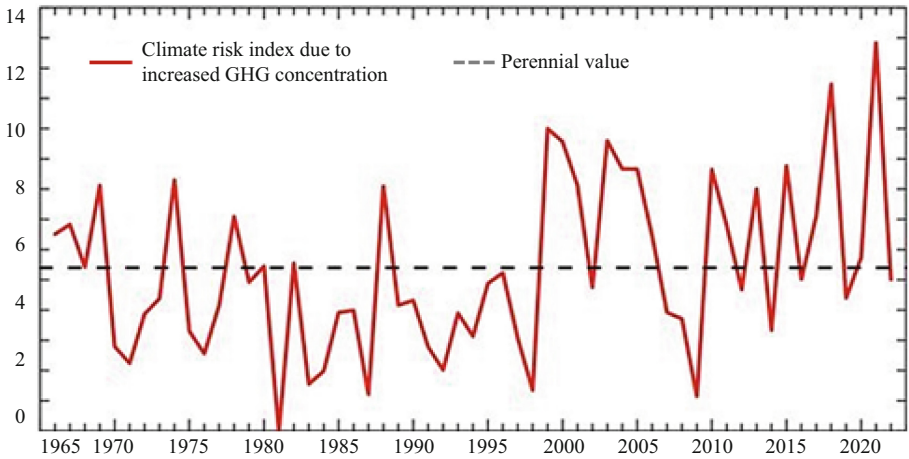


Fig. 1. Climate risk index of global GHG stock concentration. (Source: China Blue Paper on Climate Change 2019)

According to historical emission data, the CO₂ concentration rose from 277 ppm to 403 ppm between 1750 and 2019, with a 45% increase. In this period, the CO₂ concentration exceeded 400 ppm in 2016 at the first time in history, and reached 420 ppm in 2017 with an annual growth of 2.5 ppm. It is expected to reach 450 ppm in about 10 years and continue rising to 550 ppm, leading to a 50% probability of rising temperature over 3 °C. According to existing developing scenario, it is estimated that the annual growth of CO₂ concentration is 3–4 ppm. In the end of this century, CO₂ concentration will increase by 57% to 550–850 ppm, causing over 50% probability of 3.5–5 °C temperature rises, while the Paris Agreement aims to control CO₂ concentration within the stock interval of 450–550 ppm. International Environmental Protection Organization forecast the probability of global temperature rises within 1.5 °C, corresponding to CO₂ concentration of 430 ppm, would be less than 50%.

2.2 Temperature Gap of Global INDCs

Global meteorological observation records show that the warming trend continues. The global average temperature in 2019 was about 1.1 °C higher than in pre-industrial period,

making it the second warmest year on record. 2015 to 2019 were the five warmest years since full temperature records began, and every consecutive decade since the 1980s has been warmer than the previous decade. Correspondingly, after the first 3 years of emission stable period, the world has been witnessed a strong growing trend again in 2017, reaching 4.1×10^{10} tCO₂e. Eliminating the influencing factors of Covid-19 in 2020, a new emission growth period will be entered in the future. The whole world set an updated climate target after the Paris Agreement, i.e., control the global temperature rises within 1.5 °C. To realize this target, global net zero emissions must be achieved by 2050.

Gap in Temperature Rises of 2 °C. Climate Action Tracker Project of WMO assessed INDCs of individual signatory countries and concluded that global warming would be projected to 2.9–3.1 °C by 2050, even if the recently updated emission reduction targets are strictly adhered to. So emissions would have to be cut down by more than 85% by 2050 compared with 2000, so as to meet the target probabilistically. Obviously, the target of keeping global temperature rises within 2 °C compared with 1750 in the pre-industrial era cannot be achieved.

