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# Wetland–agriculture interactions: sustaining intergenerational ecosystem services

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When I received the letter from the President of the Agricultural Economics Research Association (AERA), India, Dr P K Joshi, informing me of the decision of the association to elect me to preside over the 29th Annual Conference of the AERA, I was humbled.

I consider it a great honour and privilege to address the distinguished members of the association and am thankful to them for electing me the president for the 29$^{th}$ Annual Conference. I wish to place on record my appreciation to Dr P K Joshi, the past presidents of AERA, and conference presidents whose thoughts, ideas, and hard work have nurtured the AERA.

I am also aware of the contribution of the members of the executive and the editorial board, and all members, over the years adding professional values to AERA and its research journal. My sincere appreciation for the fact that not only did they contribute towards the development of the field of agricultural economics but also devised ways and means through which AERA addresses socially and contextually relevant agrarian issues at different policymaking levels.

At this auspicious moment, I wish to express my gratitude to Prof William E Phillips, University of Alberta, Edmonton, who has been my mentor since the 1970s, in helping me to understand complex natural and environmental ecosystems, including wetlands. I owe an intellectual debt to him.

Prof Daniel W Bromley, University of Wisconsin-Madison, has always been generous in encouraging me to promote natural resource economics teaching and research in the Indian context.Over the years, his scholarly writings have added value to my understanding of complex ecosystems and public policies. I am grateful to him for shaping my thoughts about institutional economics of natural and environmental ecosystems.

I have benefited greatly over the years from the joint work I did with a dear colleague and friend, Prof Brij Gopal, an internationally known wetland ecologist. He unexpectedly passed away early this year, a great personal loss to me and the community of interdisciplinary scholars. Both of us began working on natural resources and wetlands in the early 1990s. I would like to mention here a few of our joint initiatives pertaining to wetlands:

- assessment of the Ecosystem Services of River Ganga (a joint initiative of National Mission for Clean Ganga, World Wildlife Fund, and National Institute of Ecology (NIE)).
- Integrating the Economics of Wetland Biodiversity and Ecosystem Services in Management of Water Resources of River Ken, India. The Economics of Ecosystems and Biodiversity (TEEB) - India Initiative.
- Conserving the Wetland Wealth of Chhattisgarh (a joint initiative of the NIE and Chhattisgarh State Planning Commission.

Presidential address delivered at the 29th Annual Conference of the Agricultural Economics Research Association (AERA), India, held at the Odisha University of Agriculture & Technology, Bhubaneswar, 27 October 2021.

- Strategies for Water and Food Security in Bundelkhand in the Face of Climate Change (a joint initiative of the NIE, Centre for Inland Waters in South Asia, and National Bank for Agriculture and Rural Development (NABARD).
- Integrated Management of Water Resources of Lake Nainital and its Watershed: An Environmental Economics Approach (a joint initiative of World Bank; the Ministry of Environment, Forests and Climate Change (MoEFCC) of the Government of India (GoI); and Indira Gandhi Institute of Development Research (IGIDR); and
- Tanks and farm ponds versus reservoirs, a viable solution to water security

We had also jointly organized capacity-building programmes in South Asia: water science and policy for sustainable development (NIE and Chhattisgarh Council of Science and Technology-CCOST) and capacity-building for conservation of biodiversity and ecosystem services of wetlands in relation to global climate change (Asia-Pacific Network for Global Change Research, Japan).

I pay my humble tribute to my friend Brij Gopal, who had tremendous capability to work with an interdisciplinary team to address the socio-economic, cultural, and political issues of the wetland ecosystem.

I stand here at this great institute of learning to speak on wetland-agriculture interactions and ecosystem services issues, a topic that fits well within the historical, socio-economic, cultural, and wetland architectural tradition of Bhubaneswar, the holy city. Most of you may know that Odisha had the distinction of having the first internationally important wetland tag (Lake Chilika). I have chosen this topic primarily for four reasons.

The Convention on Wetlands of International Importance Especially as Waterfowl Habitat[1] ("Ramsar Convention" or "convention") adopted Resolution VIII in 2002 to enhance the interactions between agriculture, wetlands, and water resource management. Subsequently, in support of the UN International Year of Family Farming, Ramsar's theme for World Water Day 2014 was wetlands and agriculture. That is the first.

Second, in the Indian context, wetlands in general, and wetland–agriculture interactions, in particular, have not received even skimpy attention over the decades of the members of the Indian Society of Agricultural Economics, AERA, and other economics-centric societies.

Third, the economic value of the goods and ecosystem services of wetlands, including their contribution to livelihoods and rural economy, is rarely accounted for in the social- ecological cost-benefit analyses of various development projects and in designing policies. Such understanding is extremely important as wetland ecosystems in India are basically multi-use and multifunctional common pool resources.

Fourth, India has no specific policy for wetland conservation and management.

To me, an inadequate research base seems to be a major deterrent in policy problem analysis, conservation, and wise use of wetland wealth in India. I sincerely believe, based on my research on wetland–agriculture interactions, that this interaction is critical to achieve a good number of Sustainable Development Goals (SDG) if the twin issues of inadequate research base and policy problem analysis can be addressed using an appropriate institutional analytical framework. For nearly four decades now, I have been concerned with the role of institutions in the sustainable development of renewable common pools in general and wetlands in particular.

For this address, I have put together my thoughts and writings that have evolved over years of research and learning. Today, I will deal with the issue of wetland–agriculture interactions and their contribution in sustaining lives and ecosystem services. I begin my address with three caveats.

First, I have adopted the Ramsar Convention's definition and classification of wetlands, as the MoEFCC (GoI) has included and excluded certain categories of wetlands in the Wetland (Conservation and Management) Rules, 2010 and 2017, and these differences may create a confusion between the

[1]The representatives of a few international organizations and national governments signed the agreement at Ramsar, a city in Iran on the Caspian Sea, on 2 February 1971.

Convention framework and the national rules, despite the fact that India is a party to the Convention.

Second, for the purpose of this address, I restrict the scope to human-made inland rural wetlands and, most importantly, the wetland–agriculture interactions (WAIs) practiced in these wetlands.

Third, the assessment of WAIs is based on four different types of multiple-use and multifunctional village wetland, managed under common property regimes. A few are also managed under private ownership.

After having briefly mentioned the theme of my address, I now proceed to discuss some basic concepts and issues of wetlands in the context of India and the Ramsar Convention.

This discussion is followed by an account of the extent, threats, and benefits of wetlands.

I also describe briefly the institutional framework I have applied for analysing the wetland–agriculture interactions under different property rights regimes or resource regimes.

Thereafter, I discuss the performance of some important practices of the wetland–agriculture interactions in multi-use wetlands being managed under alternative resource regimes and ecosystem services derived from different types of wetlands.

Finally, I identify a few emerging issues for further research and policy interventions in sustaining wetland wetland-agriculture frontiers.

## Wetlands: India and Ramsar Convention

Wetlands are places where water accumulates for sufficiently long periods of time to allow the occurrence of plants and animals specially adapted to the water-dominated environment.

Wetlands occur in all climatic zones and practically in all parts of the world. They occur along the rivers, streams, lakes, reservoirs, and sea coasts; in arid deserts (oases and saline lakes); from below the sea surface (coral reefs) to snow-clad mountains (glacial lakes); and even below the ground (caves and karst systems) (Gopal and Marothia 2017).

Wetlands drew attention in western countries during the 1950s and 1960s for their huge migratory water bird populations. The representatives of a few international organizations and national governments signed the Ramsar Convention on 2 February 1971. The convention was originally contracted by seven countries when it came into force on 21 December 1975. As of October 2019, there are 171 contracting parties and over 2,000 designated sites covering over 200 million hectares.

The Ramsar Convention aims at "the conservation and wise use of wetlands with local, national and international cooperation for overall sustainable development of the world" (Ramsar Convention Secretariat 2016, 14). The convention provides a platform for stepping up action to accomplish the aspiration of the SDGs (Ramsar Convention Secretariat 2016).

Wetlands are a distinct category of ecosystem that has its own international convention, the Ramsar Convention, for international cooperation on wetland conservation. The Ramsar Convention works and collaborates with international organizations and a network of other Convention partners. In the past 50 years the convention has introduced many resolutions for sustaining different types of wetlands in the changing socio-ecological systems. However, despite Ramsar's incredible achievements, the threat to the health and survival of many wetlands across the globe has not diminished since 1971(Bowman 2002. Marothia 2019).

