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CLIMATE CHANGE AND SEA LEVEL RISE IN THE LAST DECADE, FROM THE PERSPECTIVE OF GOALS SET IN THE PARIS AGREEMENT-AN APPRAISAL

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ABSTRACT

In the United Nations Framework Convention on Climate Change (UNFCCC), during the conference of 196 parties on 12 December 2015, the Paris Agreement was an international treaty on climate change aiming to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. It was for the first time a binding agreement took place bringing all nations into a common cause towards undertaking ambitious efforts to combat climate change. The parties agreed to adopt economic and social transformation, based on the best available state of the art of science to strategize the adaptability to unavoidable imminent changes. The first 5-year cycle of increasingly ambitious climate action carried out by countries is now over and at the end of 2020, while entering into the new decade, it's time to evaluate the effect based on the decided obligations of the participating national governments – the most important being the development and implementation of their" nationally determined contributions" (NDCs). Scientific research, being a continuous process there has been evaluation in the theories related to climate models and the speculations had been undergoing changes. Although the melting of large quantity of ice was not fully unexpected but the acceleration of melting in the last lustrum and the expected huge volume of melt water has led the scientific community to believe that the speculations on the resultant effects of warming could vary to a large extent. The agreement was entered into force on 4 November 2016 and meanwhile there has been continuation of accelerated increase in melting of ice shelves in Greenland and Antarctica. Besides, almost simultaneously in the decade from 2010-20, a number of anomalies in IPCC projections, observations on uncertainties and advent of CMIP5 to CMIP6 have also been documented in literature. Based on these facts by researching in different randomly chosen publications vis-à-vis current observations of United Nation Environment Programme Report 2020 and Climate-Transparency-Report-2020, this paper retrospectively inspects the past findings. The paper attempts to evaluate the present situation and assess how much has been achieved as per Paris agreement. While evaluating the achieved goals, the recent approaches on effect of orography, glacier geo engineering and ansatz approach have been examined this may usher out a clue towards newer direction of research.

KEYWORDS: *Climate Change, Global Warming*

INTRODUCTION

Way back in 2007, vulnerabilities of three global coastal cities to climate hazards viz. Mumbai, Riode Janeiro and Shanghai was identified by AlexDe Sherbininetal. In terms of three elements: system exposure etocrises, stresses and

shocks; inadequate system capacity to cope; and consequences and attendant risks of slow (or poor) systemrecovery by developing a vulnerability framework. They addressed the then and future vulnerability to climatehazards using standard sets of climate change and sea-level rise in a sustainable path (reduced emissions) and business as usual (increased emissions) scenarios. Projections of sea-level rise due to melting land-based glaciers and polar icecaps was stated to range from 0.2 to 0.9 metres by 2100 highlighting the apprehension that estimates could be superseded duet orapid melting in Greenland and Antarctica. They adopted a common projected sea-level rise of 50 centi metres by 2050, although local variations in land subsidence was believed to affect the relative sea-level rise in each location[1].

In 2008 it was found that total impact of climate change on economy of the city of Mumbai, even when conservatively estimated would be enormous. Rakesh Kumaretal. Computed the economic impact to infrastructure at Mumbai city getting affected in the region near the shore. They assumed that sea water will penetrate 200 min land and because of rise in the sea level and ingress of sea water infrastructure along the coast line and inside the shore will get affected [2].

Rajawat AS et al. noted in 2010 that IPCC, 2007 has predicted that the global sea level will rise by about 18 to 59cm by the 2100, whereas newer models suggested that the sea level rise because of melting of glaciers, vanishingof ice sheets could by the end of this century be 1.5 m. They mentioned about contemporary evidences of large-scale ice melt in the three major icere positories of the world– the Arctic, the Greenland and the Ant arctic regions and proclaimed that there is a further possibility of increase of as much as five meters, in the event of the collapseof the Greenland and West Antarctic ice sheets. It was stressed upon that the impact of the rising sea levels would be variable depending upon the characteristics of the coast such as geomorphology and slope and waves andtidesat coastal periphery. A CVI (Coastal Vulnerability Index) was prepared by the authors.

They integrated theweighted rank values of the five different variables using a formula viz.:

CVI = 4g + 4s + 2c + t + w,

where g wascoastal geomorphology,

s was coastal slope,

c was shoreline change history,

t was mean spring tide range and

w being significant wave height.

