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Understanding the Kole Lands in Kerala as A Multiple Use Wetland Ecosystem

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Understanding the Kole Lands in Kerala as A Multiple Use Wetland Ecosystem

Jeena T Srinivasan♦

Abstract

Wetlands which face several anthropogenic and other threats are complex ecosystems providing substantial benefits to human society. This paper is an attempt to understand the ecological and economic importance as well as the associated property rights issues of wetlands in general and the Kole wetlands in Thrissur, Kerala in particular. It also seeks to analyse the wetland agriculture interactions in Kole lands and identify the various livelihood and other activities undertaken with a purpose to identify the various interlinkages and feedbacks between various uses and the pressures facing the ecosystem. Both secondary and primary data have been used. We have used the Driver Pressure State Impact Response (DPSIR) framework to understand wetland-agriculture interactions and the various pressures facing the ecosystem. It is seen that Kole lands support various types of onsite and offsite livelihood activities which are sometimes in conflict with each other. Even though fewer and fewer households consider Kole as their exclusive source of livelihood, it does not reduce the pressure on the resources but exposes it to different types of interrelated pressures which are very complex to understand. In such a situation, there is a need to disentangle the complex web of interrelated pressures on this wetland ecosystem beyond its significance in supporting the local land based livelihoods alone.

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1. Introduction

Wetlands which face several anthropogenic and other threats are complex ecosystems providing substantial benefits to human society. Lack of a single definition has made it difficult to take stock of the wetlands globally, and therefore, reasonable estimates about its loss are not available. It is generally believed that approximately 6 per cent of the world's area is covered by wetlands, whereas in 1900 global wetland area may have been twice as much of that exists at present (Bateman *et al* 1992). According to the World Conservation Monitoring Centre (WCMC 1992) there are approximately 5.3 to 5.7 million km^2 of freshwater wetlands in the world and Canada is thought to contain the most wetland area around a quarter of the global total. Matthews and Fung (1987, cited in Adger and Luttrell 2000) observes that the global area of wetlands has decreased at an ever-increasing rate during the course of the century. Out of the wetland area lost, 87 per cent has been lost due to diversion for agricultural development, 8 per cent to urban development, and 5 per cent to other conversions (Barbier 1997).

Reliable estimates on the loss of wetlands in India are not available. According to the survey carried out by the Ministry of Environment and Forests in 1990, about 4.1 million hectares are covered by wetlands of different categories in India. They are predominantly located in the Himalayan Terai, Gangetic and Brahmaputra floodplains, deltaic regions of east-coast, forested valley swamps of north-eastern India, saline expanses of hot-arid regions of Gujarat and Rajasthan, the deltaic region of east and west coast, the wet humid zones of the peninsula, the fringing mangrove swamps of Andaman and Nicobar and the glacier and snow-cycle dependent high altitude regions of Himalayas. Over 98 wetlands in India meet the criteria under the Ramsar Convention[1] and some 68 wetlands are under the Protected Area Network and protected by the Wildlife (Protection) Act of 1972, with 21 wetlands supported by the National Wetland Programme. Mangroves, the coastal wetlands occupy an area of about 6740 km^2, of which about 80 per cent is in the Andaman and Nicobar Islands (Biswas and Trisal 1993). It has been noted that the conversion of wetlands to agriculture, urban and

1 The Convention on Wetlands of International Importance especially as Waterfowl Habitat- commonly referred to as the Ramsar Convention which is named after its place of adoption in Iran in 1971- was the first of the modern global intergovernmental treaties on conservation and wise use of natural resources (Barbier et al 1997).

other uses has profound ecological impacts, especially at local levels. Here it needs to be noted that the development of wetlands are irreversible in nature and imposes external losses on renewable resource production. The irreversibility places wetlands in non-renewable resource sector (Krutilla 1967, Swallow 1994). Therefore, assessing the various uses and the impact of depletion and degradation of the wetland ecosystem on the goods and services provided by it is important. Addressing these issues by taking into account the associated property rights is expected to provide useful information for designing appropriate wetland conservation policies.

2. Objectives, Data and Methodology

Against the above background, the broad objective of the paper is to understand the ecological and economic importance as well as the associated property rights issues of wetlands in general and Kole wetlands in Thrissur, Kerala in particular. The paper also seeks to analyse the wetland agriculture interactions in Kole lands and identify the various livelihood and other activities undertaken with a purpose to identify the various interlinkages and feedbacks between various uses and the pressures facing the ecosystem.

Both secondary and primary data have been used. By literature survey and analysis of secondary data attempts have been made to understand the economic and ecological importance of wetlands in general and with specific reference to Kole lands. Important goods and services provided by Kole lands have been classified into marketed and non-marketed based on whether they are available onsite or offsite. Primary data mostly qualitative in nature have been collected by conducting focus group discussions among the major stakeholders of Kole wetlands. The focus group discussions have been carried out during August-September 2009 and further in-depth data collection is in progress. Qualitative data collected have been tentatively organised under the Driver Pressure State Impact Response (DPSIR) framework to understand wetland-agriculture interactions and the various pressures facing the ecosystem. In this framework, the ***drivers*** are the underlying causes that lead to the pressures on wetlands or agriculture-wetland related process and are considered as indirect drivers. These can be both biophysical or socio economic factors that directly or indirectly cause a change to the ecosystem or its processes. Among other drivers, population growth, market opportunities, changes in land use, etc are important. ***Pressures***, on the other hand are direct drivers which are the consequent results of the drivers. In other words, pressures are how the drivers manifest themselves on wetlands. An example is intensification of agriculture. Changes in ecosystem services are the ***state changes*** in this framework. It can be in terms of biophysical processes that determine the ecological character of the ecosystem and / or the natural resource base. This includes both quantitative and qualitative changes occurring on the wetlands. These in turn affects the provisioning of the goods and services. Soil characteristics, water quality and pollution, biodiversity are some examples. ***Impacts*** on human well being and poverty reduction are the socio economic results that come from changes in the state of the wetland. Changes in the subsistence to market oriented production, socio economic differentiation and conflicts, recreational and education development etc are some of the impacts. Finally, ***responses*** are strategies and interventions in response to drivers, pressures, state changes, and impacts. These can be both technical and institutional or policies and planning (FAO, 2008).

3. Understanding wetland ecosystems

Due to lack of scientific understanding, wetlands were once considered as wastelands and vast areas have been converted for various other purposes. Attempts have been made however in the recent years to improve the understanding of wetlands from both natural and social sciences disciplines. A major difficulty in assessing wetlands is the lack of a universally agreed classification of wetland types and these vary greatly both in form and nomenclature (Turner *et al*, 2000). The generic system produced by Cowardin *et al* (1979) has been based on factors such as salinity and power hydrogen (pH); the characteristic vegetation and dominant plant species, the frequency and duration of flooding, and the organic or mineral composition of soils. The degree of water permanence is a dominant feature of the wetlands, which determines the nature of soil development and the types of plant and animal communities living at the soil surface. As a result, the wetlands are having dual complexity of having water-related and terrestrial-related properties. Maltby (1986) defines wetlands as a place that has been wet enough for a long time to develop specially adapted vegetation and other organisms. Cowardin's approach has provided the basis for simplified methodologies for the classification of wetlands by Larson *et al* (1989), which has been used by the Ramsar Convention (Scott 1989).

The Ramsar International Convention defines wetlands[2] 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 6 m (Barbier *et al* 1997).

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[2] However, Ramsar Convention had not defined wetlands in the context of a river basin as is widely followed now.

Table 1. Functions, Products and Attributes of Wetlands

	Wetland types							
	Estuaries	Mangroves	Open coasts	Flood plains	Freshwater marshes	Lakes	Peat lands	Swamp forests
	Functions							
1.Groundwater recharge	×	×	×	✱	✱	✱	•	•
2. Groundwater discharge	•	•	•	•	✱	•	•	✱
3. Flood control	•	✱	×	✱	✱	✱	•	✱
4. Shoreline stabilisation, erosion control	•	✱	•	•	✱	×	×	×
5. Sediment / toxicant retention	•	✱	•	✱	✱	✱	✱	✱
6. Nutrient retention	•	✱	•	✱	✱	•	✱	✱
7. Biomass export	•	✱	•	✱	•	•	×	✱
8. Storm protection / windbreak	•	✱	•	×	×	×	×	•
9. Micro-climate stabilisation	×	•	×	•	•	•	×	•
10. Water transport	•	•	×	•	×	•	×	×
11. Recreation, tourism	•	•	✱	•	•	•	•	•
	Products							
1. Forest resources	×	✱	×	•	×	×	×	✱
2. Wildlife resources	✱	•	•	✱	✱	•	•	•
3. Fisheries	✱	✱	•	✱	✱	✱	×	•
4. Forage resources	•	•	×	✱	✱	×	×	×
5. Agricultural resources	×	×	×	✱	•	•	•	×
6. Water supply	×	×	×	•	•	✱	•	•
	Attributes							
1. Biological diversity	✱	•	•	✱	•	✱	•	•
2. Uniqueness to culture / heritage	•	•	•	•	•	•	•	•

Key: × = absent or exceptional; • = present; ✱ = common and important value of that wetland type

Source: Dugan (1990) adapted from Dixon and Lal (1997)

Dugan (1990) modifies the classification by Scott (1989) and classifies the wetlands into salt water, freshwater and manmade wetlands. While salt-water type wetlands include marine, estuarine, lagoons and salt lakes, the freshwater type wetlands are riverine, lacustrine and palustrine. Finally, there are man-made wetlands, which include aquaculture/mariculture, agriculture, salt pans and salines, urban/industrial and water storage areas.