In the scenario of controlling temperature rises within 2 °C (Table 1), IPCC required the balance of global INDCs' emission level in 4.2×10^{10} tCO₂ before 2050, and in order to control temperature rises within 2 °C, global INDCs must be reduced by 2.3×10^{10} tCO₂e. Current INDCs scenario stipulates that annual emission reduction will be 5.0×10^9 tCO₂e, and by 2030 the emissions will be reduced to $4.0\text{--}6.0 \times 10^9$ tCO₂e. If the above INDCs scenario can be fully performed, it is expected to reduce emissions up to 1.1×10^{10} tCO₂e by 2030. To reduce to 5.4×10^{10} tCO₂e level, the emissions must be further reduced by 1.2×10^{10} tCO₂e, while global temperature will still rise by 3 °C. It will cause a 57% increase in global emissions at the end of this century, reaching the level of 5.4×10^{10} tCO₂e, and causing atmosphere CO₂ concentration up to 550 ppm and global temperature rises to 3.5 °C track [15]. UNDP forecast global CO₂ concentration and temperature rises in 2100 under different emission reduction scenarios, and showed a yellow card for current global efforts for mitigating climate change. Current INDCs of individual signatory countries are estimated to reach only one-third of the stipulated emission reduction in 2030. Even if the targets are updated and fully implemented, global warming is likely to rise by more than 3 °C by 2100, which has a great difference from the climate target of 2 °C (see Fig. 2). Considering the US has withdrawn from the Paris Agreement on November 4, 2020, things may get worse in the future.

Table 1. INDCs scenario for global temperature rises of 2 °C. Unit: 10^8 tCO₂e

National INDCs	Cumulative emission reduction by policies	Expected emission reduction by 2030	Emission target in 2050	Gap
Without INDCs	0	650	420	230
With INDCs	110	540	420	120

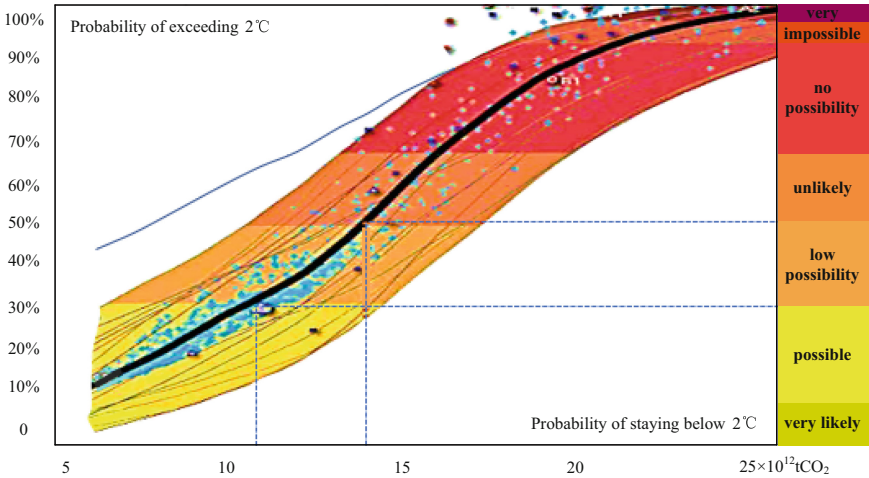


Fig. 2. Possibility of global temperature rises within 2 °C (Source: CDIAC/GCP Data 2019)

Gap in Temperature Rises of 1.5 °C. World Wide Fund for Nature reported that emissions must plummet after a peak in 2030 if global warming was to be controlled within 2 °C or a lower target of 1.5 °C. Total affirmatory emission reduction of current global INDCs was only to reach the half of target, thus having a gap of $1.2 \times 10^{10} \text{tCO}_2$ – $1.6 \times 10^{10} \text{tCO}_2\text{e}$. Under the current INDCs target scenario, global temperatures will rise between 2.6 °C and 3 °C by 2100 and 3.5 °C by 2200. Therefore, most climate researchers believe that current climate target of 1.5 °C is not scientifically justified. There is a high probability of prediction that emissions will reach $5.5 \times 10^{10} \text{tCO}_2\text{e}$ level in 2030. The global INDCs target falls short of the 2 °C target by 2030. Only when reducing the emissions to $4.2 \times 10^{10} \text{tCO}_2\text{e}$ level, which is far greater than the existing level of emission reduction of INDCs target, it is possible to control the temperature rises within 1.5 °C.

According to the gear mechanism of the Paris Agreement, the US Department of Energy made an overall estimation of global INDCs target, and believed that to keep the temperature rises within 2 °C, it was necessary to achieve global net zero emissions in 2080–2090, while the temperature rises within 1.5 °C would require net zero emissions in 2050–2080. It is not sufficient for existing global INDCs to achieve temperature rises of 2 °C, let alone the target of 1.5 °C. Even if the US returns to the Paris Agreement and implements the protocol with EU, China, and other parties in the future, it is necessary to reduce the emissions to 50% of current level by 2050. In this situation, CO₂ concentration will not exceed 450 ppm, while global temperature can only decrease by 0.07 °C. In addition, annual cost will reach up to $\$1.0$ – 4.0×10^{11} , which will be disproportionate to benefits. Now Alliance of Small Island States and the least developed countries demand that temperature rises should not be more than 1.5 °C and CO₂ concentration should not be over 350 ppm, then global CO₂ emissions must be reduced by more than 90% in 2050. However, this scenario is basically impossible to achieve.

