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Editorial Introduction

K. Ravi Srinivas*

Welcome to ABDR issue Vol. 23, No. 2. This issue has four articles, one perspective article and a book review. Given the importance of biodiversity and the forthcoming Conference of Parties- Meeting of Parties under Convention on Biological Diversity, two articles and one perspective article discuss biodiversity related themes. While in the other two articles, one deals with innovation and corn seed industry in Thailand and the other is on bioenergy and bioeconomy policies in India. There is a book review of the volume on biosecurity and biodefense.

A contentious issue in plant variety protection and innovation in seed sector is the role and position of Multinational Corporations (MNCs) vis a vis that of indigenous or home-grown corporations. Ofen it is argued that while the former has access to global technology, large investments in R&D and capacity to produce seeds of good quality that are much needed while the latter is weak in capacity to innovate and invests a little in R&D. Taking the corn seed industry in Thailand as a case study in '*R&D Intensity and Technological Capacity in Agriculture: A Case of Corn Seed Industry in Thailand'* Orachos Napasintuwong shows that the real picture is not that simple and instead policies also play a major role in promoting innovation. Despite the distinct advantages enjoyed by MNCs, local companies have their own strengths and advantages such as understanding and meeting the needs of farmers of Thailand, capacity to develop and build upon brand names and willingness to make use of the incentives to promote R&D. Her study shows the need to enhance the technological capacity of Thai seed companies so that they can make use of R&D and develop and market seeds and compete well with MNCs. After examining the impact of the various programs of incentivisation she points out capacity building through various measures such as strong linkage between academic institutions and industry, regional networks focussing on R&D in collaboration with research

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institutes abroad and tapping the resources available with public academic institutions for sophisticated technical training in seed technology and plant breeding. This article is relevant as it gives pragmatic suggestions based on the experiences in Thailand.

If bioeconomy is a buzzword now, bioenergy is an earlier one. Many countries have policies on bioeconomy and are trying their best to reduce undue dependence on fossil fuels. While concerns over climate change have been a major factor in the increasing importance to bioenergy, it deserves support even otherwise. Taking bioenergy sector and the policies related to those fuels in about two decades in '*Transitioning to a Bio-Based Economy: Indian Initiatives in the Bioenergy Domain'*, Poonam Pandey analyses the priorities, the shifts and the issues faced. As clean energy is becoming even more important and with the need to enhance farmers income, the thrust towards producing Second Generation bioethanol and advanced biogas harnessing agriculture and forest residues. While cautioning against overestimating the availability of resources such as land, residues, feedstock, and the need to return organic matter and manure to soil, she points out that production of energy cannot be over emphasized at the expense of ecological dynamics of agriculture. She advocates a platform for genuine and greater public engagement in this regard so that stakeholders' views are known and considered. Obviously, any sensible biofuel policy must balance multiple objectives and cannot be thought in terms of technical feasibility alone. It should contribute to making the bioeconomy more sustainable. Hence the suggestions she has put forth deserve a serious consideration.

Regime Complex is a well-known concept and is used widely, inter alia, in environmental law and politics. Understanding Regime Complexes enables mapping of interactions and interfaces among laws, institutions, and policies. Policy coherence between national laws/regimes and the global conventions/treaties is always an issue of contention for the simple reason that countries often prefer to do what is more convenient for them and give priority to principles and goals that are nationally acceptable and adoptable. In *'Global Biodiversity Regime Complex and Sustainable Development Goals: Implications for India'*, Shailly Kedia,and, Manish Anand examine link between global biodiversity regime, national level planning and reporting on SDGs. SDGs have indicators that are linked to goals and sub-goals and have been developed after much deliberation.

In addition to these countries have their own specific indicators for goals and sub-goals. According to them global biodiversity regime has a wide normative scope, encompassing principles like science-based policy, sustainable development and this has evolved over a period of time, Whereas national level reporting on biodiversity related SDGs lags the global one. For better policy coherence and to fulfil objectives of SDGs as well global biodiversity targets this gap needs to be bridged although it is not that simple. They call for better science-policy interface and argue that transdisciplinary research and integrative collaboration among disciplines and divisions in knowledge systems is necessary.

Almost a decade ago an ambitious strategic plan for biodiversity was adopted under the auspices f Convention on Biological Diversity (CBD) for 2011-2020. The plan consists of 20 Aichi Biodiversity Targets and five strategic goals. These are ambitious and necessary goals and targets and were accepted by all the Parties to the CBD. Of these Aichi Target 6 aims that by 2020 all the fish and invertebrate stocks besides aquatic plants are harvested sustainably and managed accordingly. Given the competing demands on fish resources, this was not easy. In *'Review of the Implementation of Aichi Biodiversity Targets with Special Reference to Inland, Coastal and Marine Fisheries Sectors,* C. Thomson Jacob, Yugraj Singh Yadava and Kuldeep Kumar Lal, point out that even though much progress has been made in achieving this target, about a third of the marine stocks have been overharvested and marine habitats are getting damaged significantly. The Global Biodiversity Outlook (GBO 5) released last year raised an alarm by pointing out that globally biodiversity in decline at levels that are exceptionally high and without any precedent. It pointed out that in the two decades none of the Aichi Targets have been met and the factors that have caused this continue unabated. Still, this does not mean that all is lost and there are good practices that have been adopted by various countries. Examining this and the progress made and the lack of it, the authors have put forth suggestions that need immediate attention of policy makers. On the other hand, the negotiations in WTO on fisheries subsidies will have an impact on conservation and sustainable harvesting of marine fish resources. Thus, the picture is likely to more complex and challenging in the days to come, and, even as report after report point out that there is a massive biodiversity crisis to what extent coherence among

policies on resource utilization and trade regulation to facilitate achieving biodiversity targets is a big question.

The recently published first draft of the Post-2020 Global Biodiversity Framework is analysed lucidly by Amit Kumar in the Perspective article 'First Draft of Post-2020 Global Biodiversity Framework and Its Salient Features.' He has highlighted the key aspects of this Framework and the likely road ahead for this.

Debanjana Dey's review of 'Applied Biosecurity: Global Health, Biodefense, and Developing Technologies' describes the issues addressed by the volume and the merits and shortcoming of the publication. Biosecurity and Biotechnology are getting more traction these days. We will cover these more in the future issues. Another important theme with which we at RIS are engaged is Digital Sequence Information (DSI). In future a Special Issue on this is likely to be published.

Your comments and suggestions are welcome.

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Research and Development Intensity and Technological Capacity in Agriculture: A Case of Corn Seed Industry in Thailand

Orachos Napasintuwong*

Abstract: The seed business is one of the promoted industries using biotechnology under the Thailand 4.0 policy which aims at improving economic development towards the fourth industrial revolution. Agriculture and biotechnology were included as one of the five S-Curve industries in Thailand 4.0. Given the importance and the success of maize seed industry, Seed Hub policy aims at promoting Thailand as a centre for high quality seed production and exports, and also aims at producing Thai-owned brand-name seeds. Evidences have shown that Thailand has a leading position in maize seed production and exports; however, the industry depends greatly on the technological capacity from R&D intensity of multinational firms. This study analyses the technological capacity of the corn seed industry in Thailand, industry that encompasses major multinational seed companies and Thai local companies. The results imply that Thai local companies have limited technological capacity compared to multinational companies. However, as local seed companies can develop Thai-owned brand-name seeds and understand local farmers' and industry's needs, public supports that create effective research network and enabling regulatory environment are strongly encouraged in order to strengthen technological capacity of the seed industry.

Keywords: seed industry, technological capacity, R&D, research and development, biotechnology, intellectual property right.

Introduction

Thailand is the twenty-third largest seed exporter in the world and is the fourth largest seed exporter in Asia following Japan, China and India in terms of value (International Seed Federation, 2018). Due to the importance of seed industry, Thai government has initiated a "Seed Hub" policy aims at setting Thailand as regional hub for high quality seed production and exports. Under this policy, the development of Thai-owned brand-name

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seeds is one of the key strategic goals so that the industry will not have to depend on the technology of foreign firms (National Center for Genetic Engineering and Biotechnology, 2007; National Science and Technology Development Agency, 2012). Maize, which has the highest value of seed exports from Thailand, was set as a prototype crop under Seed Hub policy. However, previous studies have found that maize seed industry in Thailand is concentrated among few multinational corporations (MNCs) (OECD, 2018; Napasintuwong, 2020). The proprietary of maize varieties in Thailand, thus, depends primarily on the technology of these MNCs. The R&D investment by the private sector has increased dramatically in the past decades, but concerns have been raised that the rising role of the private sector in agricultural technology development may result in the loss of national control over food systems, especially if foreign MNCs become dominant suppliers of inputs to farmers (Fuglie, 2016). So far, there has not been sufficient evidence to suggest that Thai companies can compete in the seed market from developing Thai-owned brand-name seeds.

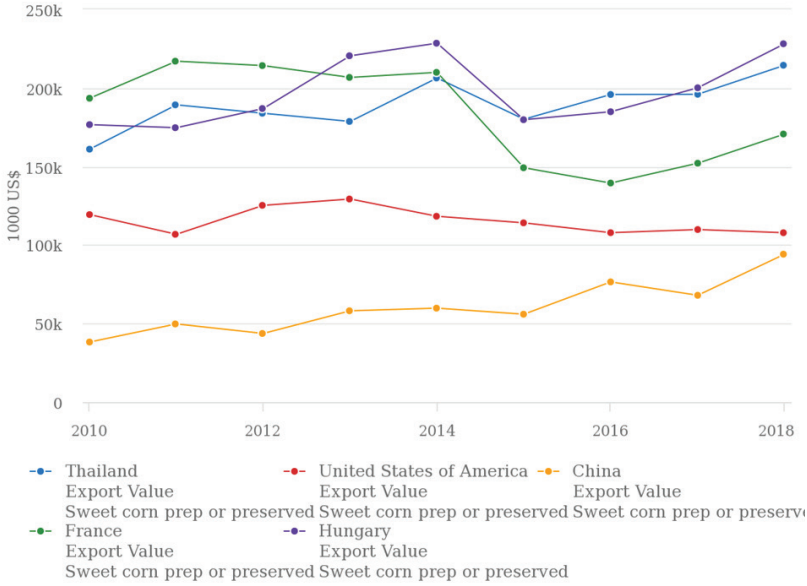
Also of importance is the corn seed industry. Corn is generally recognised as for human consumption while maize is for animal feed. According to the size of the industry, corn seed is much smaller than maize seed. However, corn seed industry became increasingly important due to the fact that Thailand is the leading exporter of sweet corn products, and the development of high-quality sweet corn varieties significantly contributes to the competitiveness of sweet corn industry. The corn seed fetches much higher prices compared to maize seed and generates incentivised profit; as a result, there has been increasing number of competitors in the past few years. Nevertheless, there is no study that reveals the capacity of Thai companies in generating Thai brand-name products and whether the regulatory and supporting policies enable the technological progress. To understand the role of research and development (R&D) and technological capacity with the emphasis on biotechnology, this study aims at analysing the technological capacity of corn seed companies in Thailand by comparing Thai local companies and MNCs. The related regulatory framework and supporting policies surrounding technology development in the seed industry is reviewed to provide implications for strengthening Thailand's technological capacity in the context of seed industry.

Corn Industry in Thailand

In Asia, corn can be classified into three groups. The largest market is sweet corn followed by waxy corn and baby corn. Corn is typically consumed fresh (grilled, steamed or boiled). In the past several years, Thailand has been one of the top five exporters of sweet corn products (i.e. canned whole kernel, canned creamy style, frozen, etc.) (Figure 1 and Figure 2) owing to the development of high yielding, good taste, easy care varieties in the 1990s which resulted in the establishment of processed sweet corn industry for exports. The demand of sweet corn in the domestic market is met by the supply of fresh produced, often sold at the fresh market while preserved (i.e. ready to eat corn on the cob, butter steamed corn, corn milk drink, canned, etc.) are available at the convenient stores and supermarkets. In 2019, Thailand exported about 208.5 thousand tons of sweet corn valued at about US$ 193.5 million. Major markets of sweet corn products from Thailand are Japan, South Korea, Taiwan, Philippines, the U.K., and the U.S. which take up about 57 per cent of total sweet corn exports from Thailand by value in 2019 (Ministry of Commerce, 2020). The value of sweet corn seed exports, however, was much smaller than that of sweet corn products. In 2019, the value of sweet corn seed exports from Thailand was about US$ 2.6 million mainly to Mexico, Malaysia, Taiwan and Philippines. China, one of the largest markets for sweet corn seeds, prohibits the imports of sweet corn seeds from Thailand. As a result, seed companies exporting to China may use sweet corn varieties developed in Thailand and produce seeds in other countries such as India and Indonesia.

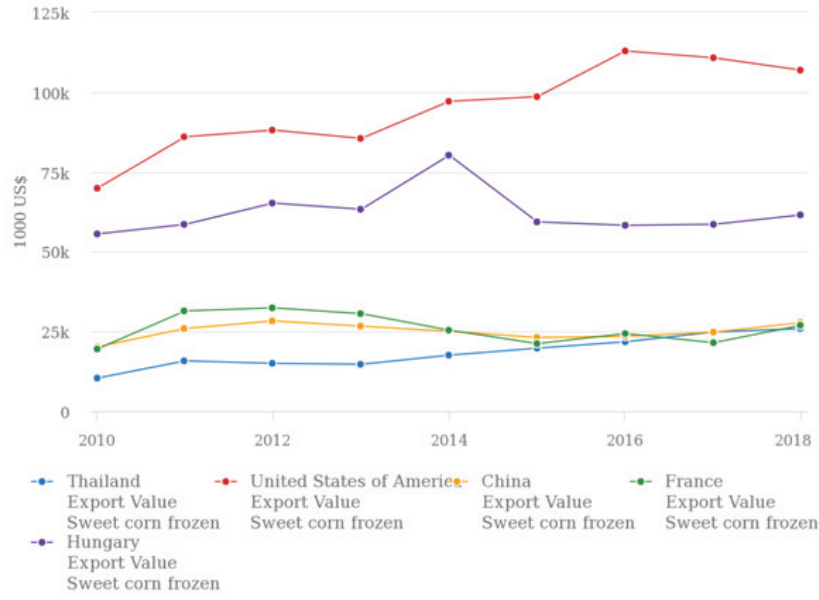
Despite increasing popularity of sweet corn products, the supply of sweet corn for processors in Thailand tends to decline in the past few years (Figure 3), mainly due to fall armyworm infestation and partly due to an expansion of fresh sweet corn and waxy corn production. Nevertheless, sweet corn seed has the highest value followed by waxy corn and maize (Table 1). The export of sweet corn seed was greater than the use in the domestic market while domestic use of maize seed was about the same as exported quantity. For Thailand to continue its leading position in the export market of sweet corn products, it is important that sweet corn supply to the processed food industry continues to be high quality and high productivity products. Thus, the development of sweet corn seeds is indisputable one of the important key factors to keep Thailand competitive in sweet corn market.

Figure 1. Top five exporters of prepared or preserved sweet corn (1000 USD), 2010 – 2018



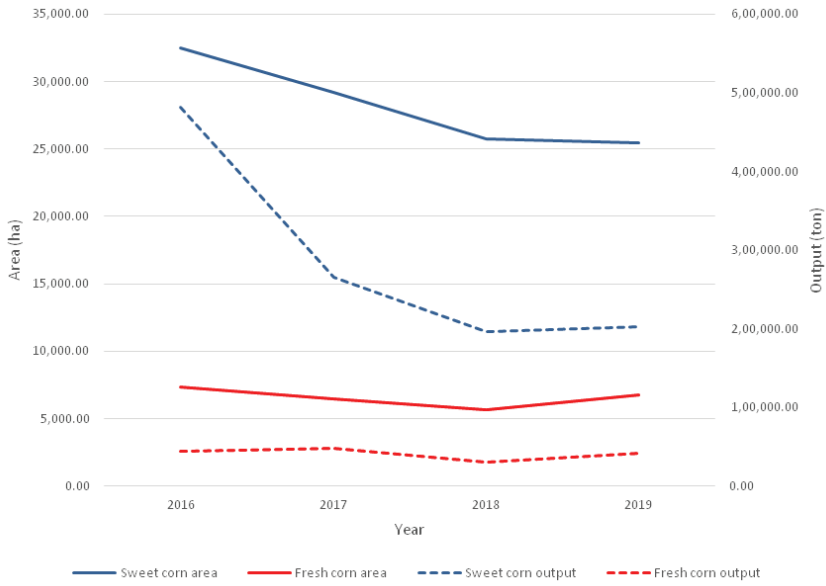
Source: FAOSTAT, 2020

Figure 2. Top five exporters of frozen sweet corn (1000 USD), 2010 – 2018



Source: FAOSTAT, 2020

Figure 3. Thailand's corn production area and output, 2016-2019



Note: sweet corn represents sweet corn used in processed food industry while fresh corn represents sweet corn, waxy corn and baby corn produced for fresh consumption

Source: Department of Agricultural Extension, 2020.

Table 1: Maize and corn seed production and trade, 2017

Crop	Domestic market			Import		Export	
	Quantity (ton)	Seed price (THB/kg)	Value (mil THB)	Quantity (ton)	Value (mil THB)	Quantity (ton)	Value (mil THB)
Maize	20,217.73	160	3,234.84	219.63	19.07	21,806.64	2,118.12
Waxy corn	120	600	72	-	-	-	-
Sweet corn	405.88	800	324.71	2.57	1.77	614.9	260.6

Note: 1 US$ = 33.9385 THB in 2017.

Source: Thai Seed Trade Association, 2020.

Seed regulatory framework in Thailand

Seed Law: Thailand's seed law (known as Plant Act) was enacted in 1975 to control the quality of seeds from production, sales, distribution, imports and exports of regulated plants including corn. For seeds to be sold in Thailand, it requires a registration of varieties, collectors, wholesalers, and retailers (Department of Agriculture, 2021). The production and sales of corn seeds must meet the requirements of minimum standards including purity and germination rates (96 per cent and 60 per cent) for all registered sellers (Ministry of Agriculture and Cooperatives, 2013). As of September 2020, there are 283 registered commercial corn (comprising sweet corn, waxy corn and baby corn) varieties eligible for sales in Thailand (Table 2). National Corn and Sorghum Research Center (NCSRC) is the only research institute that sells corn seeds. Its research station is affiliated with Kasetsart University, the latest agricultural university in the nation. NCSRC has been the main public maize breeding research institute established by the Rockefeller Foundation under the Inter-Asian Corn Programme (IACP) and has the largest collection of public maize germplasm under Thailand National Corn and Sorghum Programme (Napasintuwong, 2017).

Plant Varieties Protection Act (PVP): PVP is an important legislation to encourage private companies who seek profits from new varieties to invest in R&D. Following the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) of WTO, Thailand's PVP came into effect in 1999. The principles of PVP gives the rights-holders of new plant varieties the sole right to produce, sell or distribute, import, export, or possess them for the above-mentioned purposes (ESCAP III, 2021). The current Thai PVP is *sui generis* which has combined the principles of International Union for the Protection of New Varieties of Plants (UPOV) 1978[1] to protect plant breeders' rights while conserving biodiversity and farmers' rights under Convention on Biological Diversity (CBD). The principles of new plant variety protection follow the distinctness, uniformity, and stability (DUS) testing under UPOV. The PVP requires the applicants to grow the subject plant variety in Thailand for the purposes of examination. Since the import of seeds for the purposes of registering a new plant variety is not considered R&D, a foreign applicant developing variety outside Thailand will still require a permit. Companies that conduct their R&D outside Thailand and want to obtain PVP may encounter more difficulties than having their research in Thailand. The PVP also requires the benefit-sharing principles

of the use of plant germplasm is clearly stated. In addition, corn is one of the commodities under *International Treaty on Plant Genetic Resources for Food and Agriculture* (ITPGRFA). Even though Thailand is not a contracting party of ITPGRFA, it has signed the treaty. Owing to the fact that corn is not native to Thailand, benefit-sharing under PVP cannot be easily calculated if the use of germplasm came from various parties under ITPGRFA. Furthermore, under Thailand's current PVP, the use of genetic materials brought into the country or the use of hybrids sold in the market in breeding for commercial ends after 1999 is considered as the use of general domestic plant varietiess (Section 52). Under this article, the use of general domestic plant varieties for varietal development or research for commercial ends require a permission from the responsible official and shall make a proceeds-sharing agreement, where part of the proceeds is given to the Plant Variety Protection Fund per the regulations, guidelines, and conditions laid out in the Ministerial Regulation. It has been criticized by plant breeders that this regulation makes any R&D using genetic materials that cannot be traced back prior to 1999 too complicated.

Table 2: Number of registered commercial corn varieties under seed law, 2008 to September 2020

Seed Company	Number or registered varieties
Chia Tai*	66
Thai Seed Research*	19
Pacific Seeds	15
East West Seeds	15
Syngenta Seeds	11
Monsanto	5
Charoen Pokphand Produce (CPP)*	4
Sweet Corn Products*	3
Limagrain	1
National Corn and Sorghum Research Center*	1
Others (48)	143
Total	283

Note: * Thai companies; Include sweet corn, waxy corn and baby corn. Some of Syngenta Seeds and all of Sweet Corn Products Co. are licensed from Sweet Seeds. Others include seed shops and seed companies that did not develop their own varieties.

Source: Thai Seed Trade Association, 2020.

In addition, it has been criticised that weak enforcement of PVP resulted in inevitable reproduction of non-licensed inbreds and created pirate seed problems (Napasintuwong, 2014), besides which the submission for DUS trials imposes a large transaction cost especially for small companies. Consequently, several companies do not see benefits outweighing the cost of registering PVP. Apparently only few varieties of corn and maize are PVP protected (Table 3). As of September 2020, only 205 out of 1,266 maize, sweet corn, waxy corn and baby corn varieties registered for sales under seed law are proprietary products. Noting that Khon Kaen University (a public university) has several products registered for PVP, but they are not under seed law. This is because it licenses its varieties to other seed companies. It is also worth noting that registered PVP varieties are not all commercial hybrids. Some of them are registered to protect inbreds used for hybrid seed production, and some are not viable for commercialisation.

Table 3. Number of corn and maize varieties petitions filed for Plant Varieties Protection, 2003-2020

Company/ Institute	Approved	Pending	Trial stage	Withdrew	Expired	Cance-llation	Total
Monsanto	87	0	6	1	0	0	94
Pacific Seeds	47	12	17	12	2	0	90
Syngenta Seeds	11	15	7	0	0	0	33
CPP*	13	0	16	0	0	0	29
Pioneer Hi-Bred	13	0	0	0	0	0	13
East West Seeds	7	0	0	0	2	0	9
Seed Asia	2	0	2	4	0	0	8
Chia-Tai*	0	0	3	0	0	0	3
KWS Seeds	2	0	0	0	0	0	2
Agrostar Seeds*	0	2	0	0	0	0	2
Sweet Seeds*	0	0	0	1	0	0	1
Novartis Crop Protection	5	0	0	1	0	3	9
Khon Kaen University*	18	0	7	0	0	0	25
Department of Agriculture*	0	0	5	0	0	0	5
Total	205	29	63	19	4	3	323

Source: Extracted from Plant Varieties Protection Office, Department of Agriculture, 2020
Note: * Thai companies/institutes;
include maize, sweet corn, waxy corn and baby corn.