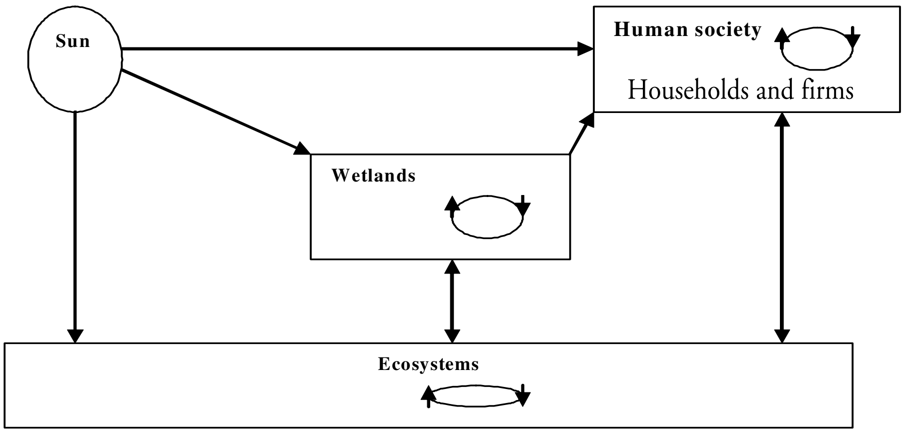
Wetlands perform a number of functions which can be summarised into hydrological, chemical, biological and socio-economic functions (Williams, 1990). The hydrological functions are important in preventing flooding and erosion of shorelines and include recharging and discharging aquifers in wetlands. The chemical functions include water quality improvement, sediment trapping and wastewater treatment. It is a sink or a natural cleaning centre for pollution, especially, with nutrients. Williams (1990) divides the biological functions into two series: productivity and biodiversity. The socio-economic functions include productive agricultural areas, production of drinking water, firewood and the stock of fish, *etc*. The non-consumptive elements in the socio-economic functions include the recreational, educational, aesthetic, archaeological and gene pool benefits. With the increase in scientific understanding, wetlands have been described both as 'the kidneys of the landscape' and 'biological supermarkets'. This is because of the functions they perform in the hydrological and chemical cycles and because of the extensive food webs and the rich biodiversity that they support (Mitsch and Gosselink 1993 cited in Barbier *et al* 1997). Table 1 given above explains the functions, products, and attributes of different natural wetlands.

4. Ecosystem Linkages, Functions and Values of Wetlands

A unique feature of wetlands is that they are often located between dry terrestrial systems and permanent deep water systems like rivers, lakes, or oceans. Because of their niche in the landscape, the wetlands are important exporters or importers of organic and inorganic nutrients respectively and are regarded as one of the most productive ecosystems. Besides these, the wetland helps to reduce the effects of floods, regeneration of groundwater and provides recreational opportunities. The climatic function of some wetlands is also important as it affects the mesoclimate of nearby land by increasing evaporation and absorbing heat during periods of drought. It also acts as barriers against strong winds (Vasicek 1985). In short, the services provided by the wetlands are many.

According to Gren and Soderqvist (1994), wetlands are considered as open systems which receive inputs from other ecosystems and also from the sun. The outputs or environmental services of the wetlands can be exported to human society and /or to other ecosystems. Synergetic effects (represented by circles in Figure 1) of hydrology, chemical inputs, and climatic conditions, which affect the productivity of the environmental services, are taking place within the wetlands. The figure also shows that wetlands export services to other ecosystems, for example, water purification, which is beneficial for downstream stretches of the river and its tributaries.

Figure 1. Flows Between Wetlands, Human Society, and Other Ecosystems



Source: Gren and Soderqvist (1994)

Human society receives products directly from the wetlands as well as indirectly through other ecosystems. Other important services include the recreational opportunities provided by the wetlands. The construction of wetlands for certain purposes such as nitrogen purification provides an example of impact of human society on wetlands. Therefore, a negative impact of conversions on wetland may imply feedbacks, such as, decreased supply of services from the wetland and from other ecosystems. A change caused by human society on other ecosystems may improve or degrade the wetland production of environmental services. Thus, it is important to note that although fluctuations are a part of the wetland ecosystem, human interventions can result in the improvement or degradation of the services provided by the wetlands.

The linkages of wetlands between different systems are explained in a simpler manner in Table 2 using input-output matrix by Gren and Soderqvist (1994). In the table, the exporters and importers of services have been presented in the first column and the first row of the table respectively. For example, the S →W element of the matrix says that the energy output of the sun works as an input for wetlands. Wetlands, in turn, produce a considerable number of environmental services.

Besides the services used by the wetlands themselves for their own development and maintenance (W→ W), there is also export of services to other ecosystems (W→ OE), and to human society (W→ HF, W→HH). An example of the W→ OE export is the nursery that wetlands provide for migratory animals. Similarly, an example of a good that wetlands export to firms (W→ HF) is peat[3] which can, in turn, be used for the production of electricity consumed by other firms or by households (HF→ HF, HF →HH).

Table 2 An Input-Output Matrix Showing, Inter Alia, Deliveries of Environmental Services

To→ ↓		Sun (S)	Wetlands (W)	Other Ecosystems (OE)	Human Society	
					Firms (HF)	Households (HH)
From ↓						
Sun (S)		S→S	S→ W	S→OE	S→HF	S→ HH
Wetlands (W)			W→ W	W→ OE	W→HF	W→ HH
Other Ecosystems (OE)			OE →W	OE→OE	OE→HF	OE→HH
Human Society	Firms (HF)		HF →W	HF →OE	HF →HF	HF →HH
	Households (HH)		HH→W	HH→ OE	HH→HF	HH→ HF

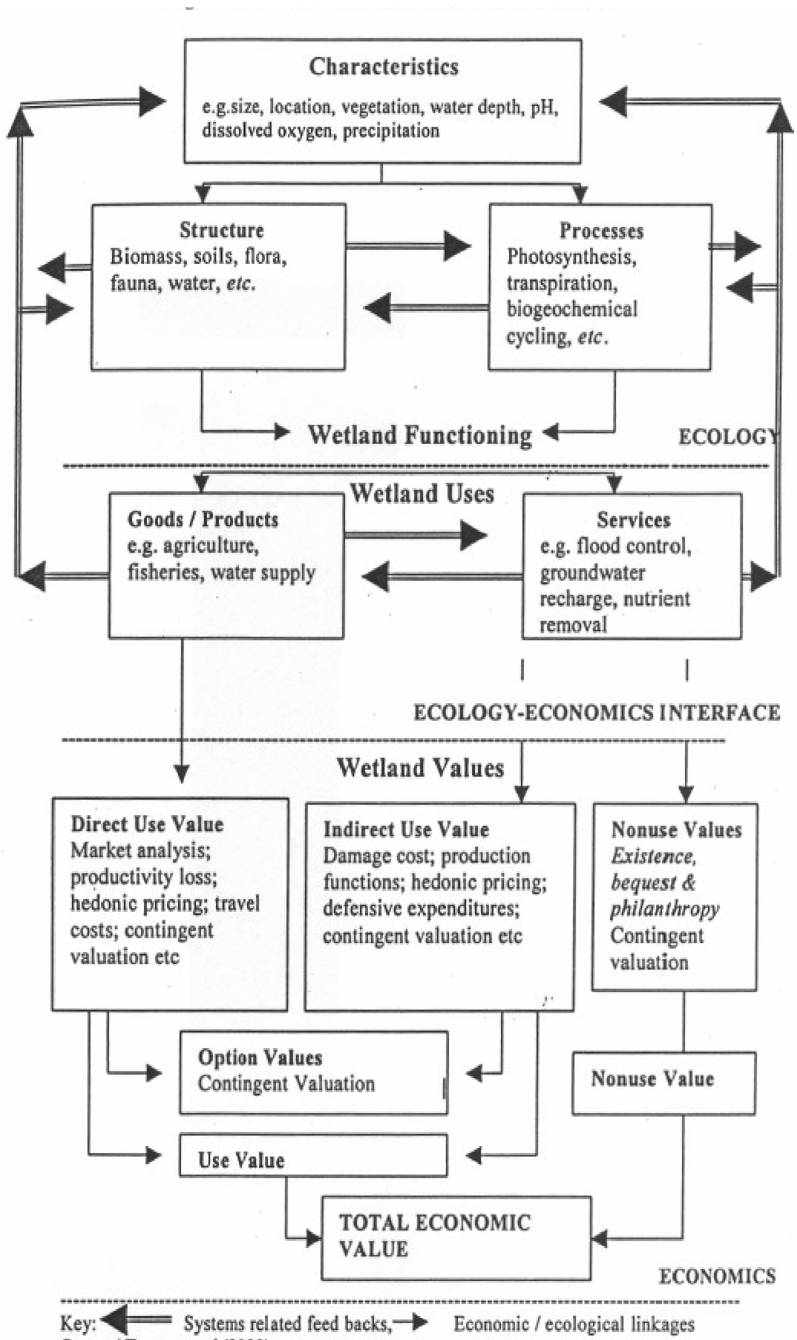
Source: Gren and Soderqvist (1994)