2.3 Quantity Gap of Global INDCs

Climate Change Impact Assessment 2010–2030 of IPCC Report (AR5, 2013) [16] indicates that the artificial CO₂ increases 2.37×10^{10} tCO₂e per year, causing the level of global CO₂ 39% higher than that in the past 650,000 years. It is estimated that the world will increase 100 million new poverty-stricken population, with total emissions of 6.5×10^{10} tCO₂e.

Emissions Gap Report 2019, released by UNDP, argued that despite some achievements in climate policies made by many signatory countries, global emissions continued to grow without any sign of reaching a peak. In the past decade, global emissions increased at an annual growth rate of 1.5%, and reached 5.53×10^{10} tCO₂e only from 2018 to 2019, which hit a record high. Even if all the current unconditional commitments of INDCs are fulfilled, global temperature rises are still likely to reach 3.2 °C. The report estimated that global annual emissions must be decreased by another 1.50×10^{10} tCO₂e on the basis of the updated INDCs schemes of individual signatory countries in 2030 if the temperature rises were controlled within 2 °C, while the global annual emissions must be decreased by 3.20×10^{10} tCO₂e in order to achieve the target of temperature rises within 1.5 °C. Estimating the annual average emission reduction rate for 2020–2030, we have to reduce emissions by 2.7% per year to achieve the target of 2 °C, while reduce emissions by 7.6% per year to reach the target of 1.5 °C.

WRI research data showed that global cumulative CO₂ emissions were about 1.1×10^{12} tCO₂e during 1850–2000. If the probability of global temperature rises of 2 °C was not more than 50%, then the global cumulative emissions cannot exceed 1.44×10^{12} tCO₂e and the annual average emissions cannot exceed 2.88×10^{10} tCO₂e. If the probability of global temperature rises of 2 °C was no more than 1/3, then the global cumulative emissions cannot exceed 1.16×10^{12} tCO₂e and the annual average emissions cannot exceed 2.32×10^{10} tCO₂e. We can conclude that it is necessary to reduce emissions by 50% in 2050 than in 1990, and the cumulative emissions must arrive at the level of 1.2×10^{12} tCO₂e from 2000 to 2050. However, current global INDCs is expected to reduce emissions up to 1.10×10^{10} tCO₂e, which is not enough to cut down the emissions of 6.5×10^{10} tCO₂e in 2030 so as to balance at the level of 4.2×10^{10} tCO₂e, thus existing a huge gap. For this purpose, Greenpeace Organization expressed that it was necessary to suspect the actual effectiveness of the Paris Agreement on curbing emissions. IPCC also clearly indicated that when updating the global target in 2020, individual signatory countries would have to improve their visions for reducing emissions and update their climate targets.

As shown in Fig. 3, under the scenario of 2 °C target, it is highly possible to experience a positive emission growth of 3% or above, in spite of China temporarily, which accounts for 28% of global total carbon emissions and has annual GDP growth rate of 6%–8%. And even if all countries follow INDCs pledge, they will only be able to achieve 30% of the Paris Agreement target by 2050.

If lacking efficient emission reduction policies and incentives, only the four large economic entities, including China, US, EU and India, will exhaust the emission reduction quota in 2030 due to the inertial factors of world economic development and human life, leaving no spare quota or emission space available to other countries. Thus, the

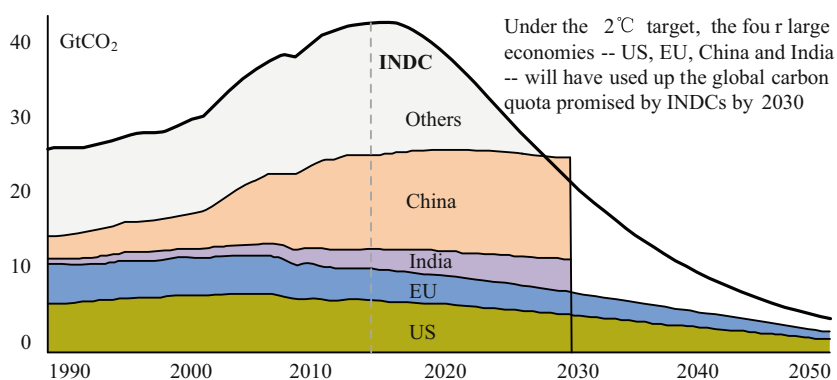


Fig. 3. Global INDCs and space for emission reduction after 2030 (Source: CDIAC/GCP data 2019)

world needs innovative solutions to reduce emission and develop new paths to increase carbon sinks.

