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Environmental Sustainability Indicators of Rice (*Oryza sativa*) Fields in Onattukara Wetlands, Kerala

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A B S T R A C T

Onattukara region is a peculiar agro-ecological zone with specific soil and climatic conditions. This region is characterized by cropping pattern of double crop system in wetland. In developing countries, particularly within Asia, rice production areas are one of the most important agricultural features that can be used to achieve sustainable agriculture. One of the increasingly applied tools for monitoring progress towards sustainable development is the use and evaluation of sustainability indicators. This study was carried out for a period of one year i.e., April 2017 to March 2018. The development of local sustainability indicators has become an important tool for assessing and monitoring sustainability of paddy fields. The sustainability indicators identified for the study of sustainability of rice fields in Onattukara wetlands are water quality and water usage, land usage, rainfall, soil type and soil loss, biodiversity, habitat value and the overall climate change. Each metric represents an important component of maintaining the overall environmental sustainability of the wetland fields under investigation. This study was aimed to estimate current status of sustainability indicators in Onattukara wetland region.

***Key words*: Sustainability, Agriculture, Onattukara, Wetland, Climate change, Biodiversity**

Agriculture in the 21st century faces the challenge of increasing food production in order to maintain adequate supplies for a growing world population while trying to improve overall environmental and social outcomes. The primary goals of Sustainable Agriculture and Rural Development (SARD) as described in Chapter 14 of Agenda 21 in the UN Department of Economic and Social Affairs are to strengthen food security by the sustainable increase of food production'. In developing countries, particularly within Asia, rice production areas are one of the most important agricultural features that can be used to achieve sustainable agriculture and rural development goals. One of the increasingly applied tools for monitoring progress towards sustainable development is the use and evaluation of sustainability indicators [2], [10].

Wetlands

Wetland ecosystems are estimated to cover more than 9% (1,280 million hectares) of the Earth's land surface. Water determines wetland formation, processes and characteristics and wetlands have diverse physical characteristics and geographical distributions. They are critical resources important for delivering a wide range of ecosystem goods and services including regulating, provisioning, livelihood services and cultural services that contribute to general human well-being [4], [12-13]. Wetlands are continuously facing serious threats of loss and degradation owing to human activities. In fact, the degradation and loss of wetlands and the associated species is more rapid than that of other ecosystems [5], [13]. Since the beginning of the 20th century a substantial area of wetlands has been lost due to engineering construction works, draining and conversion to arable land, exploitation of groundwater and dumping of refuse. Furthermore, many have been degraded through nutrient enrichment, the main sources being sewage effluents and agricultural fertilizers. Environmental deterioration particularly that due to global climate change is expected to exacerbate the loss and degradation of many wetlands and lead to the loss of biological species in many regions.

Paddy wetlands of Kerala

A rice paddy is a shallow pond with a flat bottom that can hold 6-8 inches of water, provides for control of water depth, and is able to drain completely. Once a rice paddy system is established, it begins to function as a manmade wetland supplying many of the same benefits that natural wetlands provide. Taking into consideration topography, soil and abiotic factors and variation in resource endowments, and reckoning the seasonal differences in which rice is grown in the state, six significant paddy - agroecosystems are identified in Kerala namely, Midland and Malayoram ecosystems, Palakkadu plains, Kuttanadu Agrosystems, Pokkali and Onattukara agro

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ecosystems and High range ecosystems [10]. The main difference between the rainfed and the irrigated practice is that in the latter the *Virippu* season commences only after the onset of the southwest monsoon (in June) and crop is established through transplanting.

Traditionally all the paddy fields in Kerala were being cultivated with various land-races of rice during the southwest and northeast monsoon seasons. In uplands, different upland varieties of rice were grown during the southwest monsoon season. Rice is a major crop of Kerala with considerable variability in duration, adapting to various agro-climatic and cultural situations and seasons, seed coat colour, shape, size, pigmentation of plant parts, plant height, tillering, lodging, grain, cooking quality and aroma. In Kerala, rice has been grown in three seasons namely *Virippu* (April-May to September-October), *Mundakan* (September-October to December-January) and *Puncha* (December-January to March-April). Paddy fields are a vital part of Kerala's environment and ecological systems that provide natural drainage paths during floods as well as inhabiting rich and unique flora and fauna. In several regions of Kerala, paddy cultivation is very conducive to the particular geographical and ecological settings. For instance, in *Kaipad* fields in Kattampally in Kannur district, paddy has been traditionally cultivated in fields filled with saline water. The *Pokkali* fields in the Kochi area and *Kole* fields in Thrissur and Ponnani are unique rice field agro systems.

Sustainability of rice fields

Rice sustainability depends upon the most efficient use of resources, effective manipulation of the environmental parameters and utilization of most productive hybrid as well as traditional cultivars. Traditional rice fields, some of which have been cultivated for several hundred years, may be considered as climax communities. The environmental indicator metrics important to agricultural sustainability include such parameters as land use, soil loss, water use, water quality, air quality, energy use, climate impact, biodiversity etc. Each metric represents an important component of maintaining the overall environmental sustainability of the agricultural enterprise. The land use metric is primarily related to the amount of land dedicated to the farming enterprise and the productivity of that land. The soil loss metric quantifies the progressive degradation of soil quality and depletion of topsoil which would critically impair the agricultural productivity of rice systems. Water use relates to the amount of water required per unit of food produced as well as the optimum input of water for maintaining the sustainability of the rice fields. Water Quality indicators attempt to quantify the water pollution impact of the system and the detrimental effect of the pollutants. The air quality metric is an assessment of the regional air pollution impact of the agricultural activity. Energy use is an estimate of the total energy required per unit of food produced, which includes the fixation of solar energy by the system and the subsidized energy input by way of fertilizers and organic manure. Climate Impact is the amount of greenhouse gasses emitted by the rice fields. The biodiversity metric is an assessment of the ability of the rice fields to remain as a habitat for native wildlife species.