Keeping in view of their relative significance in influencing the coastal response tosea-levelrisethenumbers 2and 4 indicated the relative weight age of different variables [3].

Stefan Rahmstorf in 2012 noted the variations in projections of global sea-level riseby different authorities. The projections upto 2100 speculated by IPCC report 2007, Delta Commission of the Dutch government 2009,Scientific Committee on Antarctic Research 2009, Arctic Monitoring and Assessment Programme 2011 and US Army Corps of Engineers were1m,1.1m,1.4m,1.6 mand1.5m respectively. These pessimistic views are perhaps due to the fact that sea level has been rising at least 50 % faster in the past decades than projected by the IPCCandtherateofriseoverthepast20years has accelerated to around 3mm yr−1i.e.,about threefold from around 1mm yr−1 at the start of the 20th century. The

observed net mass loss of the two big continental ice sheets raisesdoubt on the assumption that ice accumulation in Antarctica would largely balance ice loss from Greenland in the course of further global warming. Hence the IPCC projections, which almost did not consider any further acceleration in the 20th century, loses its merit to be plausible. The foregoing facts speak about inconsistent and varying results [4].

Williams Jeffress S acknowledged in 2013 about the strong consensus among climate scientists that sea level isvery likely to rise at accelerated rates for the rest of the 21st century and for centuries beyond. Also, concurrently it was agreed that the evidence for Global Sea Level Rise due to climate warming is debated. It was pointed outthat IPCC 2007 projections did not include the potential for melting of major land-based ice sheets on Greenlandor West Antarctica due to a lack of understanding of ice sheet dynamics at that time. A very large amount of potential sea-level rise from melting of this ice sheets but could not be modeled with high confidence and revision in IPCC's next report was expected. It was stated that the gravitational effects and shifts in ocean circulationpatterns are likely to result in a nonuniform rise in sea level. The topic sea level rise was viewed as a subject ofdebate in the literature. Questions remained whether Global Sea Level will be as predicted from semi empirical models and can be linked to observed global warming? And is it a global acceleration, a region-specific acceleration due to warming, the product of a multi decadal variation, or some combination of these [5]?

BhoreS.J., opined about' Paris Agreement on Climate Change' in 2016 as a Booster to Enable Sustainable Global Development and Beyond; reiterating its main objective to decrease greenhouse gas emissions significantly as soon as possible, keeping the increase in global average temperature to well below 2^0C, and to1.5^0C if possible. Increased greenhouse gas emissions and the rise in global temperature had been damaging global climate, biodiversity, and ecosystems. It is also adversely affecting the global food supply chain, global public health, and global advancement as a whole. If all these are considered the green house gas emissions and the resultant rise in global temperature will affect the atmosphere, the biosphere, the lithosphere, and the hydrosphere. It was considered extremely necessary for the global community to come together and act together to combat with the challenges posed by climate change. The predicted data suggest that global average temperature could increase by 4.8^0C by the end of 2100, whereas the intended threshold is 2^0C (Figure 1). To make this planet a sustainable healthier and happier place to live, PACC is regarded to be very bold and ambitious step taken by the UN to achieve the SDGs (sustainable development goals) globally [6].

Paris Agreement called for achieving the SDGs (Sustainable Development Goals) based on implementation of NDCs (Nationally Determined Contributions) by respective nations. However, finding it difficult for Govt. alone to combat the situation, Schaer, C. et al. in 2018 mooted the idea of promoting private sector engagement in climate change adaptation and flood resilience in their case study undertaken at Mumbai. The authors presented a framework developed for MSMEs (Micro Small and Medium Enterprises) to make informed risk reduction and adaptation decisions to implement effective measures to minimize the recurring adverse impacts of climate related disaster like floods on their business operations. 100 nos. of MSME units were served detailed questionnaires which focused on recurrent floods, associated damage costs and available response measures. The authors established the need to encourage private sector participation in adaptation efforts. Also, in the case of smaller actors such as MSMEs they insisted for a policy push from the government in the form of incentives to new industrial estates. Inclusion of flood resilience in building codes as a key element in support of the adoption of resilience building measures by private sector players was also suggested [7].