3 Carbon Budget and Emission Reduction Dilemma

The Future Earth project have updated its data of Global Carbon Atlas and released Global Carbon Budget. Since the era of industrialization, artificial emissions were about 2×10^{12} tCO₂e, accounting for 70% contribution to global temperature rises. According to IPCC, total emissions need to be controlled within 3.2×10^{12} tCO₂e to keep temperature rises of 2 °C, leaving only 1.2×10^{12} tCO₂e quota. By January 2020, The top 5 economies in terms of carbon emissions are China (27.2%), US (14.6%), the 28 EU countries (9.6%), India (6.8%), and Russia (5.0%). Japan also has higher emissions (2.56%), just behind Russia. Germany and UK in the EU account for 2.2% and 1.1% of emissions respectively. Table 2 shows the global shares of carbon emissions in developed and developing countries.

Table 2. Emission shares of developed and developing countries

Duration	Shares of emissions from top 10 developed countries	Shares of emissions from developing countries
1750–1949	95%	5%
1950–1999	77%	23%
2000–2011	75%	23%
2012–2014	70%	30%
2015 and beyond	50%–60%	40%–50% (China accounts for a quarter of global emissions)

The International Energy Agency (IEA) released 2019 annual report of global carbon emissions, pointing out that global carbon emissions have increased by 1.6% in 2017 and 2.7% in 2018, and the emissions resulted from economic growth have been roughly offset by emission reduction actions in 2019. Global carbon emissions were 3.3×10^{10} tCO₂e, in which EU, US, Japan and other developed countries still accounted for 1/3 of global emissions. Along with the rapid development of world’s emerging economic entities, the proportional pattern of global emissions has emerged a new trend. The emissions from developed countries have actually been replaced by outsource processing emissions with annual growth rate of 11%, affecting global emission peaking in 2030 and the balance of net zero emissions in 2050. In general, developed countries ought to reduce 80% emissions in 2050 than 1990, and cumulative emissions per capita must be maintained at the level of 560tCO₂e, thus achieving the target of net zero emissions.

China National Center for Climate Strategy Research analyzed the dynamic growth index under low-carbon scenario, and found that the cumulative emission ratios of US, EU and China during 1750–2030 were 1.4:1.2:1, and China’s emissions in 2030 would be still lower than the historical cumulative emission level of US and Europe during 1750–2015. If China’s carbon intensity reduces by 60%, China will hit an emission peak at approximately 1.28×10^{10} tCO₂e in 2030. And if the carbon intensity reduces by 65%, the emission peak of China will be about 1.12×10^{10} tCO₂e in 2030 (see Fig. 4).

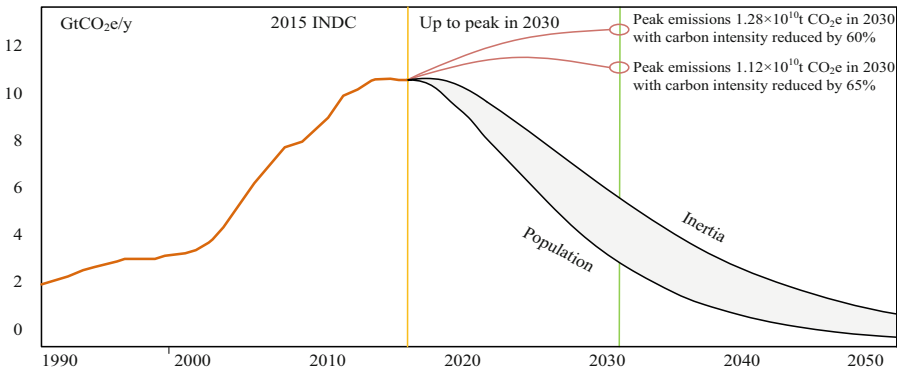


Fig. 4. Emission peaking of China in 2030 with carbon intensity reduced by 60% and 65% (Source: GCP data 2019)

