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One Health for Sustainable Development

An Eco-Social Design for a Climate Resilient Health Systems in the Sundarbans of Bay of Bengal

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Abstract

The paper is based on a pilot study conducted in the Sundarbans of Bay of Bengal (in South Asia) to understand the human-animal-ecosystems interfaces for mapping the wider determinants of human, animal and ecosystem health. The pilot study illustrated the key characteristics and ecological vulnerabilities of the Sundarbans ecosystems and the latter's implications on society and economy.

It then provides a gap analysis in current approaches to health systems policy which focus predominantly on the financing, governance and service delivery components of medical care systems at the neglect of wider determinants of health, impeding collaboration with other key sectors (education, urban development, environment and forestry for example). This makes health systems detached from the causal factors of disease production in social, ecological, and environmental landscapes, and addresses diseases through expensive techno-managerial solutions.

The paper seeks to delineate the path of sustainable development at the interface of human-animal-ecosystems to promote human health and well-being, protect against pathogens (pandemic security), and halt and reverse environmental degradation. Using the One Health approach, it models a system-wide intervention design to embark on an eco-social contract in climate vulnerable contexts.

Contents

1. Introduction	1
1.1 Structure of the paper.....	2
2. Conceptualization and methodology	2
2.1 Gap diagnosis in current health systems design	3
2.2 Wider determinants of health for designing new interventions.....	4
2.3 Policies to programmes: A step towards systems thinking.....	4
2.4 Methods.....	5
2.5 Study limitations	6
3. The Sundarbans and its Fragile Ecosystems	6
3.1 Effects of global warming on the Sundarbans	6
3.2 Anthropogenic effects on the Sundarbans	8
3.3 Timeline study of the Sundarbans landscape	9
3.4 Impacts on human health	11
3.5 The rift in the social contract.....	11
4. One Health: An Eco-social pathway for Sustainable development.....	12
4.1 Resilience, adaptability and transformation cycle	12
4.2 Biodiversity and sustainable development.....	14
4.3 Application of One Health in the Sundarbans	15
5. Current Approaches at the International Level to Address the Human-Animal-Ecosystem Interface	17
5.1 UNESCO’s Man and Biosphere (MAB) programme.....	17
5.2 UNEP’s Nature 4 Health investment initiative	18
5.3 IUCN’s Nature-based Solutions.....	18
5.4 One Health for a healthy and sustainable future.....	18
6. Conclusion	18
References	20

Acronyms

FAO	Food and Agriculture Organization of the United Nations
GEN	Geneva Environment Network
GFA	Global Financial Architecture
GIS	Geographic Information System
HiAP	Health in All Policies
IUCN	The International Union for Conservation of Nature
MAB	Man and Biosphere Programme
MERS	Middle East Respiratory Syndrome
NbS	Nature-based Solutions
RATA	Resilience Adaptation Transformation Assessment
SARS	Severe-Acute Respiratory Syndrome
SCBD	Secretariat of the Convention of Biological Diversity
SDG	Sustainable Development Goals
UNSDSN	United Nations Sustainable Development Solutions Network
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNRISD	United Nations Research Institute for Social Development
WHO	World Health Organization
WNBR	World Network of Biosphere Reserves
WOAH	World Network of Biosphere Reserves

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1. Introduction

Designing new eco-social contracts in the aftermath of the Covid-9 pandemic is a new vision of governance and policy priority. The destruction of nature and its impacts in social and economic lives of the people are detrimental for physical, social and mental well-being and sustainable development. Environmental crisis is creating a humongous pressure on social and political institutions and even instigating political instability in different parts of the world (Worland 2020). This, under the growing discourse of sustainability science, invokes various public policy measures to innovate, experiment and implement in sectors like the economy, agriculture, health, animal husbandry and others.

This paper takes public health as a central policy plank to conceptually diagnose the problem, analytically investigate the problem, and theoretically model a One Health intervention design for its operational uptake.

The onslaught of the Covid-19 pandemic structurally attacked the sustainability of societies by putting the globe upside down on health, economic, environment, energy, ecological, and social fronts (Mofijur et. al. 2021). The Sustainable Development Report, published by the United Nations Sustainable Development Solutions Network (UN SDSN) in 2023, provides a grim picture on the progress of the global Sustainable Development Goals (SDGs). Standing exactly at the midpoint of the 2030 Agenda for Sustainable Development, the report concludes that all the SDGs are off track. Moreover, the study finds that 15 percent of the SDGs are showing a reverse trend in progress (UNSDSN 2023). The 17 goals, 169 targets, and 232 monitoring indicators of the SDGs were conceived to integrate economic, social and environmental goals for development. This holistic framework is a political agenda to address the perils of poverty, inequality, social injustice, environmental degradation and biodiversity loss, climate change and so on. The severe lag in SDG achievement is a serious threat to the global development agenda and halting the path of recovery in the aftermath of the Covid-19 pandemic.

The current state of SDG progress is illuminating global governance forums to bring forth new ideas and approaches for achieving sustainable development. In its assessment, the UN SDSN Report considers the SDGs as an investment framework, and thus calls for an overhaul of the Global Financial Architecture (GFA) to enhance funding, reorganizing financial systems and establishing standards for sustainable financing to accelerate SDG realization. While financing is indeed crucial for promoting the SDGs, the structural causes of underachievement need deeper attention. The economic and social arrangements behind the twentieth century social contract are now failing for their inability to maintain a balance between the needs of growth and productivity demand and the wants of redistribution and social protection necessities, and the neglect of environmental issues. This has cascading effects in political (societal divisions), economic (rising inequalities), environmental (climate change) and social (human well-being) spheres (Kempf and Hujó 2022).

The United Nations Research Institute for Social Development's (UNRISD) 2022 Flagship Report (Crises of Inequality: Shifting Power for a New Eco-Social Contract) considers that 'multiple and overlapping global crises' are linked with rising inequalities over the last four decades and has undermined social contracts. It proposes a new eco-social contract as a governance arrangement for economic, social and environmental justice (UNRISD 2022). This restructuring proposition centers around the interdependence of 'human-environment' relationship to achieve stability and power balance in social arrangements. But in light of climate change-induced impacts and the continuous emergence and resurgence of pathogens, it is challenging for both states and citizens to maintain stability. However, with the advent of the Covid-19 pandemic, there are increasing attempts to frame health, environment, safety and sustainability in a one chain of policy action (Alshubait et. al. 2022).

Prepared for the 'Global Policy Seminar for a New Eco-Social Contract', this paper brings out the findings from a pilot study, conducted by the authors in the Sundarbans of Bay of Bengal (in South Asia) to demonstrate the social, ecological and economic sustainability crises in a typical climate-vulnerable context. The study was conceived to delineate the path of sustainable development at the interface of human-animal-ecosystems to promote human health and well-being, protect against pathogens (pandemic security), and halt and reverse environmental degradation. Using the One Health approach, it models a system-wide intervention design to embark on an eco-social contract in climate vulnerable contexts.

