A COMPARATIVE REVIEW OF AGRICULTURAL CARBON EMISSION MITIGATION STRATEGIES AND PATHWAYS TO NEUTRALITY IN CHINA AND BANGLADESH

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Abstract. Limiting global warming to the critical 2 °C threshold necessitates the development of effective policies and practices for mitigating atmospheric greenhouse gases (GHGs). Agriculture, a major contributor to non-CO_2 emissions, particularly methane (CH_4) and nitrous oxide (N_2O), poses dual challenges to climate stability and food security. Moreover, agriculture's potential as a carbon sink, through judicious agroecosystem management, offers a crucial tool for combating anthropogenic climate change. China and Bangladesh reported 662.23 $MtCO_2e$ and 90.61 $MtCO_2e$, respectively, for agriculture (IPCC category), accounting for over 10% and below 2% of global emissions for the year 2020. CH_4 and N_2O remain prominent culprits in both countries. Both countries have unwavering commitment to GHGs emission reduction, employing multifaceted, nuanced strategies, regulatory frameworks, and economic instruments. Own to commendable efforts, agricultural emissions of CH_4 and N_2O in China peaked in 2016, while their emissions continued to rise in Bangladesh. However, significant challenges persist, such as China's reliance on conventional energy sources and Bangladesh's need for infrastructural development and financial resources. Both countries share the ambition and necessity of achieving carbon neutrality. China has developed a strategic framework encompassing sustainable agricultural practices, innovative approaches to mitigate livestock emissions, optimized rice cultivation techniques, and robust strategies for soil carbon sequestration. In contrast, Bangladesh's efforts are centred on enhancing energy efficiency and advocating for organic fertilizer usage. The adoption of collaborative strategies offers a multifaceted approach to addressing the intricate challenge of balancing agricultural production with emissions reduction.
Keywords: *agricultural greenhouse gases, carbon emission reduction, carbon neutrality pathways, comparative review, China, Bangladesh*

Introduction

The urgency of climate change mitigation reverberates globally, necessitating effective environmental policies. The United Nations Environment underscores this imperative (UNEP, 2022). Anthropogenic emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs) have emerged as pivotal drivers of global warming and interconnected environmental challenges (Eyring et al., 2021; IPCC, 2007). The commitment of over 170 countries, including China and Bangladesh, to the Paris Climate Agreement by December 2016 (Glemarec, 2019) exemplifies the recognition of excessive GHG emissions as a pressing concern. While the agricultural sector, vital for ensuring food security and uplifting rural livelihoods, plays a pivotal role, it is concurrently a significant source of non-CO_2 emissions like methane (CH_4) and nitrous oxide (N_2O). These emissions exert disproportionately higher warming potential of 38 and 298 times that of CO_2, respectively, over a 100-year timescale. Remarkbaly, the food system alone

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accounts for approximately one-third of total GHG emissions, equivalent to 18 gigatons of CO_2 equivalent ($GtCO_2e$) per year (Crippa et al., 2021). The sector's resonance extends to contributing to environmental issues such as land-use changes, biodiversity loss, freshwater depletion, and pollution of aquatic and terrestrial ecosystems due to nutrient runoff from fertilizers and manure (Crippa et al., 2021, 2022; IPCC, 2022; UNEP, 2022). Agriculture occupies nearly half of global vegetated land, harboring immense potential for mitigating climate change through GHGs reduction and enhanced soil carbon sequestration (Lehner and Rosenberg, 2017). However, the escalating global population and an expanding affluent class forecast a 35% to 56% rise in food demand between 2010 and 2050 (Zhao et al., 2021), potentially exacerbating agricultural GHG emissions and jeopardizing emission reduction goals (Searchinger et al., 2019). These endeavor towards carbon–neutral agriculture thus faces the dual challenge of catering to escalating food demands while curtailing GHG emissions.

Notably, GHG emissions from food systems alone could undermine the Paris Agreement's mission of limiting global warming to under 2°C, with an aspirational target of 1.5°C (Clark et al., 2020). In the agricultural context, CH_4 and N_2O emissions demand particular scrutiny due to the equilibrium between CO_2 absorption and emission. These emissions predominantly arise from rice cultivation, nitrogen fertilizers usage, and enteric fermentation in ruminant livestock, and fluorinated greenhouse gases (F-gases), including HFCs, PFCs, SF_6, and NF_3, are potent, long-lived synthetic gases with high global warming potential. (UNEP, 2022). Conversely, agriculture assumes significance as a carbon sink, with potential for organic carbon storage and soil carbon sequestration that concurrently mitigate climate change, bolster soil fertility, and enhance crop yield. Worldwide, diverse policies and measures have been instituted, encompassing GHG emissions reduction in farming, livestock breading and grazing, sequestration promotion, emissions curbing in food systems, financial incentives and market regulations (Tian et al., 2014; UNEP, 2022; Zhu and Huo, 2022; Wang et al., 2022). This study presents as a comparative analysis of China and Bangladesh, scrutinizing their strategies for curbing carbon emissions in agriculture and assessing their potential for future mitigation endeavors.

China, a principal emitter of total GHG emissions and the third-largest per capita emitter in 2020 (UNEP, 2022), has made substantial climate commitments. President Xi Jinping's 2020 pledge of carbon emission peak by 2030 and carbon neutrality by 2060, supplemented by the Fifth Plenum report outlining carbon emissions decline after peaking in 2035, underscores China's ambitious climate agenda. This paradigm shift imposes augmented standards on the agricultural sector, which contributes significantly to national and global emissions. As China cultivates about 9% of the world's arable land and generates 20% of global food and fibers production, agriculture emerges as a potent force in emissions. Particularly, China stands as the leading rice producer globally (*Fig. 1*).

Bangladesh, despite contributing less than 1% of global GHG emission, ranks among the ten most climate-affected natation. The Global Climate Risk Index for 2021 identifies Bangladesh as the seventh most influenced country between 2000 and 2019. Bangladesh's pioneering Climate Change Strategy and Action Plan, formulated in 2009, exemplifies its commitment to combating climate change. Notably, rice production, a vital sector (*Figs. 1* and *2*), also bears the potential for heightened CH_4 emissions due to rice cultivation. The intensified use of nitrogen fertilizers further threatens N_2O emissions. Bangladesh reaffirmed its dedication at the Glasgow climate summit, pledging to reduce carbon emissions by 89.47 million tons, equating to 21.9% of CO_2 by 2030.

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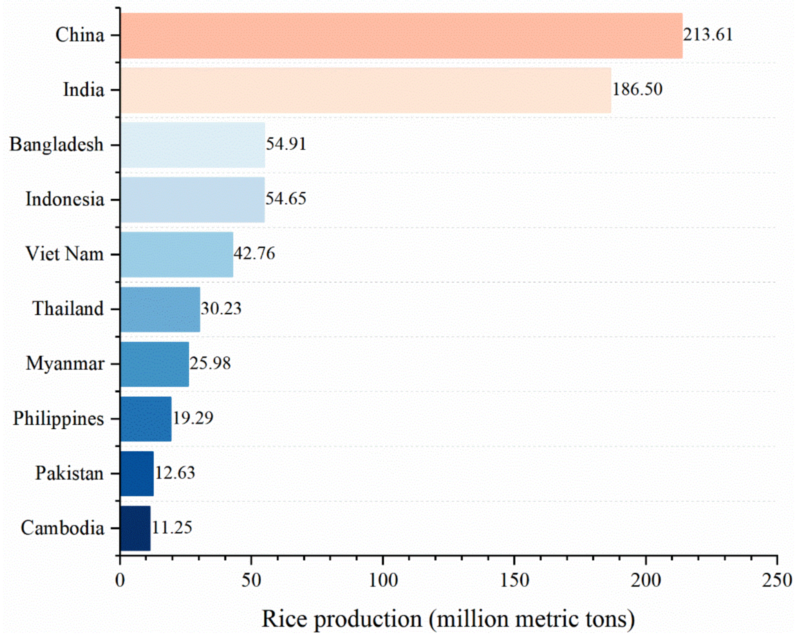

Figure 1. *Top ten largest rice producers worldwide. (Data sources: https://www.fao.org/faostat/en/#data)*