Seed Industry Supporting Policies

The seed business is one of the promoted food and agricultural industries using biotechnology under Thailand 4.0 policy which is the promotion of the fourth industrial revolution of industries that Thailand either has strong potentials and/or pressing needs. In specific to biotechnology, the policy provides a framework aiming to stimulate R&D and its applications of biotechnology by promoting private sector's investments and deepening community engagement in biotechnology. Agriculture and biotechnology were embedded as one of the five S-Curve industries in Thailand 4.0. (Office of the National Economic and Social Development Board, 2017).

To promote R&D investment in plant breeding using biotechnology, Thailand Board of Investment (BOI) has provided technology-based incentives such as 10-year corporate income tax exemption with no limit for businesses involved in plant propagation and development and seed production using biotechnology (Table 4). For businesses involving plant breeding that are not eligible for biotechnology activity, a 5-year corporate income tax exemption is provided. Furthermore, business that involves R&D activity and/or manufacturing of seed, the tax on goods imported for R&D is exempted. To promote R&D, BOI provides merit-based incentives for businesses conducting R&D including in-house R&D, outsourcing R&D in Thailand or joint R&D with overseas institutes. Under merit-based incentives, corporate income tax is exempted for investment in human resource development including donations to relevant educational and training institutes in specialised science and technology and for intellectual property acquisition/licensing fees for commercialising technology developed in Thailand. Such investment in R&D specifically in biotechnology and plant breeding technology which is the core of technology in seed business is supported by the government. The incentives for R&D via capacity building are also encouraged. Provided these incentives, it gives both Thai and foreign seed companies an opportunity to boost their technological capacity.

Market players in corn seed industry

The production volume of maize seeds in Thailand is much larger than corn seeds due to a larger demand from the feed industry. In 2017, Thailand

produced about 20,217 tons of maize seed covering about 1,078 hectares while the production of sweet corn and waxy corn was about 105 and 120 tons covering about 32,470 and 9,600 hectares, respectively. At present, Thailand does not allow the production and commercialisation of genetically modified (GM) crops; however, nearly all maize and corn seeds in Thailand are F1 hybrids (Napasintuwong, 2017). Provided that *farm-saved seed* will not produce *plants* or perform similar to the *hybrid* parent, corn hybrid seed market is almost completely privatised.

To compare the technological capacity between Thai national companies and MNCs, major market players in corn seed industry are first identified. Although there are several companies in maize seed market, only few companies operate in corn seed market. Large MNCs that dominate maize seed market in Thailand, specifically *Pacific Seeds* (taken over by Advanta), *Monsanto* (taken over by Bayer) and *Syngenta Seeds*, also have sweet corn in their seed product portfolio. These major maize MNCs have research stations in Thailand, and maize is their main seed product. The corn seed market in Thailand is led by three major companies, namely *Pacific Seeds*, *Sweet Seeds*, and *Syngenta Seeds* (National Science and Technology Development Agency, 2020). Among the three, *Sweet Seeds* is the only Thai local company. *Sweet Seeds* is a research company focusing on varietal development of sweet corn and plays a significant role in Thailand's corn seed industry, not only because it takes a leading position in sweet corn seed sales, but also because it frequently is the first company to release innovative and unique products such as red sweet corn, a market segment that *Sweet Seeds* has predominantly dominated. Furthermore, *Sweet Seeds* owns two other businesses. One is *Thai Seed Research* which is a biotechnology firm providing consulting services for plant breeding, production and sales of corn and maize varieties, and *Sweet Corn*, a sweet corn marketing company. From registered commercial corn varieties in 2020, there were 58 companies that sold corn seeds in Thailand (Table 2). It is worth noting that registered corn seeds of *Syngenta Seeds* and all of *Sweet Corn Products Co*. are licensed from *Sweet Seeds*.

Chia-Tai and *East-West Seeds* also have small shares in the corn market. Both are considered Thai MNCs although the founder and management

team of the latter is Dutch. Among corn seed products, the main market segment of *East-West Seeds* is waxy corn (estimated at about 80-90 per cent of waxy corn seed market[2]) while *Chia-Tai* gains a small market share in sweet corn and waxy corn.

Chia Tai has the largest number of registered commercial corn varieties followed by *Thai Seed Research*. *Sweet Seeds* which has the largest market share of corn seeds does not have any of its varieties protected under PVP. Similar to other MNCs, the number of PVP protected varieties of *Chia Tai* and *Thai Seed Research* is much smaller than the number of registered commercial varieties. Part of the reasons is that they frequently release new superior varieties that will replace old varieties so that pirate seeds will not create much trouble compared to the complexities of registering new plant varieties discussed above.

R&D intensity and technological capacity

From the number of registered commercial corn varieties, number of corn varieties submitted for property right protection and the domination of sweet corn seed sales, it is believed that technological capacity of seed companies depends heavily on the investment in R&D. The technological capacity is usually in the form of proprietary crop breeding programmes (Spielman *et al*., 2011). The innovation as measured by R&D investment and patents has been argued to have a strong relationship with firm's performance (Jin *et al*., 2017). However, as argued by Grillitsch *et al*. (2019), the shortcoming of using patent to indicate the innovation of the firm is due to the fact that the analyses are restricted to patent-intensive sectors. As we may see from the registration of PVP in Thailand discussed above, most seed firms do not have their commercial varieties registered for property right protection. In other words, seed industry in Thailand is not a patent-intensive sector, and using patent to indicate research/innovation capacity might not be appropriate. The number of improved commercial varieties, on the other hand, might better reflect firm's capacity to innovate and its performance (Pray and Nagarajan, 2012; Spielman and Kennedy, 2012). In seed industry, technological capacity may be measured from access to genetic materials (i.e. the company collection of germplasm and collaborative research with

other institutions), capital investment in R&D, and human capacity or employees engaging in research activities (Paiva *et al*., 2020; Matricano, 2020). In addition, the competency or education of employees also associates with the performance the knowledge base of the firm (Grillitsch *et al*., 2019), and the scale of investment in human capital may also be measured by the employment of R&D staff.

To compare the technological capacity of Thai national companies and MNCs, key market players in Thailand's corn seed industry were randomly selected, one Thai local company representing small and medium enterprises (SMEs) and three foreign MNCs. The information on R&D investment, technology used, and human capacity was obtained by a survey of private companies. Table 5 summarises corporate information on the R&D and biotechnology applied in product development of corn seed market leaders. This information does not limit to corn seed products but all research activities of both maize and corn. We can see that all leading corn seed companies also operate in maize seed business. Other than sweet corn, some companies also have waxy corn and baby corn in their seed product portfolio. This operation creates economies of scope from operating in several seed businesses of related crops. All selected companies have their in-house R&D, and licensing products are not uncommon. All of the four companies have released new products in the past five years, and all of their products are single cross hybrids. None of their newly released seed products are double cross hybrid. These new products are all developed from their own R&D programme. The licensing is exclusively from private companies, and not from local public institutes or individual breeders.

MNCs have much larger investment in R&D, and greater access to genetic materials than Thai local company. This selected Thai local company creates its breeding lines mainly from the germplasm collected in the country by selfing technique. On the contrary, MNCs utilise back crossing, market assisted selection (MAS), and double haploid in their breeding programme. The biotechnology used in breeding does not include genetic engineering by any companies in Thailand, but some MNCs have used genetic engineering technology in other countries. This implies that Thai local company still has less advanced technology and limited genetic materials than MNCs.

Table 4: Incentives for R&D and biotechnology investment in seed business

Targeted core business	Conditions	Incentives	Effective date
Biotechnology Development[a]	1. Target technology development procedures shall be used as a base for the manufacturing process or service provision in the target industry as approved by the BOI	Exemption from corporate income tax for ten years with no limit on the income tax exempted	From February 8, 2017 onwards
	2. There must be a technology transfer with an educational institution or research institute as approved by the BOI e.g. Technology Research Consortium.		
	3. Project located in a science and technology park promoted by the BOI or one that is approved by the Board will receive an additional 50 percent reduction in a corporate income tax for 5 years after the end of its corporate income tax exemption period.		
Research and development (R&D) activity and/ or manufacturing of seed industry, improvement of plants, animals or microorganisms using biotechnology[b]	1. Projects must use modern biotechnology approved by the National Science and Technology Development Agency (NSTDA) or the Thailand Centre of Excellence for Life Sciences (TCELS)	Import tax exemption incentives on goods imported for R&D	From February 8, 2017 onwards
	2. Projects located in a science and technology park promoted by BOI or one that is approved by the Board will receive an additional 50 per cent reduction in corporate income tax for 5 years after the end of its corporate tax exemption period.		

Table 4 continued...

Table 4 continued...

Targeted core business	Conditions	Incentives	Effective date
Plant breeding (only those that are not eligible for biotechnology activity)[c]	1. Projects must have research and development activities.	5-year corporate income tax exception	From January 1, 2015 onwards
	2. For breeding of sensitive plants according to the policy of the Ministry of Agriculture and Cooperatives, projects must have Thai nationals holding shares totaling not less than 51 per cent of the registered capital.		
	3. Projects must have expenses for salaries for R&D personnel of at least 1,500,000 baht per year. Or projects must have the minimum investment capital directly for the activity of at least 1 million baht (excluding cost of land and working capital).		
	4. Projects located in the science and technology park, promoted by BOI or one that is approved by the Board will receive an additional 50 per cent reduction of corporate income tax for 5 years after the end of its corporate tax exemption period.		
	5. Revenue derived from plant propagation after plant breeding in the project shall be regarded as revenue of promoted projects, except for the propagation of cassava.		

Table 4 continued...

Table 4 continued...

Targeted core business	Conditions	Incentives	Effective date
Merit-based incentives[c]	1. Research and development in technology and innovation including in-house R&D, outsourcing R&D in Thailand or joint R&D with overseas institutes.	1. One additional year of corporate income tax exemption will be granted if qualified investments or expenditures are not less than 1 per cent of the project's total revenue of the first 3 years combined, or not less than 200 million baht, whichever is less. However, the total period of corporate income tax exemption shall not exceed 8 years. 2. Two additional years of corporate income tax exemption accounting will be granted if qualified investments or expenditures are not less than 2 per cent of the project's total revenue of the first 3 years combined, or not less than 400 million baht, whichever is less. However, the total period of corporate income tax exemption shall not exceed 8 years.	From January 1, 2015 onwards
	2. Donations to Technology and Human Resources Development Funds, educational institutes, specialized training centres, research institutes or governmental agencies in the science and technology field in Thailand,as approved by the Board.		
	3. IP acquisition/licensing fees for commercializing technology developed in Thailand.		
	4. Advanced technology training		

Table 4 continued...

Table 4 continued...

Targeted core business	Conditions	Incentives	Effective date
	5. Development of local suppliers with at least 51 per cent Thai shareholding in advanced technology training and technical assistance or	3. Three additional years of corporate income tax exemption will be granted if qualified investments or expenditures are not less than 3 per cent of the project's total revenue of the first 3 years combined, or not less than 600 million baht, whichever is less. However, the total period of corporate income tax exemption shall not exceed 8 years.	
	6. Product & Packaging Design; either in-house or outsourcing in Thailand, as approved by the Board		
Source: a=BOI, 2020; b= BOI, 2017; c=BOI, 2014 Last updated: March 23, 2020			

The employees play an important role in product innovation (Freel and Robson, 2004; Matricano, 2020). Investment in human capital is shown in Table 5. MNC1 has the largest number of research staff while MNC3 has largest number of research staff with graduate degrees. Thai local company, on the other hand, has several research staff with the education below bachelor's degree, does not have any technology development staff (those to develop seed products from breeding programme to commercialisation), and all of its staff engage in some research activities.

As maize is one of the most advanced seed sectors in Thailand and in the region, maize breeding programme of these MNCs is believed to be much more advanced than corn; however, it may be presumed that breeding technologies in maize of these MNCs also spillover to corn. Napasintuwong (2017) shows that major maize seed MNCs including the selected MNCs have a long-term investment in maize breeding programme in Thailand. An in-depth interview with this selected Thai local company reveals that the owner has a long experience in maize and sweet corn business. He earned a Ph.D. in plant breeding, spent over a decade as a research manager of one prominent seed MNC, was a managing director of a company that has operated in sweet corn business from development, production, and sales, and was a sweet corn business regional manager of one large MNC. In addition, as a family business, this Thai local company involves other family member who has a graduate degree in plant breeding majored in genomics in R&D. Although the number of employees of Thai local company might not be as large as that of MNCs, the company also promotes capacity building by sponsoring its research staff to continue in higher education.

Government supports such as access to public research facility, germplasm collection, and tax exemption was not much utilised by this local company perhaps due to the focus of the company on corn which is a commodity that the public institutes do not emphasize in R&D activities. The technological capacity is approximated from all factors mentioned above and presented in Figure 4.

Table 5. R&D intensity and biotechnology investment of leading corn and maize seed companies in Thailand, 2016

Company	Thai local company	MNC1	MNC2	MNC3
Seed Products				
Sweet corn	Yes	Yes	Yes	Yes
Field maize	Yes	Yes	Yes	Yes
Waxy corn	Yes	Yes	No	Yes
Baby corn	No	Yes	No	No
Did your firm carry-out any in-house R&D?	Yes	Yes	Yes	Yes
Did your firm use any public R&D?	No	Yes	No	No
Did your firm sell varieties' licenses?	Yes	Yes	No	Yes
Did your firm buy varieties' licenses?	No	No	No	Yes
Are there any new products in the past five years?				
Single cross hybrid	Yes	Yes	Yes	Yes
Modified single cross hybrid	No	No	Yes	No
Double cross hybrid	No	No	No	No
Are the new varieties from company's own R&D	Yes	Yes	Yes	Yes
Are the new varieties protected under PVP in Thailand?	No	Yes	Yes	No
Are the new varieties protected under PVP in other countries?	No	No	No	Yes/No
Current breeding technology used in Thailand				
Selfing	Yes	Yes	Yes	Yes
Back crossing	No	Yes	Yes	Yes
Marker Assisted Selection (MAS)	No	Yes	Yes	Yes
Double haploid	No	Yes	Yes	Yes
Genetically engineering	No	No	No	No
Multi-location yield trial	Yes	Yes	Yes	Yes
Current breeding technology used in other countries				
Selfing	n/a	No	No	Yes
Back crossing	n/a	No	No	Yes
Marker Assisted Selection (MAS)	n/a	Yes	Yes	Yes
Double haploid	n/a	No	No	Yes
Genetically engineering	n/a	No	Yes	Yes
Multi-location yield trial	n/a	No	Yes	Yes

Table 5 continued...

Table 5 continued...

Company	Thai local company	MNC1	MNC2	MNC3
Human capacity				
Research staff (including manager and consultants)				
PhD	1	0	0	1
MSc	4	5	3	9
BSc	3	2	0	9
Other diploma/degree	15	49	0	0
Technology Development staff				
PhD	0	1	3	1
MSc	0	0	4	3
BSc	0	7	5	1
Other diploma/degree	0	0	4	0
Total number of local employees	23	302	163	123
Total number of local R&D employees	23	56	61	19
% of R&D employees	100	18.54	37.42	15.45
Research expenditures (mil. Thai THB)				
In-house (Thailand)	10	38	120	100
In-house (other countries)	0	50	n/a	n/a
Tax credits for R&D expenditures	No	Yes	No	No
Government financial support for your firm's research	No	No	No	No
Government other support for your firm's research	No	No	Yes	No
Collaborative research with government research institutes	No	Yes	No	No
Use government research pedigree or germplasm	No	No	Yes	Yes
Collaborative yield trial with government research institutes	Yes	Yes	Yes	Yes
Collaborative research with international research institutes (not private companies)	No	No	No	No
Collaborative research with other private firms	Yes	No	No	No

Note: 1US$= 35.0137 THB in 2016

Source: Author's private company survey.

Figure 4A. Number of commercial sweet corn varieties eligible for sales in Thailand, 2008- September 2020

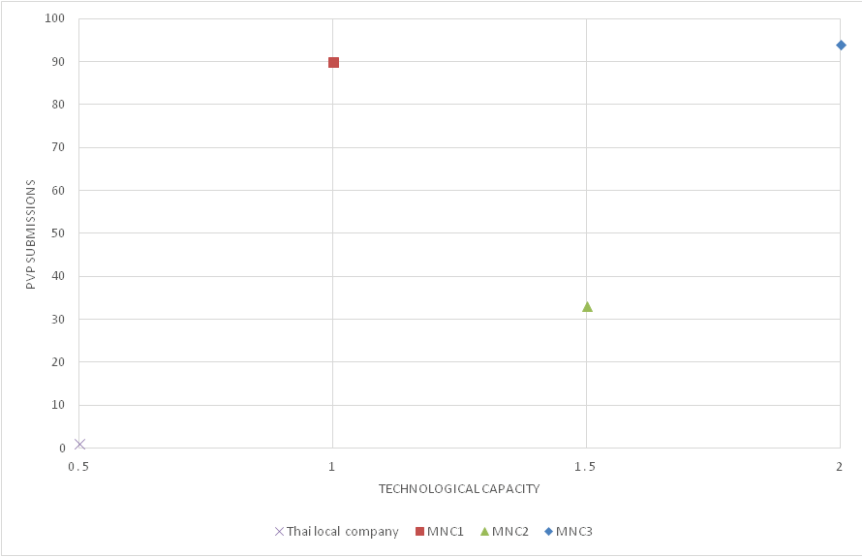
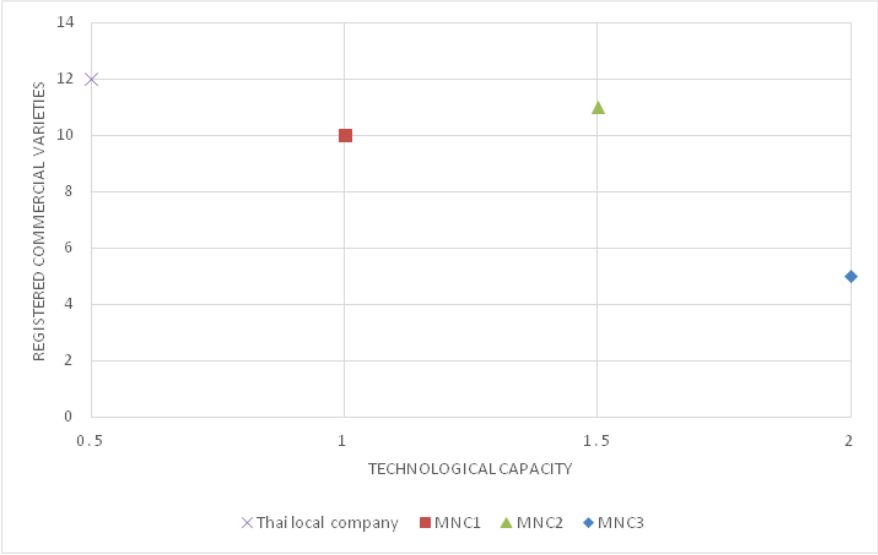


Figure 4B. Number of plant variety protection submissions for corn and maize in Thailand, 2003-2020.



Note: Estimated technological capacity technological capacity: 0.5 = very low; 1 = low; 1.5 = medium; 2 = high

Source: Author.

The mapping of PVP submissions and number of registered commercial varieties against technical capacity is approximate and only for illustrative purposes.

MNC3 has the highest technological capacity, followed by MNC2 and MNC1 while Thai local company has the lowest technological capacity. Although Thai local company has the most concentrated breeding programme in sweet corn than any other companies, the research investment and human capacity is relatively much lower. Its number of registered commercial varieties is the greatest among the four (Figure 4A). Furthermore, this local company also licenses some lines to other MNCs. As a result, MNC2, for example, has the second largest number of registered commercial varieties possibly from licensing from a Thai company. MNC1 is a leading sweet corn seed producer; its registered commercial varieties are also higher than those of MNC3.

Regarding, plant variety protection, the application for PVP provides a clear indication of how seed companies have responded to the regulatory regime. When the transaction cost is not prohibitive and intellectual property right legislation is fully enforced, companies that has greatest technological capacity should have the greatest number of property right protections of their innovations. Figure 4B, shows somewhat consistent results. However, the submission of PVP by MNC2 is much lower than MNC1 even though it has greater technological capacity. This may imply that the legal environment of intellectual property right protection for plants is still not efficient or does not offer full benefits for the right holders compared to transaction cost associated with it. One barrier of current PVP, especially to SMEs is the submission of documents for DUS which requires extensive paperwork preparation and good coordination with the Department of Agriculture for examination. The PVP also requires benefit sharing of any use of genetic material dated after 1999. To avoid unsettled principles of benefit sharing among companies and benefit sharing from using general domestic plant varieties, none of the submissions of PVP has stated the use of maize or corn parental lines generated after 1999. Furthermore, the registration of PVP as mentioned before is not only for commercial hybrids but also parental lines. Most of MNC3's PVP protected varieties are parental lines. Similarly, MNC1's PVP protected varieties also include both commercial hybrids and parental lines. Other companies typically

register only the commercial hybrids. Thai local company, although has the greatest number of registered commercial varieties eligible for sales, none of the varieties is PVP protected.

Discussion and Conclusion

Provided Seed Hub policy aims at promoting seed industry and creating Thai brand-name products, the analysis of technological capacity in corn industry shows that Thai local companies have a good potential to generate Thai brand-name products as we may see from the number of registered commercial sweet corn varieties by *Thai Seed Research*, a local SME. However, these Thai brand-name products are not much protected under current PVP legislation. On one hand, it implies that current legal environment may not provide incentives for companies to submit for the right protection. One the other hand, the management of local SMEs may require a different business model to build up the technological capacity.

Sweet corn is one of the important export industries and the quality of sweet corn products depends largely on the varietal characteristics such as sweetness, crunchiness and thickness of the corn kernels. The review of public policies toward investment incentives and corn seed companies' survey shows that local SMEs did not receive much government support for technology development. This study reflects that the development of sweet corn varieties by Thai local companies depends exclusively on private sector' technological capacity. Although there are investment incentives for R&D for seed companies particularly those using biotechnology and for capacity building such as training in specific technological programme, the R&D investment of the companies has a time-lag effect on their technological capacity and performance. Thus, for Thai local SMEs, that have limited technological capacity, a strong research platform, that would enable continuous technological capacity development, should be supported.