The Ramsar Convention entered into force in India on 1 February 1982 and designated Keoladeo National Park (Bharatpur) and Lake Chilika (Bhubaneswar, Odisha) as internationally important wetlands. Since then, India has designated 42 sites as Wetlands of International Importance (Ramsar Sites) under the Ramsar Convention, with a surface area of 1,067,939 hectares. Despite several wetland-related programmes and activities at the central and state level, there has been, however, increasingly greater concern about the degradation and loss of wetlands in different parts of the country.

### Wetlands

The Ramsar Convention has adopted a rather broad definition of wetlands to cover almost the whole range of inland and coastal aquatic ecosystems. Under the text of Ramsar Convention Article 1.1, "wetlands" are defined as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres".

"may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands" (Ramsar Convention Secretariat 2013).

For practically the same reason, the Ramsar Convention considers lakes and rivers also as "wetlands in their entirety, regardless of their depth" (Ramsar Convention Secretariat 2013).

The Ramsar Convention (2013) recognizes five major wetland types:

- marine (coastal wetlands including coastal lagoons, rocky shores, seagrass beds and coral reefs);
- estuarine (including deltas, tidal marshes and mudflats, and mangrove swamps);
- lacustrine (wetlands associated with lakes);
- riverine (wetlands along rivers and streams); and
- palustrine (meaning "marshy" – marshes, swamps, and bogs).

In addition, there are human-made wetlands such as fish and shrimp ponds, farm ponds, irrigated agricultural land including rice paddies, salt pans, dams, reservoirs, gravel pits, wastewater treatment ponds, and canals.

The Convention has adopted a Ramsar Classification of Wetland Type, which includes 42 types, grouped into three categories: marine and coastal wetlands, inland wetlands, and human-made wetlands (Ramsar Convention 2016).

The Ramsar Convention cuddles diverse environments, spatially and temporally, but also in terms of physical size, ecology, hydrology and geomorphology in a single definition, grouping together a wide variety of landscape units whose ecosystems share the fundamental wetland characteristic of being strongly influenced by water (Davis 1994).

Although a wide variety of wetland definitions is used by different scholars[2], the fact remains that some 171 countries have adopted a common definition by signing the Ramsar Convention on Wetlands of International Importance. The Convention adopts an exceptionally broad approach in determining "wetlands" which come under its aegis (Ramsar Convention Secretariat 2018).

## Wetlands: Extent, Threats, and Benefits

### Extent of Wetlands

Estimates of wetlands' coverage of the earth's surface are not known precisely. According to a recent report of the Ramsar Convention (2018), global inland and coastal wetlands cover over 12.1 million square kilometre (sq km), an area almost as large as Greenland, with 54% of it permanently inundated and 46% seasonally inundated (cited from Global Wetland Outlook: State of the World's Wetlands and their Services to People. Gland, Switzerland: Ramsar Convention Secretariat 2018).

India has large physiographic diversity (from sea level to high mountains) and high average rainfall (120 cm) marked by extreme temporal and spatial variability. Therefore, India enjoys a rich diversity of wetland types. Over millennia, humans have modified and

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[2]The Ramsar Convention's definition of "wetland" reflects a hydrological perspective, with water as the key factor.
Other scholars stress the link between hydrology and biology and propose "ecohydrological" definitions. Yet others suggest geomorphological definitions (Dugan 1990, for example) or agricultural (crop) definitions (for example, FAO 1998).
Wetlands are "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land and is covered by shallow water" and "must have one or more of the following three attributes: at least periodically, the land supports predominantly hydrophytes; the substrate is predominantly undrained hydric soil; and the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year" (Cowardin et al. 1979).
Pittock et al. (2015) define wetlands as "places where water is the primary factor controlling plant and animal life and the wider environment, where the water table is at or near the land surface, or where water covers the land".
See McCartney et al. (2010) for a classification of wetlands in the context of agriculture and poverty.

managed most of the natural wetlands for specific purposes, such as paddy and fish. Innumerable tanks were created in the arid and semi-arid regions of western and peninsular India. More wetlands have also been created by damming the rivers (Gopal and Marothia 2017).

Whereas several attempts had been made earlier to document the wetlands in the country, they focused only on the better known habitats. In 1998, the Space Application Centre Ahmedabad (SACA) conducted the first survey based on remote- sensing satellite images (Gopal and Marothia 2017).

Recently, SACA conducted a study to estimate wetland areas in the country (Patel 2018). The study adopted the Wetland Classification System, based on the Ramsar Convention definition of wetlands, which provides a broad framework for delineating wetlands and is acquiescent to remote-sensing data. The SACA study considered all the aspects of a water mass including its ecotonal area as wetland. In addition, in the Ramsar Convention wetland classification, fish and shrimp ponds, saltpans, and reservoirs were also included as wetlands.

Besides using the Wetland Classification System, the SACA study incorporates deepwater habitats and impoundments. It estimates 15.26 million hectares (mha) of total wetland area, which is around 4.63% of the geographic area of the country. A total of 201,503 wetlands larger than 2.25 ha have been mapped at 1:50,000 scale. In addition, 5,55,557 small wetlands (<2.25 ha) have also been identified. Inland natural wetlands account for around 43.4% of the total area, while coastal natural wetlands account for 24.3%.

The human-made inland wetlands cover about 37% of the area (3,941,832 ha) and the remaining 63% are the natural wetlands (6,623,067 ha).

It is noteworthy that paddy fields are not included as wetlands in this inventory (Patel 2018). However, paddy fields are part of the Ramsar Convention definition, as mentioned in the earlier paragraph. For wetland statutes in India see also Bassi *et al.* (2014)).

## Threats to wetlands

In a comprehensive study of 189 wetland assessments, Davidson (2014) estimates that wetland losses in the 20th century were 64% to 71%, and for some regions, notably Asia, even higher. He found that

> "losses of natural inland wetlands have been consistently greater, and have occurred at faster rates, than [those] of natural coastal wetlands".

His review found that the extent of inland wetlands declined 69–75% during the 20th century, while coastal wetlands declined 62–63%. Further, 64% of the wetlands have disappeared since 1900. The loss has been four times faster in the 20th century. The loss of freshwater wetlands worldwide from 1997 to 2011 is valued at USD 2.7 trillion per year (Briggs 2014). India is losing wetlands at the rate of 2–3% each year (Prasher 2018). The drivers of this decline are overfishing, agriculture, deforestation, introduced species, climate change, water drainage, land encroachment, urban development, upstream and downstream pollution, uncontrolled growth of exotic species and the absence of wetland policy (see Marothia 1995 a, 1997, 2004 a; Gopal and Marothia 2017).

The most significant factor responsible for the present state of wetlands is the absence of a clear national or state policy devoted to wetlands, natural or man-made. Wetlands receive no attention in the development plans concerned with land use changes or the development of water resources (Marothia 1995 a, 1997, 2019, Gopal and Marothia 2017; Gopal 2018).

## Benefits of Wetlands

Wetlands, the most valuable ecosystem, provide services worth USD 47 trillion a year. More than a billion people rely on wetlands for income, and 40% of the world's species live and breed in wetlands. Annually, about 200 new fish species are discovered in freshwater wetlands. Aquaculture is the fastest-growing food production sector, while inland fisheries alone provided 12 million tons of fish in 2018. Rice paddies feed 3.5 billion people annually. Coral reefs are home to 25% of all species. Wetlands provide protection from floods and storms, with each acre of wetland absorbing up to 1.5 million gallons of floodwater. Wetlands help regulate the climate. For example, peat lands store twice as much carbon as forests, with salt marshes, mangroves, and seagrass beds also holding vast amounts of carbon (cited from Global Wetland Outlook: State of the World's Wetlands and their Services to People. Gland, Switzerland: Ramsar Convention Secretariat 2018).

Humans benefit in many ways from all kinds of wetlands. These benefits arise either directly from the use of the water, plants, animals, soils, and other components of the wetland ecosystem, or indirectly from their ecosystem functions. These benefits are now called ecosystem services and categorized into provisioning, regulating, supporting, and cultural services (Gopal and Marothia 2017).