International Environment Organization predicted global population would be 9 billion in 2050, with 1.5 billion and 7.5 billion living in developed and developing countries, respectively [17]. CAT organization analyzed global medium- and long-term carbon emission trends, and concluded that carbon emissions would increase to 1.39×10^{11} tCO₂e in 2100 under normal development scenarios of the Paris Agreement from global emissions of 5.7×10^{10} tCO₂e in 2015. In this case, compared with pre-industrial, global temperature will increase 2.7–5.9 °C, and the concentration stock of CO₂ will reach the historical extreme value of 889–922 ppm, causing the climate to become extremely dangerous [18].

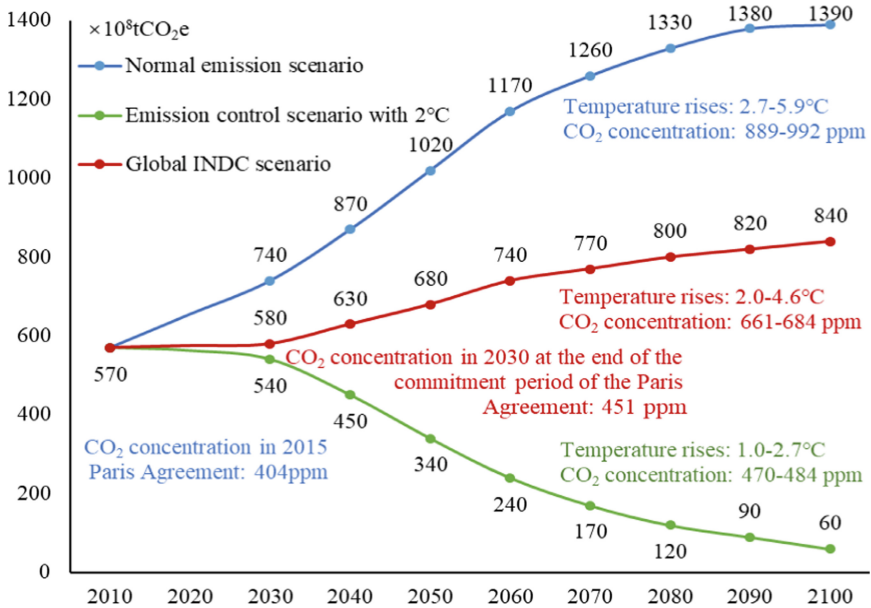


Fig. 5. Global emission scenarios for CO₂ concentration and temperature rise control in 2030, 2050 and 2100 (Source: GCP Data 2019)

In Fig. 5, the three colored curves represent different trends of temperature rises under different emission scenarios, where the intersection point represents global carbon emission level before the 2015 Paris Agreement. If we can follow the 2 °C temperature control scenario (green line) and the global INDCs commitment scenario (red line), then the temperature rise will peak steadily over the next decade or so, and then decline or continue gentle evolution. Under these two scenarios, in theory it is possible to achieve the INDCs commitments to control CO₂ concentration in 450 ppm in 2030 and temperature rises within 2 °C. However, if current normal emission scenario continues, 2100 will witness temperature rises of 2.7–5.9 °C as shown in the blue line, which would be completely unsustainable for the natural ecology.

According to the Global Carbon Project (GCP), the artificial carbon emissions arrived at a new high point during 2017–2018 at $3.68 \pm 1.8 \times 10^{10} tCO_2e$. Based on current growth rate, artificial emissions will increase to $4.1 \times 10^{10} tCO_2e$. The world will run out of carbon budget quota in next 20–30 years. Even if we improve current temperature control target of 2 °C to a more practical level of 3 °C, namely increasing the carbon budget to $2\text{--}2.5 \times 10^{12} tCO_2e$, the carbon budget will still be used up in about 30 years, see Fig. 6. Based on current emission trend and INDCs target committed by individual signatory countries, global warming will be at least 3 °C by the end of this century (UNEP, 2019), which is twice the temperature control target of 1.5 °C set by the Paris Agreement. The catastrophic effects will increase exponentially with each 1 °C increase in atmospheric temperature. Therefore, there are 114 countries around the world having announced plans to update their targets with enhanced INDCs, and 121 countries having pledged to realize carbon neutrality by around 2050.