In 2019 it was noted by Kulp et al. that in the case of early-onset of Antarctic ice sheet instability, under higher emissions scenarios, the twentyfirst century sea level rise may approach or in the extremes exceed 2 m. Such a rise obviously can create havoc devastating flood and they opined that in order to undertake proper efficient coastal planning translating sea-level projections into potential exposure of population is of paramount importance and critical to determine benefits to people during climate mitigation, as well as to evaluate the costs of failure to act. According to them, the estimated quantity of global mean sea-level rise (i.e., below 2m) is comparable to the positive vertical bias in elevation data in the principle digital elevation model (DEM), derived from NASA's Shuttle Radar Topography Mission (SRTM), used to assess global and national population level exposure to projected sea or coastal flooding is most commonly expressed as total exposures to extreme coastal water levels. Population Exposure (the total estimated exposure below a particular water level), but is increasingly also presented as marginal exposure (the difference in exposure above a contemporary baseline). End century projections ranged from 50–70 cm under representative concentration pathway (RCP) 4.5 and 70–100 cm under RCP 8.5. Two representative sea- level projections K14 & K17 were considered. K14 is a probabilistic projection and K17 although not probabilistic emphasizes the possibility of more rapid sea-level rise because of unstable ice-sheet dynamics. It was observed that 190 M people (150–250 M, 90% credible intervals) currently occupy global land below projected high tide lines for 2100 under low carbon emissions These figures in fact is triple from the SRTM-based estimates of 28 M and 65 M. Irrespective of emissions scenario or sea-level model, it was found that more than 70% of the total number of people worldwide currently living on implicated land are in eight Asian countries. These countries are China, Bangladesh, India, Vietnam, Indonesia, Thailand, the Philippines, and Japan [8].

L. C. HAHN et al. stressed upon the Importance of Orography for Greenland Cloud and Melt Response to Atmospheric Blocking in 2019. They reanalyzed the satellite data in addition to a regional climate model with a focus on the previously neglected role of topography. During recent extreme blocking summers, it was found that that anticyclonic circulation anomalies over Greenland produce cloud changes are dependent on orographiclift and descent. The resulting increased cloud cover over northern Greenland was found to promote surface longwave warming, while reduced cloud cover in southern and marginal Greenland favours surface shortwave warming. It revealed that orographic effects were responsible to produce area-averaged decreasing cloud cover. Incidentally the extreme melt was observed in the summer of 2012. The melt response to large-scale circulation variability was partially dependent on the Greenland topography. These results suggest that future melt will depend on the pattern of circulation anomalies as well as the shape of the Greenland Ice Sheet [9].

Marco Tedesco et al. observed in April 2020 that understanding the role of atmospheric circulation anomalies on the surface mass balance of the Greenland ice sheet (GrI S) is fundamental for understanding contributions to sea level rise. A combination of all the factors like reanalysis data, remote sensing observations, regional climate model outputs, and artificial neural networks was considered. It was found that those unprecedented atmospheric conditions occurred in the summer of 2019 over Greenland. These generated new records of surface mass balance (SMB), runoff, and snowfall. The anticyclonic conditions were also responsible for reduced cloudiness in the south and consequent below-average summer snowfall and albedo in this area [10].

Recently in International Conference on Oceanography for West Asia held at Tehran, Iran in September 2020 Ahammed Basheer K. K. expressed their concern on the anthropogenic activities raising conflict in bio rich marine ecosystem in the eastern coast of India. They highlighted the sensitivity of coastlines to sea-level rise and commented

about higher impact of the increasing trend of cyclones and associated storms, increases in precipitation, and changes in the ocean temperatures. They mentioned about availability of varieties of tools and techniques for studying climate vulnerability. The vulnerable locations were identified using a digital elevation model with extreme surge height, sea level rise rate, historical cyclone events, and intensity. They observed that around 8000Km^2 areas in the states viz. West Bengal, Odisha, and Andhra Pradesh are vulnerable and susceptible to storm surges, whereas Tamil Nadu and Puducherry are least sensitive regions on the eastern coast of India. It was revealed that the use of the geospatial application is the most reliable and coast effective approach for disaster preparedness and management. They also advised that for addressing the additional stress of climate change may require new approaches to managing land, water, waste, and ecosystems [11].