[3] Partly decayed, moisture absorbing plant matter found in swamps.

It is important to observe from Figure 1 and Table 2 that the environmental services that wetlands export are partly used directly by human society and partly indirectly through wetland transports to other ecosystems. The multi-level model of wetland depicted by Turner *et al* (2000) helps one to understand the complexities involved in the modelling of wetlands. In this, the foundations of the model are provided by the natural science which defines the characteristics of the ecosystem, its processes and functions. It should be mentioned that the characteristics are those properties, including biological, chemical and physical that describes the wetland area in the simplest and most objective terms. The ecosystem processes refer to the dynamics of transformation of matter or energy[4] . From an anthropocentric view, all ecosystems can be classified in terms of their structural and functional aspects (Westman 1985). The ecosystem structure is defined as the tangible items such as plants, animals, soil, air and water of which it is composed and the structural benefits include the direct harvest of marketable products and the use of ecosystems for recreation and aesthetic enjoyment. According to Turner *et al* (2000), it is the interactions between wetland hydrology, geomorphology, saturated soil and vegetation that constitute the functions of the wetland ecosystem. The functions performed by the wetlands determine the general characteristics and significance of the processes that occur in any given wetland. Moreover, it is the processes that are responsible for the services, the life-support services, such as assimilation of pollutants, cycling of nutrients, etc. They also enable the development and maintenance of the ecosystem's structure which, in turn, is a key to the continuing provision of goods and services. In short, the ecosystem functions which provide humans with goods or products are the result of interactions between structure and processes.

[4] Of the basic constituents of matter and energy of our biotic and *abiotic* environment, energy has an unidirectional flow, while, material moves in circular pattern passing back and forth between organisms and their *abiotic* environment and such material cycles are termed as bio-geo-chemical. There are three types of cycles- hydrological, gaseous and sedimentary. The hydrological cycle is concerned with the movement of a compound H_2O, the other two types of cycles, gaseous and sedimentary are concerned with the movement of basic chemical elements (Sengupta 2001).

Figure 2. Wetland Function, Uses and Values



Source/ Turner *et al* (2000)

The next level of this model of wetlands contains the interrelated uses (activities) that socio-economic systems derive directly and indirectly. These have been classified into various categories using the total economic value framework [for example, see Barbier (1994) and Turner *et al* (1997)]. In this, a distinction is made between direct, indirect and non-use values. While direct use values are those derived from the direct use or interaction with a wetland's resources and services, indirect use values are those arising out of the indirect support and protection provided to economic activity and property by the wetland's natural functions, or regulatory environmental services. Non-use values are those derived from neither direct nor indirect use of the wetland. Option value is a special category of value which arises because an individual may be uncertain about his or her future demand for a wetland resource and /or its availability in the future. Contrary to this, there are individuals who do not currently make use of tropical wetlands but nevertheless wish to see them preserved 'in their own right'. 'Intrinsic' value is often referred to as existence value. Thus, the total economic value of a tropical wetland ecosystem may comprise of use, option and existence values.

Finally, the methods and techniques that available for the economic valuation of wetland goods and services form the last level of the Turner *et al* (2000) model. A wide range of valuation techniques exist for assessing the economic value of the functions performed by wetlands as many wetland functions result in goods and services which are not traded in markets and are not priced. Approaches related to market analysis include the assessment of the productivity losses that can be attributed to changes in the wetland, and the incorporation of the wetland as an input in the production function of other goods and services.

The total economic value, however, fails to reflect the total primary value of an ecosystem. Gren *et al* (1994) elaborate that the total production output of a wetland system can be divided between three different uses: (i) for its own development; (ii) exports to other ecosystems and/or (iii) exports to human society. The first type of output refers to the build-up and organising capacity of the wetland itself and the other two to exported life-support values and the authors call these as 'primary' and 'secondary' values respectively. In this categorisation, the prior existence of primary value is necessary for the derivation of secondary values since there cannot be any production of life-support. In other words, the total primary value reflects the total 'life-support service' of an ecosystem as an integral whole. These are essentially the existence, functional operation, and maintenance of the entire ecosystem that are behind the ecological services and resources of value to human beings. In short, the wetland and its functional relationships in their entirety are the source of total primary value, which is over and above the combined economic value of the various wetland 'characteristics'. Thus, the total economic value of wetlands is in some sense a total 'secondary' value which is always less than the total primary value (Barbier 1995).

Table 3. General Categories of Wetland Values at Three Different Ecological Scales

Ecological scale	*Value*
Population	Animals harvested for skin, fur, *etc*, waterfowl and other birds, Fish and shellfish, timber and other vegetation harvest, Endan gered / Threatened Species
Ecosystem	Flood mitigation, storm abatement, Aquifer recharge, water quality improvement aesthetics, subsistence Use
Biosphere	Nitrogen cycle, sulphur cycle, carbon cycle

Source: Mitsch and Gosselink (1993), cited in Mitsch and Gosselink (2000).

Mitsch and Gosselink (2000) explains that the value of wetlands occur at three levels of ecological hierarchy[5] , that is, population, ecosystem and global. The wetlands provide resources like fish which are generally harvested for food or fibre at the population scale. At the ecosystem scale, wetlands provide flood control, drought prevention, water quality protection, and similar values. These are referred to as ecosystem values because the ecosystem provides them most effectively when the abiotic and biotic parts of the ecosystem are synchronised. Then there are values of wetlands at biosphere scale. Recently there have been increased attempts to consider wetlands as an integral part of river basins as hydrology is the single most important characteristics of a wetland (James, 1997). The Millennium Ecosystem Assessment (MA) (2005) introduced a new classification of the services provided by ecosystems such as: provisioning services (e.g. food, water, fibre and fuel); regulating services (e.g. water regulation and purification, erosion control, and climate regulation); cultural services (e.g. spiritual and recreational values); and supporting services (e.g. soil formation and nutrient recycling) (Hassan, *et al*, 2005). The concept of 'ecosystem services' is useful to identify the linkages and interactions between the various ecosystem services, and to determine those whose services are mutually supportive or incompatible. Understanding this relationship is central to the development of sustainable wetland agricultural systems.

[5] In its simplest terms, a hierarchy is an ordered ranking. Within ecological systems, hierarchies can be described as ordered ranking of biotic and *abiotic* interactions. These interactions are intrinsically interconnected by such complex patterns as food web dynamics and energy flows. Inherent in any discussion on ecological hierarchies is the concept of scale. The scale of an ecosystem refers to the spatial and temporal dimensions of the system.

The above paragraphs explain the ecological and economic importance of wetland ecosystems. However, the divergence between private and social values of wetlands has been pointed out as one of the most important reasons for the loss of wetlands worldwide (Vuuren and Roy, 1993; Danielson and Leitch, 1986). In other words, although preservation benefits exceed all conversion benefits from the nation's point of view, from a private point of view conversion benefits exceed those of preservation. This highlights the importance of public policies and property right issues that emerge in the case of wetlands. Property rights are the social institutions that define or delimit the range of privileges granted to individuals to specific assets, such as parcels of land or water. The property rights institutions range from formal arrangements, including constitutional provisions, statutes, and judicial rulings, to informal conventions and customs regarding the allocations and use of property. Such institutions critically affect decision-making regarding resource use (Libecap 1989). These various issues emerge from certain characteristics of some wetlands such as its multiple use, indivisibility and seasonal alternations. Mention may be made that these unique features are not only a result of the specific ecological characteristics that make up wetland areas but also the historical, social and institutional contexts which interact with these ecological aspects. All the three characteristics pose specific management problems. This is because not only that most management strategies are built around specific boundaries but also due to the externalities and conflicts arising out of multiple activities undertaken on wetlands and the changing property rights owing to seasonal alterations. When non-fixed resources move in and out of geographical boundaries, the definition of property rights of wetlands becomes problematic. For example, the activity in one territory, which affects the supply of fugitive resources, like fish in other areas puts forward serious management problems. Often there is a lack of appreciation of the value of wetlands to the local people and it has been argued that the effect of ignoring the role of local resource users is particularly acute in the case of tropical wetlands which tend to be heavily utilised by subsistence users (Adger and Luttrell 2000).