Irrespective of the kinds of organisms living there, the most important function of wetlands is to regulate the hydrology of the region. The retention of water in them controls flooding (especially downstream), recharges groundwater, and provides water for various human uses including irrigation. The amount and duration of water in the soil and above it governs the diversity of biota, which mediates other ecosystem functions and determines various benefits. Indirectly, wetlands support high levels of biodiversity (fish, frogs, turtles, birds, molluscs, arthropods, and insects) by providing habitat and food Thus, various kinds of wetlands differ in their dominant biota and the ecosystem services (Gopal and Marothia 2017; for the details of ecosystem services derived from different categories of wetlands, see Marothia( *forthcoming* ).

Another highly important function of wetlands benefitting the humans directly is related to their recreational (swimming, bathing, diving, boating, angling, fishing, bird watching) and social-cultural use, besides contribution to the aesthetics of the surroundings (Gopal and Marothia 2017).

**Wetlands and Sustainable Development Goals (SDG)**

Wetlands are implicitly or explicitly mentioned in the SDGs mentioned in the Ramsar Convention's fourth Strategic Plan 2016–2024. The sustainable use of water and wetlands, by protecting the services they provide, is critical to enable society to achieve sustainable social and economic development, adapt to climate change, and improve social cohesion and economic stability. The proposed UN SDGs offer a universal agenda that, for the first time, recognizes the need for restoration and management of water related ecosystems, including wetlands, as a basis for addressing food and water scarcity and water risks.

Wetlands are a solution for several key challenges around the world related to water, food, and climate, and key to meeting the SDGs. The multiple benefits and services provided by wetlands are essential in achieving the SDGs. Most of the SDGs are relevant in some way or another to wetlands, but the following are of particular importance in the Indian context.

SDG 1 End poverty in all its forms everywhere

SDG 2 End hunger, achieve food security, improve nutrition, and promote sustainable agriculture

SDG 5 Achieve gender equality and empower all women and girls

SDG 6 Ensure availability and sustainable management of water and sanitation for all,

SDG 8 Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all

SDG 9 Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation,

SDG 11 Make cities and human settlements inclusive, safe, resilient, and sustainable

SDG 13 Take urgent action to combat climate change and its impacts

SDG 14 Conserve and sustainably use the oceans, seas, and marine resources for sustainable development

SDG 15 Protect, restore, and promote the sustainable use of terrestrial ecosystems; sustainably manage forests; combat desertification; and halt and reverse land degradation and halt biodiversity loss

## Institutional Framework for Analysing Multi-use Wetland Ecosystems

To assess WAIs in the selected wetlands I have borrowed the basic framework of Oakerson (1992) and subsequently developed by E Ostrom (1990) and Tang (1992) (represented through seven boxes in Figure 1). Attributes of property rights regimes (Bromely's work) and distributed governance components of Townsend and Polley are also incorporated. I have used in my earlier work different institutional approaches—developed by Oakerson (1992), Elinor Ostrom and her co-authors, Tang (1992), Townsend and Polley (1995), Bromley (1978, 1989 a, 1989b, 1991, 1992), Bromley *et al.* (1980), Gibbs and Bromley (1989), and Rawls (1971) to assess the performance of various CPR-based development programmes implemented under different governance structures or property regimes or combination of property rights regimes (Marothia 1992, 1993, 1995 a, 1995b, 1997 a, 2002, 2004 a, 2005 a, 2005b, 2012, 2017, 2019; NIE 2003).

Physical and technological attributes, decision-making arrangement, patterns of interaction and outcomes (box 1,4,6 and 7 of Fig.1) are the core attributes of Oakerson's conceptual framework to analyse common pool resources under common property regime. Each set of attributes relates to the others. For example, physical and technological attributes and decision-making arrangement jointly affect patterns of interactions. The physical and technical characteristics of the CPRs can affect the outcome directly or through patterns of interactions.

In the long run analysis, institutional changes are exogenous and their effects could be iteratively assessed on interactions and outcomes (Oakerson 1992, 41–62). Oakerson model also has dynamic application if applied iteratively.

Kiser and E Ostrom (1982) included social characteristics along with physical attributes and institutional arrangements in their institutional analysis development framework (for detailed interpretation of Kiser and E Ostrom 1982 attributes of institutional analysis development framework see Tang, 1992; Folke and Berkes, 1995; Edwards and Steins, 1996). Several researchers, in addition to four attributes of Oakerson model, added social characteristics of resource users and community (Arnold and Stewart 1991; Tang 1992; Marothia 1993, 2001, 2002 (pp 701–16), 2004 a, 2004 b, 2005, 2012; Singh 1994; Singh and Ballabh 1996).

The nature of institutional arrangements defines the extent of property regime over land, water multi-use wetlands and related resources. (Bromley 1989; Bromley and Cernea 1989; Gibbs and Bromley 1989; see also the classic work of Commons (1934) on the role of institutions, property rights, and collective action).

The basic requirement for any property rights regime (or a combination of property rights regimes) is an authority system (local governing body/Panchayat/state/federal government) that can guarantee the security of expectations for the rights holders.

Box 3 of Figure 1 deals with resource or property rights regimes distributed or shared management of multiple-use CPRs, including multi-use wetlands.

The four categories of resource governance or property rights regimes—state, private, common, and open access regimes (Bromley 1989, 1991; Ostrom, E 1990; Gibbs and Bromley 1989; Bromley and Cernea 1989)—have been extended by Townsend and Polley (1995) to recognize that natural resources governance can be shared among states, communities and private interest groups in various ways at different decision-making levels. Distributed governance involves the external institutional arrangements[3] among government and local communities or resource users as well as internal institutional arrangements[4] within local community institutions or resource users. Government, local communities and private parties utilizing CPRs bring different interests, capabilities and understanding to the resource management and decision-making process (Townsend and Polley 1995; for an application of the Townsend and Polley framework in the Indian

[3]An external governance structure has essentially three alternatives of management systems (Townsend and Polley 1995): *rights-based management* (the government grants usufruct rights to individual resource users under well specified constraint conditions and assumes the role of monopoly over the resource base and retains all responsibility/authority for conservation decision); *co-management* (the government and the local communities share ongoing responsibility for decision-making over all or most of the resource management decisions); and *contracted management* (to transfer large part of the decision-making process to local bodies).

[4]Townsend and Polley (1995) associate with the concept of distributed governance four alternative internal institutional arrangements: *self-organizing institutions* (institutional and organizational decisions remains with local communities and the government may use the institutional building capacity to support and gain strength from self-organization); *communal management* (to reduce the existing authority of state and vest more localized interest); *cooperative management*(membership is limited with well-defined working rules for collective governance);and *corporate* (under the corporate governance the owners and shareholders of the corporation would operate under governance rules typical of private corporations).

context, see Marothia 2012). Complex multi-use wetlands can also be managed under a polycentric governance regime[5] developed by E Ostrom et al. (1994) and Andersson and E Ostrom (2008).

CPRs, including wetlands, can be managed or mismanaged under any of the four resource regimes: state property, private property, common property, and open access CPRs (Calabresi and Melamed 1972; Ciriacy-Wantrup and Bishop 1975; Bromley 1989a; Gibbs and Bromley 1989; Bromley and Cernea 1989; E Ostrom 1990; Marothia 1993, 1996b, 2002, 2004b) are also subject to degradation under distributed governance (Marothia 2001, 2002, 2005, 2012).

Alternative institutional perspectives shape the decision-making process among government and local resource users' communities and within members of local community for managing a resource by converting unorganized structures into organized ones (Marothia and Phillips 1985).

Oakerson (1992) model's decision-making institutional arrangements deal with operational rules – limits on users' behaviour, specification of relationship among co-users, if a resource has multiple-use, rules about highly subtractive behavior of co-users; – Individual share of benefits is protected by the authority system and boundary rules determine the legal domain of collective choice. Under the decision-making arrangements (Box 4, Figure 1), among other sub-attributes (Operational rules, conditions of collective choice, boundary rules of Oakerson 1992), the conditions of collective action have three levels. At the operational level, users interact with each other to use or withdraw resource units from a CPR (including multi-use wetlands). At the collective choice level, rules are established and decisions are taken by existing and potential resource users to define the operational, institutional, and technical arrangements. In constitutional situations, decisions are taken to determine who has the authority to structure rules for collective choice situations (E Ostrom 1989).

Action situation (Box 5) is the crucial point of the IAD framework (Kiser and Ostrom, E 1982; E Ostrom 1986; E Ostrom and Crawford 1995, see also Edwards and Steins, 1996; and Aligica, 2006 and Marothia 2005). Tang (1992: page 19) had added action situations, mode of individuals in terms of bounded rationality and opportunism, and incentives in the Oakerson model.