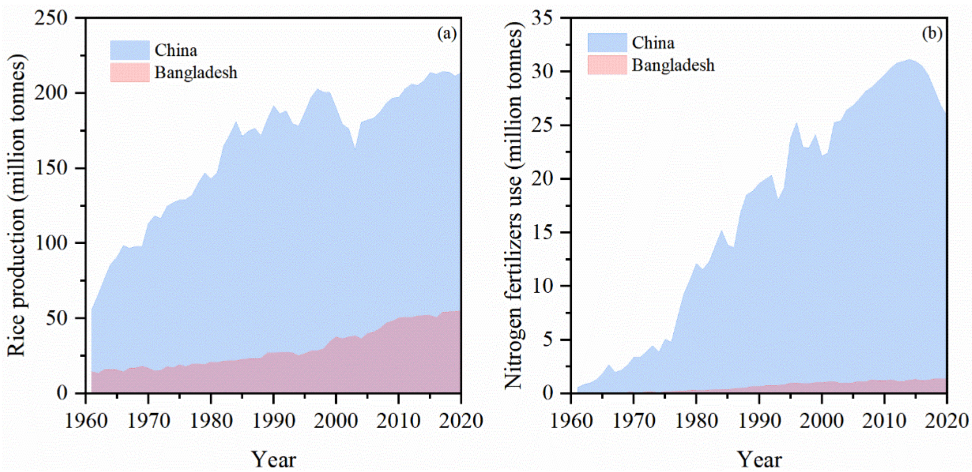

Figure 2. *Rice production quantity (a) and nitrogen fertilizers use (b) in agriculture from 1961 to 2020 in China and Bangladesh. (Data sources: https://www.fao.org/faostat/en/#data)*

The selection of China and Bangladesh for this comparative analysis is deliberate and grounded in both contrast and comparability. China represents a large-scale, highly intensive agricultural system with advanced technological integration and established mitigation policies, whereas Bangladesh typifies a smallholder-dominated, resource-constrained system undergoing rapid agricultural development. Despite these structural differences, both countries share critical commonalities, including a strong reliance on rice-based production systems and significant contributions of CH_4 and N_2O emissions from agriculture. This duality enables a meaningful comparative framework to evaluate how differing socio-economic conditions, technological capacities, and policy environments influence greenhouse gas mitigation pathways. Consequently, the comparison provides

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broader insights into scalable and adaptable strategies for achieving carbon neutrality across diverse agricultural systems rather than reflecting arbitrary country selection.

National GHG emissions from agriculture

Both China and Bangladesh boast agrarian economies characterized by smallholders managing 1.23 and 0.72 mu of arable land per capita, sustaining a population of 1.46 billion with 1.19 billion ha and 167.4 million with 8 million ha, respectively (FAOSTAT, 2022). China' agricultural output, constituting 32.3% of the global share, yield 213.6 million tons of rice in 2020. While Bangladesh's global agricultural output contribution is smaller than 1%, it ranks third as a rice producer.

Present status of agricultural GHG emissions (2020)

Our analysis leverages the FAOSTAT dataset (https://www.fao.org/faostat/en/#data/GT), which encompasses GHF emissions estimates for agriculture, forestry, and other land uses (AFOLU), land use, land-use change, and forestry (LULUCF), and agriculture alone from IPCC. *Table 1* summarizes the GHG emissions of China, Bangladesh, and the world in 2020. In 2020, China reported GHG emissions of 14.98 $MtCO_2e$ for AFOLU, 647.24 $MtCO_2e$ for LULUCF, and 662.23 $MtCO_2e$ for agriculture (IPCC category). In Bangladesh, 108.40 $MtCO_2e$ for AFOLU, 17.78 $MtCO_2e$ for LULUCF, and 90.61 $MtCO_2e$ for agriculture were reported.

Table 1. *Estimation of GHG emissions ($MtCO_2e$) for 2020 in China, Bangladesh, the while world*

Estimations	Area	GHG ($MtCO_2e$)	CO_2 (Mt)	CH_4 ($MtCO_2e$)	N_2O ($MtCO_2e$)	F-gas ($MtCO_2e$)
AFOLU	Global	7425.11	1172.69	4083.43	2168.99	8.18
	China	14.98	-647.85	373.48	289.36	1.09
	Bangladesh	108.40	17.54	67.94	22.92	0.09
IPCC Agriculture	Global	6031.64	0.00	3959.41	2072.23	7.82
	China	662.23	0.00	373.15	289.08	1.09
	Bangladesh	90.61	0.00	67.81	22.80	0.09
LULUCF	Global	1393.47	1172.69	124.02	96.75	0.37
	China	-647.24	-647.85	0.32	0.28	0.00
	Bangladesh	17.78	17.54	0.13	0.11	0.00

The agriculture domain in China stands as a promising reservoir for carbon sequestration, boasting negative emissions of CO_2 as deduced from both AFOLU and LULUCF sectors. Interestingly, it is crucial to underscore that CO_2 emission, a pivotal facet, were excluded from the IPCC estimates. This observation aligns seamlessly with prior research (UNEP, 2022), reiterating that CH4 and N2O remain the principal culprits in the realm of agricultural GHG emissions, both within China, Bangladesh, and on a global scale when focusing exclusively on agriculture (*Fig. 3*). A compelling insight emerges as CH4, a potent GHG, emerges as the dominant force, constituting a significant portion of total GHG emissions in both China and Bangladesh. Strikingly, in the context of Bangladesh, CH4 claims a staggering 74.8%, overshadowing the global average of

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65.6% and China's proportion of 56.4%. This nuanced distribution underscores the unique challenges faced by Bangladesh in taming CH_4 emissions from its agricultural pursuits, while accentuating the shared responsibility of both nations in mitigating the far-reaching impacts of agricultural emissions. In navigating the intricate landscape of agricultural emissions, understanding the significant role of CH_4 and N_2O is paramount. These insights drive home the imperative for tailored mitigation strategies that grapple with these emissions, thereby carving a sustainable path forward for both nations and the globe at large.

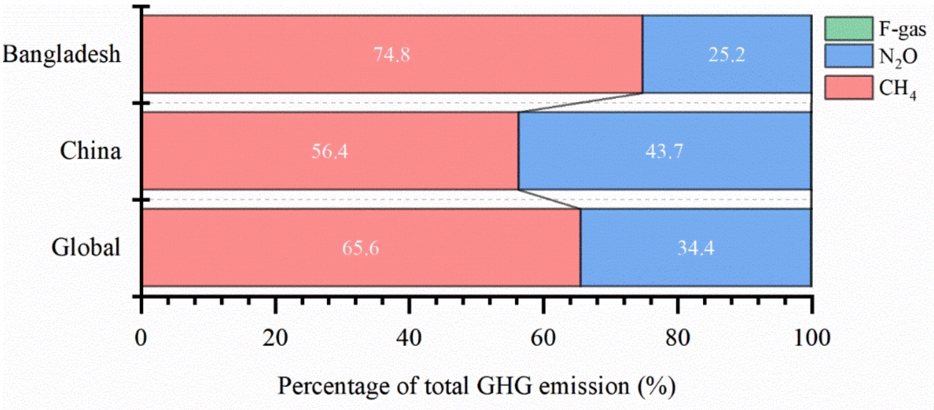

Figure 3. *Percentage contribution of three GHG potent to total GHG emissions in China, Bangladesh, the globe in 2020*

Temporal trend of agricultural GHG emissions

The past six decades (1961-2020), exhibit a discernible trajectory in global agricultural GHG emission, mirrored in Bangladesh (*Fig. 4a*). China's emissions, however, display a rapid escalation until 1996, followed by fluctuations until 2015, when they commence a decline (*Fig. 4a*). CH4 and N_2O emissions demonstrate continuous growth globally (*Fig. 4b*) and in Bangladesh (*Fig. 4d*). However, noteworthy is the trend reversal in 2016 and 2015 for CH4 and N_2O emissions, respectively (*Fig. 4c*).

A visionary glimpse into the future trajectories of agricultural greenhouse gas (GHG) emissions reveals intriguing patterns. By contrasting the emissions estimated for 2020 with IPCC projections, a compelling narrative emerges. The global stage presents a promising proposition with an anticipated decline in agricultural emissions of total GHGs and exhaustive CH_4 and N_2O, projected to unfold by 2030, only to be succeeded by a paradoxical upswing 2050 (*Fig. 4e*). China, a pivotal player on the world stage, traverses a distinct path. The trajectory of national agricultural emissions paints a steadfast rise, and indicated by the projections of total GHGs, CH_4 and N_2O each charting a continuous ascension (*Fig. 4f*). This trajectory underscores the critical nature of the challenge at hand, necessitating strategic interventions to balance the imperatives of food security and environmental stewardship.

In stark contrast, the Bangladeshi narrative showcases a different story. The projections put forth an intriguing trajectory for N_2O emissions, envisaging relative stability until 2030, which is followed by an anticipated escalation by 2050 (*Fig. 4g*). This projection brings to the fore the need for targeted strategies to curtail the expected surge in N_2O emissions, underscoring the urgency of sustainable practices.

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These diverse trajectories provide a glimpse into the dynamic interplay between policy, practices, and environmental outcomes. As the global community seeks to navigate the intricate landscape of sustainable development and climate change mitigation, these projected pathways serve as guiding beacons, illuminating the complexities that define the intersection of agriculture, emissions, and the quest for a resilient future.