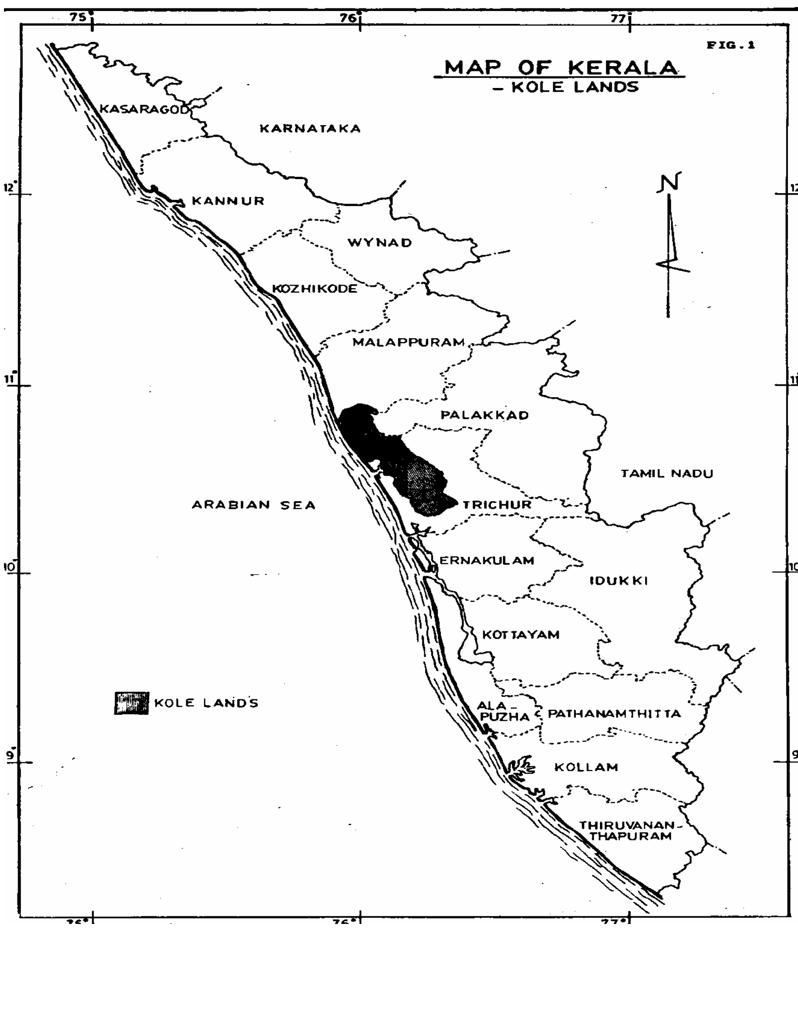
5. Characteristic Features of the Kole Wetlands in Thrissur, Kerala

The Kole lands which form one of the rice granaries of Kerala are part of the unique Vembanad-Kole wetland ecosystem comprising of 151250 ha included as a Ramsar site in 2002[6]. As per the Information Sheet on Ramsar site, the Vembanad-Kole Wetland System is the largest brackish, humid tropical wetland ecosystem in the Southwest coast of India. The Vembanad-Kole system is fed by 10 rivers. All these rivers originate from

[6] Wetlands included in the List acquire a new status at the national level and are recognized by the international community as being of significant value not only for the country, or the countries, in which they are located, but for humanity as a whole.

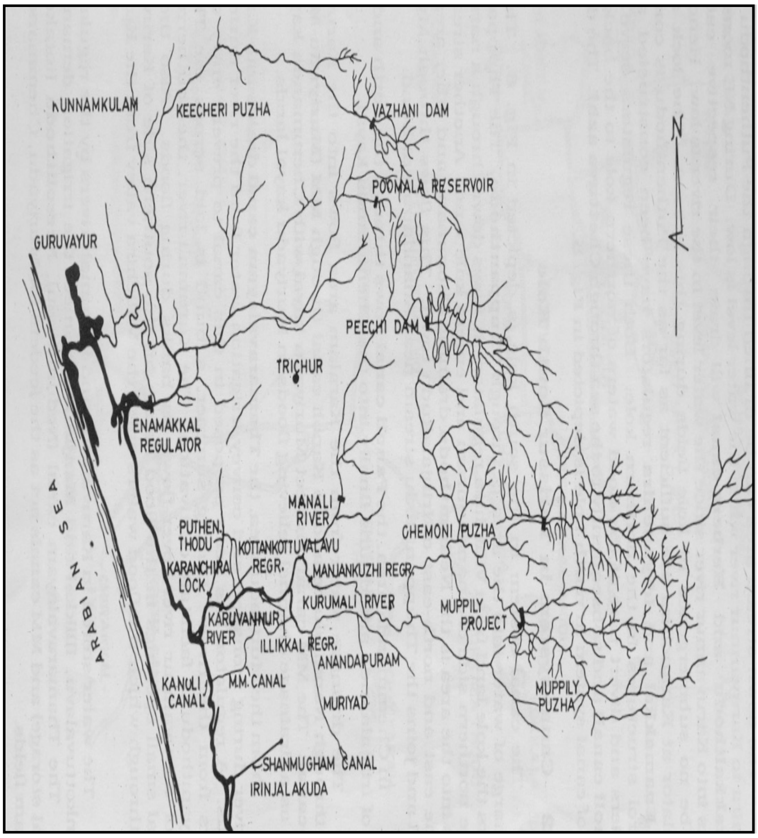
Western Ghats, flow westwards and join the Arabian Sea. The area is also exposed to diurnal tidal cycles. It is known that the Vembanad-Kole system together contains the floodwater and saves about 3500 sq.km thickly populated area of Alappuzha, Ernakulam and Thrissur districts of Kerala from flood damages (Ramsar Information Sheet). This wetland come under the 'Central Asian-Indian Flyway' (Anonymous, 1996) and serves as 'stepping stone' for the trans-continental migrant birds. It is found that the wetland system supports 20000 residential as well as migratory water birds. The Vembanad-Kole system supports the third largest population of waterfowl in India during the winter months. About 91 species of resident/local migratory and 50 species of migratory birds are found in the Kole area. The birds come here from different regions for nesting and feeding. Kole supports eight Red data book species birds according to the IUCN category (Nameer, 2002).

Figure 3: Location Map of Kole lands, Thrissur



Within the Vembanad-Kole wetland ecosystem, the Kole lands cover an area of about 13,632 ha spread over Thrissur and Malappuram districts. The name Kole refers to the peculiar type of cultivation practice carried out on these lands. Kole in the regional language Malayalam indicates bumper yield or high returns in case floods did not damage the crop. Kole lands extend from the northern bank of Chalakudy River in the south to the southern bank of Bharatapuzha River in the north. They are low lying tracts located 0.5 to 1 m below mean sea level located between 10°20' and 10°40'N latitude and between 75°58' to 76°11'E longitude. The fields are geographically distributed in Mukundapuram, Chavakkad and Thrissur taluks of Thrissur district and Ponnani Taluk of Malappuram districts. The area from Velukkara in the south on the Chalakudy river bank in Mukundapuram Taluk to Mullassery of Chavakkad Taluk and Tholur-Kaiparama areas of Thrissur taluk is designated as 'Thrissur kole' and the contiguous area from Chavakkad and Choondal to Thavannur, covering Chavakkad and Thalapally taluks of Thrissur district and Ponnani Taluk of Malappuram district form the 'Ponnani kole'.

Figure 4: Kole lands in Thrissur: Kecheri and Karuvannur River System



Source: Johnkutty and Venugopal (1993)

The Kole lands remains submerged under flood water for about six months in a year and this seasonal alteration gives it both terrestrial and water related properties which determine the ecosystem structure and process which in turn give rise to various provisioning services. It is reported that about 233.74 mm^3 water is contained in the Kole lands which is in fact more than what is stored in the Chimmony and Peechi dams for irrigation of summer crop in the Kole lands (District Plan Thrissur, undated). This area lies parallel to the sea and flood waters are mainly brought by two rivers Kechery and Karuvannur[7] which finally drains into the sea. A net work of main and cross canals provides external drainage and connects the different regions of the Kole to the rivers. Below we present a brief overview of the river and canal systems of the Kole wetlands on which the important uses of Kole are dependent.