Action situation is affected by external variables (biophysical and technical condition of a resource, attributes of resource users community rules in use (E Ostrom 2005) or decision-making institutional arrangement – represented in Box 1,2, and Box 4 of Figure 1 under alternative governance structures (Box 3).

In action situations, individual resource users or groups of users adopt actions or strategies. Different outcomes may result from interactions among users, depending on number of users, choices available to users (Box 4), capability of processing information and incentives faced by users (see Tang, 1992 for detailed description of action attributes).

Sub-attributes of patterns of interaction of Oakerson model include reciprocity – individual co-users contribute to each other's welfare, and free riding behaviour – degrades reciprocity, breeds destructive competition, conflicts and ultimately leads to over-exploitation of a resource (see Box 6 of Figure 1). Edwards and Steins (1996, 1999) connected the "context- bound" factors to patterns of interaction attributes of Oakerson (1992), Tang (1992) and E Ostrom (2005).

The Oakerson (1992) outcomes attributes (box 7 of Fig.1 has two sub-attributes to analyse CPRs under the common property regime: economic outcomes, evaluated using concepts of efficiency (overall use rates of a resource) and distributive outcomes, evaluated in terms of equity (fair share to co-users on their contribution to a collective choice, effectiveness of a management system to exclude non-users' enforcement

[5]The polycentric governance regime, developed by E Ostrom et al. (1994) and Andersson and E Ostrom (2008), "is a system that seeks to unleash ingenuity and stimulates the creativity of political entrepreneurs. It is a system that is structured so that actors within the system are given opportunities for institutional innovation and adaptation through experimentation and learning" (E Ostrom et al. 1994). K Andersson and E Ostrom (2008) state: "A key aspect of all proposals for increased polycentricity (as opposed to *just* centralization or *just* decentralization) is the effort to enable institutions of multiple scales to more effectively blend local, indigenous knowledge with scientific knowledge."

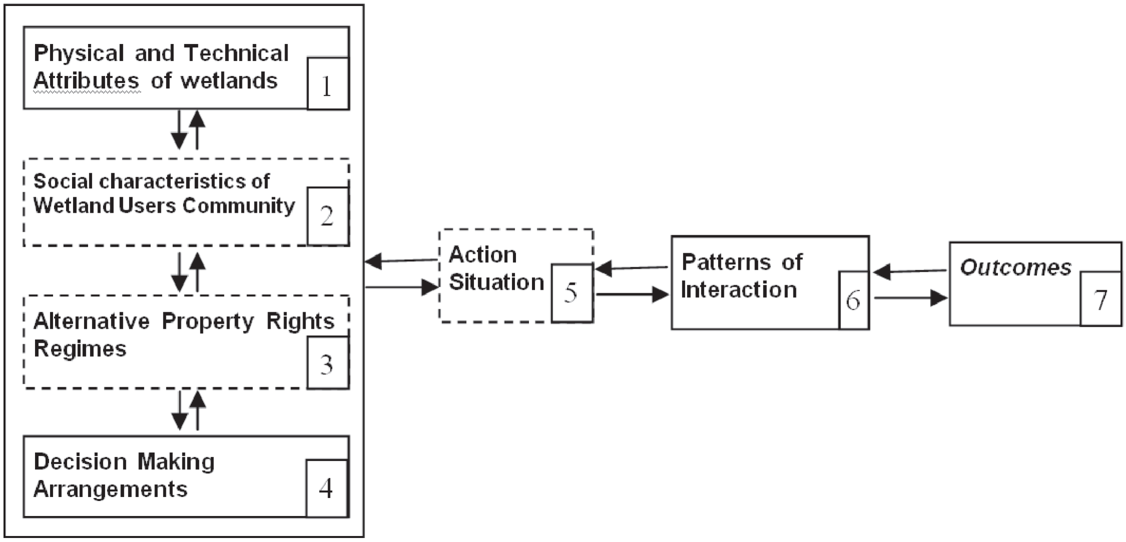


**Figure 1 Institutional framework for analysing wetland ecosystems**

*Note* Basic framework borrowed from Oakerson, Ostrom and colleagues and Tang, Berkes and Folke, Folke and Berkes added Bromley and Townsend and Pooley attributes of property rights regimes/ structures. Interpretation of boxes marked with solid and dashed lines is given in the text.

of rules. A few researchers have incorporated sustainability criteria to the outcome attribute of Oakerson framework, just after the inception of his framework (Marothia 1993; Folke and Berkes 1995).

Researchers have adequately documented the contribution of wetlands to total economic value and ecosystem services.[6] The seven boxes in Figure 1 are in dynamic interrelationship with one another. Feedback loops among the seven components are indicated with arrows (see Folke and Berkes, 1995 for details of dynamic institutional framework). To this end, I propose to analyse the wetland–agriculture interactions using the institutional framework depicted in Figure 1.

## Assessing Wetland–Agriculture Interactions

In this section, I have analysed the comparative performance of the wetland–agriculture interactions in rural wetlands, being managed under different property rights regimes, through the application of institutional framework (Figure 1). All the attributes of the framework (Figure 1) are now used for assessment of different combinations of the wetland–agriculture interactions. Sub-attributes of the main seven attributes are listed in Tables 1 and 2. As mentioned in the introductory remark, the wetland–agriculture interactions analysis is confined to major rural multiple–use wetlands (community wetlands, Riverine wetlands, private ponds and paddy fields converted for lotus cultivation. Information presented in Tables 1 and 2 is extracted from the case studies, carried out by me in the Chhattisgarh state of India. I also discuss herein briefly the process by which institutional arrangements affect multi-use wetlands management, and in turn the transformation of wetland- agriculture partnership.

[6]The total economic value and ecosystem services of wetland ecosystems have been empirically estimated under different socio-ecological settings (Costanza, Farber, and Maxwell 1989; Aylward and Barbier 1992; Munasinghe 1992; Costanza et al. 1997; De Groot et al. 2002; Marothia 2001, 2004; Finlayson et al. 2005; MEA 2005; Maltby 2009; Gopal 2015; Gopal and Marothia 2015, 2016, 2017; Gopal et al. 2016; Kumar et al. 2017, 2020). Further, any change in physical and technical parameters of a CPR, including multi-use wetlands, can alter the use and non-use values and ecosystem services depending on the behaviour of users and non-users, effectiveness of institutional arrangements, and the authority system (Marothia 2001, 2004 a; Samaraweera and Marothia 2008). Several multi-use wetlands have been reported in this address; their contribution to SDGs is also assessed (see also; Pal 2018 for case studies pertaining to agriculture and ecosystem services valuation).

**Table 1 Attributes of Wetlands, wetland-agricultural interactions, social structures of users, decision making arrangements, action situation and patterns of interaction**

| Attributes of Wetlands | Community Wetland (1) | Riverine Wetlands (2) | Private and Community Ponds for Foxnut (3) | Paddy field converted for Aquatic Crops(4) |
|---|---|---|---|---|
| i. Original management Regimes | Private (Zamindars) | Territorial rights over flood plain stretch | Private/ Panchayats | Private ownership |
| ii. Current management Regime | Panchayat of Kurra Village used by local community under common property regimes | Village Panchayats at local level, seasonal *Usufructuary* rights to fruits and vegetables growers | Private property regime, and Panchayats | Private property regime, collectively owned by group of farmers |
| iii. Number of wetlands included | 29 (12 Perennial, and 17 Seasonal) | 4 tracts of floodplains | 6 private ponds, and 7 community ponds* | 5 individual + 3 pooled land groups* |
| iv. Average water spread aera (ha) | 1.87 ha | Restricted to riverbed in a village | 1.60 ha private ponds and 1.25ha community ponds | 1.50 ha average |
| v. Multiple Objectives of wetland Management | Domestic, Crops and fish production | To minimize agricultural labors distress migration during summer, production of summer season fruits and vegetables | Fox nut Production | Lotus cultivation, pulses on bunds of fields |
| vi. WAI Combinations | Fish + Paddy | (i) Watermelon<br>(ii) Muskmelon<br>(iii) Cucumber | Foxnut | Lotus |
| vii. Main uses | Food and nutritional security | Food and nutritional needs | Dry fruit, sweet dishes, Medicinal, starch use for silk and cotton polishing, Fox nut straw for as a poultry birds & cattle feed | Food, Socio-cultural, religious medicinal, cosmetic, leaves of lotus vital for water purification of wetlands |
| viii. Physical and Technical Attributes of Wetlands | In a good condition due to continued maintenance | Riverbed still in a good condition despite large scale sand mining and construction of many stop dames along riverbeds | In a good condition due to continued maintenance | Sustaining converted fields, Good water management flowing in from lower range of hills |
| ix. Social structures of Users and community | Heterogeneous | Homogeneous (landless, agricultural labourers and marginal farmers) | Homogeneous | Homogeneous |
| x. Decision Making Institutional Arrangements* | Effective coordination between internal and external decision making | Collective decision in case of group is using flood plains collectively | All decisions made by individual farmer in case of private ponds, collective decision in case of community ponds by members* | All decisions made by individual, in a group collective decision are made* |
| xi. Action Situation | Positive situation among users and Panchayats | Positive relation among growers and local body | Positive action situation in both regimes | Independent / group driven situation |
| xii. Patterns of Interaction | Conducive to collective behavior | Conducive to collective behavior | Not applicable in case of individual ponds, condusive to collective behaviour | In a group collective decisions induce collective rational behaviour |