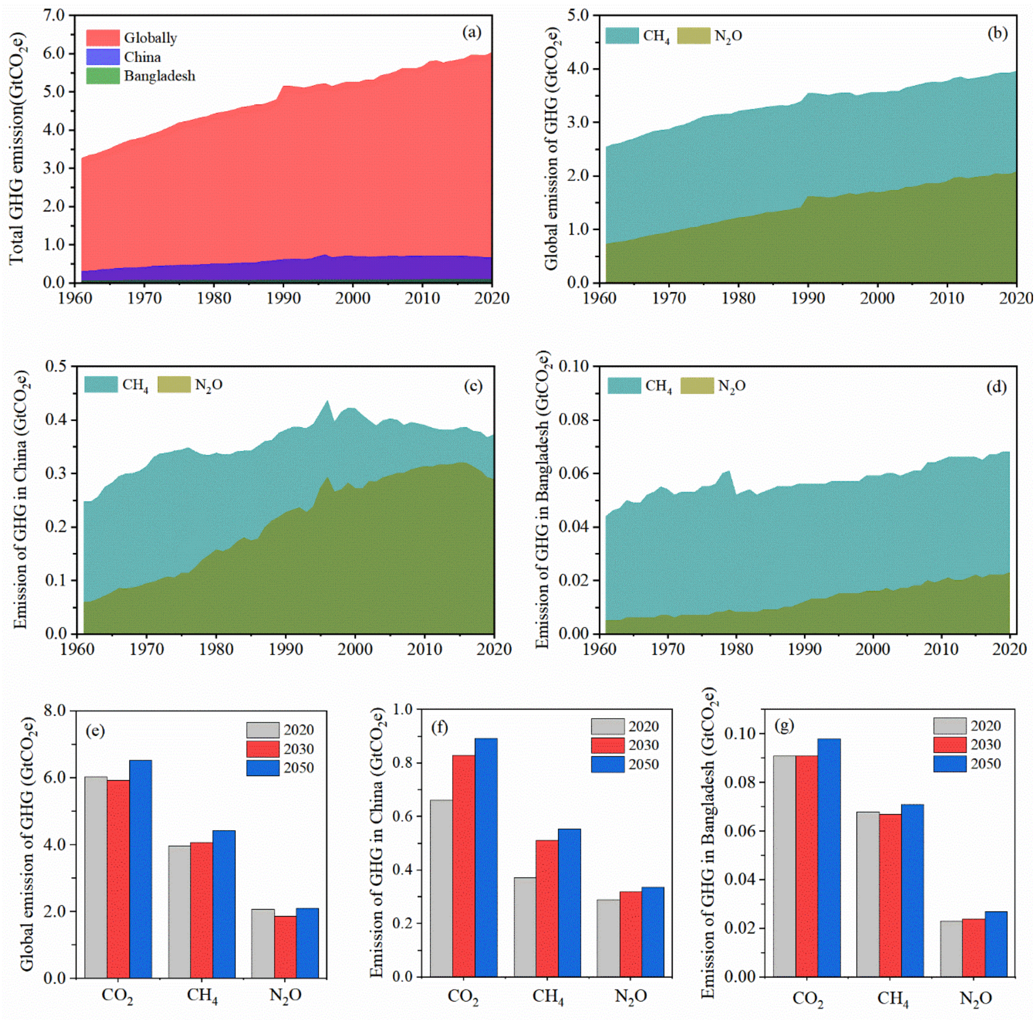

Figure 4. *Temporal trends in agricultural GHG Emissions: Total GHG emissions worldwide, in China, and in Bangladesh (1961-2020) (a); CH_4 and N_2O emission (1961-2020) worldwide (b), in China (c), and in Bangladesh (d); Projection of CO_2, CH_4 and N_2O emission for years 2030 and 2050 worldwide (e), in China (f), and in Bangladesh (g). The emission projections in (e-g) are benchmarked against 2020 baseline emissions and extrapolated following IPCC-based scenario trends for 2030 and 2050*

Shares of agricultural GHG emissions

The contemporary global landscape is marked by the pressing concern of climate change, a phenomenon largely driven by the surge in GHGs emissions. Amid this challenge, the agricultural sector emerges as a significant contributor, wielding substantial influence on worldwide emissions. Despite the prevailing focus on sectors like energy and transportation in the discussions of GHGs, the agricultural sphere's importance cannot be overstated. This becomes evident when considering the substantial

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output of CH_4 and N_2O, potent GHGs, through agricultural activities such cattle rearing, rice cultivation, and fertilizer application (Maraseni et al., 2018). In shaping efficient mitigation strategies and aligning with climate targets, comprehending the intricate landscape of agricultural GHG emissions across nations assumes paramount significance. In this discourse, we turn our gaze to two distinct nations, China and Bangladesh, characterized by disparate agricultural systems and environmental contexts. This comparative exploration unveils not only commonalities and disparities but also potential avenues for policy intervention to navigate the intricate confluence of sustainable agriculture and climate change mitigation (Crippa et al., 2021; Raihan et al., 2023).

China, bearing the mantle of the world's most populous nation and a formidable agricultural producer, confronts unique challenges in curbing agricultural GHG emissions. A landscape dominated by intensive livestock production, widespread use of synthetic fertilizers, and substantial rice cultivation underscores the intricacies of China's agricultural economy. This intricate web significantly influences the tapestry of China's GHG emission profile. Among the contributors, CH_4 emissions loom large, emanating primarily from livestock, especially ruminant species like cattle and sheep. The genesis of CH_4 transpires during enteric fermentation within their digestive systems and during dung handling. Noteworthy is the significant population of cattle that amplifies China's CH_4 emissions. The deployment of synthetic fertilizers in agricultural sets in motion process of nitrification and denitrification, adding to the accumulation of N_2O emissions (Zhang et al., 2022). Moreover, inefficient and excessive fertilizer use has the propensity to elevate N_2O emissions, exacerbating the agricultural sector's GHG footprint. Furthermore, rice farming is an essential part of Chinese agriculture and a large contributor to GHG emissions. A cornerstone of Chinese agriculture, rice cultivation contributes substantively to GHG emissions. Under submerged conditions, rice paddies create an anaerobic milieu that facilitates the breakdown of organic matter, leading to CH_4 emission. Microorganisms flourish in these flooded conditions, engendering CH4 production. The magnitude of emissions is contingent upon multifaceted factors encompassing rice variety, irrigation methods, and soil management (Chen et al., 2022).

In contrast, Bangladesh, a South Asian nation, grapples with an agricultural landscape distinct from its Chinese counterpart. Dominated by smallholder farms, limited mechanization, and a heavy reliance on rice cultivation, Bangladesh's agricultural domain confronts challenge in reining in GHG emissions. The pivotal role of rice cultivation is evident, encompassing a significant majority of the populace in this agricultural endeavor. Analogous to China, CH_4 emission burgeon in the flooded paddy fields dedicated to rice cultivation. The anaerobic degradation of organic waste fuels substantial CH_4 release in these locales. However, compared to China, Bangladesh's livestock industry contributes relatively modestly to GHG emissions, a phenomenon primarily rooted in the country's fewer livestock numbers (Chen et al., 2023; Das et al., 2020).

Both China and Bangladesh have embarked on multifarious strategies and regulations aimed at mitigating agricultural GHG emissions. China, with its formidable agricultural sectors, directs its focus towards enhanced livestock management practices, promotion of precision agricultural technologies to optimize fertilizer application, and adoption of innovative practices such as alternative wetting and drying methodologies in rice cultivation to mitigate CH_4 emissions. In contrast, Bangladesh's emphasis gravitates towards pioneering rice cultivation techniques, including alternating soaking and drying, along with the strategic deployment of CH_4 inhibitors (Islam et al., 2021).

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To enable a more robust assessment of nitrogen-related emissions, nitrogen fertilizer use should be evaluated relative to agricultural output rather than in absolute terms. Although Bangladesh demonstrates a consistent increase in nitrogen fertilizer consumption, this trend alone does not substantiate excessive intensification. When normalized by productivity indicators such as kg N per ton of crop yield or per hectare fertilizer use intensity in Bangladesh remains lower than or comparable to that of China's highly input-intensive agricultural system. This disparity reflects structural differences, including lower baseline yields, limited mechanization, and less optimized nutrient management practices. Consequently, the rising nitrogen input in Bangladesh is more plausibly linked to yield improvement efforts rather than systemic over-application. A more accurate evaluation therefore requires the integration of nitrogen use efficiency (NUE) metrics and yield-scaled N_2O emission intensities (e.g., kg N_2O–N per unit yield), which provide a clearer indication of environmental performance and mitigation priorities within the agricultural sector.

Challenge of GHG Emissions reduction from Agriculture

As underscored earlier, the agricultural sector assumes a pivotal role in the national GHG emissions profiles of both China and Bangladesh, with a distinct focus on emissions of CH_4 and N_2O. Yet, the mounting pressure to satisfy the escalating demands for livestock and crop production, driven by burgeoning populations and evolving dietary preferences, presents an intricate challenge in the realm of climate change mitigation and the assurance of future food security within these nations. In the context of China and Bangladesh, these challenges manifest differently: China faces pressures from large-scale, input-intensive agriculture, whereas Bangladesh is constrained by smallholder systems, limited mechanization, and financial capacity.