Blank (2008) found that without cooperative efforts in R&D in biotechnology, SMEs would have competitive disadvantages and may not even emerge. This could partly be due to inability to exploit economies of scale, and partly due to inhibitive regulatory and legal resource needs. SMEs generally depend greatly on the partnership with local R&D research centres and higher education institutes to build up the technological capacity, but rarely collaborate with large enterprises as they see larger firms as competitors

(Paiva *et al*., 2020). It was found that small biotechnology firms are lack of technically qualified competences and constitute high level of engagement with monitoring their marketplace and other marketing activities. The in-depth interview with Thai local company has observed the same evidence. To build up technological capacity and create Thai brand-name seeds especially by SMEs, the innovation system in agricultural biotechnology may be reinforced by an innovation system that supports accessing and managing resources, particularly genetic materials and human capital. The fact that Thai local company can still be a leading company in the local seed market where several competitors are MNCs suggests that the innovation cannot be measured only from the PVP of new varieties. Similar to what Knickel *et al*. (2009) suggested, this study suggests a system of innovation that integrates farmers (i.e. seed growers), higher education institutes, and research centres in the R&D network so that research skills and technological capacity are endorsed. R&D policies, government supportive innovation policies and international corporate collaboration policies were found to have a strong influence on the development of biotechnology innovation (Aghmiuni, *et al*., 2020). Although Thailand's Seed Hub policy aims at promoting the seed industry, the strategic instruments might have to be designed to stimulate R&D activities, for example, a collaboration with academic institutes with and/or other firms. Furthermore, supporting systems such as regulations and enforcement that will stimulate the innovation is also needed.

Technological capacity is an important factor in the sustainability of seed business. Several mergers and acquisitions that occurred in the seed industry have shown that local SMEs were typically acquired by large MNCs (Howard, 2018; Napasintuwong, 2019). Thus, for local companies to innovate and sustain in the business, enhancing country's technological capacity is unavoidable. The advantage of local SMEs is the ability to understand the local environment. Not only that the rural communities will benefit from technology created for the local needs, but small farmers involving in seed production will also benefit from improving technological capacity. For example, *Thai Seed Research* company became well-known among sweet corn growers from knowledge transfer on farm management and agronomic training to small farmers who are interested in sweet corn production. This small but close network, together with outstanding quality of sweet corn varieties, makes *Thai Seed Research* one of the most successful

SMEs in seed business in Thailand. Furthermore, *Thai Seed Research* company has created a partnership in R&D not only with local institutes in Thailand but also private companies and research centres in designated sweet corn seed markets such as Indonesia and China. This regional partnership not only increases technological capacity of Thai local company but also improves the knowledge of the market needs. To summarise, this paper suggests that government supported programmes should be stimulated for technological capacity building such as public-private partnership R&D programme, university-company partnership, and regional R&D network with foreign research institutes. Advanced technical training in breeding and seed technology from public academic institutes that have strong research programmes is also encouraged so that technological capacity of Thai seed companies will be enhanced.

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Endnotes

1 At present, Thailand is not a member of UPOV so the scope and details of plant breeders' rights under UPOV 1991 is not used in Thai PVP.

2 Corn seed market experts' interview in March 2021

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Transitioning to a Bio-Based Economy: Indian Initiatives in the Bioenergy Domain

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Abstract: In the context of climate change, countries all over the world are making numerous efforts to transition to a bio-based economy from a fossil fuel-based economy. This paper looks at the motivations and policy initiatives in India that drive the transition to a bio-based economy. This article focusses on the bioenergy sector and the comparative analysis of the historical developments in the biofuels domain leading to the biofuel policies of 2009 and 2018. As a potential contributor to bio-based economy by ensuring energy self-reliance, clean energy and increasing farmers income, this article analyses the shifts in the policies, the technical trajectories. It examines the opportunities and challenges in developing and harnessing the advanced biofuels and the initiatives taken in recent years in this regard. It points out that there are many challenges and highlights the importance of engaging with stakeholders in development of policy. Considering the opportunities, the issues that could arise and the potential and need for biofuels for energy security and to fulfil other objectives, it makes some suggestions for policy makers.

Keywords: National Biofuel Policy (NBP), Second Generation (2G) Bioethanol, Advanced Biogas, Bioeconomy, India

Introduction

As one of the main focus of Sustainable Development Goals (SDGs), the equitable and just distribution and access to energy will be at the core of sustainability debates for the coming decade (El-Chichakli *et al*, 2016). Bioenergy is one of the central focus of more than 30 countries that are developing policies to transition to or boost their bio-based economy (Bosch et al. 2015, El-Chichakli *et al*, 2016). In the light of impacts of non-renewable sources of energy on earth and environment and their limited availability, government and businesses all over the world are investing heavily on R&D of bio-based energy. In India, over the past two decades, there has been an aggressive focus and successful execution of multiple central and state-led programmes to promote renewable energy, the most

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notable among them is the National Solar Mission. Bioenergy, although being one of the oldest and most used sources of energy in rural India, has received milder support from the government1 and mixed response from government and private sector (Sarvanan *et al*. 2018). In a series of recent initiatives, including the revision of the National Policy on Biofuels, Indian government has attempted to revamp its focus on bioenergy. This paper looks systematically at the previous (2009) and current (2018) biofuel policies in order to decipher patterns of opportunities, challenges, and points of considerations for the development of bio-based economy through advanced biofuels in India.

The new Biofuel Policy was approved in June 2018 and it was released by the Prime Minister on 10th August 2018.[2] This paper relies on a qualitative methodology and data collected through a diversity of primary and secondary sources. Scientific conferences could be a very good site of data collection, specially in the field of emerging technologies, where many new developments that are still not out in the public domain are discussed and presented (Campbell et al. 2014). The author attended multiple national and international meetings which focused on most recent developments in the advanced bioenergy domain. These meetings included EU-India Advanced Biofuel Conference for three consecutive years (2018-2019) and the National Biofuel Day for four consecutive years (2016-2019). Along with the data gathered from biofuel conferences, government documents and public websites, interviews were conducted with key stakeholders from 2017-2019. These include farmer groups from Punjab and Haryana, civil society groups such as Kheti Virasat Mission, entrepreneurs developing agri-residue based biogas and 2G bioethanol, and scientists from Ministry of Petroleum and Natural Gas (MoPNG), Ministry of New and Renewable Energy (MNRE), DBT-IOC (Faridabad) DBT-ICT (Mumbai) IIT (Delhi), and IISc (Bangalore).

The organisation of the paper is as follows: First, it presents a broad overview of bio-based economy in relation to definitions, international policy developments, issues, and concerns. The next section briefly discusses different aspects of bio-based economy in India, leading to a discussion on the historical context and the development of two biofuels policies in India. Finally, the paper discuss the opportunities, challenges, and consideration for the development of advanced biofuels in India – Second Generation (2G) bioethanol and agri-residue based biogas.

Bio-based Economy: A Broad Overview

In the light of global concerns for climate change, growing resource scarcity, increasing population and unstable political environment, majority of the leading economies of the world are focussing on the shift from fossil fuel based economy to a bio-based economy (McCormick and Kautto 2013). A bio-based economy would mean developing relations of socio-economic exchange around the use of locally available bio-based resources to produce energy, chemicals and materials (Laibach *et al*, 2019). The sustainable use of biomass is the central aspect of bio-based economy. It has been argued that a bio-based economy will contribute towards major sustainable development goals (SDGs) such as sustainable consumption, energy, and climate change (Laibach *et al*, 2019). The Organization for Economic Co-operation and Development (OECD) in 2006 published a document 'The bioeconomy to 2030: designing a policy agenda'. This document highlighted the need for R&D and investment in the bioeconomy domain and urged for the active engagement of public and private sector to realise its full potential (OECD 2006, McCormick and Kautto 2013). The agenda of the OECD document, however, was still more focussed on existing biotechnology industry rather than exploring the possibilities of new developments.

Since 2009 countries like USA, Canada, Sewden, Finland, Australia and Germany have outlined there strategy to move towards bio-based economy. Countries like the Netherland, Russia, China, and Malaysia are showing active interest in formulating their national strategies (Staffas, Gustavsson and McCormick 2013). In 2012 European Union published their policy agenda 'Innovating for sustainable growth: a bioeconomy for Europe' which shifted the focus to knowledge based bioeconomy which encompasses R&D, network building, and institutions in the field of agriculture, bioenergy, new materials and biorefineries (EU 2012, Staffas, Gustavsson and McCormick 2013).

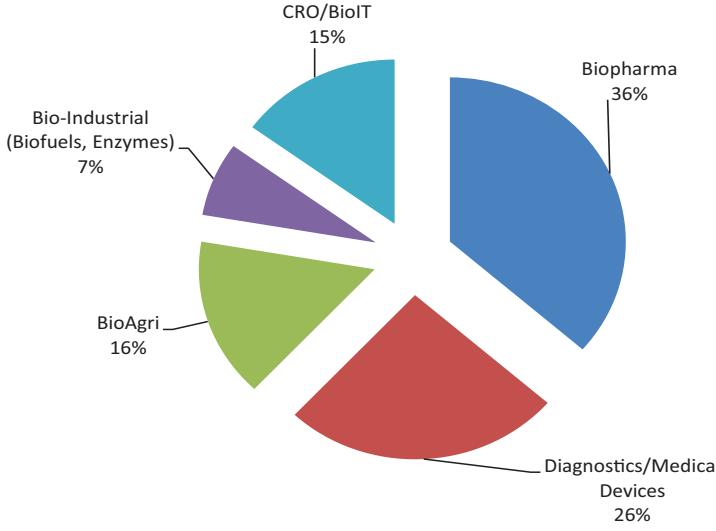
Along with the political activity all over the world to move to a bio-based economy, there are many concerns about the absence of standards, sustainability matrics and international reguatory body (conflict resolution centre) that could facilitate a smooth transition (Bosch *et al*. 2015). Birch and Tyfield (2013) argue that bioeconomy is yet another layer to the ongoing transitions in life sciences that is reorganising and transforming the socio-economic relationships which characterise value in modern capitalism.

Schmidt *et al*. (2012) have argued that the trope of bio-based economy is deployed by the policy to open-up agricullture even further as a source of cheap raw material for industrial exploitation. The bias towards industry and technological innovation in current vision of bio-based economy sidelines the complex relationships between land, labor, environment, and agriculture.

Indian Bio-Based Economy

In India, the term bio-economy or bio-based economy has gained a lot of prominence, recently. In March 2021, the Biotech Industry Research Assistance Council (BIRAC) and Association of Biotech led Entreprises (ABLE) jointly published the *India Bioeconomy Report* (IBER 2021). The report noted an upward growth trend of the Indian bioeconomy and estimated the value of the bioeconomy to be 70.2 Billion USD with 2.9 per cent contribution to national GDP in 2020 (IBER 2021). While the majority of the value of bioeconomy is derived from the biopharma and medical device sector, bioenergy industry (enzymes, biomass, biofuels) is projected to be a potential area of growth in the future. In order to reach the projected target of 125 billion dollars by 2025 additional support from policy, government, and industry is recommended in the report (IBER 2021).

Figure1: Bioeconomy in India.



Source: Author's chart based on IBER 2021 data.

The Indian government is making active efforts to support the growth and development of bioenergy industry. Along with harnessing the growth potential of this industry, the efforts to boost bioenergy production lie in multiple national and international concerns around fossil fuel based economy. For example, the Paris Agreement of 2015, for capping the global temperature rise at 2 degrees Celsius (the so-called *two-degree scenario*[3]), guides the move towards biofuels, internationally. Based on the two-degree scenario, projections on the impacts of road transport on climate change have been developed, leading to action plans and interventions to reduce GHG emissions. According to the Director General of the International Energy Agency (IEA), biofuels will play a significant role in achieving the two-degree target. Early-mover advantages offer a significant potential gain in global competitiveness for renewable energy R&D for technology providers.[4] During the launch of the National Biofuel Policy (NBP) 2018, Prime Minister Narendra Modi asserted that the new biofuel policy aims to initiate efforts to support India's commitment to COP21 Paris Agreement for climate change, and address domestic challenges of energy security and income generation.[5] In a recent EU-India meeting on advanced biofuels, the minister of petroleum and natural gas emphasized that India is aiming for a 10 per cent cut in its fossil fuels imports by 2022.[6] Recently, India entered into many strategic alliances with international partners such as the *Biofuture* Platform and Mission Innovation (MI). The Biofuture Platform is an action-oriented multi-stakeholder coalition, formed in November 2017, to support bio-economy and low carbon transport.[7] MI is a joint initiative by 22 countries in the world, including India and the European Commission, to promote clean energy development under the Paris Agreement 2015. India co-led the sustainable biofuel innovation challenge of MI, along with Brazil, China, and Canada.

Biofuels are considered as one of the potential candidates for the replacement for fossil fuels in national energy mixes (Sorda *et al*, 2010). There is growing agreement that, in order to deal with the challenges of fossil fuels, any national energy policy should offer a diverse mix of energy carriers, rather than aiming for a single 'silver bullet' solution (IEA 2017). This implies, for example, that electrification and bio-energy should not be positioned as alternatives or competitors, but rather as complementing each other.[8] Biofuels, then, are especially important for heavy vehicles and

airplanes, while electrification is useful for light-vehicle mobility (Peters and Thielmann 2008). Also, in order to achieve functional electric mobility, much additional investment in infrastructure would be required, while liquid biofuels do fit well in the existing automobile infrastructure (Zhao 2017).

Biofuels in India: Policy Change in Historical Context

Systematic efforts and the initiatives to develop a biofuel policy started in early 2000s by the planning commission.[9] The Ministry of New and Renewable Energy (MNRE)[10], which previously had only played a marginal role in the planning commission's scheme, was assigned the responsibility of formulating a National Policy on Biofuels, in consultation with other ministries and departments (GoI 2009). In 2009, National Biofuel Policy (NBP 2009) was launched by MNRE. In 2012, the Department of Biotechnology (DBT) released the bioenergy roadmap and its vision for 2020. While the NBP 2009 laid out the policy measures and support for bioenergy production and procurement, the bioenergy roadmap developed a vision to provide stimulus to bioenergy industry through R&D and capacity building. Over the years, MNRE has been overburdened by multiple responsibilities related to renewable energy. The National Solar Mission, which was launched in 2010, has drained most of the resources from the ministry with little attention left for other programs. Given the technological immaturity and lack of proper implementation of both biodiesel and bioethanol programmes, questions were raised about capacity of MNRE to run biofuels programs.[11] As a result, after multiple rounds of consultation with different government agencies, industry organisations and other relevant stakeholders, in June 2018, the new National Biofuel Policy 2018 (NBP 2018) was launched by Ministry of Petroleum and Natural Gas (MoPNG), Government of India. MoPNG, who were till now, only active in the procurement and supply of biofuels, were, from now on, also given the responsibility of taking care of production, promotion and R&D of biofuels.

Two major constituents of bioenergy in India are biomass power and biofuels. MNRE has been implementing the biomass power/cogeneration programmes in various formats since the mid-1990s. In 2018 the biomass power and cogeneration programme was re-launched with the aim of promoting technologies and industry for efficient use of the biomass resource of the country, primarily for grid power generation.[12] As of December 2019,

total installed capacity for biomass power and co-generation, in the country, is 10145 MW.

Biofuels can be primarily categories into ethanol, biodiesel, advanced biogas, and hydrogen fuels. Based on the source of raw materials/feedstock they are futher categoried as first generation, second generation, and third generation. Currently, the bioenergy domain of India is dominated by first generation biofuels[13] (1 G). In the light of raging international criticism on resource exploitation from developing countries for biofuels and food versus fuel debate, the 2009 version of the biofuel policy categorically distanced itself from the use of food grains for the production of bio-energy (MNRE 2009). The policy explicitly stated that 'the Indian approach to biofuels is different from current international approaches [since] it is based solely on non-food feedstocks to be raised on degraded land not suited for agriculture, thus avoiding a possible conflict of food vs. fuel' (GoI 2009: 4-5). In recent years this aspect of the policy was severely criticised by domestic sugar industry. In a conference organised at Vigyan Bhawan on the event of world biofuels day 2016, the representatives of the sugar industry urged the government to utilise the full potential of already existing sugar industry for bioethanol production before looking at new sources and ways of producing and procuring it. The controversies associated with non-payment of cash by sugar industries to sugarcane farmers are one of the major agricultural challenge in India associated to a cash crop. The possibility of diversification of outputs in the form of 1G and 2G bioethanol is being seen as a major policy intervention by policy-makers, sugar industries as well as farmers. Since sugar industry already has well established supply chain for feedstock, it has an advantage in setting up 2G ethanol plants as compared to other industries.

As a result of continuous pressures from the sugar industry, and inability to meet the blending targets for bioethanol, the new biofuel policy allows the direct conversion of sugar to ethanol in 'surplus' years (MoPNG 2018). The price of ethanol from 100 per cent sugarcane juice is fixed at 59.13 per litre (compared to 47.13 before) in order to support sugar industries that want transition to complete ethanol production (IANS 2018). State governments that are primary producer of sugar are actively taking advantage of the recent biofuel policy initiative. The UP government has promised an investment of INR 1500 crore to upgrade sugar mills to

diversify towards ethanol production, while Maharashtra government has promised to invest INR 2500 Crore on similar ventures.[14] With the NBP 2018 the possibility of producing ethanol from 100 per cent sugarcane juice, B-heavy molasses/partial cane juice, heavy molasses and damaged food grains have been opened. The OMCs such as Indian Oil have already opened tender for ethanol procurement for the 2018-19 season and there has been a bid for 485 million litres of ethanol from B heavy molasses and 18.4 million litres from sugarcane juice.

A major focus of the NBP 2009 was on bio-diesel and plantation of crops suitable for biodiesel production. The policy also discusses continued support for molasses-based, non-food, traditional feedstock for bioethanol. The choice to focus on first generation biodiesel and bioethanol might result from a risk mitigation strategy for new initiatives. Due to the estimated more demand for diesel in the country as compared to ethanol, risk aversion strategy is further undertaken in going for plantations in the case of biodiesel and support of the traditional route for bioethanol.

The NBP 2018, however, is keen to explore the second generation and advanced bioenergy options in the form of 2G bioethanol, advanced biogas and di methyl ether, and hydrogen fuels (MoPNG 2018). Where considering the shortcomings, EU policies recommend a gradual phasing out of 1G biofuels by replacing them with 2G by 2030[15], Indian policy-makers are following a multi-pronged approach to promote bioenergy in all forms. 2G biofuels, that include agri-forest residue-based bioethanol and biogas, and Municipal Solid Waste (MSW) and Used Cooking Oil (UCO) based biodiesel, present multiple opportunities, challenges and points for consideration[16] (discussed below) for a bio-based economy. There needs to be a serious engagement and foresight from policy makers in order to make the NBP 2018 a useful guiding document for moving towards a bio-based economy in the energy sector.

Table 1: Biofuel policy evolution in India from NBP 2009 to NBP 2018

Policy Initiatives	National Biofuel Policy 2009	National Biofuel Policy 2018
Emphasis on	Production (Bioenergy crops such as Jatropha and sugarcane)	Procurement
Treatment of different bioenergy options	Mostly skewed towards molasses-based ethanol and jatropha-based biodiesel	Relatively balanced view on different bioenergy options including 1G, 2G, 3G ethanol, advanced biogas, hydrogen fuels, methanol and di-methyl ether
Responsible Ministry	MNRE	MoPNG
Match between policy goals and initiatives	Aspirational (of target of 20% blending of ethanol by 2020, only a meagre 2% was achieved)	Relatively realistic (of the target of 10% blending by 2022, a little more than 6 % is achieved by July 2019)
Indigenous technology readiness to match policy push	Good research being done but quite disconnected to market mechanisms.	Good (Praj and DBT-ICT as new actors with world class technology for 2 G ethanol)
Commitment to buy-back	No	Yes (10-year guarantee by MoPNG)
Dominant industry	Sugar mills and biodiesel processing industry	OMCs and Sugar mills with space for the entry of new small and local entrepreneurs in case of biodiesel and biogas
Questions of social justice and environmental sustainability in terms of land use pattern and food versus fuel	No direct conversion of food to fuel permitted; criticized for land-use, water use, local conflicts	Direct conversion of surplus and damaged food-items permitted (criteria unclear); no other critical studies have yet appeared; serious challenge of water use.

Sustainable supply chain	weak	Weak
Issues of risk and public awareness	Human consumption of Jatropha seeds	use of GMOs and synthetic biology for enzymes
Co-ordination between different ministries (centre and state)	Direct government intervention (through mission mode programs like biodiesel initiatives)	Delegated through private companies (OMCs forging links with state departments)
Co-ordination between government and private actors	Region-specific differences for production (differences in interaction of sugar industries in Maharashtra and UP) and procurement	Mostly big incumbent firms are involved with the government that connect with small regional firms

Source: Author's compilation based on interviews with key stakeholders, policy documents from MNRE and MoPNG and newspaper reports.

Opportunities for Advanced biofuels

Energy Security

For India energy security is a two-fold endeavor. First, due to the uncertainty and fluctuations in crude oil prices, moving away from fossil fuel-based energy to bio-based energy could be beneficial for political and strategic reasons. Achieving energy security through domestic sources would mean reduced reliance on politically unstable oil exporting countries. Currently only 17.9 per cent of the total energy needs for transportation sector are met by domestic production while a large 81.1 per cent is import dependent (MoPNG 2018). As a result, the NBP 2018 has aimed that by 2022 import dependency could be reduced by 10 per cent (MoPNG 2018). Secondly, securing and ensuring energy access to each and everyone in the fast-growing population, demands diversification of energy options. India already has the advantage of being a major agriculture-based economy where

vast population is still associated with it. This would act as an important enabler in the transition towards a bio-based economy. Realising this potential, recent version of the National Biofuel Policy puts special emphasis on indigenous feedstock for the generation of bioenergy (MoPNG 2018).

Research efforts for meeting bioethanol blending targets

A major focus of the NBP 2009 lied in devising a support mechanism through R&D for the production of energy crops (such as Jatropha) for biodiesel. While energy plantations didn't turn out to be as expected, the lack of focus on other biofuel sources such as bioethanol and biogas resulted in India to lag behind severely on the blending targets that were proposed through the same policy (Sujatha and Kaushal 2020). Against the blending target of 20 per cent, both for biodiesel and bioethanol by 2017, only a meagre 0.12 per cent for biodiesel and 1. 9 per cent for bioethanol was possible to be achieved (Abdi 2018). This blending target still depends on import of biofuels from other countries (Bandyopadhyay 2015, Ray *et al*, 2012). Most of the domestic bioethanol is still provided by the sugar industry from converting molasses. The availability of 1G bioethanol is subjected to competition from already existing market for ethanol such as the alcohol and chemical industry. As a result, multiple steps are being taken by the government to develop an innovation ecosystem for lignocellulose-based bioethanol that could be derived from agriculture and forest residues such as rice straw, bamboo, coconut shells and cover, etc. The new policy proposes a blending target of 5 per cent of biodiesel and 20 per cent of bioethanol in diesel and petrol respectively by year 2030 (IANS 2018).