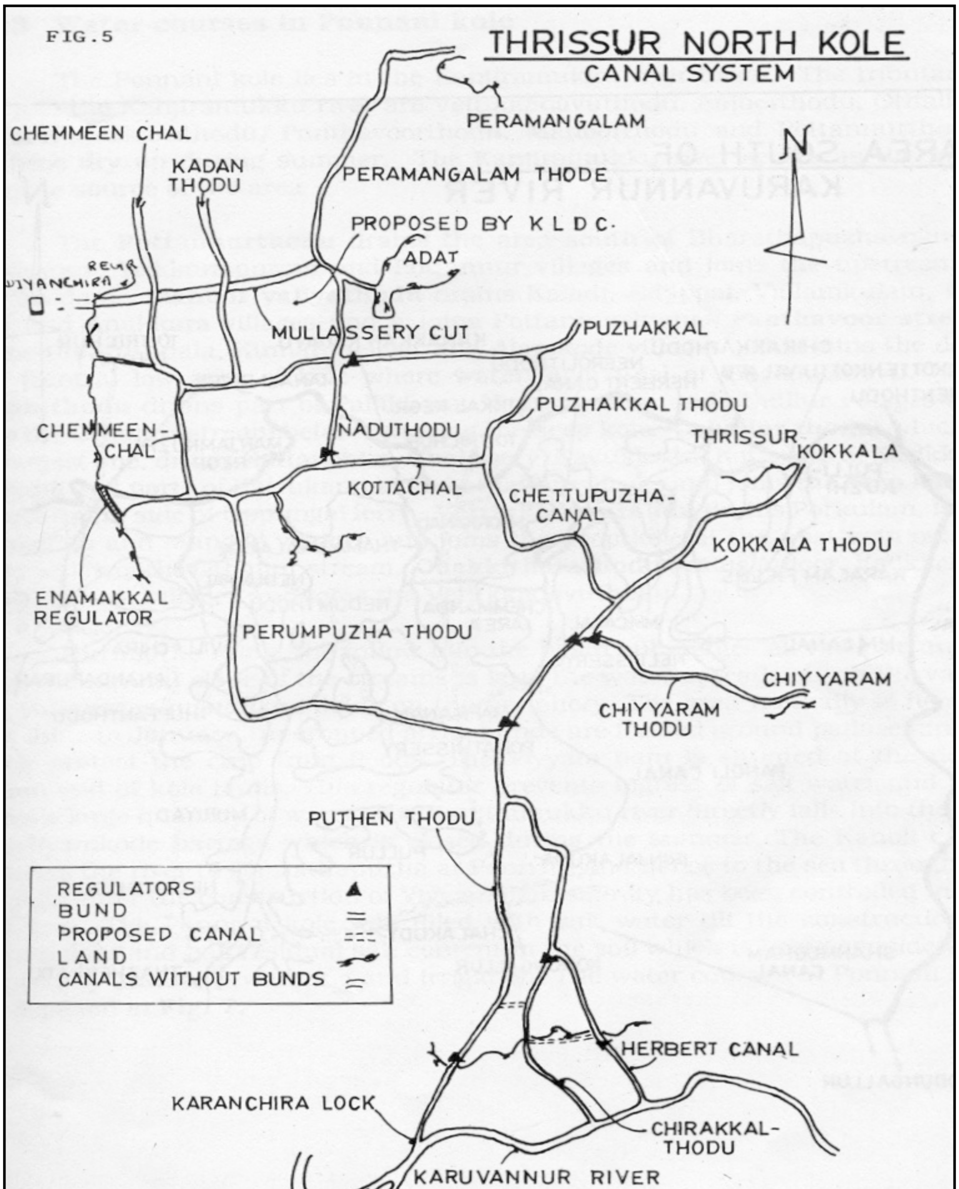
The Thrissur Kole can be divided into North and South Koles. The Thrissur North Kole is a stretch of low lying lands extending from the Karuvannur River in the south to Kaiparamba in the north. The Thrissur North Kole is divided into three basins, namely the north covering *Kechery*, *Peramangalam* and *Chemmen* basins, the central comprising of *Puzhakkal Naduthodu, Chiyyaram* and *Kokkala* basins and the south consisting of *Puthenthodu, Herbert Canal* and *Chirakkal thoudu* basins[8] . The main exits for the flood water that enter the Kole fields are *Enamakkal* and *Idiyanchira* regulators. These regulators also serve as salt barriers and divert part of the flood waters of northern Kole to the backwaters through *Kanoli* canal and subsequently to the sea through *Chettuva azhi*.

On the other hand, the main discharge of water into the South Kole area is through *Thuppanthodu* which enters the Kole land from *Villichira* regulator. Another stream Nedumthodu enters this area draining *Thommana* and other areas of east and north-east of Irinjalakuda town. Panoli canal flows through north and north-west of *Irinjalakuda* and drains finally into the *Chemmanda kayal. Thamaravalayam* canal from the *Muriyadu* area drains into *Karuvannur* River during monsoon and convey irrigation water from the river during crop periods.

[7] The Karuvannur river has two tributaries viz Manali and Kurumali. Kurumali is formed of two tributaries, Chimoni and Mupli. All these start from the Western Ghats. When the river reaches the west it branches into two, one going directly to north joins the Chettuva lake and the other flowing south joins the Manakodi lake. The Kecheri river flows down from the Machad hills, traverses west and then turns south and joins the kole lands on the northern side draining finally into Enamakkal lake, which is connected to Chettuva lake.

[8] For details of Canal system in the Kole lands refer Johnkutty and Venugopal (1993).

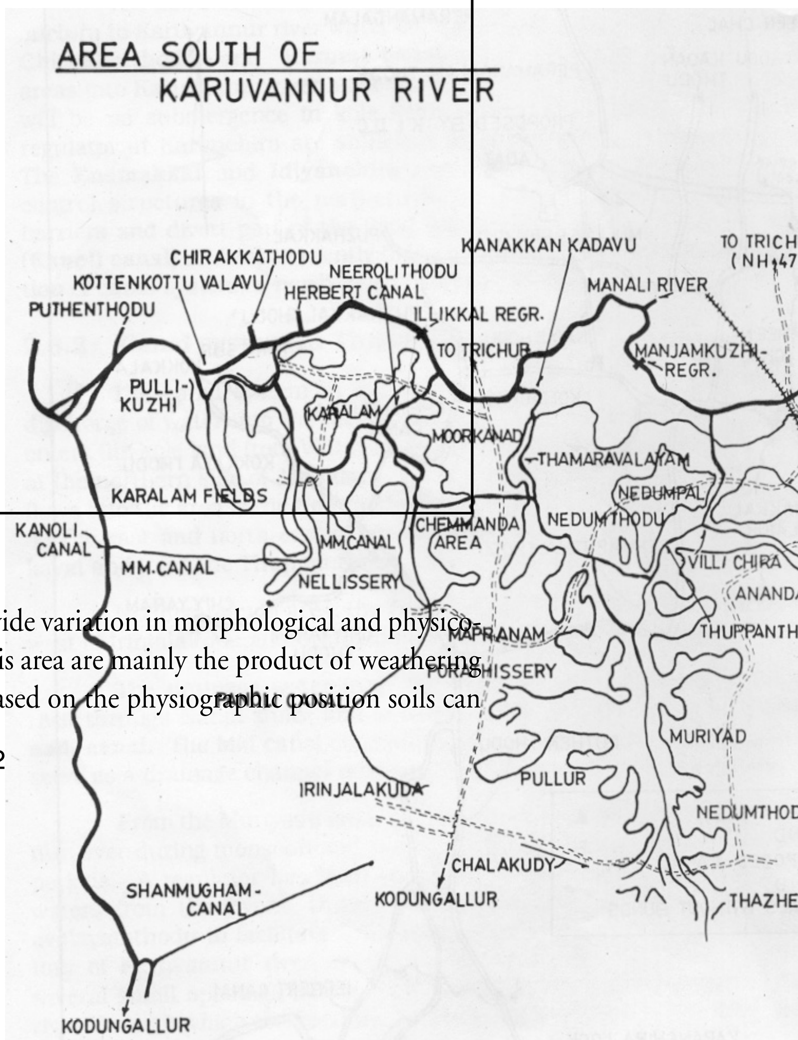
Figure 5: Canal System in the Thrissur North Kole



Source: Johnkutty and Venugopal (1993)

Geologically, Kole is a low lying area with alluvium deposits brought down by the Kechery and Karuvannur rivers. It is a basin with a saucer shape flanked by laterite hills in the western and eastern margins. Some portion of Kole area exhibits a lacustrine environment and contains black carbonaceous clay with many plant parts and in some places withered tree trunks (Johnkutty and Venugopal, 1993). Also, the subsurface exploration of Kole land shows fine sandy deposits due to which mining has become an important activity in certain parts of the Kole lands recently.