In this pursuit, the delicate equilibrium between meeting food requisites ameliorating the ecological imprint of agriculture becomes pivotal. The trajectory towards this equilibrium rests upon the foundations of innovative and sustainable agricultural practices, intertwined with strides in technological prowess and strategic policy interventions. The potent synergy of these elements has the potential to curtail GHG emissions while concurrently safeguarding food security, epitomized by the promotion of sustainable agricultural development and the cultivation of a robust food system. The recent surge in emphasis on sustainable agricultural expansions father substantiates this approach (Nema et al., 2012). Illustratively, precision farming methodologies emerge as a beacon of hope, the empower optimal fertilizer application thus minimizing nitrogen losses and the subsequent N_2O emissions (Hassan et al., 2022). This advancement leverages precision technology, such as remote sensing and GPS-guided machinery, enabling farmers to administer fertilizers with heightened precision and minimal wastage (Muller et al., 2011). While China has made notable progress in adopting precision agriculture technologies, Bangladesh still faces barriers in access, affordability, and technical expertise, limiting large-scale implementation.

The ethical management of livestock assumes paramount importance in our quest. In both China and Bangladesh, livestock husbandry emerges as a formidable GHG contributor. Taming CH_4 emissions from cattle necessitates the adoption of measures like enhanced feeding efficiency, sophisticated waste management techniques, and the deployment of biogas digesters. By can be decreased by putting into practice methods like increased feeding effectiveness, better waste management techniques, and the usage of biogas digesters. For example, methane from animal waste may be captured by biogas

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digesters and turned into electricity, lowering emissions and the need for fossil fuels. Additionally, supporting a resilient food system is essential in overcoming the difficulty of reducing GHG emissions in agriculture. To boost resistance to the effects of climate change, this entails diversifying agricultural methods and crop options. For instance, encouraging agroforestry systems, which mix trees with crops or animals, can help to store carbon while giving farmers access to new forms of revenue. Crop variety diversification can help agricultural systems adapt to shifting climatic circumstances and lower the demand for synthetic pesticides and fertilizers (Thangarajan et al., 2013; Yu et al., 2020). In China, intensive livestock production significantly amplifies methane emissions, whereas in Bangladesh emissions are primarily associated with traditional small-scale livestock practices.

In this pursuit of mitigating the complexities of agricultural GHG emissions, technology emerges as the lodestar. In the age of agricultural innovation, developments such as sensors, drones, and data analytics facilitate more efficient and targeted farming practices. Though these technologies, farmers can navigate their agricultural landscapes with precision, optimizing resource inputs and curtailing emissions. Furthermore, the synergy of sustainable intensification and emissions abatement finds resonance in the evolution of climate-smart agricultural practices. These innovative approaches incorporate climate change considerations into agricultural systems, enhancing their adaptability and emissions mitigation potential. However, policy measures remain pivotal in propelling the adsorption of sustainable agricultural practices and curtailing GHG emissions. Both the Chinese and Bangladeshi governments have enacted an array of legislation and policies to incentivize the adsorption climate-friendly methods. Notably, subsidies for precision agriculture technology stand as a tangible example. Concurrently, elevating awareness and imparting education on sustainable farming practices acts as the lynchpins for orchestrating the transition towards a low-emission agricultural paradigm.

In sum, the tapestry of agricultural GHG emission reduction unravels a mosaic of intricate challenges and promising solutions. By navigating the interplay of innovation, sustainability, technology, and policy, we forge a path towards sustainable agricultural growth that not only safeguards our environment but also ensures the sustenance of future generations.

Reduction potential of GHG emissions from agriculture

Unlocking reduction potential of GHG emissions from agriculture production

In the journey towards achieving carbon-neutral agriculture, a comprehensive understanding of reduction potentials stands as imperative (Zhao et al., 2023). Given the pivotal role that agriculture plays in the realm of emission mitigation strategies, a multitude of investigations have been undertaken to assess the scope of mitigating GHG mitigation, particularly those stemming from non-CO_2 carbons sources (Chen et al., 2022). Realizing the prospect of reducing GHG emissions from agricultural operations hinges upon a tapestry of factors, ranging from technical innovations to management paradigm shifts and legislative transformations. These factors collectively influence resource utilization efficiency, the curbing of carbon-intensive inputs, and the assimilation of climate-resilient farming practices. The realization of these mitigation potentials differs between China and Bangladesh due to variations in technological advancement, policy enforcement, and agricultural infrastructure.

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Among the domains with discernible potential emission reduction lies livestock production—a potent contributor to agricultural GHG emissions. A notable avenue towards reduction entails the refinement of livestock management practices (Shi et al., 2023). Here, strategic interventions such as the integration of feed supplements and dietary alterations stand as viable approaches to ameliorate enteric fermentation, consequently abating CH_4 emissions from ruminant animals. Furthermore, harnessing CH_4 emissions through advanced manure management techniques like anaerobic digestion embodies an avenue replete with promise.

The judicious application of fertilizers emerges as another pivotal determinant. Synthetic fertilizers, notorious for eliciting pronounced emissions of N_2O, a potent GHG, underscore the need for precision. The adoption of precision agricultural strategies, incorporating sensor technology and site-specific nutrient management, holds promise to optimize fertilizer application efficacy while constricting nitrogen losses and the ensuing emissions. Concurrently, the orchestration of sustainable soil management techniques presents an avenue for emissions reduction. Conservation agricultural practices, including minimal tillage, cover cropping, and crop rotation, substantiate a pathway to elevate soil organic carbon storage, bolster soil vitality, and subsequently enhance water retention. This confluence culminates in a diminution of synthetic fertilizers reliance and a concomitant reduction in GHG emissions (Dong et al., 2018; Uusitalo et al., 2014).

Rice cultivation, particularly in flooded paddy fields, also harbors prospects for emissions alleviation. This intermittent flooding and drainage of rice fields, encompassing the innovation concept of alternative wetting and drying, is pivotal in this regard. By abbreviating periods of anaerobic conditions, wetting and drying effectively curtails activity of CH_4-generating bacteria, thereby diminishing emissions. The conjunction of wetting and drying adoption and optimized water management constitutes a powerful toolset for the mitigation of emissions arising from rice cultivation. The fulcrum of realizing the promise of reduced GHG emissions from agricultural production pivots upon technological innovation. Climate-smart agricultural practices epitomized by precision agriculture technology, remote sensing, and data analytics bear the potential to revolutionize resource allocation, waste minimization, and emission reduction (Arai et al., 2021; Cheng et al., 2022). In tandem, the harnessing of biogas and renewable energy sources within agricultural operations such as solar-powered irrigation system further galvanize emission mitigation efforts. Given that both China and Bangladesh are major rice producers, mitigation strategies such as alternate wetting and drying are particularly relevant, although adoption is more advanced in China than in Bangladesh.

In the orchestration of emission-reduction paradigms within agriculture, the efficacy of policy interventions remains indisputable. Governments wield a pivotal role in enacting regulatory frameworks, disbursing subsidies, and offering technical support. The provision of incentives to foster the adoption of climate-resilient agricultural technologies, like renewable energy sources and precision farming machinery, emerges as a tangible avenue. Additionally, robust awareness campaigns and capacity-building measures stand as instrumental conduits for enlightening farmers about the merits of emission reduction techniques and facilitating their seamless integration into practice.

Delving into the pursuit of carbon neutrality in agriculture

In recent years, the pursuit of achieving carbon neutrality within agriculture sector has emerged considerable attention, owing to its substantial contribution to GHG emissions. With agriculture responsible for a noteworthy share of these GHG emissions, particularly

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from sources such as CH_4 and N_2O stemming from livestock practices, rice cultivation, and synthetic fertilizer use, the imperative to attain carbon neutrality within this sector has grown imperative. The attainment of such a goal necessitates a dual approach: the effective reduction of emissions and their subsequent offset trough mechanisms like carbon sequestration. However, this pursuit is complex, requiring a delicate equilibrium between emission reduction and safeguarding global food security (Kong et al., 2022). Thus, a comprehensive and harmonized strategy is indispensable, one that meticulously combines emissions abatement with the tenets of sustainable food production. Achieving carbon neutrality in agriculture requires differentiated pathways, with China focusing on technological innovation and large-scale policy implementation, while Bangladesh prioritizes low-cost, adaptable, and resilience-based strategies.

A pivotal facet of realizing carbon neutrality in agriculture resides in the widespread adoption of sustainable farming practices. Embracing methodologies such as precision agriculture, conservation agriculture, agroforestry, and organic farming is organic farming is instrumental in this endeavor. Precision agriculture harnesses technology and data to optimize resource utilization, thereby curtailing inputs like water, fertilizers, and pesticides, thus contributing to emissions abatement. Conservation agriculture, on the other hand, accentuates minimal soil disruption, persistent soil cover, and diverse cropping systems, elevating carbon sequestration capabilities and mitigating emissions attributed to soil management (Li et al., 2022). Agroforestry, by interweaving trees cultivation with conventional agricultural practices, establishes supplementary carbon reservoirs and fosters biodiversity. Concurrently, organic farming mitigates GHG emissions by eschewing synthetic fertilizers and pesticides, thereby trimming their carbon-intensive production and usage.