*Managed under common property regime by the members of community/group

*Note* Price determining mechanism and marketing of paddy is well regulated (Mandi and Minimum Support price system) in case of fish, fox nut and lotus products price mostly fixed by producers. Fox nut and lotus products have export potentiality due to value addition options.

**Table 2 Outcomes of Wetland-Agriculture Interactions in different types of wetlands**

| Attributes of WAIs | Community Wetland (1) | Riverine Wetlands (2) | Private and Community Ponds for Fox nut (3) | Paddy field converted for Aquatic Crops (4) |
|---|---|---|---|---|
| i. Efficiency criteria: (a) Productivity kg/ha | 554 (Fish)<br>38 (Paddy)<br>600 (Cucumber) | 800 (Watermelon)<br>730 (Muskmelon) | 275 (Fox nut) | 1000 (Lotus flower)<br>50 (Rhizome)<br>500 (Pods nos.)<br>5 (Seeds) |
| (b) Return per rupee investment income levels (ratio) | 1:3.99 (Fish)<br>1:1.26 (Paddy) | 1:4.50 (Watermelon)<br>1:5.60(Muskmelon)<br>1:5.30 (Cucumber) | 1:1.80 (Fox nut) | 1:1.98 (Lotus) |
| ii. Nutritional security in terms of nutritional components | Fish- Calories: 280, Fat: 12.5g Sodium: 86mg Carbohydrates: 0g, Fiber: 0g Sugars: 0g Protein: 39.2g<br>Paddy- Calories: 242, Fat: 0.4g, Sodium: 0mg, Carbs: 53.4g, Fiber: 0.6g Sugars: 0g Protein: 4.4g<br>Lotus - Calories: 74, Fat: 0.1 g, Sodium: 40 mg, Potassium: 556 mg, Carbs: 17.23 g, Protein: 2.6 g<br>Watermelon- Calories: 46, Fat: 0.23 g, Carbs: 11.48 g, Fiber: 0.6 g, Sugars: 9.42 g, Protein: 0.93 g, Calcium: 11 mg, Water content: 139 g<br>Muskmelon- Calories: 61, Fat: 0.2g, Carbs: 15 g, Fiber: 1.5 g, Protein: 1 g<br>Cucumber- Calories: 30, Fat: 0 g, Carbs: 6 g, Fiber: 2 g., Protein: 3 g<br>Fox nut- Calories: 35, Fat: 0.3 g, Carbs: 7.3 g, Fiber: 0.4 g, Protein: 0.7 g | | | |
| iii. Equitable distribution of costs and benefits | Equitable distribution of cost and benefit among members of FCs, paddy gains and investment are attached with individual farmers | Equitable distribution of cost and benefit among group members | Individual investment and gains, Equitable distribution of cost and benefit among members of group | Individual investment and gains, Equitable distribution of cost and benefit among members of group |

Decisions about price and marketing mechanism value addition and export potentiality of different wetland farming products (fish, lotus, fox nut, paddy)[7] are briefly explained in Table 1.

The main attributes of institutional framework related to current biophysical and technical attributes, social structures of users and non-users, and decision-making arrangements are briefly described in Table 1. All these attributes and resource regime have an important role in creating action situations among users–practically a process of transforming individual users' behaviour to collective action. This in turn affects the patterns of interaction. Assessment of the wetland–agriculture interactions was carried out using criteria related to efficiency and equity taking into consideration the wetland–agriculture interactions (Table 2).

## Extent of ecosystem services derived from multi-use wetlands

Ecosystem services provided by multi-use wetlands, included for the wetland–agriculture interactions investigation, are presented in Table 3 separately. Multi-use wetlands provide a wide range of ecosystem services such as provisioning services for protective irrigation, and fish and aquatic crops (lotus and fox nut). Besides providing provisioning services, wetlands also support biodiversity, regulating the water cycle, and microclimate and water quality, promoting social, cultural, and recreational activities, and enhancing aesthetics. Often, they support subsistence and livelihoods of poor and wetland dependent local communities of the society.

[7]Scientists of KVK Dhamtari (IGKV, Raipur) have been working on agronomic aspects of fox nut at experimental level and covered case study of two field sites which have been converted from paddy fields to lotus cultivation. Refer Sahu and Chandravanshi (2017 a, b). Scientists at KVK Dhamtari and Jagdalpur are also working on other wetland crops, including lotus and chestnut. Dr. S S Chandravanshi assistance for data collection on basic economics parameters for fox nut on private and community ponds, and lotus crop on paddy converted fields for my research work is gratefully acknowledged.

**Table 3 Extent of Ecosystem Services Derived from Different Categories of Wetlands**

| Ecosystem Services | Community Ponds (1) | Riverine Wetlands (2) | Private and Community Ponds (3) | Paddy Field converted for Aquatic Crops (4) |
|---|---|---|---|---|
| Provisioning Services | | | | |
| Food | ♦ | ♦♦ | ♦♦♦ | ♦♦♦ |
| Fodder | ◊ | ♦♦♦ | ◊ | ◊ |
| Fuel | ◊ | ♦♦♦ | ◊ | ◊ |
| Fiber | ◊ | ♦♦♦ | ◊ | ♦ |
| Medicinal | ◊ | ♦♦♦ | ◊ | ♦ |
| Bio-chemicals | ◊ | ♦♦ | ◊ | ♦ |
| Genetic materials | ◊ | ♦ | ◊ | ♦♦ |
| Water storage | ♦♦♦ | ♦♦ | ♦♦ | ♦♦ |
| Domestic requirement of local community* | ♦♦♦ | ♦♦ | ♦ | ◊ |
| Regulating Services | | | | |
| Sediments | ♦ | ♦♦♦ | ♦ | ◊ |
| Heavy metals | ♦ | ♦♦♦ | ◊ | ◊ |
| Toxics | ♦ | ♦♦♦ | ◊ | ◊ |
| C- Sequestration | ◊ | ♦♦♦ | ♦ | ♦ |
| GHG emission | ◊ | ♦ | ◊ | ◊ |
| Erosion control | ◊ | ♦♦♦ | ◊ | ♦♦ |
| Disease vectors | ♦♦ | ♦♦ | ♦ | ◊ |
| Pollination | ◊ | ♦♦ | ◊ | ♦ |
| Cultural and Social Services | | | | |
| Recreation | ♦ | ♦♦♦ | ◊ | ♦ |
| Aesthetics | ♦ | ♦♦♦ | ♦ | ♦ |
| Spiritual | ♦ | ♦ | ◊ | ♦♦ |
| Religious | ♦ | ♦ | ◊ | ♦♦ |
| Education, R&D | ♦♦♦ | ♦♦♦ | ♦♦♦ | ♦♦♦ |
| Supporting Services | | | | |
| Soil formation | ♦ | ♦♦♦ | ◊ | ♦ |
| Groundwater recharge | ♦♦ | ♦♦♦ | ♦ | ♦♦ |
| Nutrient cycling | ♦ | ♦♦♦ | ♦ | ♦♦ |
| Water cycling | ♦ | ♦♦ | ♦ | ♦♦ |
| Photosynthesis | ♦♦♦ | ♦♦♦ | ♦♦♦ | ♦♦♦ |
| Biodiversity | | | | |
| Microphyte | ♦♦ | ♦♦ | ♦♦♦ | ♦ |
| Macrophyte | ♦ | ♦♦ | ♦ | ♦ |
| Fish | ♦ | ♦♦ | ♦♦♦ | ♦ |
| Zooplankton | ♦♦ | ♦♦ | ♦♦ | ♦ |
| Benthos | ♦ | ♦♦ | ♦♦ | ♦ |
| Birds | ♦ | ♦♦ | ♦ | ♦♦ |
| Herpettofauna | ♦ | ♦ | ♦ | ♦ |
| Lotus diversity | ♦♦♦ | ♦ | ♦♦ | ♦♦♦ |
| Aquatic crops diversity (Fox nut, Water Melon, Seasonal Vegetables) | ♦♦ | ♦♦ | ♦♦ | ♦♦ |
| Floral diversity | ♦♦ | ♦♦ | ♦♦ | ♦♦ |
| Screeds vegetation | ♦♦♦ | ♦♦♦ | ♦♦ | ♦♦ |