1.1 Structure of the paper

The paper is divided in five sections: After the introduction, the second section conceptually describes the study problem and discusses the methods employed. It especially criticizes the limitations of existing health system models for their inability to address the sustainability question and argues for a system-wide approach (the One Health approach) to redesign health systems so they safeguard the human, animal and ecosystem health. The third section presents the findings of the pilot study describing the key characteristics and ecological vulnerabilities of the Sundarbans ecosystems, and the latter's implications on society and economy. The fourth section analyses the Sundarbans crises and suggests developing a new eco-social contract to address these, highlighting one health interventions as a key contribution to the agenda of sustainable development. The fifth section gives an overview of the initiatives currently in place at the behest of various international organisations to improve relationships between nature and society for a sustainable future, and proposes an internationally coordinated framework to protect, conserve and restore climatically strategic hotspots in view of public health benefits (human well-being, safety and security) and halting environmental degradation.

2. Conceptualization and methodology

In the discourse of sustainability science, the idea of sustainable development was introduced in 1980s to protect and restore ecosystems worldwide. Ecosystems are enduring the threats of human-induced climate change factors for long. The incidences of food insecurities, natural disasters, infectious diseases and sea level rise had already been identified early on as the climatic factors

affecting sustainable development (Martens et. al. 1997). Along with climate change of 1.1 degrees C growth of global temperature since 1850-1900, the loss of nature and biodiversity, and the pollution and waste are now identified as triple planetary crisis for the sustainability of earth systems (Hellweg et. al. 2023).

While the loss of natural resources and biodiversity are caused by climatic factors like sea level rise, draughts or cyclones, the anthropogenic factors (like air pollution, chemical waste) disturb species diversity and nature-based infrastructures (river streams, forest, soil) of any ecosystem. The term ecosystem refers to all living and non-living things that are together in a geographic area. Apart from humans, the animals, insects, plants, land, water, soil and even microorganisms are part of ecosystems and its diverse services (Fleurbaey and Leppanen 2021) Ecosystems services form the basis of human and animal existence on earth. These basics of life include, for example, the supply of clean drinking water and oxygen, nutritious food, regulating disease and climate, supporting the pollination of crops and soil formation, and also providing recreational, cultural and spiritual benefits among many others (Mace et. al. 2012).

Both the climatic and anthropogenic factors are impacting on ecosystems' well-being (that includes of humans and animals) in any particular contexts and thus adversely influences the sustainable use and management of ecosystems services. The health consequences of the degenerated ecosystem services in human and animal lives are detrimental and even fatal (Coutts and Micah 2015; Teresa et. al. 2019). On this backdrop, the earth systems (a composite web of five sub-systems; atmosphere, hydrosphere, biosphere, cryosphere, and geosphere) is reconceived as a single planet wherein the health of humans, animals and ecosystems are interrelated and collectively producing and/or influencing each one's health outcomes (Redford et. al. 2022). As a consequence, health policy and the design of health systems and intervention operations need to work at the interface of the human, animal and ecosystem triad to primarily address environmental degradation in order to avert a range of public health threats and promote human well-being.

2.1 Gap diagnosis in current health systems design

The current models of health systems are not well equipped to deal with human-animal-ecosystem complexities. They are mostly designed with the objectives of a medical care system to organise health care services for the population (Fleurbaey and Leppanen 2021). In health policies, the strengthening of health systems (for medical care) is an important policy action to ensure a healthy population for productive human lives. It considers that a health system is an operative means to achieve human development, while also contributing to economic growth (Chenery et. al. 1974). But the growth model is often subject to criticism for its exploitative role over nature (and natural resources) causing climate change and biodiversity loss. Both have severe impacts on public health and health security ranging from environmental risks to emergence of infectious diseases (Remoundou and Koundouri 2009; OECD 2020; Millennium Ecosystem Assessment 2005). The pandemics (Severe Acute Respiratory Syndrome/SARS, Middle East respiratory syndrome/MERS, and Covid-19) that afflicted the world population in the last two decades have strong associations with biodiversity loss (Tollefson 2020). The existing design of health systems needs to consider the

socio-ecological transitions taking place due to climatic and aggressive anthropogenic actions, rather than encompassing the human body as the primary subject of intervention.

With the advent of the Covid-19 pandemic, the exhaustion of national health services, especially in advanced countries such as the United Kingdom and the United States of America, and limitation of social security support and access to basic services (such as income/food/education), in advanced and non-advanced countries alike, have not only shown the vulnerability of people but also raise questions on the interrelationship between health and development. Addressing wider determinants of health (social, economic, environmental, ecological, medical) warrants a new design of systems thinking to address ecosystems vulnerability-led public health challenges and accelerate sustainable development.

2.2 Wider determinants of health for designing new interventions

In the classical public health approach, the epidemiological triad (host-agent-environment) is considered to be the fundamental concept to identify and understand the consequential effects on human health from the triangular relationship. The chain of these relationships helps to understand the determinants of health, such as social determinants of health (education, gender), environmental determinants of health (air, water or soil pollution). In the context of economic development, climatic change and human-induced actions have acted as an ecological disruptor (Phillip 2009). The ecological determinants are those that are essential for ecological processing (for example, the nutrients needed for plants and therefore for all food depend on the circulation of nitrogen and phosphorus cycles) to produce 'goods and services' for health and well-being of human and other species (Canadian Public Health Association 2015). Importantly, the ecological determinants need to interact with other determinants of health (social, environmental, political and so on) along complex and dynamic pathways to make impacts on population health (Huynen et. al. 2005).

The new design of health systems needs to be informed by these complex and dynamic pathways. The human-animal-ecosystems interface is a key to design such systems. The nature of ecosystems is diverse and varies from context to context. Thus, it is a necessity to identify the service interaction points between ecosystems, human and animals for preparing a multi-level and multi-layer context-specific determinants matrix. This will help not only in tracking the degradation of ecosystem services needed for human health and well-being, but also in mapping the zoonotic diseases (diseases transmitted from animals to humans) and identifying the sources of antimicrobial resistance by designing a systems-wide intervention.

2.3 Policies to programmes: A step towards systems thinking

The health determinants instrumental at the interface of human-animal-ecosystem services are linked to various sectors of governance. These sectors represent different policies and diverse interests. The objective of one sector may contradict the target of another sector. For example, the decision of increasing cargo movements by the Ministry of Shipping Industry on economic grounds might hamper the activities of coastal saltwater fishing for sourcing air, water and oil pollution. This affects fishing industry and marine coastal ecosystems alike. In this case, a sector-wide collaboration for an

integrated marine coastal ecosystems sustainability policy is a necessity. In public health, the Health in All Policies (HiAP) approach is a tool to reckon with assessing health impacts and measuring health equity of policy decisions made in other sectors of governance to promote ‘positive health’ and well-being (Leppo et al. 2013). The inter-sectoral collaboration is a prerequisite in HiAP to identify the key determinants affected by other governance policies (Green et. al. 2021). Similarly, the human-animal-ecosystems services interface in any particular ecosystem (as geographically defined) could be a subject to HiAP assessment for primarily identifying both the proximal (downstream factors or direct association) and distal (upstream factors or indirect association) determinants.