My interviews with officials at DBT revealed that the department has 2G bioethanol as one of the central focus areas. The centres such as DBT-ICT, Mumbai and DBT-IOC, Faridabad are involved in conducting cutting edge, globally competitive research on conversion technologies and enzymes that are crucial for reducing the operational cost of the bioethanol plants and making them cost-effective. There are also multiple research efforts directed towards the most optimized pre-treatment methods for diversity of feedstock options available in India. DST and DBT are supporting the Pan–IIT energy research group which is a consortium of multiple new and old IITs working on collaborative research projects on bioenergy.[17] Similarly, there is a joint research Centre on energy at TERI supported by DBT that

is engaged in multiple bioenergy-based studies.[18] Some of the initiatives at these centres include - finding different sources of feedstocks, developing feedstock agnostic technologies, synthetic enzymes, lignin valorization and development of value added commodities such as bioplastics.

Harnessing the Vast Potential of Advanced Biogas

India has a very well-developed research capacity in the field of biogas for the past 100 years (Chanakya *et al*. 2006). Despite that the NBP 2009 failed to recognise the domestic competence of biogas and its potential in contributing clean household as well as transport fuel. The Centre for Sustainable Agriculture at Indian Institute of Science (CSA-IISc) Bangalore and the Centre for Rural Technologies and Development at Indian Institute of Technology (CRTD-IIT) Delhi have developed notable competence in building advanced biogas technologies (Chanakya *et al*. 2006, Vijay *et al*. 1996). The NBP 2009 document only passingly mentions biogas, leaving out a leading field of technological competence out of its preview and support (MNRE 2009). It has been noted during our research that even without the lack of proper support by the policies, technologies from both the institutions are making inroads to domestic as well as foreign markets.[19] Focus on biogas has another advantage in the context of India. Due to its long-term presence in rural and urban centres in India, it does not require additional efforts in popularisation and public acceptance (Chanakya *et al*. 2006).

The recent initiative by government in the form of SATAT (Sustainable Alternatives Towards Affordable Transportation) recognises the role and potential of biogas in diversifying the bioenergy domain. SATAT is an umbrella platform launched by government of India along with public undertaking-oil marketing companies to support and encourage local entrepreneurs for developing advanced biogas plants (PBI 2018). The government has budgeted INR 5000 crore to support development of advanced biogas network (IANS 2018) Developed in a decentralised, bottom-up manner, the initiative supports entrepreneurs by giving them buy back guarantee and standard price for compressed biogas to be distributed through vast network of oil and gas marketing companies (interview with policy-maker 2019).

Burning of Biomass, Waste Management and Air Pollution

A major reason for an urgent need in India to focus on advanced biofuels led bio-based economy is the phenomenon of burning of agricultural residues. In Punjab alone around 100 metric tons of rice straw is burned every year (Mukherjee 2016). Along with rice straw in northern parts of the country there is coconut residue, corn stover, sugarcane tops and bamboo tree residues that is set on fire as waste. The burning of rice straw not only results in loss of valuable biomass, it also damages soil microflora and fauna and contributes to serious air pollution in its vicinity and nearby areas including capital city of Delhi (Mukherjee 2016, Kazmin and Singh 2017). Due to a short period of just 15-20 days between harvesting rice and sowing wheat and immediate need to prepare the fields, high cost of labor, expensive remedial technologies and no other use of surplus residue, farmers have to burn it (Pandey *et al*, 2017). Recently, the issue of straw burning has caught national and international attention because of the scale of burning, legal ban and criminalisation of farmers and the lack of efficient alternatives (Kazmin and Singh 2017, Pandey *et al*, 2017). Lignocellulosic bioethanol and advanced biogas are projected to be some of the most efficient solution to the burning of biomass, with the potential to build a bio-based economy around agricultural and forest residues.

Doubling of Farmers' Income and Rural Development

It has been noted widely that agriculture in India is suffering from a deeper crisis (Deshpande and Arora, 2010). The effects of high input costs, low output, climate change, and deteriorating social and cultural institutions are making agriculture an unsustainable livelihood choice (Pandey et al. 2017). In 2019 alone, 10, 281 farmers have committed suicide in India.[20] The finance minister of India has been talking about inputs needed to improve the conditions of farmers and efforts needed to double farmers' income by 2020 (Satyasai and Bharti 2016). Lack of infrastructure, efficient local market mechanisms and disconnect with global value chains, purchasing power of consumers, and proper information are some of the factors that contribute to rural challenges in India. Bio-based economy, which centers on biological resources is a very good opportunity to rethink rural livelihoods and development. Second generation biofuels that utilise agri-residues could provide extra income opportunities to farmers who could be incorporated in the feedstock supply networks.

Challenges Ahead

The new biofuel policy, along with promoting the ways of procuring 1G bioethanol, has made active attempts to support the innovation ecosystem of 2G biofuels. The basis of 2G thinking is that materials such as rice straw and forest residues, which are simply considered 'waste', needs to be put to 'better' use. Often, this biomass is assumed to be 'surplus', 'given', 'stable' and 'available'. The estimation of availability of surplus biomass becomes the basis of biofuel potential calculation that feeds government policy decisions.[21] We argue that this is a simplification. Agricultural and forest ecosystems are very complex and the functions performed by specific substances or organisms are never a binary of useful versus useless. Even if the straw/forest residues have no or little value on the commodity market, there are local microbes, birds and animal species that sustain on residues. Along with biodiversity, there are parallel local economies and livelihood networks that thrive on foraging the agri-/forest residues. Attention needs to be given to biodiversity conservation and livelihood networks preservation, before devising any value chain for biomass (Baka 2014).[22] Besides the challenges of setting up a just and sustainable biomass value chain, the production of 2G biofuel is far from straightforward. A variety of problems exist across the full production chain that include sustainable supply chain for biomass, pre-treatment, enzymatic processes, high investment and high risk and market demand. The setting up of a sustainable business ecosystem for advanced biofuels, thus, requires strategic focus on R&D, regulatory and institutional innovations, and transparency and effective engagement with relevant stakeholders along the supply chain.

Strategic Focus on Entrepreneurship and Scaling-Up

Notable efforts are being made for R&D of advanced biofuels in India (refer to previous section). The Indian Government is planning to invest INR 12,000 crore to set up 12 bioethanol plants in partnership with public-undertaking oil marketing companies in the coming years (PBI 2018, Abdi 2018). Three of these plants have already been commissioned and they are known to being set up using the indigenous technologies developed by Praj Industries and DBT-ICT, Mumbai. As per the policy-makers and scientists working on advanced biofuels, the capital intensiveness of the

technology and risks involved are a major reason for the dis-interest of medium enterprises in this domain. However, a prominent scientist and technology developer, who has been involved in the development of advanced biofuels, argued that the policy focus only on the Oil Marketing Companies for the development of advanced biofuels is not the appropriate approach.[23] A supportive ecosystem that has a good mix of OMCs and medium entrepreneurs for different components of advanced biofuels is needed.

Regulatory and Institutional Innovations

A bio-based economy cannot be imagined without regulatory and institutional innovation that are developed in parallel to technological innovations (Bosch *et al*, 2015). Based on the previous biofuel policy, there have been reports of dis-interest for 2G biofuels among the private sector due to lack of efficient policies that would address the challenges of competition from fossil fuel sector along with dynamic and fluctuating oil prices, lack of consensus on blending percentage and unclear procurement mechanisms and policies (Bandyopadhyay 2015, Ray *et al*, 2012). The current policy seems to be making an active effort in streamlining many of these processes such as ensuring buy-back guarantee, fixing price and reduced taxes on bioenergy (MoPNG 2018) However, despite these efforts many stakeholders are dissatisfied by the current progress and report lack of transparency in decision-making as a major challenge for the bioenergy sector (Mishra 2018).

The current biofuel policy takes due note of the role of technology assessment in scaling up bioenergy projects and advocates for Life Cycle Assessment (LCA) (MoPNG 2018). Although it is a very welcome move from the policy makers, there are certain aspects that need to be taken into account so that LCA can make a useful contribution to the bio-economy. For example, one of the limitation of traditional LCA methods is their emphasis on environmental aspects only (Hellweg and iCanals 2014). In the context of biofuels it is extremely essential that along with the environmental, social, cultural, ethical and economic aspects are taken into proper consideration while developing a holistic LCA methodology (Ekener-Petersen et al. 2014, Benoit *et al*, 2010).

Effective Stakeholder Engagement and Supply Chain Networks

The presence of a sustainable supply chain that includes evaluation of available feedstock, transportation cost, collection and storage mechanisms, is key to the success of bioenergy programs. However, this seems to be the weakest link in current efforts by the government in transitioning to a bio-based energy economy. Based on quantitative studies, the availability of biomass as a feedstock for bioenergy production is often taken for granted (Sukumaran *et al*. 2010). Once agri and forest residues get tied to bio-energy production network, their availability and cost of acquisition can both become a challenging task. It is also possible that this supply network might interfere with already existing informal economies based on agri-and forest residue (Baka 2014). It is thus crucial for the industry and the government to take pro-active measures and engage with local people in order to have a proper communication about the aims and purposes of bio-energy and its costs and benefits for the local economy (Ravindranath and Rao 2011).

Points for Consideration and the Way Forward

Assuring the Co-Existence of Energy and Agricultural Systems

The food-fuel debate has been a long-standing point of contention in relation to biofuels (Borras *et al*, 2011). Proponents of the lignocellulose-based biofuels claim that due to the use of residues and wastelands, advanced biofuels offer a good alternative to the food vs fuel dilemma (Mohr and Raman 2013). It is important to note in this context that reducing agricultural and energy systems to merely food and fuel might be a huge misrepresentation of their complexity. This might result in policies and solutions which would just be a temporary relief for current problems (Oliveira et al. 2017). A holistic consideration of the interaction between agriculture and energy systems would be advisable. This would mean paying a close attention to transformation of agricultural systems owing to the requirements of the bioenergy industry, (Oliviera *et al*, 2017), flora and fauna associated to certain crops and cultivation patterns, and local rural economy that sustains on alternative use of 'wastelands' (Baka 2014).

Assuring Return of Organic Manure Back to the Soil

The continuous, long term removal of agricultural and forest residues for energy production would result in severe impoverishment of the soil (Gomiero, 2018). This might lead to low water retention capacity, absence of soil micro-flora and severe reduction of productivity. The application of chemical fertilizers might help as outside supplement but their over-application is dangerous to health and environment. Also, chemical fertilizers are no substitute for complex and organic matter that is naturally produced through degradation of residues by micro-organisms (Pandey 2021). As a result, biofuel policy should focus on enabling strong mechanisms to ensure that organic matter and manure is returned back to the soil. Farmer organisations and civil society groups should be involved to be the connecting link between private companies and farmers to ensure the replacement of organic matter to the agricultural lands. Due to the absence of any common stakes, ensuring such a mechanism for forests becomes even more difficult. Biofuel policies should find innovative ways of engaging the forest department, civil society, local dwellers and corporations to ensure that forest soils are also replenished with organic matter.

Availability of Land Resources and Feedstock

The NBP 2009 talks about development of domestic renewable energy in a way that does not impact the land available for food production and people would be encouraged to undertake the production of bio-fuel based plantation on waste and degraded land to prevent the possibility of food vs fuel dilemma (MNRE 2009). The new biofuel policy also actively supports use of 'wasteland' for plantation of bioenergy crops in order to boost production and support livelihood of local communities (MoPNG 2018). However, research has shown that all land that is not under cultivation does not mean it that it is available for bioenergy cultivation (Baka 2013). There are many reasons why local communities have left that land uncultivated (animal grazing, recreational purposes) and these uncultivated lands form an integral part of their social life, rural economy and local source of livelihood (Jodha 2000). As a result, it is clear that there is a difference between 'wastelands' and 'uncultivated' land. Declaring uncultivated land as 'wasteland' for biofuel production may cause serious damages to rural livelihood and social life (Baka 2014).

The NBP 2018 allows the use of food grains for fuel production in years when there is 'surplus' food grain production or if food is 'damaged' and unfit for human consumption (MoPNG 2018). This step is taken to meet the blending targets for bioethanol along with preventing damages to the annual 'wastage' of food grains due to lack of proper storage facilities and supporting farmers' income (MoPNG 2018, interview with policy maker 2019). Although, one might be prompted to question the lack of efficient storage and distribution mechanisms of food grains in the country, this makes a topic for a whole new and different paper. Our point here is to bring to the notice, the complicated nature of the term 'surplus' and 'waste' and the need of effective regulatory mechanisms to ensure that scarce resources such as water, soil and land are not misused for the production of energy to the extent that they damage the current ecological dynamics of practicing agriculture (De Fraiture *et al* 2008, Ravindranath *et al*, 2011).

Mechanisms for Productive Public Engagement

1 G biofuels are severely criticized worldwide for being inconsiderate about environmental concerns, resource exploitation in less developed countries and impacts on local people (Olivira *et al*. 2017, Mohr and Raman 2013, Borras *et al*. 2011). As a result of strong opposition from the civil society and criticism from media and academic researchers, many countries in the UK and EU have made it mandatory in the biofuel policies to cut down and eventually phase out the use of 1 G biofuels (HLPE 2013, OECD 2017). India has a strong and active civil society that is significant for the regulatory governance of S&T led projects (Pandey and Sharma 2017). Over the years CSOs have played a vital role as intermediary organisation by connecting governmental programmes to the people of remote areas. Among other things, majority of times public controversy emerges due to lack of effective public engagement from government and industry, leading to irreparable damages to ongoing S&T programmes (Haerlin and Parr 1999, Arimoto and Sato 2012, Pandey and Sharma 2021). Lack of trust on the information provided, its incompatibility with the local ways of understanding and knowing things and top-down, ad-hoc delivery mechanisms are some of the reasons that fuel such controversies (Millstone and Zwanenberg 2000). It is important in this regard, that an independent platform is developed with primary objective of ensuring regular interaction between different stakeholders starting from the early phases of development of technology.

Different countries in the world have experimented with developing such platforms in the context of potentially contentious technologies such as nanotechnology and Artificial Intelligence and synthetic biology (Rip and van Lente 2013; Arimoto and Sato 2012). 2 G bioethanol has synthetic biology as a central feature and it is essential for the success of bioenergy programs that efforts are made to engage the public with different aspects of synthetic biology. This platform could begin with funding support from the government with independent researchers trained in interdisciplinary aspects of science policy, science communication and capability to conduct multiple stakeholder-based exercises. The platform could also act as unbiased and non-partisan public information site, where interested people can access information on regulatory aspects of certain contentions issues as well as reports of different stakeholder meetings and their perspectives. Having such a platform would act as a medium of building trust between government, industry, civil society and the public. The provision of regular meetings conducted through such a platform would also encourage different stakeholders to share their anxieties and fears related to the future of emerging contentious issues in the advanced biofuel domain. A democratic and transparent platform, where people could freely express, share, and discuss their ideas could be very helpful in building a just and sustainable bio-based economy.

Conclusion

The National Biofuel Policy 2018 brings many promises, opportunities and challenges in relation to a transition to bio-based energy economy in India. In order to realise the full potential of these promises, there are few points that need serious consideration from policy-makers, scientists and industry. These points include developing a sustainable supply chain, focus on R&D to bring down operating and capital costs, public engagement mechanisms and platforms to understand local use of biomass and bioenergy, proper understanding of the dynamics between agriculture, energy and environment, and streamlined regulatory and institutional systems to facilitate bioenergy production, distribution and use. A clarity on the role of different government departments and a proper communication between all concerned agencies is a defining aspect of a smooth and effective transitioning to bio-based energy economy.

Endnotes

1 The support for bioenergy in India goes back to over a century. However, most of this support is concentrated towards animal waste-based biogas. For more details on biogas in India see Chanakya et al. 2004.

2 10th August is also celebrated as World Biofuel Day.

3 The 2-Degree Scenario was developed by International Energy Agency in 2017. The scenario builds on the global energy needs and consumption patterns and it proposes measures to be taken for reaching the target of not more than 2-degree increase in global temperature (http://www.iea.org/publications/freepublications/publication/EnergyTechnologyPerspectives2017ExecutiveSummaryEnglishversion.pdf ; Accessed on 14 March 2017)

4 Presentation by DG, IEA, at the EU-India Conference in New Delhi, 7 March 2018.

5 https://ddnews.gov.in/national/prime-minister-inaugurates-world-biofuel-day-2018-delhi

6 EU-India Conference on Advanced Biofuels held in New Delhi on March 7-8, 2018.

7 http://biofutureplatform.org/wp-content/uploads/2017/11/Biofuture-Platform-Vision-Statement-Final.pdf accessed on 15 April 2018. http://www.dbtindia.nic.in/mission-innovation-accelerating-the-clean-energy-revolution/ accessed on 16 April 2018

8 This was the broadly shared view during the EU-India Conference on Advanced Biofuels, New Delhi, March 7-8, 2018.

9 Prior to these developments, India had the power alcohol act that recognised blending of ethanol with petrol since 1948. The act was repealed in 2000.

10 The nodal ministry responsible for funding and promotion of R&D in renewable energy.

11 Interview with an official from Ministry of Petroleum and Natural Gas, dated 01 March 2020.

12 https://mnre.gov.in/bio-energy/current-status.

13 First generation biofuels are characterised as being derived directly from food grains such as corn in USA, sugarcane in Brazil. In India, currently, sugarcane molasses is used as a primary source of bioethanol.

14 https://www.business-standard.com/article/economy-policy/rs-8-500-crore-investment-lines-up-for-ethanol-two-third-by-sugar-mills-119020600305_1.html

15 Presentation by Kyriakos Maniatis DG ENER, European Commission 7 March 2018, New Delhi

16 Here we are considering these aspects for second generation bio-ethanol and advanced biogas only.

17 https://www.che.iitb.ac.in/bioenergy

18 https://www.teriin.org/dbt-teri-centre-excellence-advanced-biofuels-and-bio-commodities

19 Biogas technologies from Prof. Chanakya's lab has been taken up by German companies and Prof. Vijay's lab has been actively involved in the R&D efforts at the *Sampoorn Agriventures* in Punjab where rice straw is being used to produce biogas.

20 https://www.downtoearth.org.in/news/agriculture/as-told-to-parliament-september-18-2020-10-281-indian-farmers-died-by-suicide-in-2019-73449

[21] https://bhuvan-app1.nrsc.gov.in/bioenergy/index.php

[22] In her study of biodiesel based on *Jatropha Curcus* in South India, Baka (2013, 2014) finds that the so-called 'wastelands' for Jatropha cultivation are already being used to produce *Prosopis Juliflora*. This crop once promoted by government through wasteland development programmes in the 1970s was later largely abandoned. However, as Baka argues, through its current inclusion in local, rural economies, Prosopis provides more livelihood support and energy security than the proposed biodiesel program (Baka 2014: 215).

[23] Online interview January 10, 2021.

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Global Biodiversity Regime Complex and Sustainable Development Goals: Implications for India

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Abstract: Regime complexes have been discussed in international literature as an intervening variable which bring about policy coherence at national levels. There is a dearth of literature which examines aspects related to the link between global biodiversity regime, national policy coherence and sustainable development goals (SDGs) reporting. By taking the case study of India and using liberal institutional approaches and critical appraisal, this paper seeks to analyse the role of SDGs reporting for promoting coherence between the international biodiversity regime complex and country level planning. This paper will have implications for praxis on biodiversity and sustainable development policy as well as have implications for theory related to liberal institutional scholarship. This paper argues that while the normative scope of the global biodiversity regime has evolved to encompass principles such as scientific enquiry as well as sustainable development, national level reporting on biodiversity related SDGs have to still catch up to facilitate better policy coherence at all levels. Further the paper also calls for a greater science-policy interface to supplement SDG reporting framework towards better understanding of conservation and ecosystem services aspects of biodiversity in India.

Keywords: Biodiversity regime, Sustainable development goals, Science-policy interface, India, Indicators, Public policy

Introduction

The pivotal role of diverse living organisms (biodiversity) for provisioning of ecosystem services and to maintain ecosystem functioning have been well emphasized (IPBES, 2019; Bennett *et al*., 2015), Since, the Convention on Biological Diversity's (CBD) in 1992 - the overarching global legal instrument for biodiversity - a series of global scientific assessments such as the Global Assessment on Biodiversity and Ecosystem Services, World Ocean Assessment, the State of the World's Biodiversity for Food and

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Agriculture and Special Report of the Intergovernmental Panel on Climate Change (IPCC) on Global Warming of 1.5°C underscore the vital importance of biodiversity for achievement of most Sustainable Development Goals (SDGs). The interlinkages between biodiversity and the SDGs have been outlined as a basis for the development of the post-2020 global biodiversity framework (IISD, 2019). Thus, the SDG framework provides a framework towards understanding the crucial knowledge gaps on the role of biodiversity in maintaining multiple ecosystem services and supporting a range of societal sectors and economic activities. As our knowledge base is getting increasingly clear about biodiversity and its importance towards sustainable futures, the SDG framework provides opportunities for complementary actions by various stakeholders at different levels and to redesign our economic, social, and governance systems to address global challenges as a whole.

Biodiversity regime complexes have been discussed in international literature as an intervening variable which bring about policy coherence at the national levels (Gomar *et al*., 2014; Mitrotta, 2021; Rabitz, 2019; Tiller *et al*., 2019). Scholars have examined the co-evolution of regime complexes and policy coherence in the context of international biodiversity governance and impact on advancing national coordination of implementation activities. Gomar et al. (2014) argue for a stronger feedback between national public policy and international regime complexes to bridge national coherence gaps. Indian literature on biodiversity has examined aspects related to national regulatory and policy frameworks and local implementation (Damodaran, 1992, 2003, 2007; Gadgil and Rao, 1994; Jha, 1995; Kothari and Kohli, 2009; Martinez-Alier, 1993; Neema and Kothari, 1998; Srinivas, 2000; Faizi and Ravichandran, 2016; Kohli and Bhutani, 2015). However, there is a dearth of literature which examines aspects related to the link between global biodiversity regime, national policy coherence and SDG reporting; this paper aims to bridge that gap. By taking the case study of India and using liberal institutional approaches and critical appraisal, the paper seeks to analyse the role of SDGs reporting for promoting coherence between the international biodiversity regime complex and country level planning. It will study implications for praxis on biodiversity and sustainable development policy as well as have implications for theory related to liberal institutional scholarship.

The paper is divided into six sections. The first section provides a brief introduction which provides a brief background and objective of the paper. This is followed by a section on theory and approach which describes the theoretical framework and research questions. This is followed by the section which discusses the evolving international regime on biodiversity and role of SDGs. Two India specific sections on the institutional framework for biodiversity protection and a critical appraisal on SDG reporting in India follow. The final section concludes.