Hofer Stefan et al. observed in 2020 that for a similar extreme surface warming of 8.5 W/m^2 in 2100, between the high-emission scenario from CMIP5 (RCP8.5) and CMIP6 (SSP58.5) Greenland Ice Sheet surface melting will almost double in the twenty-first century. It is stated that future mass loss rate of Greenland Ice Sheet strongly depends on the future global temperature rise and therefore anthropogenic greenhouse gas emission rates and also on the strength of melt-albedo feedback. The Global climate models (GCMs) of the Climate Model Inter- comparison Project 5th Phase (CMIP5) show a clear signal of above average temperature rise in various different emission scenarios. However, due to imperfect cloud microphysics and missing recent Greenland circulation anomalies, the absolute magnitude is still subject to uncertainties, mainly. The latest CMIP 6th Phase (CMIP6) incorporates more complex model physics, a higher spatio-temporal resolution, and a more realistic coupling between the different Earth system components and better constrained emissions of aerosols and other near-term climate forcers. [12]

Shane Elipot very recently in October 2020 commented that modern global mean sea level (GMSL) rise is an intrinsic measure of anthropogenic climate change which is triggered by thermal expansion of the warming ocean's water and the melting of terrestrial ice. He showed that an array of surface drifting buoys tracked by a Global Navigation Satellite System (GNSS), could provide estimates of global mean sea level (GMSL) and its changes. It was demonstrated that with an uncertainty less than 0.3 mm yr^{-1} could be achieved with GNSS and such measurements could ultimately provide an independent and resilient observational system. This was opined to be a better option in comparison to the ongoing tide gauge and satellites records [13].

Elhacham, E. et al. for the first time in history commented in 2020 that humanity has become a dominant force in shaping the face of Earth. They quantified the ‘anthropogenic mass’ i.e., human-made mass and linked itwith the overall living biomass on Earth (1.1 teratonnes). It is opined that due to ramped up consumption the weight of natural resources - the living biomass for trees, plants and animals—has halved since the agricultural revolution. For every person on the world, anthropogenic mass adequate to quite his or her bodyweight is produced hebdomadally. Manmade material is likely to weigh about three teratonnes by 2040 at the current growth rate, [14].

Jennifer Huang et al. in the report of Centre for Climate and Energy Solutions,2020 highlighted a broad range of climate actions across many spheres of society inspired by the Paris Agreement. The agreement, according to the report, provided a strong signal to actors beyond national governments, served as both a driver and abenchmark for climate action across society. The Agreement has inspired countless commitments and actions by a wide range of actors across society. The long-term goals that countries built into the agreement to guide national efforts have served at the same time as a driver and benchmark for a growing abundance of bottom-up efforts. In the oil and gas sector, Shell, BP, and Equinor

committed in 2020 to net-zero emissions by 2050 at the latest. Volkswagen in transportation sector committed to being carbon neutral by 2050 and announced a decarbonization program to fulfil its commitment to the Paris Agreement. Maersk, the world's largest container ship and supply vessel operator, set a net- zero carbon goal for its operations to contribute to reaching the Paris Agreement's goal of staying well below 2C temperature rise. In the building materials sector, Lafarge Holcim, the world's largest producer of cement, committed in September 2020 to become a net-zero company by 2050 and to join Business Ambition for 1.5°C. In February 2020, CEMEX, a Mexican multinational company and one of the biggest building materials companies worldwide, committed to net-zero emissions across its products and operations by 2050.In the mining sector, Vale, a Brazil multinational mining and logistics company and the world's largest producer of iron ore, pellets, and nickel, committed to carbon neutrality by 2050 to align with the Paris Agreement, a goal referenced throughout its 2019 sustainability report.42 In 2019, BHP, one of the world's largest mining companies, committed to net-zero operational emissions by 2050, and in 2020, the company updated its climate goals aligned with the Paris Agreement[15].

Lockley Et al. recently in 2020, mentioned that the high-end sea level rise (SLR) threat over the next few hundred years comes almost entirely from only a handful of ice streams and large glaciers but acknowledged that literature on ice sheet conservation is limited. The trend of research focuses on blocking warm ocean waters accessing ice shelf cavities and increasing snow fall. The ideas evolved included draining or freezing the seabed, altering albedo, keeping snow intact, create obstacle like buffer, increasing shear strength of ice, limit fracturing of ice, buttressing etc. and also novel ideas like cooling glaciers through cloud by reengineering climate science. They opined that spatially limited interventions at source may provide globally-equitable mitigation from rising seas. It is stated that even if emissions fall to zero after say 2050, the risk of dramatic sea level rise will continue. They outlined new potential interventions summarizing novel and extant geotechnical techniques for glacier restraint on ice sheets with an overview on solar radiation management, seeking to address impacts (like sea-level rise) by controlling global average surface temperature (Figure 2). They expressed their grave concern on the severe unresolved scientific and engineering challenges in this regard and suggested to explore more applying Glacier Geo engineering [16].