The identified determinants will be of help in designing a programmatic intervention. In the context of climate change, the One Health approach is getting a lot of traction for its application of systems thinking and integrated assessment of health risks (Zinsstag et. al. 2018). It aims at protecting humans, animals (both domesticated and wild) and the environment from climatic change and anthropogenic activities. Though in the literature it is conceived more as an application of global health security than environmental healing and restoration, its designing composition has the potency to address both the dimensions. One Health is not a new concept and has its close association with other similar concepts (such as eco-health and planetary health) that explicitly acknowledge the importance of environmental or ecosystems health. It acknowledges that health of humans, animals and overall ecosystems are interconnected and interdependent (Adisasmito et. al. 2022). This framework of systems thinking makes it a fitting approach for designing programme interventions for a sustainable and healthy future.

2.4 Methods

The study was conducted as a pilot work under the aegis of The United Nations Educational, Scientific and Cultural Organization (UNESCO) for exploring innovative models for climate resilient health systems. It was a situation analysis in the Sundarbans of Bay of Bengal (South Asia). The situation analysis gives an understanding of the present condition of any given context. It is an advanced application of the grounded theory to conduct both contextual and complexity analysis (Kalenda 2016). This particular method of analysis enabled the researchers to identify the research priorities for studying the human-animal-ecosystems services interface. Based on the narrative and systemic reviews of literature from various secondary sources, the study further used field visit information (conducted in the Sundarbans Tiger Reserve Forest, West Bengal, India) to model a health systems intervention for a new eco-social contract. It also benefitted from a policy consultation event organized by the United Nations Environment Programme’s (UNEP) Geneva Environment Network (GEN) in Geneva to disseminate the findings of the pilot study. During the field work, the study team, in collaboration with the local community, also made a documentary for citizen science engagement and public communication (*Chaos in the climate of the Sundarbans*). That exercise helped to understand the community perspective of a vulnerable ecosystems context and inculcate the values of bottom-up planning in intervention design.

2.5 Study limitations

The human-animal-ecosystems interface is a new concept of understanding sustainability. From the perspective of health intervention, there are no empirical studies known so far that looked into the triad for enhancing both public health and environmental benefits. This is primarily because the concept is still at its nascent stage. Similarly, the applications of One Health are also at the level of programmatic ideation and thus operationally yet to be tested in full scale. These factors limit the scope for the study to empirically assess the findings in other contexts and replicate the same in the field of the Sundarbans. Moreover, there are inconspicuous literature available on the health status of humans and animals in the Sundarbans. In the absence of longitudinal studies (like a cohort design) in the Sundarbans, it is very difficult to epidemiologically (the science of Public Health) establish a causal chain of climatic/anthropogenic factors-ecosystems vulnerability-human health outcomes. Hence, we had to depend on small scale surveys and media reports to describe the impacts of ecosystems vulnerability on human health. For the purpose of this study, we broadly follow the perspectives of classical public health to describe the problem using cutting edge concepts, ideas and practices from various disciplines and holding bottom-up dialogues (from the field discussion to policy consultations) to plan an intervention design.

3. The Sundarbans and its Fragile Ecosystems

The Sundarbans, located at the edge of West Bengal in India and Bangladesh and spreading over close to 10,000 square kilometers, is the largest mangrove forest on Earth. The three rivers (namely, Ganges, Brahmaputra and Meghna) and their tributaries flow through this ecological system and create the world's largest delta. A vast part of the entire Sundarbans in Bay of Bengal is already designated as wetlands of international importance under the Ramsar Convention, along with the status of UNESCO World Heritage Sites since 1987 and 1997 respectively for India and Bangladesh. The Indian side of Sundarbans is also a UNESCO listed biosphere since 2001 (UNESCO).

The Sundarbans delta is famous for its rich biodiversity. Here the Mangroves, a tropical plant, grow as the land meets the sea. They are noticed for their adaptable characteristics, like tolerance to salt and breathing roots. This particular mangrove forest is also famous for the great Royal Bengal Tiger, apart from Ganges River Dolphin, Irrawaddy Dolphin, the Indian Python, the Estuarine Crocodile. It is also home to more than 400 species of resident and migratory birds, and various fishes including the migratory Hilsa. Out of 102 islands, 48 islands are home to four million humans. They are mostly engaged in fishing, agriculture and the collection of wood and honey for livelihood. Additionally, the mangroves and their resources also provide livelihood options for the people of Sundarbans (UNEP).

3.1 Effects of global warming on the Sundarbans

This biodiversity rich mangrove forest is a severe climate vulnerable region. Global warming is a major threat in this regard. Several studies concluded that the Sundarbans' temperature is showing a rising trend in recent decades. It is estimated the mean temperature will increase by 1.5 – 2.0 °C and

2.5 – 3.0 °C, respectively for summer and winter seasons, by 2050s (Gain and Giupponi 2014). The rising sea level is also a cause of concern for these delicate ecosystems. One study found that the average sea level rise in the Sundarbans is higher than the worldwide trends (Mondal et. al. 2021). The Sundarbans is a flood-prone delta as its average elevation is lower than one metre above sea level. So it is volatile to any bulge in the ocean water. The mangroves are also not effective in such a situation as they die if the flood occurs too frequently or lasts too long. Flooding also causes soil erosion in the coastal belt and thus reduces the total land area. The disappearance or shrinking of land of the Sundarbans islands is a grave concern for its mixed biodiversity. Loss of human habitable lands drive people to emigrate, becoming climate refugees (MIT Technology Review 2020). The sea level rise is also a threat for animal habitats: It is estimated that if the sea level rises 28 cm above the level of the year 2000, then 96 percent of the Bengal Tiger's habitat in Bangladesh would be eroded (Loucks et. al. 2010).

On the other hand, due to the rise of ocean levels, there is now an unwarranted inundation of saline water inside the areas of the Sundarbans. It is damaging the ecosystems as salts are increasingly getting accumulated in the soil and thus obstructing plant growth. Similarly, the aquatic life of freshwater is also affected as fish and giant prawns are not tolerant to this excessive salinity. This further hampers the availability of water for agricultural irrigation and drinking especially in the human habituated islands. Because of all these factors agricultural (a monocrop region) and fish production have become economically less attractive livelihoods (Sarovar 2019).

The Sundarbans are also the region that experiences some of the major tropical cyclones of the world. For the past two decades, these storms have been frequent and severe in nature. There were 13 severe cyclones happening in both sides of the Sundarbans between 2007 and 2022, which resulted in 4,876 human fatalities and an estimated loss of USD 32,518.3 million for the economy (Ghosh and Mistri 2023). The frequency and severity of cyclones are attributed to the rising level and temperature of the oceans. The cyclones are not only bringing health threats to the islanders, but also livelihood insecurity. The following figure shows the collection of honey between 2014-15 and 2022-23 in the Sundarbans Tiger Reserve/STR (Forest Department, Government of West Bengal, India). In these nine years, there were eight cyclones (as highlighted in blue boxes), which affected the forest production (i.e. honey collection) in the STR zone of the Sundarbans.