Theory and Approach

With growing recognition of interdependencies across issue areas between states, liberal institutional scholarship affirms the role of international organisations as an arena of cooperation involving member states along with other interest-based stakeholders (Keohane *et al*., 1993; Keohane and Victor, 2011; Young, 2002). Liberal institutional approaches including constructivism consider multi-actor norm based processes and accord primacy to activities such as socialization, education, information creation, persuasion, discourse, and norm evolution (Barnett and Finnemore, 1999; Finnemore and Sikkink, 1998; Haas, 2002; Weiner, 2009; Wendt, 1992; Young, 2002).

To better understand environmental issues in the multilateral space, the concept of regime by Stephen Krasner is useful. According to Krasner (1982), international regimes are defined as: "Principles, norms, rules, and decision making procedures around which actor expectations converge in a given issue-area" (Krasner, 1982: 185). Regimes have been conceptualised as intervening variables, standing between basic causal factors and related outcomes and behaviour. The concept of international regimes has been used in international organisation scholarship for many environment issues such as climate change and natural resources (Abbott and Bernstein, 2015; Keohane and Victor, 2011; Thoms, 2002; Young, 1989). Keohane and Victor (2011: 19) frame 'regime complex' which better consider real world political, organisational, and informational constraints. Regime complexes are more flexible and adaptable than integrated comprehensive regimes as they are also sensitive to national interests. Scholars have also highlighted the functional aspects of international organisations and regimes that encourage learning among stakeholders including member states (Haas and

Haas, 1995; Haas, 2002; Keohane *et al*., 1993). Regimes and information sharing contributes to broader process of governance and to stronger and more effective environmental governance involving state and non-state actors at all levels by establishing and reinforcing 'constructivist functions' (Haas, 2002; Oestreich, 2011).

By taking the case study of India, this paper seeks to analyse the role of SDGs in promoting coherence between the international biodiversity regime complex and country level reporting. Towards this, the three research questions include:

- How has the biodiversity regime complex evolved at the international level? How has the institutional framework on biodiversity in India evolved?
- Has SDGs reporting played a constructivist role in terms of promoting coherence between international biodiversity regime complex and national planning?
- With specific reference on biodiversity related goals of SDGs in the national indicator framework, how can India improve?

Taking a cue from liberal institutional scholars, it is assumed that international organisations (in this case the United Nations), seek to influence international cooperation as well as national processes such as producing information (reporting) and planning. This paper will examine the efficacy of SDG reporting in terms of promoting coherence within the international regime as well for national level planning through cross-cutting linkages.

Evolving global regime on biodiversity and role of SDGs

Increasing role of international organisations to institutionalise the governance of nature started evolving in early 20th century with the creation of the International Council for the Exploration of the Sea (ICES) in 1902, wherein the principle to use scientific inquiry as the basis for a rational exploitation of marine resources emerged as an international norm. In the years that followed, goals of state sovereignty and protection of biodiversity as a global commons have been at conflict with each other. Largely in the sustainable development discourse, the 'anthropocentric' or 'nature for humans' norm, which views the utilisation of natural resources as a means

for economic development, dominated global development narrative and continues to do. The initial discussions in the multilateral space was more about protecting state sovereignty and territorial rights (especially for marine areas) to exploit natural resources to advance economic growth. This is evident in the discussions of the League of Nations which identified territorial waters regime and exploitation of ocean resources as two issue areas. The International Union for the Protection of Nature (IUPN) was established in 1948 under the auspices of UNESCO. In 1956, the International Convention for the Regulation of Whaling signed in Washington for regulating whaling based on maximum sustainable yield for allocating quotas. The International Biological Programme of UNESCO was instrumental in raising awareness about the need for nature conservation. In 1971, the Ramsar Convention in wetlands led to a space-based approach to conservation and management of wetlands through ecosystem approaches for maintenance of their ecological character. The Man and Biosphere (MAB) programme of UNESCO in 1971 led to further awareness on ecosystem approaches. The United Nations Conference on Human Environment in Stockholm in 1972 formed the foundation for a number of international instruments and confirmed the evolution of the principle of national sovereignty over natural resources but also recognised internationalisation of environmental issues.

Along with the establishment of United Nations Environment Programme (UNEP), 1972 also saw UNESCO World Heritage Convention for the Protection of the World Cultural and Natural Heritage is adopted in Paris. This Convention recognised duty of states as well as international community. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington) entered into force in 1975 which linked biodiversity protection with trade. The international institutional framework for biodiversity was solidified with the birth of the United Nations Convention on Biodiversity (CBD) which was drawn up at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992. As is the case with most environmental regimes, following the 1992 convention, two protocols, namely the Cartagena Biosafety Protocol of 2000 and the Nagoya Protocol on Access and Benefit Sharing of 2010 were adopted under CBD. In 2015, member states of the United Nations adopted the Sustainable Development Goals (SDGs) which have 17 goals and 169 targets. Table 1 lists all the mechanisms of the biodiversity regime complex.

Table 1: Mechanisms under the biodiversity regime complex

Intergovernmental mechanisms	• International Council for the Exploration of the Sea, 1902 • International Convention for the Regulation of Whaling, 1946 • International Union for the Protection of Nature, 1948 • Convention on the Conservation of Antarctic Marine Living Resources, 1959 • Convention on Wetlands of International Importance (Ramsar Convention), 1971 • Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention), 1972 • Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1975 • Convention on Migratory Species of Wild Animals, 1979 • Convention on Biodiversity (CBD), 1992 • United Nations Convention to Combat Desertification, 1994 • United Nations Framework Convention on Climate Change, 1992 • Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests, 1992 • Cartagena Biosafety Protocol, 2000 (under CBD) • Nagoya Protocol on Access and Benefit Sharing, 2010 (under CBD) • Sustainable Development Goals, 2015
Science-policy interface	• Intergovernmental Platform on Biodiversity and Ecosystem Services • Intergovernmental Panel on Climate Change • International Council for Science • International Resource Panel • UNESCO Man and Biosphere Programme • International Association for Plant Taxonomy • International Commission on Zoological Nomenclature • Intergovernmental Oceanographic Commission under UNESCO

Source: Authors' compilation.

Economic growth as the main driver of climate change related biodiversity loss has been well established by the scientific community (Canadell *et al*. 2007; IPCC 2007). This was increasingly realised at the global level with the establishment of IPCC in 1988 and the Earth Summit in 1992. In case of biodiversity, the international discussions initially revolved around the principles of 'national sovereignty' and scientific enquiry and conservation based principles propagated by UNESCO, World Conservation Strategy of 1980 and the World Commission on Environment and Development of 1987. With the evolution of sustainable development as a concept, socio-economic related principles also became a part of the biodiversity regime including aspects such as the 'precautionary principle', 'right to development' and 'sustainable use'. Figure 1 shows the key principles and norms in the evolving international biodiversity regime.

Figure 1: Principles in the international biodiversity regime complex

Scientific enquiry	National sovereignty	Conservation	Precautionary Principle	Right to development	Sustainable use
← Pre sustainable development principles →			← Additional post sustainable development principles →		

Source: Authors' representation.

It can be said that deliberations in the multilateral space have led to the widening of scope of the international biodiversity regime from being scientific-political (principles of scientific enquiry, conservation and national sovereignty) to being scientific-political-developmental by incorporating principles related to sustainable development. Thus the normative scope of biodiversity regime has evolved to be a regime complex involving various dimensions of sustainable development. Further, the 17 SDGs have the potential to play a constructivist role in facilitating a conversation with cross-cutting linkages involving all three pillars of sustainable development including social, economic and environmental. In the next section, by taking the case of India, we will examine the state of biodiversity and the role of SDGs in facilitating informed public discussions.

Institutional Framework for Biodiversity Protection in India

With a forest cover of 71.22 million hectares, which constitutes nearly 21.67 per cent of the land area of the country (FSI, 2019), India is also a mega-biodiversity country in the world and contains almost 7 per cent and 6.5 per cent of the world's flora and fauna, respectively. Based on climatic and edaphic features, the country has 16 major forest types and 251 sub-types and four of the 35 global biodiversity hotspots. India is biologically a mega-diverse country as with only 2.4 per cent of the world's land area but has over 45,000 species of plants and 91,000 species of animals (MOEFCC, 2018a). The country has significant endemism; about 4045 species of flowering plants (angiosperms) endemic to India are distributed amongst 141 genera belonging to 47 families. In terms of endemism of vertebrate animals, India has been globally ranked tenth in birds, with 69 species, fifth in reptiles, with 156 species, and seventh in amphibians, with 110 species (MOEFCC, 2018a). India is home to over 50 per cent of the world's wild tigers in spite of having a growing human population of over a billion (MOEFCC, 2018a). Nevertheless, according to the International Union for Conservation of Nature (IUCN), 1039 species are threatened in India (MOEFCC, 2016). Forests provide fuel-wood, fodder, small timber and non-timber forest produce to communities that live in and around them. Additionally, these forests provide globally valued ecosystem services supporting rich biodiversity, carbon sequestration and sustained supplies of freshwater. As per the National Wetland Atlas, India has 55862 natural wetlands which provide a range of ecosystem goods and services and support rich biodiversity (SAC, 2011).

India as a party to the United Nations Convention on Biological Diversity (CBD) of 1992 has also enacted the Biological Diversity Act in 2002 and Biological Diversity Rules in 2004. At the Conference of Parties (COP) in 2015, the Government of India took a pledge under the Bonn Challenge to bring 13 million hectares of degraded and deforested land into restoration by 2020 and an additional 8 million hectares by 2030, in line with the Forest Landscape Restoration approach. As a signatory to the Man and Biosphere Programme, launched by UNESCO in 1971, India has established 18 Biosphere Reserves (out of this, 11 are recognised under the

World Network of Biosphere Reserves of the UNESCO). For conservation of lakes, rivers and wetlands, financial assistance is provided under the National River Conservation Plan (NRCP) and National Plan for Conservation of Aquatic Eco-systems (NPCA). As a part of the Nationally Determined Contribution (NDC), India has made international commitments under the Paris Agreement of an additional cumulative carbon sink of 2.5−3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030 (GOI, 2015).

The Sustainable Development Goal 14 includes targets to reduce marine pollution, manage marine and coastal ecosystems, and end overfishing, among others. Mountain ecosystems also play an important role in India and under the National Action Plan on Climate Change (NAPCC), there is a dedicated National Mission for Sustaining the Himalayan Ecosystem (NMSHE) which is a multi-pronged, cross-cutting mission across various sectors. The Indian Himalayan Region (IHR) has a geographical reach of more than 530 thousand square kilometres between the Indus and the Brahmaputra river systems and includes twelve states in India: Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, and Meghalaya, as hill states; and Assam and West Bengal as two partial hill states (DST, 2020).

Under NMSHE, there are six taskforces which include: natural and geological wealth; water, ice, snow including glaciers; forest resources and plant diversity; micro flora and fauna and wildlife and animal population; traditional knowledge system; and Himalayan agriculture. To address, various dimensions of climate vulnerability, there has been an attempt to develop state level, district level and sub-district level vulnerability assessments using "Climate Vulnerability Assessment for the Indian Himalayan Region Using a Common Framework".

In the context of uniqueness of mountain ecosystems, addressing the various dimensions of climate vulnerability would help in better designing of the sustainable green economy interventions (MOST, 2020). Under the Wildlife (Protection) Act, 1972, 25 Marine Protected Areas (MPAs) in peninsular India and 106 Island Marine Protected Areas in islands have been identified for protection (MOES, 2018). According to the Ministry of Environment and Forest and Climate Change, critically endangered

marine species include four species of fishes (Pondicherry Shark, Knife-tooth Sawfish, Large-tooth Sawfish, Long-comb Sawfish or Narrow-snout Sawfish), two species of turtle, (Hawksbill Turtle and Leatherback Turtle) and one species of coral (Fire corals) (MOES, 2018).

The Himalayan ecosystem supports over fifty million people in terms of livelihoods. To sustain and enhance mangrove ecosystems in the country, promotional and regulatory interventions have been adopted. Promotional measures are implemented through centrally sponsored schemes on conservation and management of mangroves and coral reefs. Regulatory measures are implemented through: Coastal Regulation Zone (CRZ) Notification (2011) and the Island Protection Zone (IPZ) Notification 2011 under the Environment (Protection) Act, 1986; the Wild Life (Protection) Act, 1972; the Indian Forest Act, 1927; the Biological Diversity Act, 2002; rules under these acts as amended from time to time. Additionally, the Himalayan ecosystem is vital to the ecological security of the Indian landmass, as it provides forest cover, biodiversity base, is a source of perennial rivers and drinking water, irrigation, hydropower, and landscapes for tourism. The Himalayas house one of the largest resources of snow and ice; its glaciers form a source of freshwater for the perennial rivers such as Indus, Ganga and Brahmaputra (MOST, 2010).

The National Mission for Green India (GIM) aims at protecting, enhancing and restoring India's decreasing forest cover and responding to climate change by a combination of mitigation and adaptation measures. The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 or the Forest Rights Act recognises tenure based and resource rights and mandates forest rights related to protection, regeneration and management of community forest resources by forest dwellers for sustainable use. An increase in forest cover in India from 67.81 million hectares in 1991 to 71.22 million hectares in 2019 through various strategies and interventions has been observed. From a conservation perspective, the total protected Areas in India have increased from 146665 square kilometres in 2000 to 165088 square kilometres in 2019 (WII, 2019). To realise the CBD objectives, India has been investing INR 700 billion per annum as against the estimated annual requirement of nearly INR

1090 billion in several central and state government development schemes and has been able to bring over 20 per cent of its area under biodiversity conservation (MOEFCC, 2018). In terms of fiscal incentives, around 4 per cent of India's GDP is distributed to states each year using the tax revenue distribution formula set by the Fourteenth Finance Commission in 2014. The tax-sharing formula includes an indicator for forest area, alongside indicators for population, poverty and land area. Moreover, a differential criterion for incentivising hill states and plain states was also brought out in the regional consultations for eastern, north-eastern, central and northern states.

Various non-forestry activities undertaken in forest areas such as mining, industries, hydel power development, railways and roads have adverse impact on forests and biodiversity (MOEFCC, 2018). Compensatory afforestation on equivalent non-forest land is done to compensate the loss of forest and biodiversity; such non-forest lands are declared as Protected Forests/Reserve Forests under the Indian Forest Act 1927. If development projects are through the central government and public sector undertakings, compensatory afforestation is done in twice the area of degraded forest area.

India is a federal country and hence policies fall under the ambit of national, sub-national agencies or both. United Nations and Intergovernmental organisations are in the Union List as per the Constitution of India. Therefore, aspects related to the international biodiversity regime and related conventions and treaties are a mandate of the central agencies. Aspects of shipping, both marine and in-land, are also a mandate of the central or national level government agencies. Aspects related to regulation of land based activities such as mines, rivers and oil exploration also are under the Union List of the Indian Constitution and hence come under the ambit of national level agencies. Issues pertaining to agriculture, irrigation and fisheries fall under the State List of the Indian Constitution and hence become a mandate for state governments. Aspects related to forests and wildlife protection fall under the concurrent list and hence become the mandate for both state and national governments. Table 2 depicts the institutional framework for biodiversity in India.

Table 2: Institutional framework for biodiversity in India

Components	List
National level	Protection of Plant Varieties and Farmers' Rights Authority, Ministry of Agriculture and Farmers Welfare ICAR-National Bureau of Plant Genetic Resources ICAR-National Bureau of Animal Genetic Resources ICAR-National Bureau of Fish Genetic Resources Ministry of Environment, Forest and Climate Change National Biodiversity Authority, MOEFCC Botanical Survey of India Zoological Survey of India Forest Survey of India Society of Integrated Coastal Management National Centre for Sustainable Coastal Management Institute of Environmental Studies and Wetland Management Indian Institute of Forest Management Indian Council of Forestry Research and Education Wildlife Institute of India Forest Research Institute Central Zoo Authority National Zoological Park National Tiger Conservation Authority Wildlife Crime Control Bureau National Afforestation and Eco-Development Board, MOEFCC Ministry of Jal Shakti Central Wetland Regulatory Authority India Meteorological Department (IMD), Ministry of Earth Sciences Ministry of Science and Technology Central Pollution Control Board Animal Welfare Board of India Compensatory Afforestation Fund Management and Planning Authority National Afforestation and Eco-Development Board Ministry of Rural Development Ministry of Panchayati Raj National Green Tribunal National River Conservation Directorate National Institute of Oceanography Centre for Marine Living Resources and Ecology Department of Science and Technology

Table 2 continued....

Table 2 continued....

Sub-national level	Departments of Agriculture of states and Union Territories Department of forest / environment State Biodiversity Board State Coastal Zone Management Authority State / UT level Environment Impact Assessment Authorities State Compensatory Afforestation Fund Management and Planning Authority Department of water resources Panchayati Raj department State Pollution Control Board Department of soil and water conservation Biodiversity management committees Eco development committees Joint forest management committees People's Biodiversity Registers Water and sanitation committees District level impact assessment authorities Panchayati Raj institutions (Gram Sabha and Gram Panchayats)
Enabling policy and regulatory framework	Protection of Plant Varieties and Farmers' Rights Act (PPV&FRA), 2001 Indian Forest Act, 1927 The Prevention of Cruelty to Animals Act, 1960 Wildlife (Protection) Act, 1972 The Forest (Conservation) Act, 1980 The Environment (Protection) Act, 1986 National Forest Policy, 1988 Biological Diversity Act, 2002 Environmental Impact Assessment Notification, 2006 (Under EPA, 1986) National Biodiversity Action Plan, 2008 Coastal Regulation Zone Notification, 2011 National Working Plan Code, 2014 (To guide the preparation of working plans for forest management) National Wildlife Action Plan (2017-2031) The Wetlands (Conservation and Management) Rules 2010 and 2017 Island Protection Zone (IPZ) Notification 2011 under the Environment (Protection) Act, 1986 National Mission for Strategic Knowledge for Climate Change

Table 2 continued....

Table 2 continued....

Implementation mechanisms	National Coastal Management Programme National Mission for Sustaining the Himalayan Ecosystem (NMSHE) National Mission on Himalayan Studies (NMHS) National Mission for a Green India Project Tiger Project Elephant Biodiversity Conservation and Rural Livelihood Improvement Project Conservation and Management of Mangroves and Coral Reefs Green Skill Development Programme Integrated Development of Wildlife Habitats National Mission for Clean Ganga National River Conservation Plan National Lake Conservation Plan National Plan for Conservation of Aquatic Eco-systems Integrated Watershed Management Programme National Water Quality Monitoring programme National Ambient Air Quality Monitoring Programme National Rural Employment Guarantee Scheme Environmental Information System (ENVIS) Indian Ocean Biogeographic Information System National Natural Resource Management System E-Green Watch Decision Support System (GIS based application for forest area mapping) Operation Thunderbird (for wildlife crime control) Operation Wildnet (for wildlife crime control) Operation Save Kurma (for wildlife crime control) Forest-proportional tax revenue transfers

Source: Author's compilation.

India and Biodiversity SDGs: A Critical Appraisal

According to the UN General Assembly Resolution 70/1, Sustainable Development Goals and targets adopted in 2015 at the United Nations Sustainable Development Summit will be followed up and reviewed using a set of global indicators developed by the Inter-Agency and Expert Group on Sustainable Development Goal Indicators (UN, 2017). As of 28 December 2020, the global indicator framework (GIF) by the UN contained 130 Tier I indicators, 97 Tier II indicators and 4 indicators that have multiple tiers[1].

NITI Aayog is responsible for overall implementation of SDGs in the country, whereas, Ministry of Statistics and Programme Implementation (MOSPI) is entrusted with the responsibility of development of National Indicator Framework (NIF) on SDGs, in sync with GIF, for monitoring of the SDGs in India. In 2018, MOSPI developed a National Indicator Framework (NIF) on SDGs, in sync with GIF, consisting of 306 national indicators (NIs) along with identified data sources and periodicity following due consultation process with concerned Ministries/Departments, UN Agencies and other stakeholders. While the goals and targets are fixed, the review of SDG indicators in GIF and NIF is a continuing and evolving process for examining the suitability of existing indicators as well as new indicators. Goal 14 (Life below Water, in brief) Annexure 1 presents the global indicators and national indicators for Goal 14 and Annexure 1 presents the global indicators and national indicators for Goal 15 (Life on Land, in brief). Table 3 summarized the state of national indicators for SDG 14 and SDG 15.

Table 3: Summary of National Indicators (NIs) under SDG 14 and SDG 15

SDG	Total number of NIs	NIs with reporting	NIs without reporting	NIs to be developed
SDG 14	15	7	6	2
SDG 15	21	10	11	0

Source: Based on MOSPI (2021).

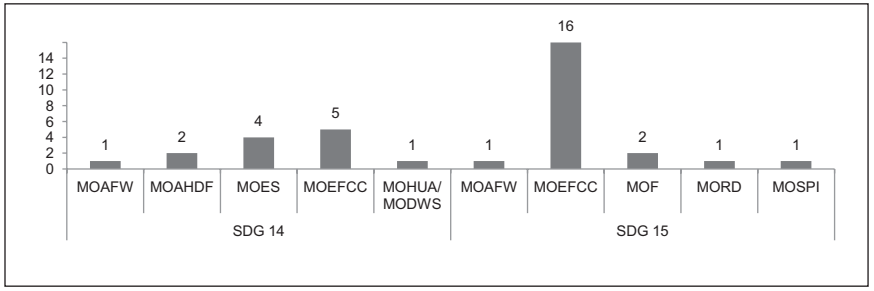
For Goal 14 under SDGs, two targets do not have national indicators. As can be seen from Annexure 1, there are inadequate source points for data collected related to quality of coastal waters for Target 14.1 and Target 14.3. For SDG 14, out of 13 indicators, there are seven indicators with reporting while there are six indicators without reporting. As a part of the Census of Marine Life (COML), a study on the Indian Ocean Biogeographic Information System, over 1,50,000 spatially and taxonomically resolved marine species distribution records from the Indian Ocean region has been archived at the Centre for Marine Living Resources and Ecology (CMLRE), Kochi. This needs to better feed into marine based biodiversity reporting including for SDGs. Presently the indicator framework only draws from concept such as the Maximum Sustainable Yield (MSY) but fails to capture

aspects such as marine species such as whales, dolphins and other species. For the indicators which have not been developed, policy cycle based qualitative scoring based approaches can be used for reporting at the national and state levels. Policy cycle considers aspects of agenda setting, policy formulation, enabling regulatory frameworks, implementation arrangements and monitoring & evaluation. Scoring based indicators should also be developed to push both national and sub-national agencies.