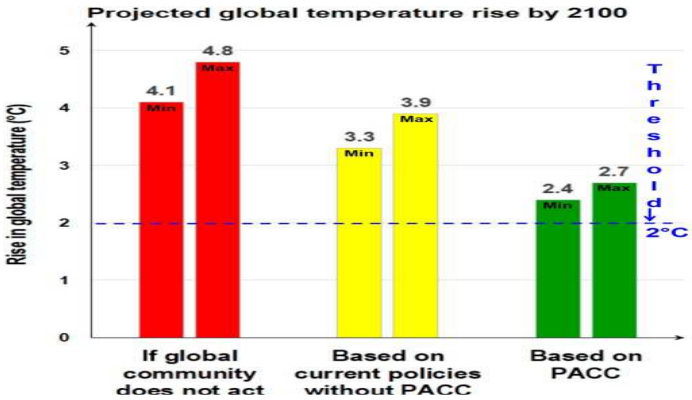
Rodehacke, C. B. et al. in 2020 examined how the implementation of an uncertain mathematical framework (ansatz) can be utilized to find sea level contribution in an ensemble of ice sheet simulations by putting the boundary condition of precipitation. They tested a hypothesis that the ansatz of the precipitation determines whether the global sea level rises or falls. They tested two precipitation boundary conditions i.e., vapor and solid for sublimation or solid and liquid for melting, considering: (i) both the ocean and air temperature anomalies and the precipitation anomalies from CMIP5 models and (ii) only the ocean and air temperature anomalies from CMIP5 models and compute the precipitation anomalies scaled by the air temperature anomalies. Clausius-Clapeyron equation pertaining to the relationship between the pressure and temperature for conditions of equilibrium between two phases was taken to resolve the hypothesis. Their ensemble study suggested that some areas glaciers will lose ice in the future [17].

Klaus Wyser et al. observed in 2019 that compared to the values obtained with earlier versions for CMIP5, many modelling groups that contribute to CMIP6 (Coupled Model Inter comparison Project phase 6) have found better Equilibrium Climate Sensitivity (ECS). They investigated the developments which caused the increase in the ECS in EC-Earth model (European community Earth-System Model) since the CMIP5 era. They also affirmed that the ECS increase has an effect on the more advanced treatment of aerosols. The largest contribution coming from the effect of aerosols is found to effect on cloud microphysics (cloud lifetime or second indirect effect). They opined that the obtained results

cannot be easily generalized as aerosol-cloud interaction process may vary from CMIP5 to CMIP6, but their results found strong ECS with the details of the aerosol forcing [18].

Zelinka, M. D et al. illustrated the causes of higher climate sensitivity in CMIP6 models in 2020. They observed that in the latest generation of global climate models, the temperature response has increased substantially. Thisaccordingtothemisduetoanabruptquadruplingofatmosphericcarbondioxide, as well as low cloud water content. Enhanced planetary absorption of sunlight itself is an amplifying feedback that ultimately results in more global warming. The enhanced sensitivity relative to the previous generation of models is driven by differences in the physical representation of clouds in models. Both the multimodal mean and intermodal variance in ECS (effective elimate sensitivity) have increased substantially in CMIP6 relative to CMIP5, though only the latter change is statistically significant at 95 % confidence [19].

The Emissions Gap Report 2020 jointly published by United Nations Environment Programme with Technical University, Denmark noted that despite a brief dip in carbon dioxide emissions caused by theCOVID-19 pandemic, in variance with the Paris Agreement goals of limiting global warming to well below 2°C and pursuing 1.5°C, the world is still moving towards a temperature rise in excessof3°Cthiscentury.Tillnowtheyear2020ison



Source: [http://doi.org/10.3390/ijerph13111134]

Figure 1: Projected Global Temperature Rise by 2100 and the Effect of the Paris Agreement on Climate Change.

Figure 2: Schematic Re Presentation of Glacier Intervention Engineering Schemes.

(**Note:** In this cartoon the ice area relative to the interventions is about 1 million times smaller than in reality, and it would beun likelyt outilize more than one method on any particular glacier.)