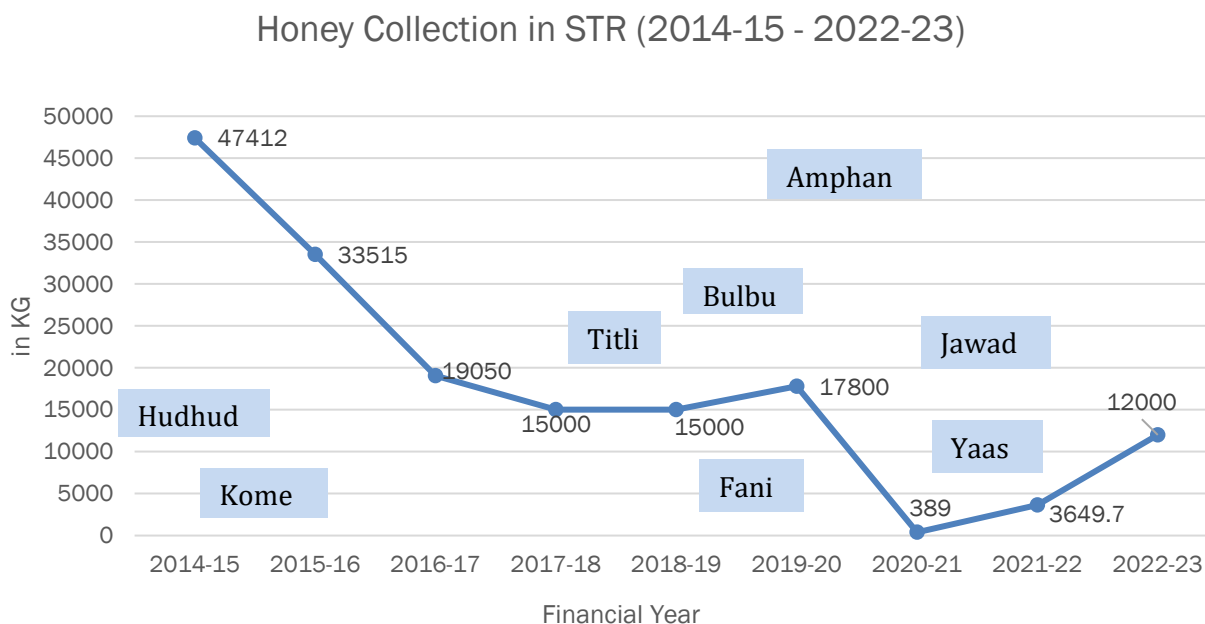


Figure 1: Honey Collection in STR (2014/15 – 2022/23) (Source: Sundarbans Tiger Reserve, Forest Department, Government of West Bengal, India)

In the light of the on-going climate change process it is now a question how these delicate ecosystems, diverse species and human habitats can be sustained, and for how long. As per the information of the Sundarbans Tiger Reserve Forest (West Bengal Government, India), Barking deer, Hog deer, Swamp deer, Wild buffalo, Javan Rhinoceros have become extinct in the Sundarbans in the last century.

3.2 Anthropogenic effects on the Sundarbans

In addition to the impacts of global warming, the anthropogenic activities too are affecting the Sundarbans ecosystems. The deforestation carried out by individuals and businesses are reducing the mangrove forest in size. The Bangladesh part of the Sundarbans lost 8.3 percent of the forest land 2000 and 2010 (Islam 2013). The big development projects like the Farakka dam in India have reduced the freshwater flows into the Sundarbans rivers, obstructing the freshening of the riverine water system for regulating salinity and eventually impacting aquacultural and agricultural diversities (Gain and Giupponi 2014). Similarly, the World Heritage Committee and the International Union for Conservation of Nature (IUCN) in its report in 2016 warned that the Rampal power plant in Bangladesh posed a serious threat to the World Heritage site of the Sundarbans. The power plant construction-led air pollution through coal ash, pollution from wastewater and waste ash, amplified shipping and dredging activities, and the adverse effects of amassing industrial and allied development infrastructure were some of the environmentally detrimental factors highlighted in the report (Doak et. al. 2016).

The waste management plan to protect the sensitive biodiversity region is also not up to the mark. For example, the Indian part of the Sundarbans have become susceptible to chemical and other

pollutants because of discharge of untreated domestic and industrial effluents to the tributary rivers flowing inside the Sundarbans (Smarzhevskiy 2013). The incidences of oil spills especially in the Bangladesh side of the Sundarbans are further worsening the situation (Sunny 2017). Last but not least, the growth of tourism in the region is disturbing the balance between livelihoods and biodiversity (Jamal et. al. 2022) It is yet to be assessed how much destruction has already taken place by all these pollution and waste related factors. For example, the following figure depicts the growth of tourists from 2012-13 to 2022-23 in the core forest of the Sundarbans Tiger Reserve/STR (West Bengal, India). The number of tourists has almost increased by 71 percent between 2012-13 and 2022-23. Except the year of 2021-22, because of the lockdown restriction on the grounds of Covid 19, there has been a steady increase of tourists since 2012-13. The tourism-related activities are increasing carbon footprints on the delta, and the field information revealed that the waste management plan for the Sundarbans tourism is inadequate. So tourism has become a tough trade-off for the vulnerable ecosystems and its cash-starved people.

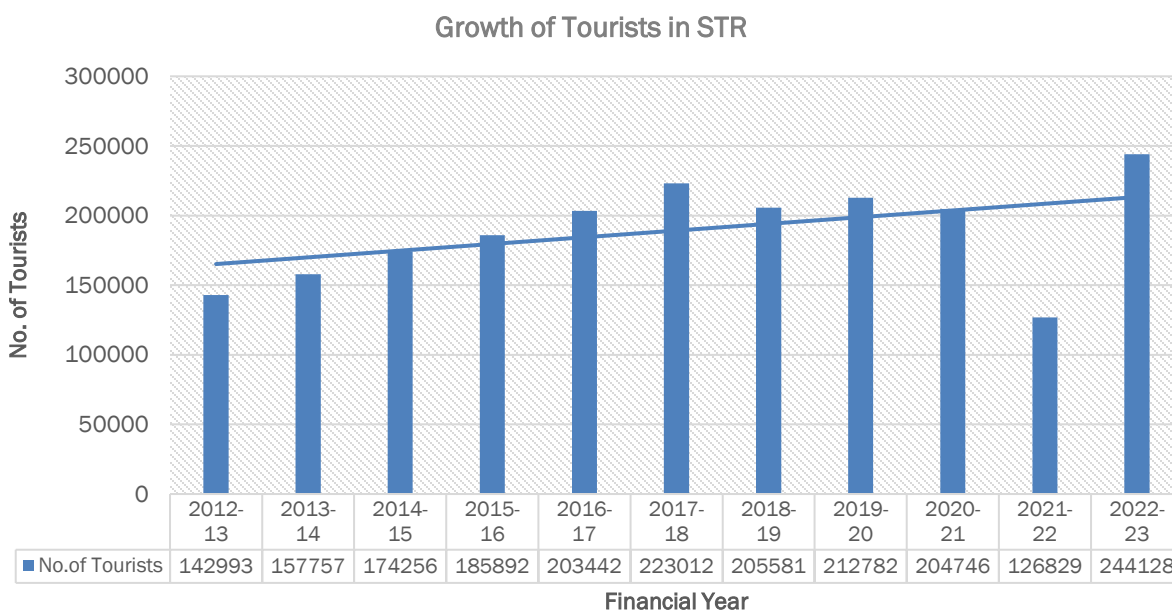


Figure 2: Growth of Tourists in STR (Source: Sundarbans Tiger Reserve, Forest Department, Government of West Bengal, India)

3.3 Timeline study of the Sundarbans landscape

High on the map of global climate vulnerability, the Sundarbans delta needs urgent attention. Our timeline study of the Sundarbans landscapes using the Google Earth Pro software shows three important changes in the last four decades. They are evident from these four GIS (Geographic Information System) photographs.