As seen in Table 3, for SDG 15 more than 50 per cent of NIs are not reported on. To better meet carbon sink targets from forestry and land-based activities, there is a need to integrate natural resource-based activities outside forest areas with those in areas under the control of forest department. Moreover, some performance indicators of watershed based programme can be better reflected. While India has managed to maintain its forest and tree cover, conflicts with regard to diversion of forest areas for non-forest purposes are intensified by unsustainable use of forest lands by local communities to meet their fodder, fuel wood and biomass needs. There are land-use related challenges for expansion of the small and fragmented protected areas so as to cover the full range of biodiversity because of competing land use also causing biotic stress in the protected areas. There is a need to also better understand and monitor sources of conflicts. Further indicators linked to forest fires can also be added. National indicators for SDG 15 can cover wildlife crime control and can include performance of Operation Thunderbird, Operation Wildnet and Operation Save Kurma.

Figure 2 shows ministry-wise source for various indicators under SDG 14 and SDG 15. As would be expected, for most of the indicators (21 indicators), the Ministry of Environment Forest and Climate Change (MOEFCC) is the main source followed by Ministry of Earth Sciences (MOES) for four indicators, Ministry of Agriculture and Farmers' Welfare (MOAFW) for 3 indicators, Ministry of Animal Husbandry, Dairying & Fisheries (MOAHDF) for 2 indicators, and Ministry of Finance for 2 indicators. Ministry of Housing and Urban Affairs (MOHUA) and Ministry of Drinking Water and Sanitation (MODWS) have been assigned the joint responsibility of reporting on "number of sewage treatment plants installed along the coast and construction of toilets under Swachh Bharat Mission" (Annexure 1). There can be a greater involvement of Ministry of Home Affairs for crimes related to wildlife.

Figure 2: Ministry-wise Source for Indicators under SDG 14 and SDG 15



Source: Based on MOSPI (2021).

Since India is a federal country, SDG indicators at the national and state level is important. The Ministry of Statistics and Programme Implementation has developed and circulated guidelines for development of State Indicator Framework (SIF) to facilitate and assist States/UTs for development of a State Level Monitoring Framework in respective State/UTs. NITI Aayog reports on SDG Index for states which capture some performance indicators for SDG 14 and SDG 15. Some indicators from NITI Aayog's SDG index can be harmonised with MOSPI National Indicator Framework and State Indicator Framework. Apart from Tamil Nadu, Assam, Mizoram, Rajasthan, Karnataka, Odisha, Tripura and Uttar Pradesh, there have been few takers for the SIFs. It is essential that reporting of SDGs take place at the state and district level along with preparation of vision documents with baselines and targets.

Apart from state level reporting, there is a knowledge gap around estimation of ecosystem services from forests, coastal ecosystems and other ecosystems. Although some estimates exist, a more consistent methodology is needed for the numbers to have usability and better policy relevance. There is a need to integrate the tracking of ecosystem services in working plans or other management plans and therefore, a need to enhance capacities around how it can be done. Knowledge base in terms of adaptive management and planning of multiple-use landscapes need to be strengthened. Studies on the impact of afforestation on functioning of natural ecosystems such as grasslands, wetlands, deserts and forest fires has to be started. There is need for assessments and studies. Long-term impact of development activities on wildlife movement has to be better understood. It has to be

assessed whether CAMPA (Compensatory Afforestation Fund Management and Planning Authority) based afforestation compensates for lost forests; factors that influence effective substitution also have to be assessed. The impact of urbanisation on existing habitat (direct and indirect impact) can also be better measured.

To supplement SDG reporting, a comprehensive database on ecosystem services along with documentation of livelihood and development opportunities and models associated with ecosystem services can be developed. There is a need to strengthen fish and marine census (similar to wildlife census). To supplement the SDGs, it is also important to assess the synergies and trade-offs among SDGs, climate targets and local livelihood issues.

On the question of whether SDGs reporting has played a constructivist role in terms of promoting coherence between international biodiversity regime complex and national planning the answer is that, until now, from India's example, as discussed above, the role of SDGs reporting has been limited when it comes to vertical coherence between the international, national and sub-national levels. While horizontal coherence between UN entities has been improved, for biodiversity goals to be realised, there is a need to strengthen vertical coherence. This vertical coherence can be improved with more interaction between the international, national and sub-national entities through activities such as capacity building, research and strengthening data reporting systems. Activities can also involve strengthening People's Biodiversity Register and Biodiversity Management Committees.

Conclusion

The international biodiversity regime complex has evolved in a poly-centric manner with conventions centred on various aspects of biodiversity and natural heritage. The normative framework of the biodiversity complex, which originated in the principles of scientific enquiry, has also evolved from a focus on national sovereignty to the principles of sustainable development. Responding to national needs and international developments, institutional frameworks in India have evolved along the federal structure to include aspects covering various conventions. Species based approaches such as Project Tiger and Project Elephant have been followed in India along with

focus on state institutions related forests, water and coasts. At the third tier of government, initiatives such as People's Biodiversity Registers and Joint Forest Management Committees have been put into place.

SDGs reported to have contributed to the function of information generation and has the potential to play a constructivist role in terms of promoting coherence between international biodiversity regime complex and national planning. The paper has discussed how major gaps still remain in reporting for SDG 14 and SDG 15 in terms of evolving national indicators as well as reporting on already formulated indicators. Unless all indicators for all targets under are reported on, the impact of SDG reporting in India will be limited in terms of socialisation and generating public discussions. SDG reporting in India on biodiversity related goals (Goal 14 and Goal 15) is weak in areas of research spending and policy and regulatory frameworks. Since the international biodiversity regime complex is based on principle of scientific enquiry, public conversations around science and research is key, and this is an area which needs urgent attention. Moreover, aspects related to rule of law and policies is another area which needs urgent attention.

Since many areas related to biodiversity policy making falls under the ambit of states, SDGs State Indicator Frameworks and district level reporting needs to be strengthened. The reporting framework can also incorporate aspects related to wildlife crime control and local institutions such as people's biodiversity register. While area based indicators are also important, indicators on science and socio-economic aspects such as ecosystem services needs to be further strengthened along with greater alignment to the international biodiversity regime complex to incorporate aspects related to conventions such as Ramsar and Heritage Conventions. Species based reporting for coastal areas also needs further strengthening along with strengthening of systems for data collection.

The paper has analysed the role of SDGs in promoting coherence between the international biodiversity regime complex and country level reporting. We are already in the last decade to contribute to global progress on sustainable development goals which have to be achieved by 2030. Regular reporting on SDGs based covering all principles of the global biodiversity regime complex, including for biodiversity based SDGs, at national and sub-national levels is essential to produce information for consumption in public discussions and policy action to accelerate

achievement of the sustainable development goals and to protecting our common natural heritage. Institutional regime of SDGs enable an expanded view of biodiversity taking into account both biophysical aspects as well as the socio-economic elements as determinants of institutional performance. Though biodiversity underpins almost every SDGs the devil lies in the detail. The growing role of non-state actors and integrating traditional and local knowledge with other sources of information is undeniable in the global environment change arena. A thorough space/area-based understanding of interactions between social and ecological systems to produce services would be a prerequisite for institutional diagnostics and governance mechanism required to improve. In this regard, there is a need for transdisciplinary research agenda and integrative collaboration across social sciences, natural sciences, and the humanities. This needs to be supplemented with greater science-policy interaction in the realm of natural systems and SDGs. This would offer avenues for innovation not only in terms of implementing global arrangements and identifying trade-off and synergies between biodiversity, ecosystem services and development but also in coming up with innovative mechanisms for establishing a responsible engagement with natural systems.

Annexure 1: Monitoring and Reporting for Goal 14 - Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Target	Global Indicator	National Indicator	National Indicator Values	Ministry for Data
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density	14.1.1 Coastal Water Quality Index	Good: 2; Moderate: 7 (2015-16)	Ministry of Earth Science
		14.1.2 : Number of sewage treatment plants installed along the coast and construction of toilets under Swachh Bharat Mission	–	Ministry of Housing and Urban Affairs/Ministry of Drinking Water and Sanitation
		14.1.3 Percentage use of nitrogenous fertilizer to total fertilizer (N,P & K)	64.39 (2018-19)	Ministry of Agriculture and Farmers' Welfare
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches	14.2.1 Percentage change in area under mangroves	1.1 (2019 over 2017)	Ministry of Environment Forest and Climate Change

Annexure 1 continued....

Annexure 1 continued....

Target	Global Indicator	National Indicator	National Indicator Values	Ministry for Data
		14.2.2 Implementation of Coastal Zone Regulation Notification of 2011	–	Ministry of Environment Forest and Climate Change
		14.2.3 Percentage change in Marine Protected Areas	–	Ministry of Environment Forest and Climate Change
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations	14.3.1 Average marine acidity (pH) measured at agreed site of representative sampling stations (Number)	Less Than 8 pH: 2; Greater Than 8 pH: 12 (2019-20)	Ministry of Earth Sciences
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	14.4.1 Proportion of fish stocks within biologically sustainable levels	14.4.1 Maximum Sustainable Yield in fishing	5.3105 Lakh Tonne/Year	Ministry of Animal Husbandry, Dairying & Fisheries

Annexure 1 continued....

Annexure 1 continued....

Target	Global Indicator	National Indicator	National Indicator Values	Ministry for Data
14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	14.5.1 Coverage of protected areas in relation to marine areas	14.5.1 Coverage of protected areas in relation to marine areas	–	Ministry of Environment Forest and Climate Change
		14.5.2 Percentage change in area under mangroves (Percent)	1.1 (2019 over 2017)	Ministry of Environment Forest and Climate Change
14.6: By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation	14.6.1 Degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing	National Indicator not yet evolved	–	NA
14.7: By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	14.7.1 Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries	National Indicator not yet evolved	–	NA

Annexure 1 continued....

Annexure 1 continued....

Target	Global Indicator	National Indicator	National Indicator Values	Ministry for Data
14.a: Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries	14.a.1 Proportion of total research budget allocated to research in the field of marine technology	14.a.1 Allocation of budget resources for research as per the EEZ or coastal line	–	Ministry of Earth Sciences
14.b: Provide access for small-scale artisanal fishers to marine resources and markets	14.b.1 Degree of application of a legal/regulatory/policy/ institutional framework which recognizes and protects access rights for small-scale fisheries	14.b.1 Assistance to the traditional / artisanal fishers for procurement of FRP boats and other associated fishing implements	1,930 Lakhs INR (2018-19)	Ministry of Animal Husbandry, Dairying & Fisheries
14.c: Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want"	14.c.1 Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nations Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources	14.c.1 Percentage compliance of international laws	–	Ministry of Earth Sciences

Source: Based on United Nations (2020), MOSPI (2020) and MOSPI (2021).

Annexure 2: Monitoring and Reporting for Goal 15 - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Target	Global Indicator	National Indicator	National Indicator Values	Ministry for Data
15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	15.1.1 Forest area as a proportion of total land area	15.1.1 Forest area as a proportion of total land area	–	Ministry of Environment, Forest and Climate Change
	15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type	15.1.2 Protected area as percentage of total geographical area	4.88 (2019)	Ministry of Environment, Forest and Climate Change
15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	15.2.1 Progress towards sustainable forest management	15.2.1 Percentage change in Forest Area coverage	0.56 (2017-2019)	Ministry of Environment, Forest and Climate Change
		15.2.2 Total area covered under different afforestation schemes	1,688,507 Hectares (2017-18)	Ministry of Statistics and Programme Implementation
		15.2.3 Tree cover as percentage of total geographical area	2.89 (2019)	Ministry of Environment, Forest and Climate Change
		15.2.4 Number of Nagar-vans and School Nurseries created	–	Ministry of Environment, Forest and Climate Change

Annexure 2 continued....

Annexure 2 continued....

Target	Global Indicator	National Indicator	National Indicator Values	Ministry for Data
15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	15.3.1 Proportion of land that is degraded over total land area	15.3.1Proportion of land that is degraded over total land area	27.77 (2015-16)	Ministry of Rural Development
		15.3.2 Increasing Tree / forest cover in degraded area	–	Ministry of Environment, Forest and Climate Change
		15.3.3 Percentage increase in net sown area	–	Ministry of Agriculture and Farmers' Welfare
15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	15.4.1 Coverage by protected areas of important sites for mountain biodiversity	15.4.1 Percentage increase in forest/ vegetative cover in mountain areas	0.19 (2017-2019)	Ministry of Environment, Forest and Climate Change
	15.4.2 Mountain Green Cover Index	15.4.2 Restoration of water bodies / stream in mountain areas	–	Ministry of Environment, Forest and Climate Change
		15.4.3 Conservation of local wildlife species	–	Ministry of Environment, Forest and Climate Change
		15.4.4 Percentage increase in per capita income of mountain dwellers	10.31 (2018-2019)	Ministry of Environment, Forest and Climate Change
15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	15.5.1 Red List Index	15.5.1 Red List Index	–	Ministry of Environment, Forest and Climate Change

Annexure 2 continued....

Annexure 2 continued....

Target	Global Indicator	National Indicator	National Indicator Values	Ministry for Data
15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed	15.6.1 Number of countries that have adopted legislative, administrative and policy frameworks to ensure fair and equitable sharing of benefits	15.6.1 Number of Access and Benefit Sharing (ABS) agreements signed	300 (2019-2020)	Ministry of Environment, Forest and Climate Change
15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products	15.7.1 Proportion of traded wildlife that was poached or illicitly trafficked	15.7.1 Percentage reduction in traded wildlife that was poached or illicitly	296 (2019)	Ministry of Environment, Forest and Climate Change
15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	15.8.1 Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species	15.8.1 Percentage change in prevention and control of invasive alien species	–	Ministry of Environment, Forest and Climate Change
15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020	15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategies Plan for Biodiversity 2011-2020 trafficked	–	Ministry of Environment, Forest and Climate Change
15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems	15.a.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems	15.a.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystem	–	Ministry of Finance

Annexure 2 continued....

Annexure 2 continued....

Target	Global Indicator	National Indicator	National Indicator Values	Ministry for Data
15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation	15.b.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems	15.b.1 Percentage of fund utilized for environmental conservation	0.09 (2018-2019)	Ministry of Finance
15.c Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities	15.c.1 Proportion of traded wildlife that was poached or illicitly trafficked	15.c.1 Number of detection and prevention of traded wildlife that was poached or illicitly trafficked	–	Ministry of Environment, Forest and Climate Change

Source: Based on United Nations (2020), MOSPI (2020) and MOSPI (2021).

Endnote

[1] According to UN (2020),

- Tier 1: Indicator is conceptually clear, has an internationally established methodology and standards are available, and data are regularly produced by countries for at least 50 per cent of countries and of the population in every region where the indicator is relevant.
- Tier 2: Indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries.
- Tier 3: No internationally established methodology or standards are yet available for the indicator, but methodology/standards are being (or will be) developed or tested.

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Review of the Implementation of Aichi Biodiversity Targets with Special Reference to Inland, Coastal and Marine Fisheries Sectors

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Abstract: The Convention on Biological Diversity (CBD) adopted the Strategic Plan (SP) for Biodiversity 2011-2020 in Nagoya, Japan in October 2010. The SP comprises five strategic goals and 20 Aichi Biodiversity Targets; these targets were agreed for implementation by the CBD signatory countries. The Aichi Biodiversity Target 6 states that by 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably. Even though substantial progress has been made towards achieving this target, globally, a third of the marine fish stocks are overfished and many fisheries are causing unsustainable levels of bycatch of non-target species and are damaging marine habitats. The Global Biodiversity Outlook-5, 2020 (GBO-5) report says that the biodiversity is declining at an unprecedented rate and the pressures driving this decline are intensifying and none of the Aichi Biodiversity Targets is fully met. The present study has reviewed the implementation of the global Aichi Biodiversity Targets by India and other countries focusing on fisheries sector and has brought out good practices adopted by the countries in implementing these targets.

Keywords: Aichi Biodiversity Targets; CBD, GBO, Fisheries; Mainstreaming; Marine Protected Areas; Other Effective Area-based Conservation Measures; Strategic Biodiversity Plan.

Introduction

Biodiversity and its ecosystem services are the basis of life and the foundation of economic growth, food, and livelihoods security. Globally, nature contributes between USD 75 and 125 trillion to the economy (Biofin Report, NBA 2019). The Inter-Governmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) warns that nature is declining globally at unprecedented rates. In 2010, the Parties to the Convention on

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Biological Diversity (CBD) adopted the Strategic Plan (SP) for Biodiversity 2011-2020 in Nagoya, Japan. This SP includes a "vision, a mission, strategic goals, and targets, collectively known as the Aichi Biodiversity Targets (ABT)." The vision states that "by 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people." The ABT comprises five strategic goals, 20 biodiversity targets, and these targets were considered for implementation by the CBD signatory countries and included in their National Biodiversity Strategy and Action Plan (NBSAP). The recently released Global Biodiversity Outlook- 5 (GBO-5, 2020) has reported that none of the 20 targets has been fully achieved by the parties to the Convention, and only six targets have been partially achieved (ABT 9, 11,16,17,19 and 20). The status of the implementation of the Global Aichi and India's National Targets is discussed below with special reference to the fisheries sector.

Progress in Achieving Aichi Biodiversity Targets

Strategic Goal A: Addressing biodiversity loss by mainstreaming biodiversity across government and society

Awareness on biodiversity

Globally, more than one-third of the people are aware of the importance of biodiversity. In India, the importance of biodiversity is appraised through the school curricula, and other awareness tools such as Eco-clubs, Natural Nature Camps, *Paryavaran Mitra*, Science Express and Media. The World-Wide Fund for Nature is organising *Ganga Mahotsav* to create awareness for conserving the River Dolphin. The corporate sector contributes to such awareness through the "India Business and Biodiversity Initiative" and taking steps in complying with the Biological Diversity Act, 2002 (BD Act, 2002) and minimising the unnecessary use of biological resources (MoEFCC, 2019). Under the BD Act, 2002, a total of 2,48,524 Biodiversity Management Committees (BMCs) have been constituted and they are engaged in the preparation of Peoples' Biodiversity Registers (PBR) and involved in creating awareness amongst the local community. Kerala has

taken the initiative for the preparation of coastal and marine (C&M) PBRs and documenting the C&M bio-resources and their associated Traditional Knowledge (TK). There are also examples of community-driven initiatives and are globally recognised for example the Asia's first green village, Khanuma in Nagaland.

Biodiversity value integrated

The GBO-5 says that only 91 countries have so far compiled the Environmental-Economic Accounting. In India, the biodiversity assessment is mandated under the Environmental Impact Assessment Notification, 2020 and it evaluates the conservation status of species at the time of approval. The Coastal Regulation Zone Notification, 2011 protects ecologically sensitive areas such as national parks, sanctuaries, reserve forests, wildlife habitats, mangroves, coral reefs, breeding, and spawning grounds, etc. The Economics of Ecosystems and Biodiversity (TEEB) - India Initiative is aimed at making valuation of biodiversity and ecosystem services explicit for integrating them into developmental planning (MoEFCC & GIZ, 2014). So far, around 150 valuation studies have been carried out, of these, 34 cover wetlands, 68 forests, and 19 C&M ecosystems. For integrating biodiversity values, Colombia has formulated a payment for ecosystem services policy; Guinea has integrated biodiversity value into the national environmental policy and in community development plans; and the European Union has supported a project for ecosystem accounting to assess bird species, pollinators, and marine environment.

Biodiversity friendly incentives

Globally, little progress has been made in reforming subsidies and incentives that are counteracting to the sustainability of biodiversity. Steps have been taken to revise the licensing processes for fishing and phasing out subsidies for pesticides and fossil fuels. The GBO-5 says that the value of subsidies that are harmful to biodiversity (around USD 500 billion) has exceeded the finance that is allocated for the conservation of biodiversity (80-90 billion per year) (OECD, 2020) such as some of the fisheries subsidies given for fuel, and establishing fish-meal plants. These policy and executive implementation are of great concern because they contribute directly or

indirectly to overfishing, and result in distortions in the trade of fisheries products. During 2018, out of USD 35 billion subsidies provided towards fishing, only USD10 billion promoted sustainable fisheries, and some of USD 22 billion was spent on overfishing through expanding the capacity of fishing fleets (Sumaila *et al.*, 2019).

The World Bank report has stated that the lost revenues due to mismanagement of fisheries amounted to USD 83 billion in 2012 and the increased subsidies for clean energy, fossil-fuel remain high at USD 478 billion (World Bank, 2017). Many countries have introduced biodiversity-relevant taxes, fees, and tradable permits. As of 2020, 206 biodiversity-relevant taxes were introduced in 59 countries (*viz.*, fees, tradable permit, etc.). Biodiversity friendly taxes were applied for pesticides, fertilizers, forest products and timber and generated revenue of USD 7.4 billion per year (OECD, 2020). Denmark has reduced its pesticide consumption by 40 per cent through tax regulation and Italy has published a catalogue of environmentally-friendly and harmful subsidies as part of the environmental and economic policies and introduced a 'green bonus' providing tax deductions for properties that include significant green cover in urban environments. India is providing subsidies for pollution control, production of eco-friendly products, green buildings, enhanced use of renewable sources of energy, waste to energy plants, diesel subsidy for fishing community etc. (MoEFCC, 2019).

Sustainable production and consumption

The FAO-UN has estimated that around USD 3 to 5.2 billion worth of Illegal, Unreported and Unregulated (IUU) fishing is reported in the Exclusive Economic Zones (EEZ) of other countries every year. Shark landings ranked the highest, the other species caught are long tail tuna, albacore tuna, mackerel, sea cucumber, squid, small demersal, etc. India's fisheries have now transformed into a commercial enterprise and it encourages integrated fisheries production and development of market and export-oriented high value species.

However, the governments and corporate establishments are developing several plans for sustainable production and consumption of food. Some of the sustainable food production and consumption practices promoted by

countries are green product labelling, engaging corporates into biodiversity-related activities, certification, organic farming practices, development of biodiversity-friendly criteria in public procurement and strategies to manage wastes including recycling to wealth (Global Foot Print Network, 2020). In 2015, the European Commission has adopted a circular economy and strategy for plastics. Mexico has taken initiatives to mainstream biodiversity into the agricultural, forestry, fishing, and tourism sectors. These include the creation of a system for evaluating the ecological footprint, providing economic incentives and campaigns to promote the reduction of waste and promote sustainability in consumption, production, and supply chains. In India, the ICAR-Central Marine Fisheries Research Institute has developed a handbook on the application of geographical information system as a decision support tool in marine fisheries. The Ashtamudi estuary short-necked clam fishery in Kerala has been certified as Marine Stewardship Council (MSC) standards-compliant. Other such initiatives include the Mobile App advisory introduced to reduce the scouting time for fishing by around 50 per cent, co-management practices, and seasonal fishing ban.