Figure 6: Canal System in the Thrissur South Kole



Source: Johnkutty and Venugopal (1993)

Studies conducted in the Kole area reveal wide variation in morphological and physico-chemical characteristics of soils. Soils in this area are mainly the product of weathering of river alluvial deposits and colluvium. Based on the physiographic position soils can be grouped into two viz (1) soils of the flood plain, comprising of *Perumpuzha, Anthikkad* and *Konchira* series and (2) soils of slightly higher elevation occupying the outer fringes consisting of *Manalur, Edathuruthy, Ayyanthole and Kizhipallikkara* series (Johnkutty and Venugopal, 1993). It is known that the soils in the Kole area especially those in the flood plain are heavy clay in texture and acidic in reaction. The presence of organic peat layer in the sub-surface of the soil profile has made soils extremely acidic. pH ranges from 2.6 to 6.3. Besides, in the Kole land adjacent to the coast, sea water inundation causes salinity levels to reach to a level where it is toxic to crops. On the whole, Kole lands are a unique wetland ecosystem whose characteristics are determined by the volume and duration of flooding and the silt brought in by the flood water.

6. Important Uses of Kole wetlands

Any analysis of wetlands is complicated by the existence of complex ecosystem interactions, the production of multiple products and services (only some of which are physically found in the wetland itself) and problems with valuation of goods and services (Dixon and Lal 1997). Due to the coexistence of water related and terrestrial related properties various types of economic activities are undertaken on Kole lands supporting livelihoods of the local population either directly or indirectly. Table 4 explains the relation between the location and type of goods and services provided by the Kole wetlands and the types of values associated with them.

The goods and services provided by the Kole wetlands have been broadly classified into two categories, namely, on-site and off-site[9] . On-site refers to those goods and services that are provided by and available in the Kole land itself and off-site to those that are provided by the wetland but not observable on-site. Based on valuation, these are classified into marketed and non-marketed. By marketed, it is meant that the value of goods and services are revealed by markets and while non-marketed means that the value of goods and services are not revealed by the market. Among the various goods and services provided by the Kole wetlands, rice cultivation, fishing, mining, water transport and tourism, are important on-site activities which are marketed. Supporting agricultural activities in the non Kole lands in the nearby areas is a major off site service provided by the Kole lands which in terms of valuation is a marketed benefit. This includes the support provided by Kole lands for the cultivation of various garden crops like coconut, areca nut, plantains etc.

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[9] This classification was developed by Dixon and Burbridge in the case of goods and services provided by mangroves and their valuation and reported in Hamilton and Snedaker (1984) (cited in Dixon and Lal 1997).

Table 4. Relation Between the Location and Type of Goods and Services Provided by the Kole wetlands and the Types of Values Associated with Them

		Location of Goods and Services	
		On-site	Off-site
Valuation of Goods and Services	Marketed	Rice cultivation, Natural Fishing and Fish Farming, Lotus farming, Clay and Sand Mining, Water tourism, water transport	Support for agriculture in the non Kole lands in the nearby areas
	Non-marketed	Habitat and nesting place for migratory birds, supporting plant and bird diversity, Water Sports and other recreational opportunities to local population, viewing and studying, carbon sink	Flood control, groundwater recharge, and nutrient retention, micro climate stabilization

Apart from the goods and services which have direct market value, the Kole lands provides a number of ecological services in the form of flood control, recharge of groundwater, nutrient retention, etc which does not have a direct market value and are offsite benefits. There are also some important non marketed on-site benefits found on the Kole lands like recreational opportunities to local population, habitat and nesting place for migratory birds, support of plant and animal diversity etc. It also performs important carbon sink function. A brief discussion of some of the most important activities undertaken on Kole wetlands are given below although there is no data available on the population supported by each of these activities.

Rice cultivation

Rice is the most important crop cultivated in the Kole land. The crop seasons in Kole lands are as follows. *Virippu* is usually cultivated in higher rice fields around the Kole land where the duration of flood lasts only for few days. Here sowing is carried out with the onset of monsoon and by the time flood water reaches the field, crop will be 30-40 days old. Varieties which can withstand floodwater for few days are usually cultivated in *Virippu*. *Mundakan* is cultivated in medium elevation fields around the Kole lands where the flood water reside by August. *Kadumkrishi* in Kole lands coincides with *Mundakan* in normal lands but usually it starts by September. However, in order to undertake *Kadumkrishi*, the Kole lands are to be protected by bunds. When the flood water in the Kole fields starts subsiding by the end of South west monsoon season, pumping out of water will be carried out in 10 to 15 days. Dewatering is carried out using *petti and para*[10] which is an indigenous pumping device developed for dewatering the Kole fields. After this bunds around the fields or *padavu's* are raised and strengthened by means of locally available materials and laterite soils to a height of 1 to 1.5 m above the field level. Crop is directly sown or transplanted when water is around 10 to 15 cm. In *Kadumkrishi* water management is very important as it requires continuous pumping out of water and towards the end of the crop there is a need to supply irrigation water as well.

Table 5. Crop Seasons of Rice in the Kole lands, Thrissur

	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
Virippu (In higher elevation field)												
Single crop *Kadum krishi/ Mundakan*												
Single Crop *Puncha*												
Double Crop *Additional Crop, Puncha*												

[10] *Petti* and *Para* an indigenous pumping device developed for dewatering the Kole fields consists of a vertical cylinder' (*para)* in which an impeller works on with electricity. The impeller pushes the water into the wide wooden box (*petti)* placed horizontally at the top of the cylinder. The outer end of the box is connected to the Kole canal. The pumpset is very effective for low head high discharge cases.

Punja is the crop raised over the entire Kole area. Wherever bunds have not been made for *Kadumkrishi* temporary earthern bunds are put up around groups of rice fields or P*adasekharams*[11] in December-January. For Punja water requirements in the early stages of crop are met from summer flow in the rivers and in the storage canals and in later stages water from dams are used for irrigation. Since late 1980s the North Kole is divided into three zones for *Punja* cultivation. Usually in the first and second zones only *punja* is taken and in the third zone an additional crop or *kadumkrishi* is also raised.

In the zonal system of cultivation, water management is very interesting. Under this system, dewatering is carried out zone wise. Water pumped out from one zone is collected in other zones and is used as irrigation water as and when required. Dates are specified in advance for starting and ending dewatering in each zone by the District Administration in consultation with the *Padasekhara Committees* who carry out pumping operations. The normal practice is to start dewatering by second week of November and complete sowing by first week of December in zone 1. Water pumped out of zone 1 will be collected in zone 2 which in turn is used as irrigation water for zone 1 and zone 3. Zone 3 would be under *mundakan* crop by then. The *mundakan* crop would have started by third week of September and lasts until end of December. Once the harvest is completed, by December end, water from Zone 2 is pumped out and stored in the zone 3. The zone 3 would be under water for almost one month after which the fields will be prepared for *punja* crop. The water which is now pumped out of zone 3 would be stored in the Kole canals for summer irrigation. Co-operation and collective action of farmers are very important in this zonal system. In order to maintain water levels *the Enamakkal* regulators, *Munayam* bund, *Chirakkal* thodu and Herbert canals are all closed on specified dates. Additional irrigation water requirements are met from Peechi and Chimony dams. The farmers consider the zonal system of cultivation as a most practical and convenient way to undertake cultivation in the Kole fields by managing flood water in an efficient manner.

Few decades back a number of local varieties of paddy were cultivated in the Kole fields. However, since last few decades *Jyothi, Uma* and *Jaya* are the major varieties of rice cultivated. Farmers prefer 'Jyothi' because it fetches better price and is relatively superior in taste. Although according to farmers productivity of 'uma' is slightly higher than that of 'jyothi' taste wise it is not as good as *Jyothi*. For almost past 20 years 'Jyothi' is cultivated in the Kole lands. Earlier seeds were prepared by the farmers themselves,

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[11] Padasekharams are institutional arrangements for carrying out rice cultivation. The size of individual holding in each Padasekharam ranges from 20 cents to 5 acres.

where as now it is supplied by the National Seeds and Karnataka Seeds Corporation (mainly Uma). Farmers are given various types of subsidies for carrying out rice cultivation in the Kole fields. This includes subsidies for dewatering, purchase of seeds, fertilisers, and pesticides. Harvested rice is procured through Civil Supplies Corporation.