**Benefits:** ◊ no benefits; ♦ little; ♦♦medium, ♦♦♦large

*Bathing, washing utensils, cloths, tending cattle, drinking and sanitation

*Note* Option value reflects future direct and indirect uses of goods and services mentioned in the above table. Non-use values include: existence, bequest and altruistic value of wetland habitats and species; Traditional/cultural knowledge and traditions.

Excessive priority on provisioning services may create an imbalance in a few cases among provisioning, regulating and supporting ecosystem services. Such imbalance may also potentially affect option values, which reflect the future direct and indirect uses of goods and services. Further, non-use values— representing the existence, bequest, and altruistic values of wetland habitats and species, and the traditional/ cultural knowledge and traditions—may have invisible implications on different ecosystem services. This needs a restructuring of the existing institutional arrangements and authority system at different decision-making levels if imbalances between different ecosystem services are observed (Table 3).

## Emerging Research and Policy Issues

The wetland–agriculture interactions in multi-use wetlands in agricultural landscapes are among the least researched and feebly understood systems in India and South Asian countries. Therefore, I propose the following unexplored research areas, followed by a policy and regulation agenda, that need collective thinking and action.

### Research agenda

1. Estimates for the extent of different categories of wetlands are required for the major agro-climatic zones and subzones and different types and sizes of wetlands. Using a remote-sensing database, field studies may be carried out to identify priority research areas in wetland–agriculture interactions. The inputs from such research efforts can help state wetland authorities to design actionable policies within a decentralized governance framework.

2. Article VIII.34 of Ramsar Convention Resolution VIII, adopted in 2002, called for setting guidelines to enhance interactions between agriculture, wetland, and water.[8] Resolution VIII.34 requested all the Conference of Contracting Parties (COP) to establish a framework for identifying, documenting, and disseminating good agriculture-related practices. For developing guidelines, a scoping document on agriculture–wetland interactions was produced and published (Wood and Halsema 2008; for further elaboration, see Zingstra (2009)) to explore the nature of the wetland–agriculture interactions through the application of the drivers, impacts, pressures, state changes, impacts and responses (DPSIR) framework.

   In view of the Ramsar Convention Resolution VIII, research studies on the variety of agricultural systems in different types of wetlands may be undertaken in different agro-climatic zones and subzones of the country to assess the contribution of the wetland–agriculture interactions in the conservation and wise use of wetlands, sustenance of livelihoods, provision of balanced ecosystem services, and the meeting of SDGs. Inputs from such studies can provide guidelines to work out payment for ecosystem services generated from the wetland–agriculture interactions in multi-use wetlands.

3. Very few studies are available, even globally, on good agricultural practices (GAP) to support sustainable wetland–agriculture interactions. To bridge this critical research gap, case studies need to be conducted taking into consideration the ecosystem services that are assigned to a specific wetland.

4. Wetland–agriculture interactions can happen *in situ* or *ex situ* (Zingstra 2009). To address *in situ* and *ex situ* issues, case studies are needed to understand the complexities of the wetland–agriculture interactions in multi-use wetlands.

## Policy Agenda

Here, I propose the policy agenda, keeping in view the role of institutional arrangements in policymaking, in the context of inland wetland ecosystem with focus the wetland–agriculture interactions in multi-use wetlands.

[8]The origins of the Guidelines on Agriculture and Wetlands Interactions (GAWI) initiative go back at least as far as October 2002. At that time and in two consecutive weeks, in Valencia (Spain), there were the Global Biodiversity Forum 17 (GBF17) workshop “Wetlands and agriculture” and Resolution VIII 34 at the Eighth Meeting of the Conference of the Contracting Parties to the Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar COP8) titled “Agriculture, wetlands and water resource management”.

1. India has no wetland-specific policy or law. The ecosystem services of wetlands are recognized in India's National Environment Policy, 2006, which also mentions the need for maintaining their ecological character. The Government of India adopted in 2010 the Wetland (Conservation and Management) Rules under the Environment Protection Act, 1986, to regulate various activities affecting the wetlands adversely. These rules were replaced by the Wetland (Conservation and Management) Rules, 2017. Frequent changes in rules may also create conflict with Ramsar Convention commitments.
2. The provision for the constitution of state wetland authorities under the 2017 Rules is a welcome step towards the decentralized governance of wetlands. A few states have recently constituted wetland authorities, but these are yet to be fully functional.
3. Floodplains and riverbeds cultivation in the summer months is very common and extensively practised by the poor and underprivileged. State wetland authorities should develop a policy to protect this cultivation system to minimize distress labour migration in summer.
4. To enhance the research and policy understanding about multiple-use commons in general and multiuse wetlands in particular, an interdisciplinary framework, for example the one used in this address, can be adopted.

I plead with this august body to collectively take up these emerging research and policy challenges so that our contribution for providing actionable research input for policymaking becomes more relevant in the changing social-economic-ecological-cultural and political environment.

Thank you all for giving me a patient hearing.

## References

Adger, W Neil, Katrina Brown, Jenny Fairbrass, Andrew Jordan, Jouni Paavola, Sergio Rosendo, and Gill Seyfang. 2003. Governance for sustainability: towards a "thick" analysis of environmental decision making. *Environment and Planning A,* 35 (6): 1095–110.

Aligica, Paul Dragos. 2006. Institutional and stakeholder mapping: frameworks for policy analysis and institutional change. *Public Organization Review,* 6 (1): 79–90.

Andersson, K and E Ostrom. 2008. Analyzing decentralized natural resource governance from a polycentric perspective. *Policy Sciences* 41 (1): 1–23.

Arnold, J E M and W C Stewart. 1991. *Common property resource management in India. Tropical Forestry*. Oxford Forestry Institute, University of Oxford.

Aylward, B and E B Barbier. 1992. Valuing environmental functions in developing countries. *Biodiversity and Conservation* 1 (1): 34–50.

Bassi, N M, M D Kumar, Anuradha Sharma, and P Pardha-Saradhi. 2014. Status of wetlands in India: a review of extent, ecosystem benefits, threats and management strategies. *Journal of Hydrology: Regional Studies,* 2: 1–19. https://dx.doi.org/10.1016/j.ejrh.2014.07.001

Berkes, F and C Folke. 1994. *Investing in cultural capital for sustainable use of natural capital.* Beijer International Institute of Ecological Economics.

Bowman, M. 2002. The Ramsar Convention on wetlands: has it made a difference? in *Yearbook of International Cooperation on Environment and Development 2002–03*, (ed) O S Stokke, 61–8, Routledge.

Briggs, Christopher. 2014. *Wise use of our wetlands*. Presentation, 12 November, Ramsar Convention Secretariat, Gland, Switzerland.

Bromley, D W. 1976. Environmental quality and economics: what are the issues? *Journal of Economic Issues*. Madison: Department of Agricultural Economics, University of Wisconsin.

Bromley, D W. 1978. Property rules, liability rules and environmental economics. *Journal of Economic Issues,* 12 (1): 43–60.

Bromley, D W. 1989a. Property relations and economic development: the other land reform. *World Development,* 17 (6): 867–77.

Bromley, D W. 1989b. *Economic interests and institutions: the conceptual foundation of public policy*. Oxford: Basil Blackwell.

Bromley, D W. 1991. *Environment and economy: property rights and public policy*. Oxford: Basil Blackwell.