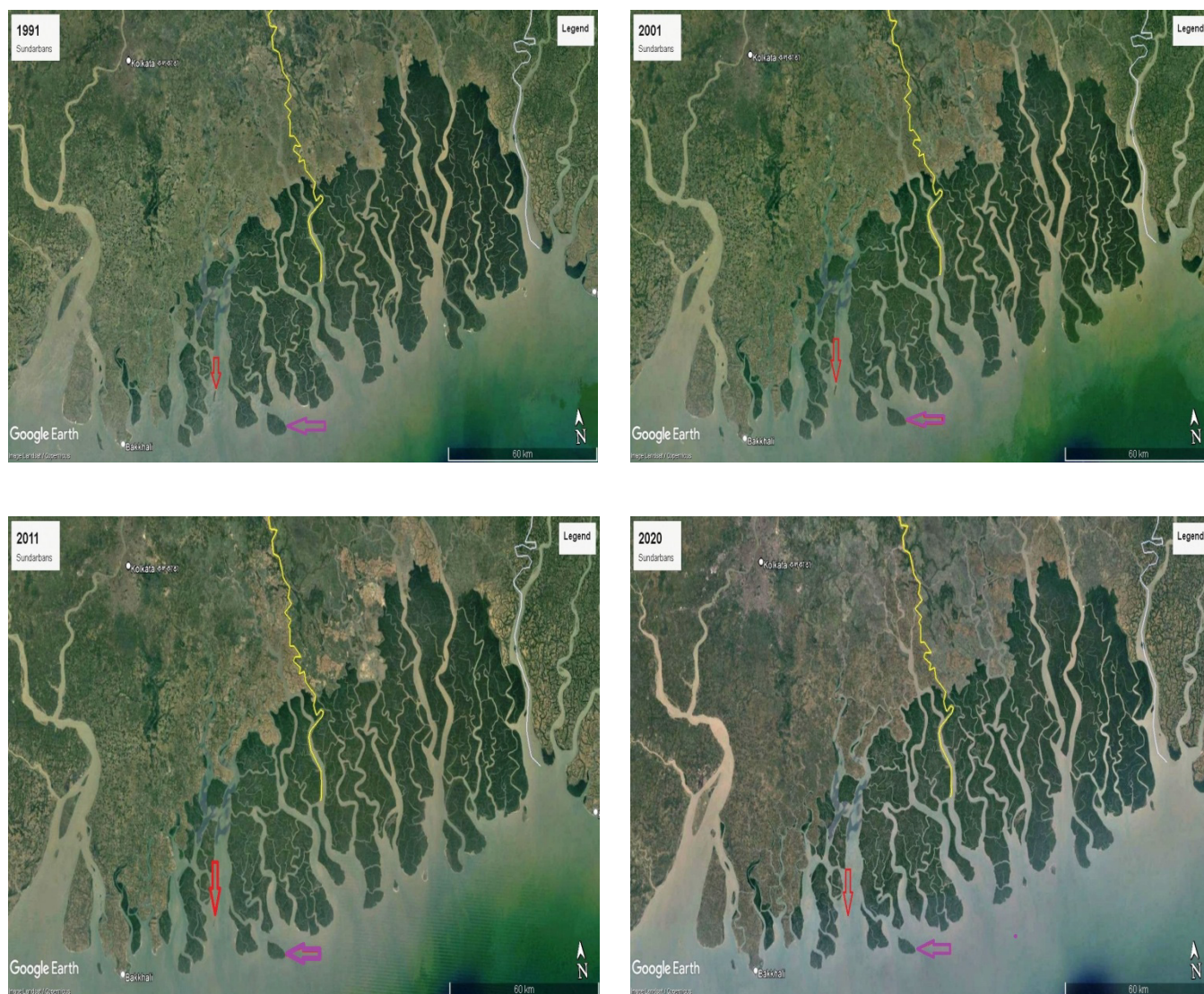


Figure 3: Satellite maps of the Sundarbans (1991 – 2020) (authors' own elaboration)

First, the overall greenery in the Sundarbans biosphere region has significantly decreased from 1991 to 2020. Second, the Sundarbans islands are shrinking heavily because of landslides and soil erosion. In the Indian side of Sundarbans delta area, the Jingira Island is now completely washed away in the ocean (as indicated by the red arrow). The similar incident happened with many small islands, which are not possible to detect through satellite monitoring. Another big island, Bhangaduani, has been thinning heavily since 1991. Considering the island's state in 2020, the Bhangaduani Island may be the next Jingira in the near future (as indicated by the violet arrow). Third, the phytoplankton community in the water of the Sundarbans are disappearing fast, as shown in the changing greenish colour of the water between 1991 and 2020 pictures. Phytoplankton has an important role in combatting climate change by inducing the splitting of climate-relevant gases between the ocean and atmosphere, while it also serves as the central pillar of the aquatic food chain (Bhattacharjee et. al. 2013). The loss of phytoplankton in the coastal ecosystems of the Sundarbans bears therefore

significant environmental consequences. It has a relationship with thermal expansion and ocean acidification.

3.4 Impacts on human health

The climatic and anthropogenic actions on the ecosystems of the Sundarbans adversely affect human health, especially of women and children in the region. In both sides of the Sundarbans, the environmental factors alone caused approximately 3'800 premature deaths and 1.9 million cases of illness every year (World Bank2020). Climate change is also providing a conducive environment for the transmission of vector borne diseases due to the extension of seasonal transmission time and even expansion in geographic coverage. In certain islands, nearly 42 percent of habitants are suffering from infectious diseases like malaria and dengue (Mukherjee and Siddique 2018). Frequent occurrences of flood and cyclones are denying fresh drinking water and food, which affects the health of mother and children alike. Among the vulnerable groups 3 of every 5 children are found to be stunted in the Sundarbans (The Hindu Business Line 2013). According to a study conducted in 2010, the average morbidity rate in the Sundarbans was higher than the state (West Bengal) average. The study also found high prevalence of mental health issues and excessive burden of malnutrition among the children and women in the Indian side of the Sundarbans (Kanjilal et.al. 2010). This summary of health status shows how the ecosystems vulnerability are implicating the health of humans in the Sundarbans.