Addressing CH_4 emission stemming from livestock farming is a cornerstone of the journey towards carbon neutrality. The production of livestock contributes substantially GHG emissions, particularly through enteric fermentation and the handling of animal waste. Pioneering approaches such as feed additives, dietary adaptations, and refined manure management systems emerges as effective tools in tempering these emissions. Furthermore, the harnessing of CH_4 through anaerobic digestion not only abates emissions but also generates renewable energy (Chen et al., 2022). In contest of rice cultivation, the adoption of alternate wetting and drying techniques exhibits potential. Alternate wetting and drying, entailing intermittent field drying between irrigation cycles, curbs CH_4 emissions while preserving crop yield (Siopongco et al., 2013). Augmenting water management practices, notably controlled irrigation, also contributes to emissions reduction in rice cultivation.

Leveraging the potential of agricultural soil for carbon sequestration stands as a formidable avenue towards carbon neutrality. Practices that enhance soil organic carbon, such as cover cropping, crop rotation, and organic amendments, amplify soil capacity for carbon storage. This not only curbs GHG emissions by sequestering atmospheric CO_2 but also augments soil vitality, fertility, and moisture retention. Augments these efforts, initiatives encompassing afforestation, reforestation, and agroforestry systems offer supplementary carbon sinks that facilitate emission balance (Balaine et al., 2019). In parallel, the establishment of renewable energy projects, such as wind or solar farms in rural enclaves, contributes to emission offsetting while diversifying energy sources.

The transition towards carbon neutrality within agriculture hinges on robust policies and financial incentives. Governments play an instrumental role by channeling funds into research and development, providing economic stimuli for farmers who adopt emission-

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curbing practices, and crafting regulatory frameworks that endorse carbon-neutral agricultural methods. Additionally, the establishment of carbon credit markets confers economic motivation for farmers to embrace practices that heighten carbon sequestration and emissions reduction. The complexity of realizing carbon neutrality in agriculture necessitates a collaborative effort involving farmers, policymakers, researchers, and stakeholders, all of whom must work synergistically to formulate and implement strategies that harmonize emission reduction with global food security. A steadfast commitment to this pursuit bolsters the transition to a more sustainable, resilient food system, offering a potent instrument against the impacts of climate change.

In summary, the journey towards carbon neutrality in agriculture is an imperative step to combat climate change. By amalgamating sustainable farming practices, innovative livestock emission mitigation, optimized rice cultivation techniques, and robust soil carbon sequestration strategies, we can forge a pathway to emission equilibrium. The symbiotic partnership of diverse stakeholders is essential to navigate the intricacies of this journey, paving the way for a more climate-resilient and sustainable future. Therefore, a comparative perspective between China and Bangladesh is essential for designing effective and region-specific mitigation strategies

Policies and strategies for attaining carbon reduction and neutrality

Enacting policies and measures in China

The realization of carbon neutrality and mitigation of GHG emissions have emerged as paramount objectives with Chinese agriculture. To navigate this challenging terrain, Chinese policymakers have proactively devised a multifaceted suite of policies and actions, a visual representation of which can be observed in *Figure 5*. A seminal step in this trajectory materialized with the inception of the National Climate Change Program in 2007, catalyzed by the United Nations Framework Convention on Climate Change. This pioneering endeavor delineated an intricate tapestry of measures and technologies engineered to attenuate agricultural GHG emissions and amplify carbon sequestration efforts. In a subsequent juncture, the issuance of ‘Responding to Climate Change: China’s Policies and Actions’ by the State Council in 2011 further crystallized the imperative to revamp animal husbandry practices, inaugurate a subsidy initiative aimed at bolstering soil organic matter, and augment carbon sequestration within agricultural landscapes.

Of particular significance is the alignment of agricultural emissions control with broader environmental pollution reduction and carbon abatement endeavors, as encapsulated within the revised Air Pollution Prevention and Control Law of the People’s Republic of China in 2015. This integrative approach enmeshes the curbing of both GHGs and other atmospheric pollutants stemming from agricultural origins. Making a period of accelerated policy reform, the 13th Five-Year Plan (2016-2020) witnessed the ascendancy of strategic environmental policies, prominently featuring the all-encompassing thrust of agricultural green development. A remarkable assemblage of milestones emerged during this epoch, accentuating the formulation of the 13th Five-Year Plan for Controlling Greenhouse Gas Emissions (2016). The blueprint resonated with directives for the cultivation of low-carbon agriculture, the harmonization of climate change mitigation and adaptation, and the attenuation of GHG emission across the agriculture spectrum. In parallel, the meticulously delineated 13th Five-Year Comprehensive Energy Conservation and Emission Reduction Work Plan (2016) not only articulated an intricate roadmap for energy conservation in rural and agricultural settings but also outlined measures to abate agricultural pollution emissions.

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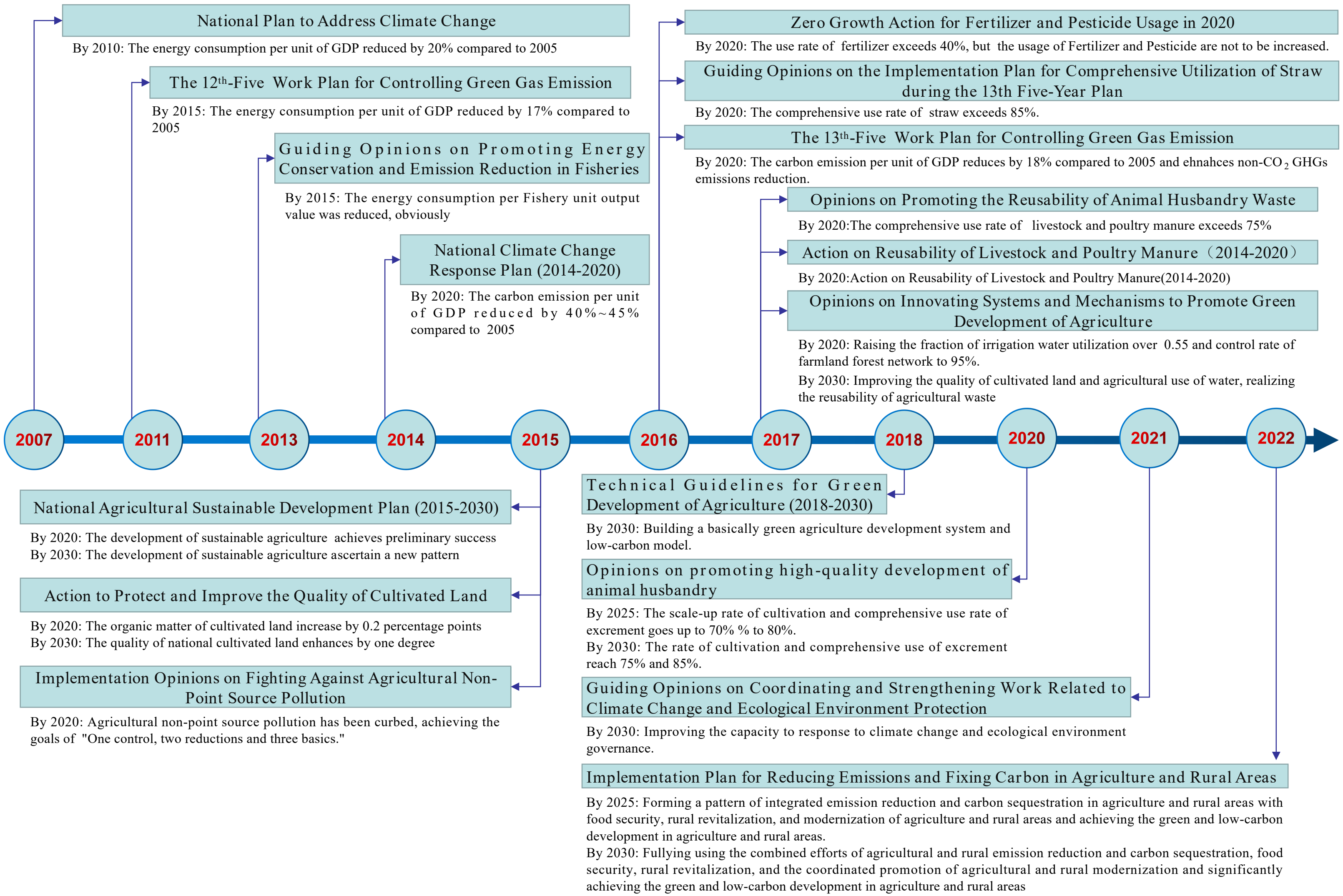