Fish farming

In some of the Kole farms, rice and fish are cultivated alternatively. Fish is cultivated after paddy harvest when the fields are flooded. The fish lings are grown in ponds until the paddy harvest is completed and fish is harvested at least 10 days before the agricultural operations for paddy starts. In Kole fields where one crop paddy and fish is cultivated, by October 15 sowing will be completed. The varieties of paddy cultivated are most often 'Jyothi' (120 days) or 'Uma' (130 to 140 days). Almost 15 days after harvest, water will be pumped in for fish farming. This is to remove the negative effects of fertilisers and pesticides. Fish farming is usually carried during March to September. The farms are leased out for about 3 years for fish farming. Katla, Rohu, Prawn are the major varieties. It is reported that fish lings are now mostly imported from Andhra Pradesh as fishing is carried out on a commercial basis by contractors in place of traditional fishing communities. Fish harvesting is carried out with the help of labourers from Tamil Nadu. In earlier times, only natural fishing was practised and that too by a community called *Padanna*. *Bral, Karimeen, Mundathi, Kolaan, Mushi, Koori, Aral, Kadu, Vala, Pallathy, paral, Potta, Cheekkori, Kalluthy, Kadu, Malinjeen, Chelli* are some of the important local fish species found on the Kole lands. Fishing in the Kole farms used to be a localised economic activity and there was substantial nutritional dependence on this resource as fish provide a crucial source of protein.

Mining

It is found that the year 1976-77 earmarked the beginning of clay mining in Kole lands where deposits of clay and sand were found. In some places, it started off as some individual's own business affair, as a raw material to one's own tile industry. Mining which has now emerged as a major non agricultural activity on Kole lands is adversely affecting the ecosystem. It is said that to start clay mining in the area permission from RDO, Geology Department, Village officer, Tahasildar, two members of Padasekhara committee are required. In addition to this, permission from Kole Development Agency is also required. Usually after obtaining permission from them agents buy land at a comparatively higher price from farmers, usually at the centre of the Kole farm. As per law, after removing top soil and mining clay, the remaining pit has to be covered using the same top soil. However, in reality both top soils and the clay beneath it are mined. This not only obstructs water flow but also leads to soil erosion in the nearby places and results in pollution of wells in the neighbourhood. This effectively makes the surrounding areas also unsuitable for cultivation. Presently data is not available on the extent of area under clay or sand mining[12]. Abandoned deep pits of 7 meters are found in several parts of *Muriyad*. Introduction of diesel engines for sand mining has become widespread and vast areas of Kole lands are turned unsuitable for cultivation in a short duration of time.

Other uses

Kole land is also used for other uses after paddy cultivation, such as duck rearing, lotus farming etc. Efforts are on to use the canal networks of the Kole land to promote water tourism. Apart from the goods and services which are marketed, Kole lands provide a number of non-marketed goods and services. The Kole lands support a large number of birds including endangered and migratory birds. It also provides other important onsite and offsite goods and services such as flood control, ground water recharge, and acts as carbon sink. It is also known that vast areas of Kole lands are also converted for housing sites and for non agricultural uses.

7. Multiple uses of Kole wetlands: Some preliminary observations

In this section, we present some preliminary observations on the various activities undertaken on Kole lands with a purpose to identify various threats to the ecosystem and the sustainability of various activities undertaken on it. It has been observed that the activities that were carried out traditionally on the Kole land has undergone considerable changes while some of the new activities undertaken are in conflict with each other threatening the sustainability of provisioning services of the ecosystem. As mentioned in an earlier section, we have adopted DPSIR framework to understand the situation of Kole wetlands today as it interact with agricultural and other pressures. The main provisioning service of the Kole wetlands is agriculture which in a broader sense includes rice, fish and other crops cultivated on Kole lands.

Drivers

Some of the important drivers identified at this stage of the study are explained briefly here. They are basically related to population dynamics and government policies related to agriculture and food production. Population has been growing steadily in the last few decades as a result of natural growth as well as in-migration from other parts of Kerala though the rate of increase has slowed now. Population growth has led to growing pressures on land resources for food production and housing requirements. As per the Thrissur District Plan (undated) the annual per capita production of rice which was

[12] Estimations of area under different uses are being made as a part of this study using Satellite data.

76.75 kilograms in 1970-71 in Thrissur district declined to 30.32 kilogram by 1997-98 and to 29.34 in 2002-03. State policies have given emphasis on modernization of rice cultivation leading to interventions in the wetland ecosystem from the creation of irrigation infrastructure to intensification of inputs. In addition to the creation of infrastructural facilities, agricultural intensification has been encouraged through various subsidies. Adoption of 'green revolution' technologies had to a large extent transformed it to an ecosystem affected by various human interventions. The national priority of food self sufficiency has made the focus on the exploitation of a single provisioning service For example, an improvement to the Kole cultivation was achieved by storing part of the pumped water in the adjacent high lying lands where no crop was taken. Also with the commissioning of the Peechi reservoir and the Chimmony dam efforts were made to stabilise Kole cultivation and to bring entire area under Punja crop. Since 1960 mechanisation of cultivation started in the Kole lands. Around this time, spread of improved varieties of seeds also began to take place. All these led to the intensification of agriculture on Kole lands. Indiscriminate and excessive use of pesticides adversely affecting the ecological sustainability is also practiced in the study area[13] .

Fishery activities wherever undertaken on Kole lands were capture fisheries traditionally managed by fishing communities. However, the subsequent introduction of fishing farming in some parts of Kole lands led to the introduction of non-fisher communities into fishery activities, creating a nexus of profit driven, capital intensive system driving away the traditional communities from such activities. Fishing farming which could be carried out without transformation of the Kole lands however led to increased pollution, adding to the cost of land preparation for the paddy farmers.

Non-agricultural activities like mining can also be considered as an off shoot of construction boom that largely took place as a result of migration to Gulf countries. Another important driver is the enactment of Land Reforms Act in 1964 while gave ownership rights to the farmers also imposed a ceiling on individual holdings. This led to subdivision and fragmentation of holdings and given the nature of Kole farming, the holding size became uneconomical to cultivate. Also the demand for land for non agricultural uses also increased opening up markets for land. The increased construction activities since early 80s also led to conversion of Kole lands in relatively higher elevation places as housing sites. This resulted in the conversion of Kole lands thus influencing the ecosystem process and water flow changes.

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[13] It was observed during the course of focus group discussions that a change from subsistence oriented cultivation practices to marketed oriented also meant that the farmers are not very much concerned with food safety arising from the indiscriminate use of pesticides.

Pressures

Agricultural intensification has been observed in the Kole lands. This is evident from the efforts made to facilitate double cropping on Kole lands by way of various types of engineering interventions aimed at improved drainage and water management. In addition to this other infrastructural developments have been carried out by Kerala Land Development Corporation and Kole Development Agency on the Kole lands like construction of canal, bunds and roads. It is found that certain activities carried with an objective of intensification of agriculture has sometimes led to trade-offs in other realms and hence has led to further pressures for intensification. Development of farm roads had both positive and negative effects. While the farm roads helped the movements of tillers or tractors, seeds and fertiliser, transport harvested products at reduced costs it had certain negative effects as well. Roads facilitated conversion of Kole lands for non agricultural uses and facilitated mining and other activities which led to the transformation of the ecosystem. Increased pressure on Kole lands for mining also exerts pressure on agricultural activities.

State

State changes or the changes in the ecosystem services are also found. As pointed out earlier, state changes can be described in terms of biophysical processes that determine the ecological character of the ecosystem and / or the natural resource base. Changes in the quantity and quality of soil, water etc is included here. Acidity of soil, decline in the quality of soil due to unscientific and increased use of chemical fertilisers and pesticides are reported from Kole lands. Moreover, water logging due to incomplete or faulty designs of bunds and canals and siltation, presence of water hyacinth etc adversely affecting water flow are some of the common problems. There is an increasing trend of Kole lands lying as fallow lands. This is due to a host of factors like high wage rates and lack of availability of labour, low price of paddy, difficulty in using mechanised farming in some fields due to which paddy cultivation has become uneconomical. Loss of biodiversity which can undermine the ecological character and resilience of the ecosystem is a common trade off associated with intensification of agricultural activities. Decrease in farmer friendly micro organisms and other birds and reptiles are reported from Kole lands. It is reported that frogs, snakes and owls which used to destroy crop damaging organisms have almost disappeared from the Kole lands. Increased mining activities has not only rendered the mined lands unsuitable for any agricultural activities but also led to the creation of nearby lands as fallow lands.