3.5 The rift in the social contract

The analysis presented in sections 3.1 to 3.4 reveals that the Delta is confronted with multiple threats, such as increasing temperature, rising sea levels, severe cyclones, salinity intolerance, mangrove loss due to land erosion and deforestation, pollution and other factors. The situation analysis indicates that both climatic and anthropogenic actions are not only distressing the ecosystems of the Sundarbans but also creating a rift in the delta's social contract.

The social contract in a context like the Sundarbans is not only limited to the state and its citizens or individuals, but it also includes the nature and animals. Each one of them is a party to the Sundarbans' social contract, yet they are violating the contracts on their own terms. From the state side, despite the continuous advocacy of several international bodies, the governance mechanisms at domestic, national and inter-governmental levels are failing to protect the Sundarbans. According to the World Heritage Charter, UNESCO has been advocating for several years to establish an ecological monitoring and surveillance system for the Sundarbans World Heritage Sites in India and Bangladesh. However, it is still at the proposal level for the respective countries. There is an urgent need for a combined action plan to restore and conserve the Sundarbans, but no policy uptake is visible so far.

Similarly, the delta's fast changing ecosystems is also bringing behavioural changes in humans, animals and environment. The water salinity makes the agricultural and freshwater fishing, once the foremost livelihood activities, economically less attractive. This pushed many habitants of the islands to convert their agricultural land into aquaculture to culture exotic shrimp. This has long-term

environmental risk at the cost biodiversity change permanently (Giri et. al. 2022). There are even examples of converting agricultural land into brick fields for better income opportunity (Priyadarshini 2015). Concomitantly, the climate change-induced land erosion and anthropogenic deforestation severely curtailed the average territory of the Sundarbans' wild animals (such as the Royal Bengal Tiger). Moreover, illegal forest infiltration for livelihood opportunity is also increasing because of continuous economic distress. This eventually is causing human – animal conflicts for not respecting each other's sovereign territories (Bera et. al. 2022). Over and above, the thinning of mangrove and forest coverage are destructive for global warming as the Sundarbans mangrove's carbon intake capacity is steadily decreasing over the period (Islam 2023). This environmental degradation places high burdens in terms of health costs, owing to environmental pollution, for the entire biosphere population and its adjacent urban clusters (such as Calcutta). All these factors are putting the social arrangements between the state and citizens in a fragile condition.

The rift in the existing social contract is innately complex and leading to complicate the policy and planning further. While this is a structural crisis for a climate-threat region, it is also an opportune moment to initiate a new process of change.

4. One Health: An Eco-social pathway for Sustainable development

The Sundarbans' present situation calls for an emancipatory change to address the ever-increasing rift in the delta's social contract. The social contract theory has its origins in political philosophy. It can inform governance systems how to devise its responsibilities when crises emerge that affect the established consensus in relation to the role of the state. The balance of power between citizens and the state is always contested and is thus a delicate deal. While theoretically there are possibilities of new roles of the state in these times of emerging environment risks (Dryzek et. al. 2022), the climate case is a critical agenda for any government to build consensus since the distribution of risk (and subsequent burden) is uncertain and also uneven (Pelling 2010).

The people of the Sundarbans are facing the wrath of climate-induced vulnerabilities for global, national and regional anthropogenic causes. They are not in violation of nature, rather subjects of immediate victims to natural disasters. The upstream causes of ecosystems vulnerabilities made them to defy certain negotiated arrangements for securing livelihoods, such as change in land usages (from agriculture to fisheries to brick field) or exploit tourism-related businesses. At the instances of continuous threats to life and livelihood, there is now forced migration from the Sundarbans (70). At the bottom of all these is unsustainable use of ecosystems services at the cost of human, animal and ecosystems health and suffering. In order to overcome these suffering and foster stability, a new contract has to be negotiated on the lines of justice, equality and sustainability. This needs a new approach of governance and programmatic pathway towards the goal.

4.1 Resilience, adaptability and transformation cycle

Some recent applications of governance innovations suggest that renegotiations of social contracts may be possible by taking the path of adaptation, resilience and transformation (O'Brien 2012; Kates

et. Al. 2012; Park et. Al. 2012). Based on the experiences of Covid-19, the resilience concept is redesigned as a multisystemic understanding for societal resilience to maintain the stability of essential functions while mitigating the adversities of sudden shocks (Wernli et. Al. 2021). The Intergovernmental Panel on Climate Change Special Report proposes incremental adaptation and transformation in social and economic structures in order to build a climate-resilient society (IPCC 2020). In this regard, the inclusion of community participation is found to be an important criterion in the development of adaptation planning and devising resilience mechanisms (De Sherbinin et al. 2011; Few et. Al. 2007). Thus finding pathways towards a renewed social contract is now a necessity for the Sundarbans to process resilience, adaptability, and transformation in its ecosystems including of humans and animals.

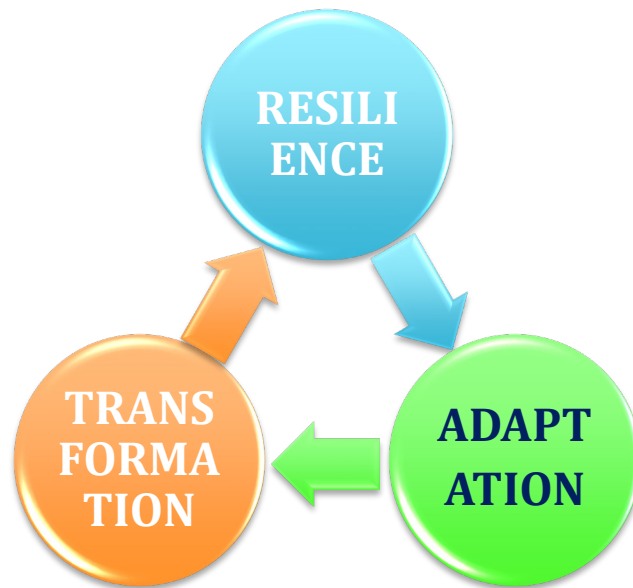


Figure 4 : Path dependence transformation cycle (authors' own elaboration).

The cyclical process of resilience-adaptability-transformation is vital to introduce new policies and make attempts for bringing changes. It has already seized the attention of the global policy community, like the Resilience Adaptation Transformation Assessment (RATA) Framework (O'Connell et. al. 2005). The usage of any such frameworks is illuminating in the different sectors of governance. However, there is at first a need to understand what the utility of these frameworks in a context like the Sundarbans would be. Any climate vulnerable context is primarily aiming at social and ecological sustainability while maintaining equilibrium among different economic interests (O'Connell et. al. 2005). Socio-economically this equilibrium is mediated by the political governance of the state, but socio-ecologically it is the ecosystems' biodiversity that maintains the very equilibrium. This entails why the role of the state in biodiversity protection is crucial in maintaining social and ecological sustainability.

4.2 Biodiversity and sustainable development

There is ample evidence to suggest that aggressive economic growth expedites biodiversity loss due to resource consumption and higher emissions (Otero et. al. 2020). The Sundarbans experience also concluded that various anthropogenic activities at the behest of a range of economic actors and global warming (which is again at aggregate level caused by the growth factors) are endangering the biodiversity of the delta's ecosystems. Biodiversity is considered as the genetic diversity within and between species, their functional properties and the diversity of habitats both on land and under water. In the discourse of sustainability, its main function is to provide ecosystems services that form the basis of human and animal existence on earth.