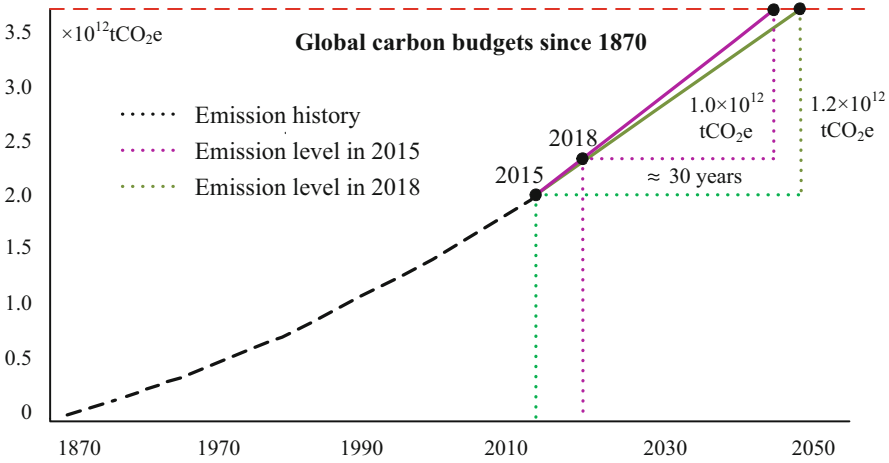


Fig. 6. Global carbon budgets compliant with concentration control (Source: GCP Data 2019)

4 New Path to Increase Carbon Sinks

It is necessary to keep global long-term temperature rises within 1.5 °C to avoid serious consequences caused by climate change. Considering the existing global carbon estimates, the emission reduction capacity of INDCs, and IPCC’s targets including emission peak in 2030, carbon balance by 2050 and net carbon emissions by 2100, the solution to climate change cannot continue to arbitrarily maintain existing carbon quota. So far, US maintains 18% of global carbon emissions, which is unfair because other countries will lose out development opportunity due to limited carbon emission space.

What is more equitable is the scheme featured with per capita cumulative emissions based on absolute equality of annual cumulative emissions of global population, because countries at different development stages need different development drivers and less developed countries need more space for their carbon budgets. The third scheme is the compromise between the first two schemes. Nature Climate Change argues for a moderate scheme that both respects history and limits global carbon budget, taking into account the mixed factors of national development status and population balance. Figure 7 shows different arrangement plans for global residual carbon budgets with respect to different emission reduction control schemes. Obviously, a more effective strategy to respond to climate change is to allocate climate resources globally by using a market-based pattern and to give full play to the potential of new pathway to carbon sink increase, based on their optimal emission reduction targets put forward by individual signatory countries.

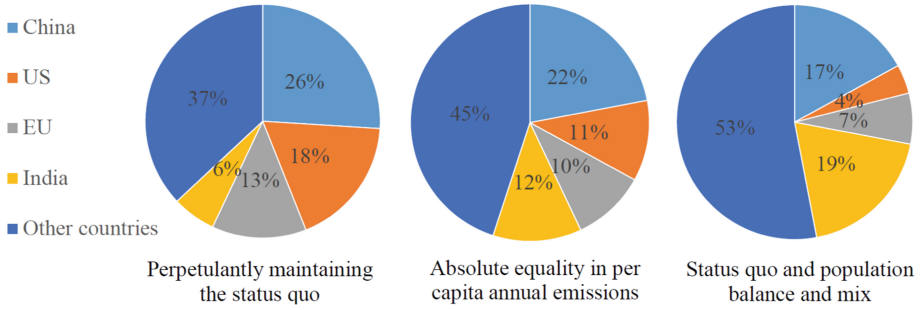


Fig. 7. Residual carbon budgets under different emission reduction schemes (Source: GCP data 2019)

The blue carbon system in the ocean, accounting for more than half of global climate resources, provides a new way to reduce emission for the market-oriented solution to global climate change, which will play a vital role in mitigating climate change. At present, the global understanding of ocean blue carbon mechanism is still very poor, especially the research on the process of ocean workings and its ecological effect is still at the stage of conceptual exploration or laboratory simulation.