***Figure 5.** Policies and measures combating reduction of agricultural GHG emissions in China (Wu et al., 2024; Wang et al., 2025)*

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The year of 2021 etched an indelible mark in the pursuit of carbon reduction and sequestration in agriculture, witnessed through the release of 'Opinions on the Complete, Accurate, and Comprehensive Implementation of the New Development Concept to Do a Good Job in Carbon Peak' and the 'Carbon Neutrality and Action Plan for Carbon Emission Peak Before 2030'. These directives unequivocally spotlighted the imperative of nurturing carbon reduction and sequestration endeavors within the realms of agriculture and rural sectors. Central to this architectural transformation is the 'Nation Sustainable Agricultural Development Plan (2015-2030)', which provides a north star for the cultivation of future-oriented sustainable agriculture. The pivotal 'Opinions on Innovating System and Mechanism to Promote Agricultural Green Development (2017)' heralded the infusion of the green development paradigm into the very bedrock of agricultural modernization. Anchoring these overarching visions, the '13th Five-Year Plan for Science and Technology Innovation in Agriculture (2017)' and the 'Reformation Plan for Establishing a Green and Ecology-Oriented Agricultural Subsidy System (2016)' stands as cornerstones, offering technological scaffolding to breathe life into carbon reduction and sequestration goals with the agricultural landscape.

To staunch the flow of agricultural carbon emissions, an intricate mosaic of policies and regulations has been artfully crafted and judiciously executed by China's policymakers. This assemblage encompasses an array of strategies, including the rationalization of fertilizer and pesticide application, and the reclamation of livestock manure and agricultural detritus. Delving into the mechanics of fertilizer reduction, an approach that adroitly spans both the supply and demand dimensions, unfolds. On the supply side, the phased discontinuation of subsidy policies such as preferential electricity and natural gas price, railway transportation grants, and value-added tax incentives within the fertilizer industry commenced in 2015. Furthermore, the reduction from elimination of export tariffs on pivotal fertilizer categories further amplifies this dynamic. Simultaneously, on the demand side, the initiation of soil testing and formula fertilization technology pilots in 2005 has steered farmers towards a scientifically calibrated utilization of fertilizers, thus eradicating excesses. Evident within the 'Action Plan for Zero Growth in Chemical Fertilizer Use by 2020 (2015)' are directives set forth by the Chinese Ministry of Agriculture. This blueprint delineates steadfast objectives pertaining to structure, method, and rate of fertilization, accompanied by bespoke technological trajectories for distinct regions. Notably, the action plan explicitly stipulates that China's fertilizer utilization rate should not transcend 40% by the year of 2020.

Incorporating nuanced strategies, regulatory frameworks, and judicious economic instruments, the Chinese approach to carbon reduction and neutrality within the agricultural tapestry stands as a testament to diligent foresight and dynamic policy orchestration. Anchored in a holistic vision of sustainable growth, these endeavors illuminate the path forward, as China embraces a future that harmoniously balances agricultural vitality with carbon abatement imperatives.

Enacting policies and measures in Bangladesh

The resolute execution of Bangladesh's Nationally Determined Contributions (NDCs) to counteract the pernicious effects of climate change is nothing short of an imperative. A carefully plotted trajectory, etched into a compressive roadmap and action plan across myriad sectors, is a quintessential need. Foremost among these sectors, agriculture stands as a veritable crucible, replete with the potential to wield substantial carbon reduction and ultimate carbon neutrality (Chen et al., 2022a). Anchoring policy formulation and

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initiatives in a bedrock of precision necessitates an assiduous calibration of the potential and impediments that punctuate the landscape of carbon reduction in agriculture. Within this matrix, an intricately fashioned policy framework (*Fig. 6*) assumes pivotal import, encompassing array of facets ranging from fortified climate change legislation to the proliferation of sustainable agriculture practices and the widescale embrace of low-carbon technologies (Raihan, 2023). Indisputably, the bedrock of this symphony is an adept bolstering of the agricultural sector's climate resilience, an endeavor that hinges upon the seamless orchestration of collaborative efforts across sectors, recognizing that the confluence of agriculture with domains such as transportation, energy, and industry can precipitate a synergetic amplification of integrated climate initiatives, while judiciously parsing the inherent trade-offs and concurrent benefits.

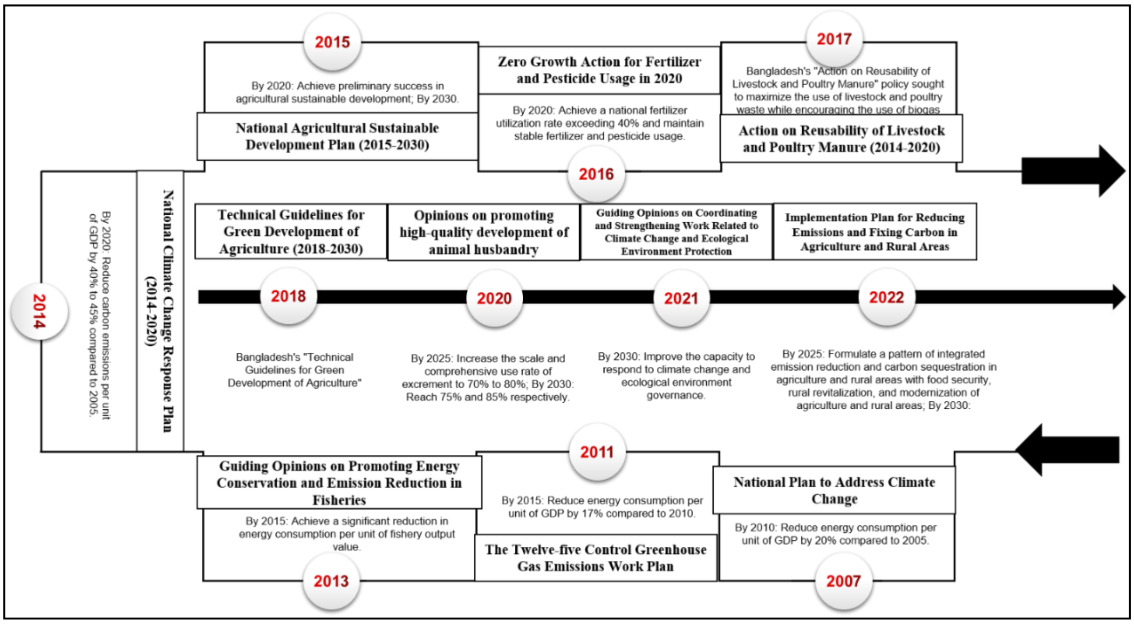

Figure 6. *Policies and measures combating reduction of agricultural GHG emissions in Bangladesh (Das et al., 2024; Hossain et al., 2025)*

A linchpin in this transformative overture resides in the realm of robust financing, sourced from both public coffers and private domains, to undergird the efficacious execution of carbon reduction programs rooted in agriculture. As seamless audit of progress, replete with unwavering transparency and accountability, is made feasible through the efficacious deployment of monitoring, reporting, and verification systems, thereby empowering stakeholders to navigate the efficacy of adopted policies with sagacious precision (Sharmin et al., 2023). The vital confluence of participatory governance, encompassing the local populace and stakeholders, unfurls as an imperious sine qua non, as the gamut of social and equitable implications is subjected to the most scrupulous scrutiny. Even as myriad challenges may cast their lengthening shadows, Bangladesh, fortified by ingenuity and resourcefulness, is poised to embrace an agriculture sector that is both sustainable and impervious to the vicissitudes of climate.

Notably, within the strategic tapestry of Bangladesh's carbon reduction pursuit, the cogent recommendation of augmenting mechanization within the agriculture sector has found primacy within its NDCs. A seminal pivot of this strategic proposition resides in

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curtailing the reliance on draught animals, heralding a departure from conventional agrarian practices. Bangladesh, keenly cognizant of its vulnerability to climate perturbations, has been steadfast in the articulation of its NDCs, meticulously articulating a comprehensive framework of activities and aspirations in its concerted endeavor to counterbalance the repercussions of climate change. Among the premier sources of greenhouse gas emissions within the agriculture sector, the phenomenon of enteric fermentation, particularly prominent among ruminant livestock, underscores the paramountcy of this strategic shift (Islam et al., 2021). Mechanization, a harbinger of transformative change, proffers the prospect of a pragmatic reduction in the employment of draught animals, commensurate with the overarching goals of carbon neutrality and carbon reduction within agriculture.