Bromley, D W (ed). 1992. *Making the commons work*. San Francisco: ICS Press.

Bromley, D W. 1993. Institutional economics revisited: discussion. *American Journal of Agricultural Economics,* 75 (3: 837–9.

Bromley, D W and Micheal M Cernea. 1989. *The Management of Common Property Natural Resources:*

*Some Conceptual and Operational Fallacies*. Discussion Paper No. 57. Washington, DC: World Bank.

Bromley, D W., D C Taylor, and D E Parker. 1980. Water Reform and Economic Development: Institutional Aspects of Water Management in the Developing Countries. *Economic Development and Cultural Change,* 28 (2): 365–87.

Calabresi, G and A D Melamed. 1972. Property Rules, Liability Rules and Inalienability: One View of the Cathedral. *Harvard Law Review,* 85 (6): 1089–128.

Ciriacy-Wantrup, S V and R C Bishop. 1975. Common Property as a Concept in Natural Resources Policy. *Natural Resources Journal,* 15 (4): 713–28.

Commons, J R. 1934. *Institutional economics*. Macmillan, New York.

Costanza, R., R d'Arge, R S de Groot, S Farber, M Grasso, B Hannon, K Limburg, S Naeem, R V O'Neill, J Paruelo, R G Raskin, P Sutton, and M van den Belt. 1997. The Value of the World's Ecosystem Services and Natural Capital.*Nature,* 387 (6630): 253–60.

Costanza, R., S C Farber, and J Maxwell. 1989. "Valuation and Management of Wetland Ecosystems". *Ecological Economics,* 1 (4): 335–61.

Cowardin, L.M., V Carter, F.C Golet and E.T. LaRoe, 1979. "Classification of Wetlands and Deepwater Habitats of the United States". U.S Department of the Interior, *Fish and Wildlife Service*, Washington, D.C., pp. 131.

Crawford, S E S and E Ostrom. 1995. A Grammar of Institutions. *American Political Science Review,* 89 (3): 582–600.

Davidson, N C. 2014. How much wetland has the world lost? long term and recent trends in global wetland area. *Marine and Freshwater Research,* 65 (10): 934–41.

Davis, T J.1994. The Ramsar Convention Manual: A Guide to the Convention on Wetlands of International Importance, Especially as Waterfowl Habitat. *Gland, Switzerland, Ramsar Convention Bureau*.

De Groot, Rudolf S., Matthew A Wilson, and Roelof M J Boumans. 2002. A Typology for the Classification, Description and Valuation of Ecosystem Functions, Goods and Services. *Ecological Economics,* 41 (3): 393– 408.

Dugan, P J.1990. *Wetland Conservation: A Review of Current Issues and Action*. Gland: International Union for Conservation of Nature and Natural Resources.

Edwards, V M and N A Steins. 1996. Developing an Analytical Framework for Multiple-Use Commons. *Voices from the Commons*, Sixth Annual Conference of the International Association for the Study of Common Property (IASCP). University of California Berkeley, June 5–8.

Edwards, V M and N A Steins. 1999. A Framework for Analysing Contextual Factors in Common Pool Resource Research. *Journal of Environmental Policy and Planning,* 1: 205–21.

FAO. 1998. *Wetland Classification and Characterization for Sustainable Agricultural Development*. Harare: Food and Agriculture Organization Subregional Office for East and Southern Africa. http://www.fao.org.

Finlayson, C M., Rebecca D'Cruz, and Nick Davidson (Co-Chair) and others. 2005. *Ecosystems and Human Well-Being: Wetlands and Water Synthesis*. Washington, DC: World Resources Institute.

Folke, C and F Berkes. 1995. Mechanism That Link Property Rights to Ecological System. in edited by Susan Hanna, and Mohan Munasinghe, *Property Rights and the Environment – Social and Ecological Issues*. Beijer International Institute of Ecological Economics and Washington: World Bank, D.C. pp.121-138.

Gibbs, C J N and D W Bromley. 1989. Institutional Arrangements for Management of Rural Resources: Common Property Regimes. in edited by F Berkes, *Common Property Resource: Ecology and Community-Based Sustainable Development*. London: Belhaven Press: 22–32.

Gopal, B.2015. Wetland Conservation for Biodiversity and Ecosystem Services: Needs a Shift in Land and Water Resources Policies. *Policy Brief*. New Delhi: National Institute of Ecology, Sept 2015: 16.

Gopal, B.2018. Science, Policy and Law of Wetland Conservation in India. *SILnews,* 72: 14–5.

Gopal, B and D K Marothia. 2015. Integrating the Economics of Wetland Biodiversity and Ecosystem Services in Management of Water Resources of River Ken: A Study. *Economics of Ecosystems and Biodiversity (TEEB)–India Initiative*. : GIZ, and Ministry of the Environment Forest and Climate Change, New Delhi, Government of India: 75.

Gopal, B and D K Marothia. 2016. Seeking Viable Solutions to Water Security in Bundelkhand. *Economic and Political Weekly,* 51 (44 and 45): 21–3.

Gopal, B and D K Marothia. 2017. Wetland of Chhattisgarh: Status and Policy Perspective. Published by Chhattisgarh State Planning Commission. Naya Raipur, Chhattisgarh, India.

Gopal, B, A P Sharma, S Sharma, S Chhatterjee, D K Marothia, M A Hassan, and K S Rao. 2016. Capacity Building in the Assessment of Biodiversity and Ecosystem Services for Conserving Wetlands for the Future-A Featured Article. *APN Science Bulletin*, Japan 6: 34–40.

Kiser, L L and E Ostrom. 1982. The Three Worlds of Action: A Metatheoretical Synthesis of Institutional Approaches. in edited by E Ostrom, *Strategies of Political Inquiry, Beverly Hills, Calif*. SAGE: 34–5.

Kumar, R., R J McInnes, M Everard, R C., K A A Gardner, and H Kulindwa. Wittmer, and Mata, D Infante.2017. *Integrating Multiple Wetland Values into Decision-Making.* Ramsar Policy Brief No. 2. Gland, Switzerland: Ramsar Convention Secretariat.

Kumar Ritesh, Robert McInnes, C Max Finlayson, Nick Davidson, David Rissik, Swapan Paul, Cui LijuanI, Lei Yinru, Samantha Capon and Siobhan Fennessy, 2020. "Wetland Ecological Character and Wise Use: Towards a New Framing". *Marine and Freshwater Research,* www.publish.csiro.au/journals/mfr

Maltby, E., ed.2009. *Functional Assessment of Wetlands: Towards Evaluation of Ecosystem Services*. Cambridge: Woodland Publishing/UK/Boca Raton: CRC Press.

Marothia, D K. 1992. Village Irrigation Tanks: Institutional Design for Sustainable Resource Use. *Agriculture Situation in India,* 47: 479–84.

Marothia, D K. 1993. Property Regimes and Institutional Arrangements: Concepts and Their Relevance in Managing the Village Commons. *Indian Journal of Agricultural Economics,* 48 (3): 557–65.

Marothia, D K. 1995a. Urban Lake Pollution: Issues of Property Rights and Institutional Arrangements., Invited Paper presented to Beijer Research Seminar organised by the Beijer Institute. Stockholm, Sweden: International Institute of Ecological Economics, the Royal Swedish Academy of Sciences, held at Kota Kinabalu. Malaysia, 16–19 May, 1995.

Marothia, D K. 1995b. Village Ponds and Aquaculture Development: Is Conflict Inevitable? Paper presented to the National Workshop on *Poultry. Fisheries and Food Processing Organized for the Members of Parliament,* National Academy of Agricultural Research Management. Hyderabad, July 4-7, 1995.

Marothia, D K. 1997a. *Property rights, externalities, and pollution.* in edited by Anil Agrawal, *The Challenge of Balance*. New Delhi: Centre for Science and Environment: 290–8.

Marothia, D K. 2001. Valuation of a day-use recreation site: application of alternative estimation techniques. *Indian Journal of Agricultural Economics*, July–September, 56 (3): 313–24.

Marothia, D K. 2002. Alternative governance in common pool resource. in edited by D K Marothia, *Institutionalizing Common Pool Resources*. New Delhi: Concept Publishing Company: 701–16.

Marothia, D K. 2004a. Restoration of lake ecosystems: an environmental economics perspective. Keynote paper. *International Journal of Ecology and Environmental Sciences,* 30 (4): 1–11.