The blue ocean is honored as the earth’s climate regulator. Ocean absorbs CO₂ in atmosphere and forms carbon capacity or sequestered carbon sinks in a long period, with inorganic, organic, particles, dissolved carbon, and other physical and chemical forms. There are quite a number of brown carbon, black carbon, and green carbon enter into the ocean through micro aerosols and river sediment. Data from Blue Carbon Report (2009) [19] showed that, the ocean covered 70.8% of the earth’s surface area, and 93% of the earth’s CO₂ is stored in the ocean and participates in carbon cycle through the ocean. Of the carbon captured by photosynthesis alone, 55% forms blue carbon sinks, whose composition containing carbon sequestration by microorganisms which account for more than 90% of marine biomass, and blue carbon ecosystems in important coastal zones such as mangroves, seagrass meadows and salt marshes. Studies have shown that large algae, shellfish, and even micro creatures and phytoplankton in the ocean dissolve CO₂ and then turn them into organic carbon and carbon particles, which gradually move from the ocean surface to the deep layer and realize efficient carbon sequestration and storage capacity through the direct effect of marine organisms and the indirect effect of the ecological food chain, thus forming the biggest aggregation system of carbon sink in the earth’s ecosystem. The storage of blue carbon sinks is about 50 times and 20 times that of atmospheric and terrestrial carbon sinks, respectively, thus affecting global phenological pattern, ecological resource form and distribution of food chain elements. It absorbs 30% of GHG generated by human activities since the industrial revolution, and plays an extremely important role in mitigating climate change and stabilizing global ecological balance.

With the development of science and technology and the deepening awareness of climate change, people gradually understand that the ocean ecology affects major global climate patterns. Report of IPCC (AR5, 2013) [16] and related studies [20, 21] pointed out that the necessity and importance of studying ocean ecology along with its role in

balancing the natural carbon cycle. The report of IPCC positioned the ocean ecosystem as the largest active carbon pool on earth, and blue carbon may have become the most major carbon sink in the post-industrial era, emphasizing to pay attention to the role of ocean system in reducing CO₂ and enhancing carbon sink capacity. The report considered that developing blue carbon sinks would not only make full use of ocean energy, develop climate resources, and expand human living space, but also provide the most practical and feasible way to reduce CO₂ emission and mitigate climate warming. The report emphasized to expand the application mode of global blue carbon sinks by drawing on existing international emission reduction mechanism and framework, build a blue carbon sink framework within the full carbon spectrum system, and develop oceanic carbon sink standards and measurement methodologies. Blue carbon provides a new direction for shaping the international product of carbon sink as a public resource and improving the ecological compensation mechanism. It also provides a new and effective path to increase carbon sinks in market-oriented response to global climate change.

China is the second largest economy and a major maritime power in the world. China's continental coastline is 1.84×10^4 km long and spans 22 latitudes, which is rich in coastal resources with seagrass beds, mangroves, salt marsh wetlands and a wide continental shelf sea. China possesses a rich and unique diversity of ocean biological resources, the largest fisheries carbon sinks in the world, and the most potential for blue carbon development. At present, the industrial structure and functions in China's coastal development zones are perfect, and the coastal zone economy occupies an important position in the total economic volume of China. Hence, China has had the capability to establish the ocean blue economy development mode based on its ecosystem.

5 Conclusions

This paper quantifies systematically the gap between global carbon emissions and INDCs targets in terms of CO₂ concentration, climate temperature, CO₂ emission quantity and other key indicators, investigates global carbon budget and carbon emission reduction dilemma. Consequently, this paper puts forward to develop the blue carbon as an innovative path to increase carbon sinks in future global climate governance. Due to the diversity of acting parties and the multi-polarization of competition, climate change is not only reflected in technology and economy, but also reflected in the political pattern game among countries. It is clear that developed countries have absolute advantages and have the ability to lead the layout of rules, thus becoming the leaders of new technologies, the drivers of new standards or even the monopolists of patents in future global climate governance. It is predictable that developed countries are about to win the initiative in a new round of protracted competition and once again gap with developing countries in national development potential in the future.

China is playing a leading role in global climate governance. As the second largest economy and the largest developing country in the world, at present China has the highest carbon emission level in history due to its development stage. It is imperative for China to explore the blue carbon sink system in climate resources and strengthen policy innovation in climate response mechanism. Therefore, China must take advantage of its unique conditions to develop blue carbon sinks, establish technical indicators of blue

carbon sinks, develop an evaluation system for blue carbon accounting standards, and formulate carbon emission lists for ocean basins and coastal zones. Equally important, China needs to build the market framework, transaction procedure and service support system based on the scheme of blue carbon sink increase, thus striving to incorporate blue carbon into the index system of INDCs under the Paris Agreement.

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