The pervasive specter of potent CH_4 looms large within the constellation of climate change dynamics. This salient consideration assumes heightened import for Bangladesh, a country harboring acute vulnerability to climate adversities, as it seeks to augment resilience and abate its carbon footprint (Rahman et al., 2013). In the wake of mechanization, emerges a cogent avenue for a transformative reduction in CH_4 emissions, an ascent towards carbon neutrality facilitated by a confluence of modernized agricultural practices and bolstered production methodologies. The amplification of mechanization within the agriculture sector is predicated on a robust mechanism of equipment infusion and technological modernity, poised to eclipse antiquated farming methods largely reliant on manual labor, often facilitated by draught animals. Tractors, harvesters, ploughs, and an array of agricultural machinery are emblematic of this resounding shift, emblematic of the transformation that ensues as physical labor is supplanted by cutting-edge technology (Chen et al., 2022). Enshrined within this transition is a palpable enhancement in efficiency and productivity, manifesting as a manifest curtailment in labor demand and temporal commitment to diverse agricultural tasks. However, the repercussions of mechanization extend beyond mere efficiency. They encompass a spectrum of resource optimization, heralding a concordant proliferation of sustainability and climate resilience.

A salient dimension of mechanization entails the perceptible reduction in the reliance on draught animals, a paradigm integral to conventional agricultural norms within Bangladesh. With draught animals historically enmeshed in tasks ranging from ploughing to transport, their utilization stands as a potent source of methane emissions, generated through enteric fermentation subsequent to digestion. The transition to mechanization, astutely embraced, paves the trajectory for a phased reduction in the demand for these animals, substantiated by a precipitous drop in methane emissions across the agricultural sphere (Huq et al., 2015). A concomitant decrease in the livestock population, a corollary of mechanization, portends a holistic reduction in methane emissions originating from enteric fermentation. Ergo, the very fabric of the agriculture sector's carbon footprint stands primed for a transformation, infused with the potential to yield resounding dividends for the nation's carbon neutrality pursuits.

As Bangladesh grapples with the profound ramifications of its shift from manual labor to mechanized practices, it discerns a multifaceted expanse of challenges and opportunities. On one hand, the financial exigencies underpinning the procurement of requisite equipment and the imperative of supportive infrastructure impede the smooth transition (Clarke et al., 2015). On the other, the socioeconomic dynamics underpinning farming communities and the central role of draught animals within their livelihoods emerge as a poignant consideration. In this context, policymakers assume a pivotal mantle, marshaling incentives and technical support to usher in the age of mechanization

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in agriculture. Financial incentives, couched in the form of subsidies and grants, stand as a beacon, fostering farmer agency in the embrace of mechanization (Faroque et al., 2011). The dissemination of knowledge, through structured training initiatives and extensive services, emerges as a linchpin, proffering the necessary education required for a seamless assimilation of mechanization. Crucially, the narrative of mechanization's benefits, both economic and environmental, must be reverberated, contextualized through the prism of climate-smart agriculture (Islam et al., 2022).

In summary, the increasing mechanization of agriculture holds the promise of significantly mitigating CH_4 emissions, thus contributing to carbon neutrality within the agricultural sector. Bangladesh has the opportunity to diminish its reliance on draught animals by transitioning from manual labor to advanced technology. Such a shift would lead to reduction in the overall livestock population, consequently lowing CH_4 emissions stemming from enteric fermentation. Furthermore, mechanization presents the potential for enhanced resource management and increased operational efficiency, thereby bolstering the sustainability and climate resilience of the agricultural sector. The effective implementation of mechanization hinges on policymakers' provision of financial incentives, educational initiatives, and awareness campaigns for farmers. Stinking a balance between promoting mechanization and upholding standards for cattle welfare is imperative. Bangladesh can play pivotal role in realizing its NDC objectives for carbon reduction within the agricultural sector by embracing mechanization and adopting other climate-smart practices. This proactive approach aligns with overarching objectives of ensuring food security, constructing a more sustainable and climate-resilient agricultural system, and mitigating the adverse effects of climate change on farming communities and the environment. Through cooperative efforts and informed decision-making, Bangladesh has the potential to lead the way towards a greener, more secure, and sustainable future for both its population and the global community.

Conclusions and policy implications

With the realm of agricultural carbon emissions, our comparative analysis discerns enteric fermentation, rice cultivation, fertilizer utilization, on-farm energy consumption, and manure management as the principal sources. These sources collectively constitute the bedrock of emissions in the agricultural sector. While the agricultural sector contributes significantly to the total GHG emissions in both China and Bangladesh, it is noteworthy that per capita and per unit output emissions these nations remain comparatively lower when juxtaposed with other global peers. This presents a distinct challenge in the quest to mitigate emissions effectively. China's agricultural sector stands as exemplar of untapped potential, capable of achieving a dual objective: enhancing food production while orchestrating a significant reduction in GHG emissions. This potential presents an opportune path towards sustainable agricultural practices.

Our data highlights a discernible pattern in agricultural GHG emissions in China and Bangladesh. Emissions reached their zenith in 2016, followed by a gradual descent in China. However, the emissions of CH_4 and N_2O potent showcase continuous growth globally and in Bangladesh. In consideration of the prevailing circumstances and our prognostications concerning the mitigation potential inherent in the agricultural sector, this paper delineates a comprehensive set of strategic recommendations for the realization of carbon-neutral agriculture. These recommendations encompass two pivotal facets: The first facet pertains to initiatives aimed at augmenting the knowledge base, skill sets, and

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technological capabilities requisite for the practice of carbon-neutral agriculture. These endeavors are critical for fostering innovation and transformative change within the sector. The second facet encompasses a suite of strategies meticulously designed to curtail emissions through the implementation of improved agricultural practices, precision farming techniques, and sustainable land management approaches. These measures hold the promise of not only mitigating the environmental impact of agriculture but also contributing substantively to the global imperative of combating climate change. In essence, the adoption of these strategies presents a multifaceted pathway to address the intricate challenge of balancing agricultural production with emissions reduction, ultimately aligning with the broader global mission of combating climate change.

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REFERENCES

[1] Arai, H., Hosen, Y., Chiem, N. H., Inubushi, K. (2021): Alternate wetting and drying enhanced the yield of a triple-cropping rice paddy of the Mekong Delta. – Soil Science and Plant Nutrition 67(4): 493-506.

[2] Balaine, N., Carrijo, D. R., Adviento-Borbe, M. A., Linquist, B. (2019): Greenhouse gases from irrigated rice systems under varying severity of alternate-wetting and drying irrigation. – Soil Science Society of America Journal 83(5): 1533-1541.

[3] Chen, L., Msigwa, G., Yang, M., Osman, A. I., Fawzy, S., Rooney, D. W., Yap, P.-S. (2022a): Strategies to achieve a carbon neutral society: a review. – Environmental Chemistry Letters 20(4): 2277-2310.

[4] Chen, M., Cui, Y., Jiang, S., Forsell, N. (2022b): Toward carbon neutrality before 2060: Trajectory and technical mitigation potential of non-CO2 greenhouse gas emissions from Chinese agriculture. – Journal of Cleaner Production 368: 133186.

[5] Chen, X., Rahaman, M. A., Murshed, M., Mahmood, H., Hossain, M. A. (2023): Causality analysis of the impacts of petroleum use, economic growth, and technological innovation on carbon emissions in Bangladesh. – Energy 267: 126565.

[6] Chen, Y., Chen, X., Zheng, P., Tan, K., Liu, S., Chen, S., Yang, Z., Wang, X. (2022c): Value compensation of net carbon sequestration alleviates the trend of abandoned farmland: a quantification of paddy field system in China based on perspectives of grain security and carbon neutrality. – Ecological Indicators 138: 108815.

[7] Cheng, H., Shu, K., Zhu, T., Wang, L., Liu, X., Cai, W., Qi, Z., Feng, S. (2022): Effects of alternate wetting and drying irrigation on yield, water and nitrogen use, and greenhouse gas emissions in rice paddy fields. – Journal of Cleaner Production 349: 131487.

[8] Clark, M. A., Domingo, N. G. G., Colgan, K., Thakrar, S. K., Tilman, D., Lynch, J., Azevedo, I. L., Hill, J. D. (2020): Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. – Science 370(6517): 705-708. https://doi.org/doi:10.1126/science.aba7357.

[9] Clarke, D., Williams, S., Jahiruddin, M., Parks, K., Salehin, M. (2015): Projections of on-farm salinity in coastal Bangladesh. – Environmental Science: Processes & Impacts 17(6): 1127-1136.