Marothia, D K. 2004b. Transforming institutions for sustainable development of natural resources programmes. *Agricultural Economics Research Review,* 17: 163–90.

Marothia, D K. 2005. Institutional reforms in canal irrigation system: lessons from Chhattisgarh. *Economic and Political Weekly,* 40 (28): 3074–84.

Marothia, D K. 2010. Decentralisation of natural resource management in India: an institutional perspective. Presidential address, *Indian Journal of Agricultural Economics,* 65 (1): 1–34.

Marothia, D K. 2012. Performance of culture fisheries under alternative property rights regimes in Chhattisgarh. *International Journal of Ecology and Environmental Sciences,* 38 (4): 163–207.

Marothia, D K. 2017. Governance for water security in 21st century: framing of institutional choices. *Third Dr. Rakesh Hooja Memorial Lecture*, delivered at Indian Institute of Public Administration, New Delhi, 22 November.

Marothia, D.K 2019. Managing wetland ecosystems: a polycentric perspective, in (eds) Rajinder Peshin and Ashok K Dhawan (eds), *Natural Resource Management: Ecological Perspectives,* Springer Nature Switzerland AG, 2019, 1–18.

Marothia, D K. (Forthcoming). *Multiuse wetlands governance: challenges and institutional choices*

Marothia, D K and W E Phillips. 1985. Analysis of natural resource problems using synthesis of neoclassical and institutional economics. *Asian Journal of Economics and Social Studies,* 4: 263–81.

McCartney, M, L-M Rebelo, S Senaratna Sellamuttu, and S de Silva. 2010. *Wetlands, agriculture and poverty reduction*. Colombo, Sri Lanka: International Water Management Institute. (IWMI Research Report 137).

McNeill, D. 1999. On interdisciplinary research: with particular reference to the field to environment and development. *Higher Education Quarterly,* 53 (4): 312–32.

Millennium Ecosystem Assessment. 2005. *Ecosystems and human well-being: wetlands and water synthesis*. Washington, DC: World Resources Institute.

Ministry of Environment and Forest. 2010. *Wetlands (conservation and management) rules, 2010*.

Ministry of Environment and Forest. 2017. *Wetlands (conservation and management) rules*. Notification, 26th Sept, 2010.

Munasinghe, Mohan. 1992. Biodiversity protection policy: environmental valuation and distribution issues. *Ambio – A journal of the human environment* 21 (3): 227–36.

National Institute of Ecology. 2003. *Integrated management of water resources of Lake Nainital and its watershed: an environmental economics approach* [NIE report]. World Bank- funded project under Environmental Management Capacity Building Programme implemented jointly by Ministry of Environment & Forest, GoI – IGIDR, Mumbai-NIE.

National Institute of Ecology. 2014. *Proceedings of the national workshop on ecosystem services of River Ganga*. Jointly Organised by NIE-WWF-NMCG, July 15–16. New Delhi: 79.

Oakerson, R J.1992. Analyzing the commons: A framework, (ed) D W Bromley, *Making the commons work*. San Francisco: ICS Press, U.S.A.: 41–62.

Ostrom, E. 1986. An agenda for the study of institutions. *Public Choice,* 48 (1): 3–25.

Ostrom, E. 1990a. *Governing the commons: the evolution of institutions for collective action*. New York: Cambridge University Press.

Ostrom, E. 1990b. Institutional arrangements for resolving the commons dilemma. in edited by B J McCay, and J M Acheson, *The question of the commons: the culture and ecology of communal resources*. 2nd ed. University of Arizona Press: 250–65.

Ostrom, E. 1992a. *Crafting institutions for self-governing irrigation systems*. San Francisco: ICS Press.

Ostrom, E.1992b. The rudiments of a theory of the origins, survival, and performance of common property institutions. (ed) D W Bromley, *Making the commons work*. San Francisco: ICS Press: 293–318.

Ostrom, E. 1999. Institutional rational choice: an assessment of the IAD framework, (ed) Paul Sabatier, *Theory of policy process*. Westview Press, Boulder.

Ostrom, E .2005. *Understanding institutional diversity*. Princeton, NJ: Princeton University Press.

Ostrom, E., R Gardner, and J Walker. 1994. *Rules, games, and common pool resources*. Ann Arbor: University of Michigan Press.

Ostrom, E and L Kiser. 1982. The three worlds of action: a meta-theoretical synthesis of institutional approaches, (ed) E Ostrom, *Strategies of political inquiry*. Beverly Hills: SAGE: 34–5.

Pal, Suresh (ed.). 2018. *Agriculture and ecosystem services*. ICAR–National Institute of Agricultural Economics and Policy Research.

Patel, J G. 2018. *National wetland inventory and assessment (NWIA)*. Ahmedabad: Space Applications Centre, February.

Pittock, J, M Finlayson, A H Arthington et al. 2015. Managing freshwater, river, wetland and estuarine protected areas. *In Protected* Area Government and Management. Canberra: Australian National University Press: 569–608.

Prasher, K. 2018. The case of India's disappearing wetlands. *The Times of India*. https://weather.com/en-IN/india/news/news/2018-11-08-the-case-of-indias-disappearing-wetlands

Ramsar Convention Secretariat. 2013. *The Ramsar Convention manual: a guide to the convention on wetlands (Ramsar, Iran, 1971)*. 6th ed. Gland, Switzerland: Ramsar Convention Secretariat.

Ramsar Convention Secretariat. 2016. *An introduction to the Ramsar convention on wetlands.* 7th ed (previously The Ramsar Convention Manual). Gland, Switzerland: Ramsar Convention Secretariat.

Ramsar Convention Secretariat. 2018. *Global wetland outlook: state of the world's wetlands and their services to people*. Gland, Switzerland: Ramsar Convention Secretariat.

Ramsar Convention, FAO and IWMI. 2014. *World wetlands day–wetlands and agriculture: partners for growth: 16.*

Rawls, J. 1971. *A theory of justice*. Cambridge, MA: Harvard University Press.

Richard, Smardon. 2015. International Wetlands Policy and Management Issues. *National Wetlands Newsletter,* 37 (3): 10–6.

Sahu, Rajeshwari, and S S Chandravanshi. 2017a. A Case Study of Lotus Farming Community. *Poster Presentation Made at the Workshop on Conserving Wetland Wealth of Chhattisgarh, Marothia, D.K., Brij*

*Gopal, and S K Patil, 2017*, *Proceeding of Workshop on Conserving Wetland Wealth of Chhattisgarh*. Chhattisgarh State Planning Commission. Naya Raipur: Yojana Bhawan: 24.

Sahu, Rajeshwari, and S S Chandravanshi. 2017b. Makhana Cultivation Practices for Chhattisgarh. *Poster Presentation Made at the Workshop on Conserving Wetland Wealth of Chhattisgarh, Marothia, D.K., Brij Gopal, and S K Patil, 2017*, *Proceeding of Workshop on Conserving Wetland Wealth of Chhattisgarh*. Chhattisgarh State Planning Commission. Naya Raipur: Yojana Bhawan: 24.

Samaraweera, Ganganee, C and D.K Marothia, 2008. User's appraisal and valuation of changes in renewable natural resources status. *Indian journal of agricultural economics,* 63 (3): 415–25.

Singh, K. 1994. *Managing common pool resources: principles and case studies*. New Delhi: Oxford University Press.

Singh, K and V Ballabh (eds). 1996. *Cooperative management in natural resources*. New Delhi: SAGE.

Smardon, Richard. 2015. International wetlands policy and management issues. *National Wetlands Newsletter,* 37 (3): 10–16.

Tang, Shui Yan. 1992. *Institutions and collective action: self-governance in irrigation*. San Francisco: ICS Press.

Townsend, R E and S G Polley. 1995. Distributed governance in fisheries, (eds) Susan Hanna and Mohan Munasinghe, *Property rights and the environment – social and ecological issues*. Beijer International Institute of Ecological Economics and Washington, DC: World Bank: 33–40.

Wood, Adrian, and Gerardo E van Halsema (eds). 2008. *Scoping agriculture-wetland interactions: towards a sustainable multiple-response strategy*. FAO Water Report 33: 177. Ramsar: Food and Agriculture Organization, WUR. WA and WI, Rome: IWMI.

Zingstra, H L. 2009. Wetlands and agriculture–relevance of good agricultural practice and wetland management guidelines for harmonizing the wise use of wetlands and agriculture". *Research Gate,* (January): 1-31.