Impacts

The impacts of the state of the ecosystem are highly diverse and vary across different types of users. The challenge is to identify the multiple stakeholders and the type of impact on each of them. While some stakeholders appear to gain at least in the short run due to the changes to ecosystem, it is a loss for other primary stakeholders. In other words, exploitation of specific ecosystem services often lead to changes in the benefits reaped by other stakeholders from other ecosystem services. For example, intensified agricultural activities by paddy farmers adversely affected the communities dependent on fishery resources. Moreover, fisheries also changed from subsistence oriented one to commercial and contract based one. In this case livelihood of traditional fishing communities got affected. This represents an overall trade off in economic benefits and livelihoods rather than transformations of livelihoods themselves that is, traditional fishing communities themselves becoming commercial fish farmers.

Mining backed by a thriving construction industry provided livelihoods to many during the late 70s and 80s. However, it was not sustained as a major source of livelihood. Often the miners were migrants from other places, had only business interests while extracting the resources, and were not concerned about sustainable extraction. This effectively gave rise to competition for the resource and conflicts with other resource users. In some cases, this competition and conflicts stem from intensification and expansion in one or both of the activities and increased claims over the available resource. The pits that remained after mining of clay and sand were not suitable for cultivation, resulted in water stagnation, and created pollution even to the surrounding wells used for drawing water for drinking and other domestic uses.

As noted earlier, the Kole wetlands is important for migratory birds. A positive development in this direction is the increase in the awareness of its international importance and the declaration as a Ramsar site in 2002.

Responses

The responses to various drivers, pressures, state changes and impacts though have been multiple are by and large focussed on wetland agriculture. The formation of *Padasekhara Samithis* was a spontaneous response to carry out farming in the Kole lands subsequent to the enactment of land reforms. As certain agricultural operations like dewatering of the Kole lands cannot be done individually, the role of *Padasekharam's and Padasekhara* committees assume importance. A collection of contiguous rice fields is called a '*padasekharam*' or '*padavu*'. The land owners form themselves into groups to form a padasekhara committee which is formulated in a democratic way under section 7 A of the Kerala Land Development Act, 1964 and registered under the Societies Act.

Padasekhara committee carries out dewatering and related activities collectively the cost of which is shared among the individual farmers according to their size of holdings. The decisions on when to start dewatering and agricultural operations are decided by the *Padasekhara* committees in consultation with the individual farmers and in some places also with the representatives of the co-operative banks who advances loans for the common agricultural operations like dewatering, bunding, cleaning of canals etc. However, there exists heterogeneity in the practices across *Padasekharams*. The District Administration in consultation with the *Padasekhara samithis* prepares guidelines to carry out various farming activities particularly focussing on water management issues.

The important responses from the state are in providing various infrastructural facilities and financial support by way of various subsidies to carry out cultivation in the Kole farms. To solve the problem of irrigation, the Peechi Irrigation System was commissioned in 1958 and this together with the operation of Enamakkal and Kottenkottuvalavu regulator and Karanchira lock controlled the water level in the Kole canals. Based on the Vasudev Committee Report of 1969, construction of permanents bunds and widening of Kole canals to prevent Kole lands from water logging was undertaken by the Kerala Land Devlopment Corporation. Later Chimoni-Mupli Kole project was also commissioned to solve the irrigation water problem in the summer.

Punja Special Office was set up as per the Kerala Irrigation Works (Execution of Joint Labour) Act 1967 in order to look after pumping in and out of water from Kole fields for facilitating cultivation. As different agencies engaged in the development of Kole have been acting rather independently, the Kole Land Development Agency was proposed and set up in 1992 for the overall development of the Kole areas by coordinating activities of different government departments and agencies engaged in Kole development. Setting up of this agency was an important response of the state government with a primary objective to raise production and productivity of the Kole lands. However, the wetlands perspective was not given much emphasis in the activities of Kole Land Development Agency. The major activities of the agency included improvement of the infrastructural facilities like construction of permanent bunds, canals, providing engine sheds, irrigation and dewatering equipments like petty and para, construction of regulators, farm roads, etc.

There is increased awareness among some of the farmers on the harmful effects from the indiscriminate use of pesticides and chemicals on food, soil and for migratory birds there is a move towards organic farming in places like Adat. As noted earlier, due to a host of economic and other reasons, traditional farming has been replaced to a larger extent by mechanised farming. Labour shortage has been an important reason for this as traditional methods of farming was highly labour intensive in nature. The government is providing several incentives to the farmers to prevent them leaving the Kole lands fallow. For example, the government is extending financial aid of about Rs 10000 per ha to initiate cultivation in fallow land.

The inclusion of Kole as a Ramsar site is the most important recent response towards the conservation of Kole lands at national as well as at the international level. With the inclusion of Kole lands as a Ramsar site, there are efforts to initiate a comprehensive conservation programme. Table 6 summarises DPSIR indicators and its characteristics.

Table 6. DPSIR Indicators and Characteristics

	Drivers
Population	Growth in district population growth: Increase in the density of population (For eg. 903 people per sq.km in 1991 to 981 in 2001 as against respectively 749 and 819 in Kerala) Per capita availability of land
Intensification of agricultural activities	Adoption of green revolution technologies Increased input use Creation of irrigation infrastructure
Land use change	Conversion to non agricultural uses
Land tenure changes	Enactment of Land Reforms Act in 1964 resulted in subdivision and fragmentation of holdings as a result of which holding size became uneconomical to cultivate
Subsidies	Resulted in indiscriminate use of chemical fertilisers and pesticides adversely affecting the sustainability of crop production
Urbanization	Developmental pressures Housing demand
	Pressures
Increased cropping intensity	Attempts to cultivate two crops instead of a single crop
Intensification of fisheries	Change from capture to commercial fisheries
Infrastructural development	Development of irrigation infrastructure, farm roads, etc
Urbanization	Increased demand for housing sites, conversion to non agricultural uses
Threats to migratory birds	Poisoning and killing of migratory birds
	State
Acidity of soil	Increase in the acidity of soil

Decline in soil quality Siltation of canals	Increased use of chemical fertilisers and pesticides Faulty design of bunds and canals
Water logging	Faulty design of bunds and canals
Presence of water hyacinth	
Increase in fallow lands	Due to mining, Increased cost of cultivation, shortage of labour etc
Loss of native plant and animal biodiversity	Decrease in farmer friendly plants and micro organisms, birds and reptiles
	Impact
Intensified agricultural activity and its effect on fisheries	Intensified agricultural activity adversely affected fisheries
Change from subsistence to commercial fisheries	Adversely affected traditional fishing communities Loss of fish biodiversity
Resource use conflicts Increased fallow lands Increased awareness of the international importance of Kole lands	Conflicts between agriculturists, miners, fishers etc After mining large tracts of land became unsuitable for cultivation Kole lands important for its migratory birds
	Response
Emergence of new institutional arrangements for management	Formation of groups of farmers, the *Padasekhara Samithis*
Increased infrastructural and financial support for paddy cultivation	Commissioning of Peechi, Chimni-Mupli dams and other regulators and bunds
Setting up of new institutions for providing support to agriculture in Kole lands	Set up Punja Special Office, Kerala Land Development Agency, etc.
Inclusion of Kole as a Ramsar site	To initiate a comprehensive conservation programme Kole land was declared as a Ramsar site 2002

8. Summing up

Wetlands are generally considered as dynamic ecosystems where the natural fluctuations are part of the system. However, human activities also can change or affect its ecological functions. As a result of the ignorance or misunderstanding of the value of goods and services provided by wetlands, these are considered as wastelands and has resulted in its conversion to intensive agricultural, industrial or residential purposes. Certain specific characteristics of the ecosystem such as its multiple use, indivisibility, seasonal alternation etc pose several challenges to manage it in a sustainable manner. The Kole wetlands, is an example of multiple use wetland ecosystem which is also subjected to seasonal alterations. Various types of activities are undertaken on Kole lands supporting the livelihood of a large number of populations. Often these activities are in conflict with each other. As a result, this ecosystem is under various pressures. Rice cultivation and other provisioning activities are most important here. The importance of this wetland can be understood from the inclusion of it as a Ramsar site. However, it has been observed that fewer and fewer households consider Kole lands as their exclusive source of livelihood. It appears that this changing trend does not reduce the pressure on Kole lands, but exposes it to different types of interrelated pressures which are very complex to understand. In such a situation, there is a need to disentangle the complex web of interrelated pressures on this wetland ecosystem beyond its significance in supporting the local land based livelihoods either directly or indirectly. Or else, there is a chance of undermining its ecological importance if viewed only from the livelihoods angle where fewer and fewer households tend to consider land as their exclusive source of livelihood.

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