In the climate vulnerable zones, on one side, the sustainability question is rooted into the environmental crises of degrading ecosystems services that are severely endangered by the drastic loss of biodiversity in recent decades. The damage in ecosystems services means incurred losses in the economic activities (such as, agriculture, forestry, fisheries, tourism and etcetera) that are directly supported by biodiversity processing (Dietz and Adger 2003). On the other side, the sustainability issue is linked to the safety and security of human and animal well-being. The degradation of biodiversity directly and indirectly impacts the health of human, animals and plants, which in turn affect the ecosystems health (Schmeller et. al. 2020: 33; Keesing and Ostfeld 2021; Diaz et. al. 2007). Ecosystems health is a necessity for ecosystem service provisioning, such as clean air, safe water, soil health, and thus the well-being of humans and animals. So the emphasis on biodiversity restoration and protection can safeguard the health interests of humans, animals and overall ecosystems.

There are conceptual attempts made in the past to link sustainable development with biodiversity and human well-being (Shahid et. al. 2016). This gives a mandate to mainstream biodiversity by instilling values of natural ecosystems into the growth model of economic development. This is recognised by several global development goals (SDG 14 and 15), international convention (Convention on Biological Diversity) and the 2011-2020 Aichi Biodiversity Targets (OECD 2018). On the pathway of a new eco-social contract, the agenda of mainstreaming biodiversity is not limited to the promise of optimal utilization of ecosystems services, rather ensuring the sustainability of ecosystems services while meeting development goals.

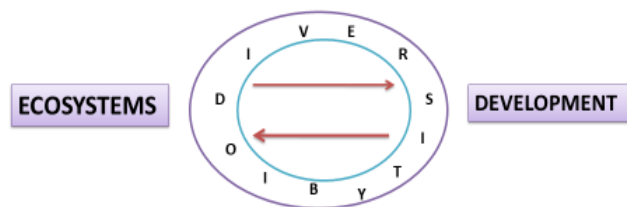


Figure 5: Biodiversity as an equilibrium between ecosystems and development (authors' own elaboration).

SDG 15 upholds to “protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss” (UN 2015). Eco-social contracts within the governance framework of resilience, adaptive capacity planning and structural transformation in a climate-vulnerable context need to be developed with an agenda of biodiversity restoration and conservation to achieve sustainable development. To this end, a programmatic action is needed to inform both citizens and the state on the importance of biodiversity of vulnerable ecosystems for achieving sustainability.

4.3 Application of One Health in the Sundarbans

Biodiversity conservation and protection is essentially an environmental management plan. The biodiversity strategy frameworks prepared by various governance actors (national-regional-intergovernmental) are mostly based on the principles of legal provisions, ecological monitoring, public awareness and so on (European Commission, Directorate-General for Environment 2021 and Federal Office of the Environment. 2017). The formulation and execution of such plans are at the full remits of national and regional governments. As a top-down model, these strategy frameworks are more of governance directives and not intervention operations. While the directives are indeed necessary to govern policies, programmatic design is also a requisite action to implement the policy objectives. There are programmes being developed to protect biodiversity through social, ecological and even fiscal interventions. On the pathway of a new contract in the Sundarbans ecosystems, a health intervention is innovated to address the loss of biodiversity and achieve sustainability among the ecosystem services for ensuring both public health and environmental benefits

The one health approach is proposed to plan an intervention design in the climate -vulnerable context of the Sundarbans. It is modelled in three steps.

1. It is necessary to identify the ecosystems of a particular context. For example, the Sundarbans has all four types of ecosystems; terrestrial, forest, coastal and agricultural. Based on the types of ecosystems, the ecosystems services are required to track, and accordingly map their linkages with human and animals.
2. Once the human-animal-ecosystems services’ interfaces are documented, the triad needs to be studied using the approach of Health in All Policies (HiAP) to identify and assess the impacts of various determinants on the health of human, animal and ecosystem services. Thereafter, the categorization of determinants (such as social, ecological, economic, political, cultural and so on) in relation to their origin (that is pathway of embodiment) at macro/global, meso/national, and micro/regional levels is required to perform.
3. Based on the determinants’ matrix made, there is a requirement to prioritize studies especially for better understanding of the human-animal-ecosystems services interfaces to conduct epidemiological or epigenetic surveillances. Similarly, a set of policies (or policy mechanisms) needs to be developed to address the causal determinants of human, animal and ecosystems health. At last, the service design and advocacy activities should also be developed to prioritize one health actions.