[10] Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., Leip, A. (2021): Food systems are responsible for a third of global anthropogenic GHG emissions. – Nat Food 2(3): 198-209. https://doi.org/10.1038/s43016-021-00225-9.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2403_60076027

[11] Crippa, M., Solazzo, E., Guizzardi, D., Van Dingenen, R., Leip, A. (2022): Air pollutant emissions from global food systems are responsible for environmental impacts, crop losses and mortality. – Nat Food 3(11): 942-956. https://doi.org/10.1038/s43016-022-00615-7.
[12] Das, A., Shuvo, R. M., Mukarram, M. M. T., Sharno, M. A. (2024): Navigating the energy policy landscape of Bangladesh: a stern review and meta-analysis. – Energy Strategy Reviews 52: 101336.
[13] Das, N. G., Sarker, N. R., Haque, M. N. (2020): An estimation of greenhouse gas emission from livestock in Bangladesh. – Journal of advanced veterinary and animal research 7(1): 133.
[14] Dong, G., Wang, Z., Mao, X. (2018): Production efficiency and GHG emissions reduction potential evaluation in the crop production system based on emergy synthesis and nonseparable undesirable output DEA: a case study in Zhejiang Province, China. – PloS One 13(11): e0206680.
[15] Eyring, V., Gillett, N., Achutarao, K., Barimalala, R., Barreiro Parrillo, M., Bellouin, N., Cassou, C., Durack, P., Kosaka, Y., McGregor, S. (2021): Human Influence on the Climate System. – In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva.
[16] FAOSTAT (2022): World Food and Agriculture—Statistical Yearbook 2022. – Food and Agriculture Organization, Rome. https://www.fao.org/3/cc2211en/cc2211en.pdf.
[17] Faroque, M., Kashem, M., Bilkis, S. (2011): Sustainable agriculture: a challenge in Bangladesh. – International Journal of Agricultural Research, Innovation and Technology (IJARIT): 1(2355-2020-1483): 1-8.
[18] Glemarec, Y. (2019): Aligning National interests and global climate justice: the role of human rights in enhancing the ambition of nationally determined contributions to combat climate change. – Fudan Journal of the Humanities and Social Sciences 12(2): 309-327. https://doi.org/10.1007/s40647-018-0249-4.
[19] Hassan, M. U., Aamer, M., Mahmood, A., Awan, M. I., Barbanti, L., Seleiman, M. F., Bakhsh, G., Alkharabsheh, H. M., Babur, E., Shao, J. (2022): Management strategies to mitigate N2O emissions in agriculture. – Life 12(3): 439.
[20] Hossain, M. A., Islam, M. S., Siddique, S. R., Samad, S., Odri, A. T., Islam, M. N. (2025): Climate change policies of Bangladesh: a review. – Open Access Library Journal 12: e13687.
[21] Huq, N., Hugé, J., Boon, E., Gain, A. K. (2015): Climate change impacts in agricultural communities in rural areas of coastal Bangladesh: a tale of many stories. – Sustainability 7(7): 8437-8460.
[22] IPCC (2007): The Physical Science Basis. – Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New, pp. 113-119.
[23] IPCC (2022): Climate Change 2022: Mitigation of Climate Change. – Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf#page=760&zoom=100:0:0.
[24] Islam, K. N., Sultana, A., Wadley, D., Dargusch, P., Henry, M., Naito, Y. (2021): Opportunities for inclusive and efficient low carbon food system development in Bangladesh. – Journal of Cleaner Production 319: 128586.
[25] Islam, S. T., Akand, M. K., Islam, M. N., Samad, S., Rishal, F. H. (2022): Systems thinking approach for disaster resilient and climate smart agriculture in Bangladesh. – International Journal of Disaster Resilience in the Built Environment 13(3): 286-303.
[26] Kong, X., Su, L., Wang, H., Qiu, H. (2022): Agricultural carbon footprint and food security: an assessment of multiple carbon mitigation strategies in China. – China Agricultural Economic Review 14(4): 686-708.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2403_60076027

[27] Lehner, P., Rosenberg, N. A. (2017): Legal pathways to carbon-neutral agriculture. – Envtl. L. Rep. News & Analysis 47: 10845.
[28] Li, G., Hou, C., Zhou, X. (2022): Carbon neutrality, international trade, and agricultural carbon emission performance in China. – Frontiers in Environmental Science 10: 931937.
[29] Maraseni, T. N., Deo, R. C., Qu, J., Gentle, P., Neupane, P. R. (2018): An international comparison of rice consumption behaviours and greenhouse gas emissions from rice production. – Journal of Cleaner Production 172: 2288-2300.
[30] Muller, A., Jawtusch, J., Gattinger, A. (2011): Mitigating Greenhouse Gases in Agriculture. – Diakonisches Werk der EKD e.V. for Brot für die Welt, Stuttgart.
[31] Nema, P., Nema, S., Roy, P. (2012): An overview of global climate changing in current scenario and mitigation action. – Renewable and Sustainable Energy Reviews 16(4): 2329-2336.
[32] Rahman, M. M., Ahsan, M. A., Hossain, M. M., Hoq, M. (2013): Green banking prospects in Bangladesh. – Asian Business Review 2(2).
[33] Raihan, A. (2023): The contribution of economic development, renewable energy, technical advancements, and forestry to Uruguay's objective of becoming carbon neutral by 2030. – Carbon Research 2(1): 20.
[34] Raihan, A., Muhtasim, D. A., Farhana, S., Hasan, M. A. U., Pavel, M. I., Faruk, O., Rahman, M., Mahmood, A. (2023): An econometric analysis of greenhouse gas emissions from different agricultural factors in Bangladesh. – Energy Nexus 9: 100179.
[35] Searchinger, T., Waite, R., Hanson, C., Ranganathan, J., Dumas, P., Matthews, E., Klirs, C. (2019): Creating a sustainable food future: a menu of solutions to feed nearly 10 billion people by 2050. – Final report. WRI.
[36] Sharmin, S., Yabar, H., Richards, D. (2023): Green energy optimization in Dinajpur, Bangladesh: a path to net neutrality. – Sustainability 15(2): 1336.
[37] Shi, W., Fang, Y. R., Chang, Y., Xie, G. H. (2023): Toward sustainable utilization of crop straw: greenhouse gas emissions and their reduction potential from 1950 to 2021 in China. – Resources, Conservation and Recycling 190: 106824.
[38] Siopongco, J. D., Wassmann, R., Sander, B. O. (2013): Alternate Wetting and Drying in Philippine Rice Production: Feasibility Study for a Clean Development Mechanism. – Technical Bulletin 17. IRRI, Manila.
[39] Thangarajan, R., Bolan, N. S., Tian, G., Naidu, R., Kunhikrishnan, A. (2013): Role of organic amendment application on greenhouse gas emission from soil. – Science of the Total Environment 465: 72-96.
[40] Tian, Y., Zhang, J.-b., He, Y.-y. (2014): Research on spatial-temporal characteristics and driving factor of agricultural carbon emissions in China. – Journal of Integrative Agriculture 13(6): 1393-1403. https://doi.org/10.1016/s2095-3119(13)60624-3.
[41] UNEP (2022): Emissions Gap Report 2022: The closing window—climate crisis calls for rapid transformation of societies. – https://www.unep.org/emissions-gap-report-2022.
[42] Uusitalo, V., Havukainen, J., Manninen, K., Höhn, J., Lehtonen, E., Rasi, S., Soukka, R., Horttanainen, M. (2014): Carbon footprint of selected biomass to biogas production chains and GHG reduction potential in transportation use. – Renewable Energy 66: 90-98.
[43] Wang, B., Li, Y., Cai, A., Liu, S., Ren, T., Zhang, J. (2022): Global agricultural emission reduction and carbon sequestration policy measures from the perspective of carbon neutrality and their implications for China. – Advances in Climate Change Research 18(01): 110-118. https://kns.cnki.net/kcms/detail/11.5368.P.20211227.1417.002.html.
[44] Wang, L., Garland, G. M., Ge, T., Guo, S., Kebede, E. A., He, C., Hijri, M., Plaza-Bonilla, D., Stringer, L. C., Davis, K. F. (2025): Integrated strategies for enhancing agrifood productivity, lowering greenhouse gas emissions, and improving soil health. – The Innovation 6.
[45] Wu, J., Xu, Y. and Liu, Z. (2024): A comprehensive review on agricultural greenhouse gas emission reductions in China: opportunities and challenges. – Carbon Footprints 3(4).

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2403_60076027

[46] Yu, Y., Jiang, T., Li, S., Li, X., Gao, D. (2020): Energy-related CO2 emissions and structural emissions' reduction in China's agriculture: an input–output perspective. – Journal of Cleaner Production 276: 124169.
[47] Zhang, X., Wu, L., Ma, X., Qin, Y. (2022): Dynamic computable general equilibrium simulation of agricultural greenhouse gas emissions in China. – Journal of Cleaner Production 345: 131122.
[48] Zhao, H., Chang, J., Havlik, P., van Dijk, M., Valin, H., Janssens, C., Ma, L., Bai, Z., Herrero, M., Smith, P. (2021): China's future food demand and its implications for trade and environment. – Nature Sustainability 4(12): 1042-1051.
[49] Zhao, M., Shi, R., Du, R., Yao, L. (2023): The pathway to China's carbon–neutral agriculture: measures, potential and future strategies. – Chinese Political Science Review 8(2): 304-324. https://doi.org/10.1007/s41111-023-00237-9.
[50] Zhu, Y., Huo, C. (2022): The Impact of agricultural production efficiency on agricultural carbon emissions in China. – Energies 15(12). https://doi.org/10.3390/en15124464.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2403_60076027