Albe do: reflective materials, draining melt ponds, snow making machines; cloud seeding. **Beddrying & binding:** meltre moval; thermosyphon base freezing; enhanced Oil Recovery analogues; CO2hydrate formation; CO2 fracking-chilling. **Ice shelf but tressing:** enhancing pinning points; thickening / strengthening ice with pumps, snow making machines, thermosyphons and wind breaks; draining shelf melt; tensilere inforcement.

Environmental modification: cloud brightening, under water berms/sheets, manipulating ocean/air currents, regional solar radiation management. Advances in Climate Change Research, 2020, ISSN1674-9278https://doi.org/10.1016/j.accre.2020.11.008

One of the warmest on record, with storms, wild fires, droughts, and in testified glacier melt. If current trends are continued, combined emissions from shipping and aviation internationally will consume between 60 and 220 percent of allowable CO_2 emissions by 2050 under the 1.5°C scenario.

The CO_2 equivalent of total greenhouse gas emissions in 2019 touched a new high of 59.1 gigatonnes. The number of countries who had adopted, announced or were considering net- zero goals counts to 126, whose contribution is 51 per cent of global greenhouse gas emissions. The report acclaims the Biden-Harris climate plan and declared that in the event the US adopts a net-zero target by 2050, this would increase to 63 per cent.The report points out a huge discrepancy between the ambition of the goals and the inadequate level of ambition in NDCs. UNEP report acknowledges that the emissioncountfromtherichestonepercentoftheglobalpopulationismorethantwiceofthatfromthepoorest50percent.This suggest that to reduce their footprint by a factor of at least 30 to stay in line with the Paris Agreement targets. The so called lite needs to be more and more responsive. [20].

CONCLUSIONS

The Climate-Transparency-Report-2020 published that G20 # countries account for90+% of cumulative historical CO_2 emissions and 70% of current emissions, where 77% of GHG emissions (primarily CO_2) are from Energy. There port acknowledged that energy related CO_2 decreased by 0.1%, share of renewable grew to 27 in G20 in 2019, continue to grow in 2020, steep decrease of aviation fuel demand (pandemic contributed) fossil fuels still counted as 81.5% of primary energy for G20Countries. The report advises that G20countries need to set targets to set targets for zero deforestation and need to mitigate emissions to limit global warming.

The Climate Transparency Report-2020 suggests 5 principles of a Green Recovery which can accelerate Climate Actions & bring sustainable co-benefits i.e.

- Investment in sustainable physical infrastructure,
- Invest in Education, Research and Development
- Reinforce Policy, Regulations & incentives for sustainable future
- Invest in Nature Based Solutions & The environment
- Introduce conditionality for greener bailouts.

However, till date as per UNEP 2020 the opening for using recovery measures to accelerate a green transition as promised in Paris Agreement has largely been missed. The Paris Agreement goals will further slip out of reach, lest the situation is reversed. Parties to the Paris Agreement are expected to update NDCs (Nationally Determined Contributions) in 2020. UNEP called the Governments should pull out all the stops to implement a green recovery and strengthen their pledges before the next climate meeting in 2021. Government pledges under the Paris Agreement, i.e., the NDCs are still woefully in adequate. Predicted missions in 2030 leave the planet on the trail to a 3.2°Cincreasethis century, albeit all unconditional NDCs are fully implemented. Although the COVID-19 pandemic caused a dip in 2020 emissions, this will not bring the world closer to the Paris Agreement goal of limiting global warming this century to well below 2° C and pursuing 1.5°C. A significant opportunity for countries to implement low-carbon policies and programmes is available to be executed. Zero-emissions technologies and infrastructure, reducing fossil fuel subsidies, barring fossil fuel plants, promoting nature-based solutions –including large-scale landscape restoration and reforestation to be prioritized. One of the most significant climate policy developments of 2020 is that number of countries committing to net-zero emissions goals by mid- century is increasing. To remain feasible and credible, the commitments of Paris Agreement need to be urgently translated intorealistic action and reflected in NDCs. More countries need to strategize for net- zero emissions goals. The shipping and aviation sector, which contributing to 5 per cent of global emissions requires more attention. Governments and people should be ready to avoid high-carbon consumption, replacing domestic short half lights with rail, enabling cycling and car-sharing, improving energy efficiency of housing, focusing more and more on renewable energy, reducing food waste etc. Private Sector participations to monitor and achieve the goals can be a usable solution and above all individual motivation to rise to the occasion is an absolute necessity.

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