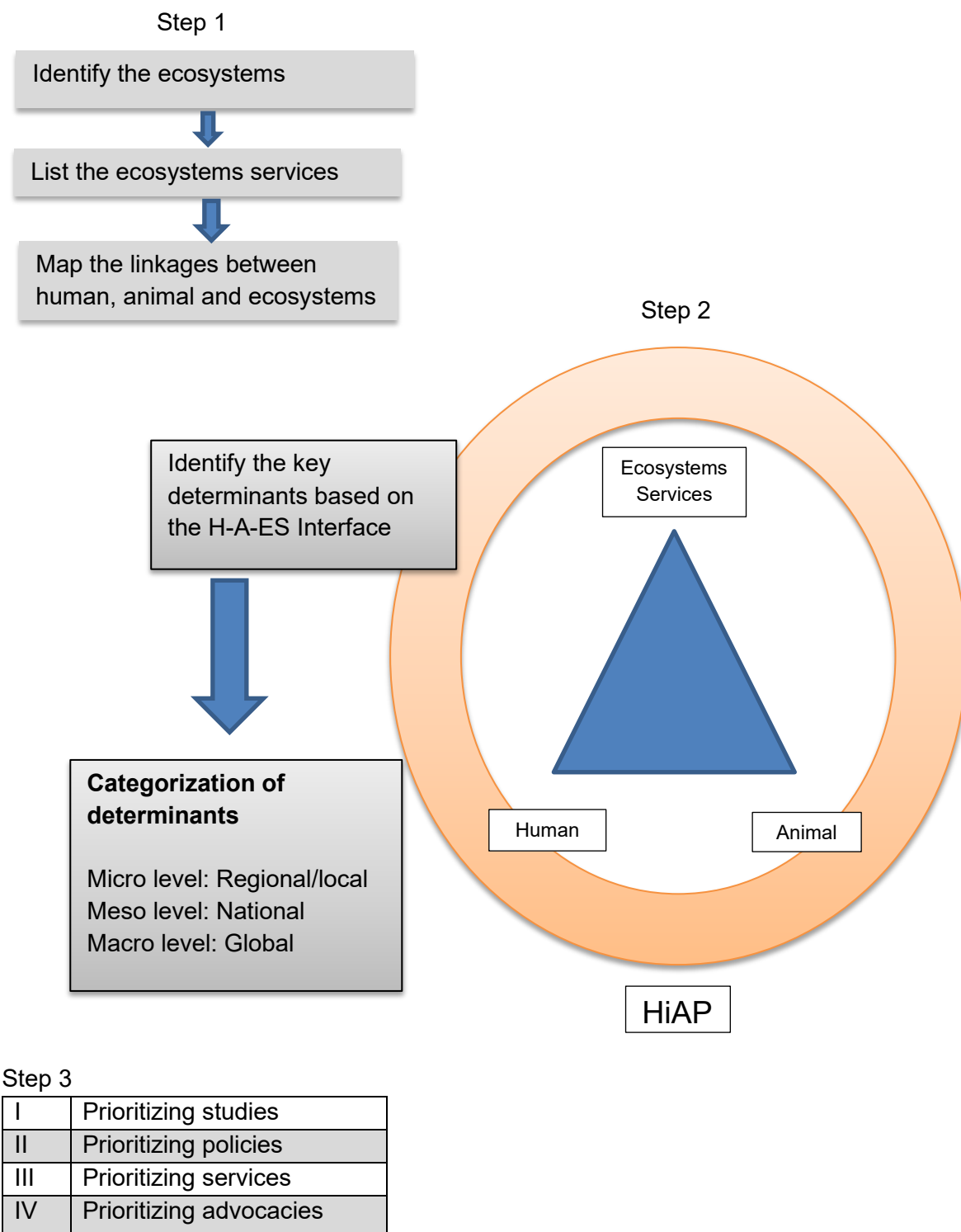


Figure 6: One Health Intervention Design (authors' own elaboration)

The above intervention design needs inter-sectoral and transdisciplinary collaborations to work at the interface of the triad and systematically navigate the complex pathways of various determinants. One health's principles of 'equity, parity, equilibrium, and transdisciplinary practices' are further emphasising the need for a new eco-social contract (OHHLEP 2022).

5. Current Approaches at the International Level to Address the Human-Animal-Ecosystem Interface

The human-animal-ecosystem interface is a circular process. There are currently four different types of initiatives in practice to work at the interface of human-animal-ecosystems. It is not objectivized explicitly in all the four initiatives, but the concerning goals of these initiatives eventually work at the interface of the triad. The four initiatives are: UNESCO's Man and Biosphere, IUCN's Nature Based Solutions, the UNEP's Nature for Health investment, and the WHO-WOAH-FAO-UNEP One Health approaches.

5.1 UNESCO's Man and Biosphere (MAB) programme

UNESCO, in collaboration with its Member States, has been devising global strategies to utilise earth's resources judiciously and effectively since 1970. The MAB programme, initiated in 1971, is the oldest among all. The MAB and the Convention for the Conservation of the World Cultural and Natural Heritage (to enunciate a World Heritage List of Cultural and Natural Sites), held in 1972, are very effective internationally constituted mechanisms to protect and conserve the natural resource-rich geographies of international importance. Along with the UNESCO designated globally important sites, the Convention on Wetlands, popularly known as the Ramsar Convention in 1971, is another internationally agreed legal instrument to conserve wetlands and judiciously use of their resources.

MAB is an important policy framework for the World Network of Biosphere Reserves (WNBR). The foremost goal of MAB is to “*develop and strengthen models for sustainable development*” in WNBR through introducing and testing new policies, tools and technologies (UNESCO 2017:16). The strategic objectives of MAB (2015 – 2025) emphasize the needs of biodiversity conservation and restoration of ecosystems services and their improvement in the Sundarbans like biosphere regions. It promotes biodiversity, and through sustainability science and education and supports mitigation and adaptation to climate and anthropogenic changes. Its second objective is very much aligned to foster an eco-social contract by “building sustainable, healthy and equitable societies, economies and thriving human settlements in harmony with the biosphere” (UNESCO 2017:17). This particular objective has the provision to support the biosphere reserve act, which the states could emancipate to facilitate a ‘sustainable contract’.

UNESCO's MAB is a global policy agenda to internationally govern the sites of biodiversity importance. It is an overarching framework to sensitize, stimulate and expedite the political commitments needed for a biodiverse world. It has immense flexibility to develop context-specific policy and programmatic action to protect and conserve biospheres. Moreover, the Sundarbans in Bay of Bengal is transboundary biosphere reserve in nature. The MAB has the political leverage to reinforce multi-level dialogues involving both Bangladesh and India to strengthen capacities for a combine transboundary biosphere management plan.

5.2 UNEP's Nature 4 Health investment initiative

In 2022, to advance the agenda of biodiversity-climate-health collaboration, UNEP, and the Secretariat of the Convention of Biological Diversity (SCBD) with the financial support of the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) (through Germany's International Climate Initiative), established a Multi-Partner Trust Fund (MPTF) on 'Nature for Health'. It is a consortium of several UN agencies (UNEP, WHO, UNDP, OIE), international organizations (IUCN) and civil society groups (EcoHealth Alliance) active in health and environment. The Fund aims to support the countries in their effective policy-making exercises for preventing future pandemics by using the application of One Health approaches. In the aftermath of the Covid-19 pandemic, the Fund is envisaged as an instrument "for putting nature on a path to recovery", as stated by Elizabeth Maruma Mrema, the Executive Secretary of the Convention on Biological Diversity (UNEP 2022).

5.3 IUCN's Nature-based Solutions

Nature-based Solutions (NbS) are now recognised as effective health intervention strategies. In urban settings, the closeness to natural environments is proved to be beneficial for psychological (such as lowering stress level) and physiological (increase in physical movements) activities (Kolokotsa et. al. 2020). IUCN, in collaboration with WHO, is in the process to prepare guidelines for integrating health with the NbS to protect biodiversity, nature and ecosystems health. It is conceived that investing in NbS to protect, conserve and restore natural ecosystems will enable health, biodiversity and climate agencies, especially at the global level, to work in a coordinated manner to address the root causes of health risks associated with ecosystem degradation, biodiversity loss and climate change (IUCN 2022). The additional benefit of using NbS in a typical climate vulnerable context is to aid the processes of social and ecological resilience. It is another example of policy coherence at the global level between public health, environment and climate agendas.

5.4 One Health for a healthy and sustainable future

One Health Joint Plan of Action for research and policy deliberations (2022-2026), was launched by the Food and Agriculture Organization of the UN (FAO), the UN Environment Programme (UNEP), the World Health Organization (WHO), and the World Organisation for Animal Health (WOAH) in October 2022. The examples from the Sundarbans ecosystems show that One Health could act as a system catalyst for promoting sustainable development by fostering the health of humans, animals, plants and the environment.

6. Conclusion

The above initiatives at the behest of various multilateral and international organizations entail the need for considering human, animal, and ecosystems health and well-being in the objectives of a one health policy and implementation plan. To this end, the UNESCO designated Biospheres and Ramsar

sites could be very effective fields for One Health implementation. They are also strategic climate hotspots and hold enormous importance in creating a healthy and sustainable future. In this regard, the upscaling of the Sundarbans study is very much needed to test the full potency of one health approach in contributing to the goals of public health and environmental management.

A multi-level governance collaboration should be envisaged to strategically pick climate hotspots for one health intervention. This will also enable the intervention sites to adapt and adopt to a new eco-social pathway for sustainable development.

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