In India, the fishing ban season is implemented for 65 days to allow a large number of species to spawn and facilitate the survival and growth of larvae/juveniles. A similar fishing ban is also imposed by Bangladesh in its EEZ for 61 days. The Minimum Legal Size of 58 commercial species was adopted by the state of Kerala for commercial fin and shellfish species. A logo is granted by the Marine Product Export Development Authority of the Government of India as a mark of quality to be affixed on seafood products exported from India by the registered seafood processors who meet the prescribed criteria. The ICAR-National Bureau of Fish Genetic Resources is undertaking activities for harmonizing conservation of indigenous fish germplasm and livelihoods, as a part of the initiatives on mainstreaming biodiversity. In one such programme, marine ornamental invertebrates, which are internationally traded through wild harvest, are captive bred and propagated through encouraging community aquaculture (Ajithkumar *et al*., 2020). The creation of best practices for sustainable harvesting of fisheries is being encouraged through initiatives such as mainstreaming coastal and marine biodiversity conservation into production sectors in the East Godavari River Estuarine Ecosystem, Andhra Pradesh, and in Sindhudurg, Maharashtra (MoEFCC, 2019).

Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use

Habitat loss halved or reduced

It is reported that worldwide the area covered by natural wetlands reduced by an average of 35 per cent between 1970 and 2015. The Latin America and the Caribbean regions showed the greatest loss of wetlands. Permanent surface water was lost from an area of almost nine million hectares between 1984 and 2015 (Darrah *et al.*, 2019). Nearly, 70 per cent of this loss was reported in the Middle East and Central Asia and linked to drought, damming, diverting rivers and unregulated withdrawal of water. Rivers are becoming increasingly fragmented, and threatening the freshwater biodiversity. An assessment in 2019 of the connectivity status of 12 million km of rivers globally found that only 37 per cent of the rivers longer than 1,000 km remained free-flowing over their entire length, and just 23 per cent flowed uninterrupted to the ocean (Grill *et al.,* 2019). Overall, an estimated 3.3 million sq. km of wilderness has been lost since the 1990s. Wilderness provides critical strongholds for endangered biodiversity, for carbon storage and sequestration, for regulating local climates, and for supporting many of the world's most marginalised communities. The largest losses of the wilderness were reported in South America (29.6 per cent) and Africa (14 per cent) (IPBES, 2019).

Sustainable management of aquatic living resources

The Aichi targets ask countries that by 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally, and applying ecosystem-based approaches. The Food and Agriculture Organisation (FAO) of the United Nations says that in 2017, 34.2 per cent of the marine fish stocks were overfished (FAO, 2020). Overexploitation and bycatch of non-target species causes negative impacts on the biodiversity and it also reduces fish production. The area with the highest percentage of unsustainably fished stocks was reported in the Mediterranean and Black Sea (62.5 per cent), Southeast Pacific (54.5 per cent) and Southwest Atlantic (53.3 per cent). In contrast, the Eastern Central, Northeast, Northwest, and Western Central parts of the Pacific Ocean had the highest percentage

of sustainably fished stocks (between 78 per cent and 87 per cent). Of the 10 species with the largest landings since 1950 are Chilean jack mackerel, Atlantic cod and Japanese pilchard. The tuna stocks have slightly improved, although 33 per cent are overfished. The extinction of the reef shark was reported due to overfishing and damaging the coral reef areas (Mac Neil *et al.,* 2020).

Some of the actions taken by countries for managing fish resources are: designating and protecting the Vulnerable Marine Ecosystems (VMEs) and nearly 320 Ecologically and Biologically Significant Marine Areas (EBSAs) have been described; assessment of fish stocks carried out; regulatory measures for IUU fishing practices undertaken; monitoring of fishing vessels and by-catch; guidelines on fish size; seasonal or periodic fishing bans; establishment of Marine Protected Areas (MPAs) and restoration of fish habitat; measures for the promotion and support of community ownership; implementation of the FAO 1995 Code of Conduct for Responsible Fisheries (CCRF); use of Ecosystem Approach to Fisheries Management (EAFM) and protection of endangered species (FAO, 2020). The Regional Fisheries Management Organisations have progressively expanded the scope of governance measures to include biodiversity-related considerations in the marine sector which *inter alia* include: shark sanctuaries, closed areas, catch limits and bans on the use of destructive gears (Mac Neil *et al.*, 2020). The volume of fish catches certified under the MSC has doubled since 2010. In 2019, 16 per cent of the wild-caught seafood consumed worldwide, accounting for 11.9 million tonnes per year, was landed by MSC certified fleets (Hilborn *et al.*, 2020). The national registry of fishing vessels and their fishing activity monitoring through satellite supported sensors are useful steps to manage marine fishery wealth.

Sustainable agriculture, aquaculture, and forestry

Aquaculture is the fastest-growing sector of global food production. World aquaculture production attained an all-time high of 114.5 million tonnes in 2018 (FAO, 2020). The recently published report on the State of the World's Aquatic Genetic Resources for Food and Agriculture (SoW-AqGR) is the first ever global assessment of the status of aquatic genetic resources reported by 92 nations by the Commission on Genetic Resources for Food and Agriculture (CGRFA) of FAO (FAO 2019, b).

Aquaculture comprises a diversity of traditional and non-traditional production methods and it includes the production of aquatic plants, seaweeds, algae, molluscs, crustaceans, echinoderms and finfish. The rice-fish farming practiced over 1,200 years in China was recognised under "Globally important agricultural heritage system" (China's 6th NR, CBD). The traditional, environmentally-friendly integrated multi-trophic aquaculture has been practiced in many countries. The other practices gaining increasing attention are the farming of seaweed and microalgae as fish feed, for human nutrition supplements, and other neutraceutical purposes. The expansion of aquaculture has also caused large-scale loss and destruction of coastal wetlands (especially mangroves) and pollution of soil and water and it has brought policy and regulatory frameworks for managing the intensive aquaculture practices (IPBES, 2019). The Satoyama Initiative of Japan promotes socio-ecological production landscapes and seascapes (IPSI, 2020). Uyana is promoting the use of local fish species in aquaculture to reduce the risk of introducing Invasive Alien Species (IAS).

The Micro, Small and Medium Enterprises (MSMEs) play a vital role for strengthening the Indian economy in the fishery sector by enhancing fish production, processing, post-harvest, generating employment and product development. India is encouraging fishery related business model through MSMEs for enhancing India's blue growth. The Government of India through the Pradhan Mantri Matsya Sampada Yojana (PMMSY) envisages an estimated investment of Rs. 20,050 crore into the Indian fisheries sector. This investment comprises the Central share of Rs. 9,407 crore, the State share of Rs 4,880 crore and the beneficiaries contribution of Rs. 5,763 crore. The Scheme will be implemented over a period of five years from FY 2020-21 to FY 2024- 25 in all States/Union Territories and is expected to enhance fish production to 220 lakh metric tons by 2024-25 from 137.58 lakh metric tons in 2018-19 at an average annual growth rate of about 9 per cent. Further, this ambitious scheme will result in doubling export earnings to Rs.1,00,000 crore and generate about 55 lakhs direct and indirect employment opportunities in fisheries sector over a period of next five years.

Pollution management

The release of chemical pollutants from industries and agricultural runoff

causes deleterious impacts to the aquatic organisms and fishery resources, these includes: damages reproduction, death, diseases, cancer and lesions, disruption of endocrine system, behavioral changes, etc. The persistent pollutants such as mercury, brominated compounds, and plastics bio-magnify in the aquatic food web and it reaches humans (IPEN, 2021). Pollution from excess nutrients, fertilizers, pesticides, plastics and other wastes continues to be detrimental to ecosystem functions and loss of biodiversity (IPBES, 2019). Plastic pollution has brought severe impacts on aquatic and terrestrial ecosystems. More than 10 million tonnes of plastic waste are entering into the oceans every year and it is estimated that over 5.25 trillion plastic particles, weighing over 260,000 tons in the world's oceans are endangering marine fauna and flora (Eriksen *et al.*, 2014). Plastic debris release life-detrimental toxins and facilitate the transport of land-based microbial pathogens to the corals and weaken their resistance to stress through deprivation of light and oxygen (Schnurr *et al.,* 2018). Abandoned, lost, or discarded fishing gear ('ghost gear') is impacting many threatened species. Nearly 46 per cent of the species on the IUCN Red List of Threatened Species has been impacted by gears. Some of the measures taken by parties for addressing the pollution are regulatory approaches; setting up monitoring systems and standards; minimising the usage of chemical fertilizers, pesticides and other industrial effluents and chemical pollutants (FAO, 2020).

India has reported that nearly 61,948 million litres per day (MLD) of urban sewage is generated daily in class I cities and only 23,277 MLD of sewage is treated. The remaining untreated sewage of 38,671 MLD is being released into the major rivers and other water bodies. India's Biodiversity Finance Initiative (BIOFIN) report has identified that nearly 2.04 lakh hectares of wetlands and lakes that are under degradation need restoration (NBA, 2019). Egypt has implemented sectoral plans (Egypt 6th NR, CBD); Panama has implemented "Zero waste recycling in Guna Yala", which aims collection and sale of recyclable and non-recyclable waste. The United Kingdom (UK), Northern Ireland, and Vanuatu calls on Commonwealth countries to pledge action to reduce plastic waste. The UK and Canada have also launched the Global Plastics Action Partnership to develop country action plans to address the plastic problem (Schnurr *et al.*, 2018). This partnership has also received support and matching grant from Coca Cola,

Pepsico Foundation, and Dow Chemicals. Measures are taken to reduce single-use plastic bags from 33 to 96 per cent (IPBES, 2019).

Invasive Alien species management

GBO-5 has reported that good progress has been made in identifying and prioritising IAS and more than 800 invasive mammals have been irradiated in many islands. In India, over 300 exotic fish species have been introduced for aquaculture, sport fishing, mosquito control and aquarium purposes. Some of them have entered into the open waters and have negatively impacted the native species. Similarly, the discharge of ballast water from the hulls of the ship has been one of the main sources of invasive marine species and is posing threat to the world's oceans. **The most unwanted marine invasive species reported by IUCN are green crab, killer algae, sea walnut, veined rapa whelk, and zebra mussel.** Belgium has initiated a project to track the progression of alien species; and the Republic of Congo has introduced weevils as a bio-control agent to control the growth of aquatic plants, such as water hyacinth, water lettuce and giant salvinia and restored the waterways in the Kouilou and Likouala regions. New Zealand has initiated a vision for predator-free New Zealand by 2050 and a goal has been set for the eradication of possums, rats, and stoats. Further, the government has committed NZD 81.28 million to suppress introduced species that prey on indigenous and endemic biodiversity. The International Convention for the Control and Management of Ships' Ballast Water and Sediments has entered into force in 2017.

Ecosystems vulnerable to Climate Change

GBO-5 has reported that there is an increasing trend of coral bleaching from 3,351 sites in 81 countries and more than 60 per cent of the world's coral reefs face direct threats and around 700 hard coral reef sites around the world are showing a declining trend. Two coral reef regions are included in the IUCN Red List of Ecosystems: Caribbean coral reefs are classified as critically endangered and the Western Indian Ocean coral reefs are considered vulnerable. Cambodia has established the Koh Rong Marine National Park to restore coastal habitats affected by climate change. Gabon has initiated a National Coastal Adaptation Plan and established a long-term

land-use and urban planning strategy. In Ghana, farmers are encouraged to plant trees as a part of climate change adaptation and mitigation strategy and this project has helped to restore mangrove ecosystems as well as reduce deforestation. The Maldives has established 61 Marine Parks and India has brought eight National Missions, which represent a multi-pronged, long-term and integrated approach for achieving key goals in the context of climate change.

Strategic Goal C: Improve the status of biodiversity by safeguarding ecosystems, species, and genetic diversity

Protected Areas

The Aichi target asks countries to conserve 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas. The growth of the global MPA network has increased ten times greater in 2020 than in 2000. This increase is due to the establishment of large MPAs in the Pacific Ocean (Gannon *et al*., 2017). Belize enacted the National Protected Areas System Act, 2015 and managed all PAs and established biological corridors to maintain biological connectivity; Canada has established MPAs and taken initiative for conserving Other Effective Area-based Conservation Measures (OECMs); China has protected important ecological areas and systems; Costa Rica is protecting sea turtle nesting sites, coral reefs, breeding grounds of commercially-important fish species and an aggregation location for whales and dolphins in the Cabo Blanco Marine Management Area. India's terrestrial conservation area adds up to 9,27,521.50 km^2, which is nearly 28 per cent of the total geographical area of the country. India has around 130 MPAs on the mainland that have a total area of about 8,214 km^2, which is about 5 per cent of the total area under the entire PA network (Thomson Jacob and Yugraj Singh Yadava, 2018).

Reducing the risk of extinction

The IUCN has reported that nearly 32,000 species are threatened with extinction, which include 41 per cent of amphibians, 26 per cent mammals, 34 per cent conifers, 14 per cent birds, 7.5 per cent bony fishes, 30 per cent sharks, and 33 per cent rays, 28 per cent coral reefs and 63 per cent

crustaceans (IUCN, 2020). India is providing legal protection to Gangetic Dolphin and declared the species as a national aquatic animal. India has also notified 159 terrestrial plants and 175 terrestrial animals that are on the verge of extinction under the BD Act (NBA, 2020).

Strategic Goal D: Enhance the benefits to all from biodiversity and ecosystem services

Ecosystem restoration and resilience

Aichi targets ask parties to contribute to ecosystem resilience and restoration to mitigate climate change and combating desertification. There have been increased efforts to restore river flows and these efforts have improved water quality. The 'Blue Carbon' strategies, contribute to mitigate climate change and improve coastal protection. There has been a surge in projects to restore coastal ecosystems, including mangroves, seagrass meadows, coral and oyster reefs (Taillardat *et al.,* 2018). Poland has increased water retention and slow runoff in mountain catchments, reservoirs, wetlands, and floodplains (Poland 6th NR, CBD).

Access and benefit-sharing

The Nagoya Protocol on Access and Benefit Sharing (ABS) entered into force on 12 October 2014 and 129 Parties have ratified the Protocol. Around 87 countries have put in place the national ABS measures. India has notified the ABS Guidelines and developed the Clearing House Mechanism (CHM) to comply with the provisions of the Nagoya Protocol (GBO-5, 2020). The Intergovernmental Conference on the Conservation and Sustainable Use of Marine Biodiversity in Areas Beyond National Jurisdiction (BBNJ) convened to develop an international legally-binding instrument under the United Nations Convention on the Law of the Sea (UNCLOS). The negotiation addresses ABS for marine genetic resources, as well as Traditional Knowledge (TK) of indigenous peoples and local communities associated with marine genetic resources. Globally, so far, a total of 2262 Internationally-Recognised Certificates of Compliance (IRCC) have been published from 22 countries in the ABS-CHM and India has generated 1424 IRCC (around 63 per cent) (as of May, 2021).

In India, the BD Act, 2002 mandates the development of Peoples' Biodiversity Registers (PBRs) at local-level by the Biodiversity Management Committee to safeguard biodiversity and its associated knowledge. The PBR is a legal document used for determining ABS provisions and so far NBA has prepared 2,48,156 PBRs and taking initiatives in the preparation of electronic PBRs towards strengthening the national-level biodiversity database. There is also a need to build a strong linkage between the National Mission on biodiversity and human wellbeing and the PBR Process.

Biodiversity Strategies and Action Plans

The National Biodiversity Strategies and Action Plans (NBSAPs) are the principal policy instruments for the implementation of the Convention at the national-level and nearly 191 out of 196 countries (97 per cent) have adopted the global SP for Biodiversity 2011-2020 (CBD, 2020). The GBO-5 revealed that countries have mainstreamed biodiversity into cross-sectoral policies, plans, poverty eradication programs and sustainable development plans. Some of the issues addressed are awareness creation, poverty eradication, conservation of genetic resources, valuation of the ecosystem, gender mainstreaming, climate change mitigation, implementation of Nagoya Protocol, documentation of TK, biodiversity database, and strategies developed for finance mobilisation, etc. The Government Departments/ Ministries involved in the implementation process are agriculture, fisheries, forestry, planning, tourism, education, finance, trade, industry, infrastructure, and transport; stakeholders involved are indigenous peoples and local communities, non-governmental and inter-governmental organisations, civil society, private sector, academia, etc. (CBD, 2020). Investments from public and private stakeholders, including through Corporate Social Responsibility (CSR) need to be fortified in the enrichment and sustaining of biodiversity in all ecological interfaces and sustained by government policy handholding.

Strategic Goal E: Enhance implementation through participatory planning, knowledge management, and capacity-building

Sharing information and knowledge

There is significant progress in the generation, sharing, and assessment of knowledge and data on biodiversity, with big-data aggregation, modeling,

and artificial intelligence. Data and information on biodiversity are being shared through free and open access to digitized records from natural history collections, citizen science networks, etc. Parties are sharing information and knowledge through the promotion of scientific research, inventories, databases, CHM and promotion of community-based monitoring, documentation, etc. The emerging technologies such as environmental DNA, metagenomic sampling, bar-coding helps to support a range of research and policy applications (Barcode of Data System, 2020). Artificial intelligence supports monitoring wildlife through images captured by camera traps.

Bio-acoustic monitoring and satellite-based animal tracking are other technological applications that are widely used (iNaturalist, 2020). The Ocean Biodiversity Information System (OBIS), which specialises in mobilising data to support research and policy on marine biodiversity provided access to 60 million records relating to more than 131,000 species (Ocean Biodiversity Information System, 2020). Global handholding systems such as G-20 in association with the relevant United Nations organisations could provide due impetus to national efforts in addition to mobilising financial support that is linked to the economic productivity from the enhanced biodiversity. Malawi is conducting spatial biodiversity assessments to identify and develop evidence related to trade-offs and policy impacts in 36 different sectors through the Mapping Biodiversity Priorities Project. Guatemala has initiated a community-based monitoring and information system that tracks status, trends, cultural values, and practices associated with threatened species and provides information to support forest management.

Finance mobilisation

The High-Level Panel on the Global Assessment of Resources for Implementing the SP says that the global financing needs for achieving the CBD's SP are between USD 150-440 billion per year by 2020 (Financial Reporting Framework Analyzer, 2020). Countries have reported that there is an increase in domestic resources and international funding for biodiversity. Some of the funding mechanisms proposed for implementing the targets are tax reforms, incentives, tourism tax, ABS, CSR, etc. The Green Climate Fund, established under the United Nations Framework Convention on Climate Change plays a crucial role in supporting developing countries

to raise their climate ambitions and to realize their Nationally Determined Contributions (NDCs) under the Paris Agreement (Green Climate Fund, 2020). Between 2015 and 2017, the private sector spent nearly USD 6.6 - 13.6 billion per year on biodiversity, which includes biodiversity offsets, sustainable commodities, forest carbon finance, payments for ecosystem services, water quality, trading and offsets, philanthropic spending, contributions for NGOs, etc. (OECD, 2020). India's BIOFIN report says that the annual average public finance available (2017-18 to 2021-22) is around Rs. 70,121 crore (USD 10 billion) and the budget required for implementing the National Biodiversity Targets (NBTs) for the same period is around Rs.1,15,970 crore (USD 16.5 billion) (NBA, 2019). The Annual average gap in available public resources for implementing the NBAP is estimated to be nearly USD 6.5 billion for the period 2017-18 to 2021-22.

Issues

In India, some of the gaps and constraint identified in managing the marine fishery resources include overexploitation, bycatch, weak regulation, inadequate documentation, illegal trade; spread of IAS through ballast water, degradation of coastal areas due to developmental activities, pollution, and accumulation of microplastic, oil spill, oil exploration, inadequate post-harvest measures, and value addition, etc. In the inland sector, some of the issues identified are depleted stocks in natural waters, lack of diversity in cultural practices and species, shortage of quality seed, lower productivity, inadequate regulatory mechanism, water abstraction and fragmentation, non-availability of data on aquatic resources, the spread of IAS, eutrophication due to agricultural runoff, sewage and industrial pollution, encroachments, etc.

Discussion

The GBO-5 report says that people are aware of the importance of biodiversity and parties have integrated the biodiversity values into their national policies and community development plans. Globally, the subsidies that are harmful to biodiversity have exceeded the finance that is allocated for the conservation of biodiversity. Some of the biodiversity-friendly practices mainstreamed across Government and society include green

product labelling circular economy, strategy for reducing the usage of plastics, MSC, mobile app advisory to reduce scouting time for fishing, etc.

The GBO-5 also reported that globally the usage of fertilisers and pesticides has been stabilised and good progress has been made in identifying and prioritising IAS and managing them. Guyana is promoting the use of local fish species in aquaculture to reduce the risk of introducing alien species. Parties have taken measures for addressing the pollution issues by setting up monitoring systems and standards and minimising the usage of chemical fertilisers, pesticides, and insecticides. China has taken initiative for reducing nitrogen fertiliser and Panama has implemented 'Zero waste recycling'. The UK, Northern Ireland and Vanuatu calls on Commonwealth countries pledged action to reduce plastic waste. The UK and Canada have launched partnership to address the single-use plastic.

Countries have made commitments for expanding the MPAs in the oceans and in their terrestrial ecological territories. The growth of the global MPA network has increased. Belize enacted the National Protected Areas System Act, 2015 and managed all MPAs and established biological corridors to maintain biological connectivity. Canada has established MPAs and taken initiative for conserving OECMs. Parties have also taken initiative in designating VMEs and described EBSAs.

Species-specific conservation measures were adopted by parties to improve the stock of the marine and inland fish resources. Costa Rica is protecting breeding grounds of commercially-important fish species and the aggregation location for whales and dolphins in the Cabo Blanco Marine Management Area. Some of the regulatory measures adopted by countries include closed areas, seasonal or periodic fishing bans, catch limits, ban on the use of destructive fishing gears, guarding the economic zones, regulating IUU fishing, by-catch reduction, restoration of degraded inland water bodies, sea ranching of indigenous fish species, protection of endangered & threatened species, documentation of aquatic biodiversity and assessment of fish stocks. It is suggested that the recommendations emerged from the study and the good practices adopted from other countries can be mainstreamed into India's fishery policies, schemes, programmes, and plans towards enhancing the fish stocks and the aquatic biodiversity.

India's Biofin report says that some of the priority areas identified for enhancing biodiversity finance for achieving the national biodiversity targets include strengthening and integration of *in-situ* conservation, regulation of introduction of IAS and their management, development and integration of biodiversity database, valuation of goods and services provided by biodiversity and the use of economic instruments & decision-making processes and international cooperation. The Biodiversity Finance Plan seeks to achieve India's biodiversity targets through mainstreaming biodiversity into sectors and cross sectoral policies such as poverty alleviation, food security and elimination of hunger, sustainable livelihoods, women empowerment, health and nutrition, mitigating and adapting to climate change and others. The other financial solutions suggested are ABS and CSR. The industries using the biological resources should be brought under the ambit of the BD Act, 2002. Similarly, the CSR funds can be used for cleaning the rivers and lakes, solid waste management, construction of crematoria and this will ultimately improve the water quality of the water bodies and enhances the aquatic biodiversity.

Conclusion

The GBO-5 report says that globally the loss of biodiversity is intensifying. The COVID-19 pandemic has further highlighted the importance of the relationship between people and nature and it is imperative to have a transformative change to achieve the vision of living in harmony with nature and to reverse the loss of biodiversity. The NBAP and other biodiversity-related multilateral environmental agreements are the key policy documents available and the recommendations that have emerged from these documents need to be integrated into various sectors. Enhanced policy and financial outlook in core and crucially significant areas of development to inculcate biodiversity sustainability will have to be stated by nations. The development finance management may attract biodiversity management as internal resource assessment and sustenance in all mega-development projects with political will and economic support. For implementing the recommendations that have emerged from the specific policy and regulatory instruments, it is necessary to broaden the political and general support for the implementation of the global framework and to make the government and stakeholders aware of the multiple values of biodiversity and related ecosystem services. The

bending of the curve of biodiversity loss can be tackled by mainstreaming biodiversity into the various sectors, committed restoration of degraded habitat, increasing the area under the MPAs, species-specific food chain conservation measures and to implement nature-based solutions to reverse the biodiversity decline.

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Perspective

First Draft of Post-2020 Global Biodiversity Framework and its Salient Features

Introduction

The UN Convention on Biological Diversity (CBD) Secretariat released the first official draft on a new post-2020 Global Biodiversity Framework 5th July this year, after almost two-and-half year long deliberations which ensued after the Decision 14/34 during the COP14 Meeting at Sharm-El-Sheikh (Egypt) in November 2018. The draft Framework is expected to undergo further refinements and revisions before being presented for adoption at the CBD's next Meeting of its 196 Parties at COP15, scheduled to be held in Kunming (China) in October 2021. Nevertheless, at this point of time, it would be useful to take stock of the present draft so as to know what's in store in terms of the vision, mission, goals, targets and action plan towards achieving the objectives of the Convention and its Protocols.

Salient Features of First Draft of Post-2020 Global Biodiversity Framework and Analysis

As stated in the draft document, the post-2020 Global Biodiversity Framework builds on the "Strategic Plan for Biodiversity 2011-2020" and the Plan's aspiration of "Living in Harmony with Nature". This is clearly evident from the fact that the Vision statement of both the documents remains the same i.e. "*By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people*."

The draft Framework aims to "*galvanise urgent and transformative action by the governments and all of society, including indigenous peoples and local communities, civil society and businesses, to achieve the outcomes.*" With this exposition, it is clear that the Framework seeks

to expand the stakeholders' universe to include not only the governments but also indigenous peoples and local communities (IPLCs), civil societies and private business players. Thus, arguing for a "whole-of-government" and "whole-of-society" approach for better and effective implementation.

The draft document also states that the Framework is fundamental contribution to the implementation of the 2030 Agenda for Sustainable Development and the progress towards SDGs will help in creating conditions necessary to implement the Framework. This indicates the strong reciprocity and complementarity that exists between the goals of the Framework and SDGs, which is rightly so, given the fact that biodiversity conservation is crucial for achieving most of the SDGs. Not only SDGs, biodiversity conservation is also critical for addressing the challenge of climate change and achieving the goals of Paris Agreement.

The draft Framework is built around a "Theory of Change", which acknowledges the imperative for policy actions at global, regional and national levels, in order to transform economic, social and financial models so that the trends that have exacerbated biodiversity loss gets stabilised in the next ten years (i.e. by 2030) and allows for the recovery of the natural ecosystems in the following twenty years, with net improvements by 2050 to achieve the over-arching vision of "Living in Harmony with Nature by 2050". It vies for the implementation by taking a "rights-based" approach while recognising the principle of "intergenerational equity".

The draft Framework has four long-term goals for 2050 and each such goal have number of corresponding milestones to assess, in 2030, the progress towards those four long-term goals for 2050. In total there are ten milestones. In addition to that, there 21 action-oriented targets for urgent actions by 2030, placed under three broad themes as follows:

- Reducing threats to biodiversity (Targets 1-8)
- Meeting people's needs through sustainable use and benefit-sharing (Targets 9-13)
- Tools and solutions for implementation and mainstreaming (Targets 14-20)

For details on each of the goals, milestones and targets please refer to the draft Framework document as released by the CBD Sectt.[1]. However, among the four goals, 10 milestones and 21 targets that are enlisted in the draft Framework, some of the following ones are quite significant.

Among the Goals (to be achieved by 2050)

- *Goal B:* Nature's contributions to people are valued, maintained or enhanced through conservation and sustainable use supporting the global development agenda for the benefit of all;
- *Goal D:* The gap between available financial and other means of implementation, and those necessary to achieve the 2050 Vision, is closed.

Among the Milestones (to be assessed by 2030)

- *Milestone B.1* Nature and its contributions to people are fully accounted and inform all relevant public and private decisions.
- *Milestone B.2* The long-term sustainability of all categories of nature's contributions to people is ensured, with those currently in decline restored, contributing to each of the relevant Sustainable Development Goals.
- *Milestone C.1* The share of monetary benefits received by providers, including holders of traditional knowledge, has increased.
- *Milestone D.1* Adequate financial resources to implement the framework are available and deployed, progressively closing the financing gap up to at least US $700 billion per year by 2030.
- *Milestone D.2* Adequate other means, including capacity-building and development, technical and scientific cooperation and technology transfer to implement the framework to 2030 are available and deployed.

Among the Targets (to be achieved by 2030)

Target 3. Ensure that at least 30 per cent globally of land areas and of sea areas, especially areas of particular importance for biodiversity and its contributions to people, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

- *Target 6.* Manage pathways for the introduction of invasive alien species, preventing, or reducing their rate of introduction and establishment by at least 50 per cent, and control or eradicate invasive alien species to eliminate or reduce their impacts, focusing on priority species and priority sites.

- *Target 7.* Reduce pollution from all sources to levels that are not harmful to biodiversity and ecosystem functions and human health, including by reducing nutrients lost to the environment by at least half, and pesticides by at least two thirds and eliminating the discharge of plastic waste.
- *Target 8.* Minimize the impact of climate change on biodiversity, contribute to mitigation and adaptation through ecosystem-based approaches, contributing at least 10 GtCO2e per year to global mitigation efforts, and ensure that all mitigation and adaptation efforts avoid negative impacts on biodiversity.
- *Target 13.* Implement measures at global level and in all countries to facilitate access to genetic resources and to ensure the fair and equitable sharing of benefits arising from the use of genetic resources, and as relevant, of associated traditional knowledge, including through mutually agreed terms and prior and informed consent.
- *Target 14.* Fully integrate biodiversity values into policies, regulations, planning, development processes, poverty reduction strategies, accounts, and assessments of environmental impacts at all levels of government and across all sectors of the economy, ensuring that all activities and financial flows are aligned with biodiversity values.
- *Target 15.* All businesses (public and private, large, medium and small) assess and report on their dependencies and impacts on biodiversity, from local to global, and progressively reduce negative impacts, by at least half and increase positive impacts, reducing biodiversity-related risks to businesses and moving towards the full sustainability of extraction and production practices, sourcing and supply chains, and use and disposal.
- *Target 18.* Redirect, repurpose, reform or eliminate incentives harmful for biodiversity, in a just and equitable way, reducing them by at least US$ 500 billion per year, including all of the most harmful subsidies, and ensure that incentives, including public and private economic and regulatory incentives, are either positive or neutral for biodiversity.
- *Target 19.* Increase financial resources from all sources to at least US$ 200 billion per year, including new, additional and effective financial resources, increasing by at least US$ 10 billion per year international financial flows to developing countries, leveraging private finance, and increasing domestic resource mobilization, taking into account

national biodiversity finance planning, and strengthen capacity-building and technology transfer and scientific cooperation, to meet the needs for implementation, commensurate with the ambition of the goals and targets of the framework.

- *Target 21*. Ensure equitable and effective participation in decision-making related to biodiversity by indigenous peoples and local communities, and respect their rights over lands, territories and resources, as well as by women and girls, and youth.

The above mentioned goals, milestones and targets signify much improvement over the Strategic Plan for Biodiversity 2011-2020 and the Aichi Targets, by being more bold, ambitious and reflective of the clearer outcomes that are expected over the period of time from the set of stakeholders. The "30x30" target (Target 3), which calls for ensuring at least 30 per cent of land areas and of sea areas of the world, are conserved through effectively and equitably managed conservation measures, by 2030, is quite pertinent, given the unprecedented rate of biodiversity loss that is being witnessed now. Similarly, the target related to invasive alien species (Target 6), which calls for reducing their rate of introduction and establishment by at least 50 per cent, is very important because the invasive plant pests and other species are one of the main cause of global biodiversity loss and their impact on terrestrial, marine and freshwater environments as well as on agriculture and forestry can be quite devastating International Plant Protection Convention (IPPC) argues that this target should also include the concept of "safe trade" and consider both the intentional and unintentional introduction of invasive species.[2]

Target 7 on reducing pollution, including by reducing nutrients lost to the environment by at least half, pesticides by at least two thirds and eliminating the discharge of plastic waste, is a critical one too, as it covers 3 Ps (pollution, pesticides and plastic), which are negatively impacting the biodiversity. Target towards climate change mitigation and adaptation through ecosystem-based approaches and contributing at least 10 GtCO2e per year to global mitigation efforts (Target 8) is very relevant in terms of achieving both the Paris Agreement goals as well as SDGs. Though, the figure of 10 GtCO2e per year is less, given the fact that in 2019, 33 gigatons of carbon dioxide were emitted; still setting a clear target to be achieved is a welcome step.

Target 13, calling for implementing measures at the global level to facilitate the access of genetic resources and to ensure fair and equitable sharing of benefits, needs to be carefully read, as it is arguing for a sort of global agreement on ABS, which hitherto has been dealt within the national legislations and guidelines. With the emergence of Digital Sequence Information (DSI), the issue of developing a proper mechanism for ABS is proving to be quite complex and is still debatable.

Targets 14 and 15, read with Goal B and Milestone B.1, are two of the most significant targets in the draft Framework, as they argue for fully integrating the biodiversity values into the policies, development processes as well as accounts, and also calling all businesses (public and private, large, medium and small) to assess and report on their dependencies and impacts on biodiversity, so that the nature and its contributions to people are fully accounted for and inform all public and private decisions. These targets gel well with the headline messages stated in "The Economics of Biodiversity: The Dasgupta Review", which was published earlier this year. The Review strongly argued for the entry of nature (natural capital) into the economic and financial decision-making, just the way it is for produced and human capital. It exhorts for going beyond GDP as a measure of economic activity and success, and to develop a measure for "inclusive wealth", which also include natural assets in the measurement of wealth, unlike GDP. Herein, it pitches for introducing natural capital into the national accounting systems (NAS), as it would greatly help making "inclusive wealth" a better measure of progress[3].

With the aim of supporting a shift in global financial flows away from nature-negative outcomes towards nature-positive outcomes by delivering a risk management and disclosure framework for organizations (major financial institutions and MNCs) to report and act on the evolving nature-related risks, a "Taskforce on Nature-related Financial Disclosures (TNFD)" has also been launched in June this year. One of the Co-Chairs of this Taskforce is Ms. Elizabeth Maruma Mrema, Executive Secretary of the CBD. YES Bank from India is also associated with the TNFD.

Targets 18 calls for eliminating incentives that are harmful for biodiversity, in a just and equitable way, reducing them by at least US$ 500 billion per year, including all of the most harmful subsidies, and ensuring that the incentives, are either positive or neutral for biodiversity. According to a

conservative estimate, the total cost globally of the subsidies that damage nature is around US$ 4 to 6 trillion per year (Dasgupta, 2021). In light of this, the reduction of US$500 billion per year is not adequate enough and more commitment is needed to be shown.

Towards reducing the negative and unsustainable impact of their economic activities on the nature and wildlife, the G7 countries, shared a "G7 2030 Nature Compact"[4] during the G7 Leaders' Summit in Cornwell (UK) in June this year. Through it, the G7 countries committed their support in taking bold action for delivery of ambitious outcomes for nature in 2021 at the upcoming COP15 of CBD in Kunming (China) and COP26 of UNFCCC in Glasgow (UK). They acknowledged the harmful effect of some of the subsidies on the environment and the need to reform policies. G7 countries also committed themselves to work intensively towards increasing the finance for nature in the next five years and also increasing their financial contributions for nature-based solutions through to 2025.

Target 19 stating the increase of the financial resources from all sources to at least US$ 200 billion per year, and increasing by at least US$ 10 billion per year international financial flows to developing countries, along with the provision of strengthening the capacity-building, transferring technologies, seems to be a step in the right direction. Unless and until, there are such supportive measures in place, the implementation within the developing countries and LDCs will remain a big challenge. However, the amount of US$ 10 billion to the developing countries per year seems to be quite less in terms of the enormity of the challenge and activities that are needed for proper and effective implementation.

Another significant target is Target 21, which calls for ensuring equitable and effective participation in decision-making related to biodiversity by indigenous peoples and local communities (IPLCs), and respecting their rights over lands, territories and resources, as well as by women and girls, and youth. The participation of IPLCs is very critical in the endeavour towards biodiversity conservation as more than quarter of the global land area is traditionally owned, managed and used by IPLCs and therefore their values and knowledge would provide valuable insights on the development and effective implementation of conservation measures. The call for their active participation had been made in the *Global Biodiversity Outlook* (GBO 5), *Local Biodiversity Outlook* (LBO) and *IPBES Global Assessment*, which where were released last year.

Concluding Remarks

The present first draft of the Post-2020 Global Biodiversity Framework is a comprehensive outcome-oriented document espousing for "whole-of-government" and "whole-of-society" approach. It's more ambitious and bold than the Strategic Plan 2011-2020 and Aichi Biodiversity Targets. As stated in the beginning, it does build on the Strategic Plan and stands to gain from the successes of it, as the Plan had led the foundation in the last ten years in terms of sensitising the governments about the topic of biodiversity conservation. There were certain gaps such as inadequate mechanism for review, monitoring and evaluation; resource constraints, both in terms of finances and technologies; which led to unfulfilling of any of the 20 Aichi Targets by 2020 (Kumar, 2020)[5]. The present draft Framework has tried to address those critical gaps. It has a sub-framework for monitoring and evaluation and clear targets on increasing the financial resources as well as provision for technology transfer. However, it is expected to go through further revisions before getting finally adopted in the upcoming COP15.

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Endnotes

1 First draft of Post-2020 Global Biodiversity Framework CBD/WG2020/3/3 https://www.cbd.int/doc/c/abb5/591f/2e46096d3f0330b08ce87a45/wg2020-03-03-en.pdf

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Book Review

Applied Biosecurity: Global Health, Biodefense, and Developing Technologies

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The debate over the idea that the SARS-CoV-2 emerged from a laboratory have raised serious concerns that if the lab leak theory is proven, than there is a conspicuous lack of global biosecurity regulations. Even if the natural origin of SAR-CoV-2 is proven, the risks of laboratory escape do not go away. The ongoing pandemic has again renewed the old debate of how scientists should study pathogens (Duprex etal. 2014) and the operational safety and security measures while conducting such research (Zimmer and Gorman, 2021). One most talked about research and development in recent times is the Gain-of-function (GOF) research, where modification of biological agent is done to confer new or enhanced transmissibility and/or pathogenicity, to better inform public health and/or to develop medical countermeasures (Selgelid, 2016), but such research is overshadowed by the concerns over biosecurity and biosafety. Because there has been several past incidences of laboratory escapes of deadly pathogens; and still there is a lack of global standards to support the conduct of best scientific practice.

The book under review '*Applied Biosecurity: Global Health, Biodefense, and Developing Technologies*' edited by Ryan N. Burnette makes the reader question what biosecurity means and how it is practiced? The book focuses on applications of biosecurity from the perspectives of laboratory programs, global health, international security and developing technologies. Since,

the shared aims of biosecurity across all domains (be it animal, plant or collections of cells, or viruses) is mainly 'to protect the biological asset itself', the common thread that runs through the book is to widen the focus to the threat management aspect of biosecurity program. The editor in the first chapter clearly outlines the directionality to understand the relationship between biosafety and biosecurity, which sets the premise of the volume. He along with Chuck Tobin in the second chapter propose a nine-point methodology using the biorisk and biothreat assessment elements to link the threats, hazards, risks and vulnerabilities for a robust biosecurity program. They emphasizes that such an approach can provide an institution to link both the upstream (in terms of likelihood of occurrence) and downstream consequences (impact such an occurrence will have) and broaden their framework to 'adopt, adapt and implement'.

Lauren Richardson in the third chapter points out in similar vein to expand the scope of biosecurity through the integrative and multi-disciplinary lens of 'One Health' approach. The core of 'One Health' approach is rooted in acknowledging and understanding the interdependence of human and natural systems to obtain optimal health for people, animals, and the environment. The author emphasizes that with increasing technological innovations in the life science and biotechnology sector, a holistic framework like 'One Health' can reduce the potential threats at the human-animal-environment interface, control diseases that spread between animals and humans, tackle anti-microbial resistance, prevent environment-related human and animal health threats and at the same time secure science.

Biosecurity and biosafety have usually been associated with laboratory efforts, where protocols are defined for working with pathogens in laboratories. But the recent COVID-19 pandemic has renewed the interest among countries to evaluate their biosecurity system for early detection of such threat and instituting appropriate response to control such public health emergency. The fourth chapter by Brittany Linkous, Ryan N. Burnette, and Samantha Dittrich discusses the application of biosecurity in major U.S. and international biodefense and threat reduction programs. They elaborated Global Health Security Agenda (GHSA) launched by the United States to analyze the crucial role of biosecurity in the context of global health security. Since, the main goal of the GHSA is "to strengthen both global and national capacity to prevent, detect, and respond to human and animal

infectious disease threats through a multi-lateral, multi-sectoral approach", it offers an opportunity for capacity building, mainly for developing countries which lacks resources and capabilities to contain an outbreak. But they call attention to the need for action package on biosafety and biosecurity to think beyond laboratory premises to minimize the risks. The same authors in the following chapter examined a few of the potential lasting effects of the COVID-19 pandemic like bioterrorism, cybercrime and offered mechanisms where the principles of biosecurity can be extended beyond the laboratory. They discussed the past epidemics and the COVID-19 pandemic and offers suggestions for managing threats and vulnerability which may require 'cross-collaboration amongst related disciplines such as infection control, infection prevention, industrial hygiene, and biosafety'.

Nicolas Dunaway and Kavita M. Berger in their chapter discusses how the advancement of biotechnology and life science research such as development of biosensors of chemical and biological agents, medical counter measures (vaccines and medicines, against high-risk pathogens) have contributed to prevent, prepare and respond to natural and man-made biological threats. The central point of discussion in their chapter is that the "changing face of biological research and progress is the need for biosecurity practices and applications to remain flexible." They also highlighted that the increasing Do-It-Yourself practitioners and the change in funding landscape beyond national borders hinders the ability of governments to regulate the development and application of biotechnologies. In the similar vein Stephen M. Lewis in his chapter highlights that increased access, improved processes, and rapid prototyping in biotechnology have increased the emergence of new threats, risks, and vulnerabilities but at the same time with technological advancements potential replacement technologies such as artificial intelligence, bioinformatics, biosensors, neurotechnology, can safeguard the world from existing and novel biotechnological threats. He presents a vigilant model for biosecurity which is a shift from an 'enterprise-level function' to 'individual-level accountabilities'. His "full stack biotechnologist" model involves multi-skilled experts with knowledge array ranging from computer programming to DNA technologies, bioprocessing, design, manufacturing etc. where different expertise provide the ability to trace the interaction between different front-end and back-end components to troubleshoot risk and threat potentials.

The concluding chapter by Kavita M. Berger engages with dual-use research from the scientific and security perspective. Dual-use research "encompasses biological research with legitimate scientific purpose, the results of which may be misused to pose a biologic threat to public health and/or national security" (NRC, 2007). The biotechnological development over the last couple of decade has increased the dilemma of dual-use implications of such research. This chapter underscores the challenges to the discourse on dual use implications and draws from the Defense Advanced Research Projects Agency's research program to present a practical approach to assess the potential dual use risks of emerging biotechnologies. The United States government policy on dual use implication of research is limiting, when it comes to the application of research that does not involve pathogens or microbes. The author vouches for a broader lens to counter the biased risk assessment by broadening the consequences of interest beyond human health outcomes and converging the security and scientific community to evaluate the potential national security risks of emerging biotechnologies.

While these chapters are persuasive, they offer a limited view with regard to biosafety and biosecurity. The various essays fail to connect to the US system to the global biological ecosystem. Moreover, the book did not highlight the effects of human activity that encroaches upon natural habitats and promotes inter-species jump of pathogens and diseases. A complementary volume should be developed that outlines how to prevent, prepare for, respond to and mitigate such human effects with more focus on loss of biodiversity and rise in infectious diseases. Nonetheless the chapters remain useful with respect to application of biosecurity and set the stage for further discussions amongst academics, public intellectuals, policy makers, legal practitioners and activists.

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4. Use figures (rather than word) for quantities and exact measurements including percentages (2 per cent, 3 km, 36 years old, etc.). In general descriptions, numbers below 10 should be spelt out in words. Use thousands, millions, billions, not lakhs and crores. Use fuller forms for numbers and dates— for example 1980-88, pp. 200-202 and pp. 178-84.
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(d) Articles from Journals:

Rao, M.G., K. P. Kalirajan and R. T. Shand. 1999. "Convergence of Income across Indian States: A Divergent View". *Economic and Political Weekly,* 34(13): pp. 769-78.

(e) Unpublished Work:

Sandee, H. 1995. "Innovations in Production". Unpublished Ph.D thesis. Amsterdam: Free University.

(f) Online Reference:

World Health Organisation. 2000. "Development of National Policy on Traditional Medicine". Retrieved on March 31, 2011 from http://www.wpro.who.int/sites/trm/documents/Development+of+National+Policy+on+Traditional+Medicine.htm

Asian Biotechnology and Development Review (ABDR) is a peer reviewed, international journal on socio-economic development, public policy, ethical and regulatory aspects of biotechnology, with a focus on developing countries. ABDR is published three times a year by Research and Information System for Developing Countries (RIS), a New Delhi based autonomous think-tank, envisioned as a forum for fostering effective policy dialogue among developing countries.

This issue has five articles and a book review. The first article is on research and innovation in the corn seed industry of Thailand. The second article explore the policies and shifts in policies on biofuels in India in the last two decades. The third article discusses the regime complex in global biodiversity complex and national level policies and implementation in the context of Sustainable Development Goals, while the fourth article analyses the progress made in achieving Aichi Target Six related to fisheries. The perspective article lucidly describes the recent 'Post-2020 Global Biodiversity Framework' and suggests what will be the way forward in this. The book review of a volume on applied biosecurity adds value to the issue by highlighting what has been covered and missed in the volume.

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