The development of local sustainability indicators has become an effective tool in implementing and monitoring sustainable development agenda and progress. It not only addresses the need to ensure the continuity of rice production for food security but points to the areas where timely and adequate actions are needed. The identification of indicators for sustainable rice production is critical in the context of ever-increasing encroachment of rice fields by border cultivation as well as expansion of housing settlements. The locally conducive methods were applied in collecting information and opinions from stakeholders to develop a set of indicators for sustainable development in local rice-growing areas. Major sustainability indicators are broadly classified under two headings: The Natural capital and Human capital. Natural capital includes: Air Quality Trend Indicator, Freshwater Quality Indicator, Greenhouse Gas Emissions Indicator, Forest Cover Indicator and Extent of Wetlands Indicator.

The National Round Table for Environment and Economy (NRTEE, Canada) recommends the regular reporting of these five indicators in order to make continuous assessment of sustainability of particular ecosystems. Some locally relevant indicators that are used to assess sustainability of ecosystems are land use, soil loss, water use, water quality, air quality, energy use, climate impact and biodiversity. Sustainability of threatened wetland ecosystems in Kerala is a critical factor which influences the judicious exploitation of natural resources. Kerala is endowed with a number of such ecosystems such as mangroves, fresh water lakes, natural plantations and agricultural areas. Rice fields are one of such wetland systems which are fast diminishing from our agricultural map. The present study attempts to analyze the modifications of rice fields at Onattukara wetland region at (Kollam and Alappuzha) District and to assess their sustainability to remain as rice field wetlands in the future. This is assessed based on the standard local level sustainability indicators which gives an indication of sustainability of ecosystems in a given set of environmental conditions [14].

MATERIALS AND METHODS

Onattukara region is a peculiar agro ecological zone with specific soil and climatic conditions. This region comprised of Muthukulam, Harippad, Bharanickavu, Mavelikkara and Ambalappuzha blocks of Alappuzha district and Chavara, Ochira, Sasthamcotta blocks in Kollam District. The area lies on both sides of NH 66 (previously) and spread from south end of Thottappally Spillway to the north end of Neendakara bridge. This region lies in the lowland tract between 8°55'44" to 9°21'09" N latitude and 76°23'13" to 76°41'16" E longitude. Average rainfall is about 2700 mm. The temperature varies from 19.2 to 33.7 °C. The terrain is more or less even and the garden lands a mean elevation of 1.0-3.5 meter above Mean Sea Level (M.S.L) (Fig 1).

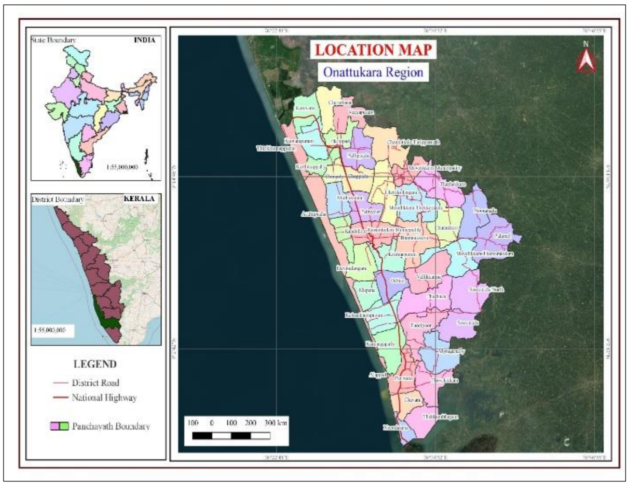

Fig 1 Map of the study area

Onattukara is located on the southern part of Kerala. On Local Self Government Department (LSGD) basis this region comprises of 40 Gramapanchayath and 3 Municipalities (Table 2). Geographically land area of the region under survey comes to about 691.38 sq.km of area (Fig 2-3). The overall process for developing a set of local-level indicators for the study is depicted in (Table 1) these local level indicators include the climate change, land use, water quality parameters and usage, border cultivation pattern and change etc. These indicators are analyzed in terms of the optimum cultivation requirements for the long-term sustainability of rice fields.

Fig 2-3 Onattukara region under the survey and paddy fields

Table 1 Sustainability indicators

Sustainable indicators	
1	Climate change
2	Soil type and soil loss
3	Water quality and usage
4	Land use
5	Rainfall
6	Biodiversity and habitat value

Table 2 Onattukara region

District	Blocks	Panchayath (Villages)
Kollam	Chavara	1. Chavara
		2. Panmana
		3. Thevalakkara
		4. Thekkumbhagom
		5. Neendakara
	Ochira	6. Ochira
		7. Clappana
		8. Kulasekharapuram
		9. Thazhava
		10. Thodiyoor
		11. Alappad
		12. Karunagappally**
	Sasthamcotta	13. Sooranad North
		14. Sooranad South
		15. Mynagappally
Alappuzha	Muthukulam	16. Kandalloor
		17. Cheppad
		18. Devikulangara
		19. Arattupuzha
		20. Krishnapuram
		21. Pathiyoor
		22. Muthukulam
		23. Kayamkulam**
	Haripad	24. Cheruthana
		25. Haripad
		26. Veeyapuram
		27. Chingoli
		28. Kumarapuram
		29. Karthikappally
		30. Thrikkunappuzha
		31. Pallipad
	Bharanickavu	32. Bharanickavu
		33. Chunakkara
		34. Palamel
		35. Thamarakulam
		36. Vallikunnam
		37. Nooranad
	Mavelikara	38. Mavelikara**
		39. Thekkekara
		40. Chettikulangara
		41. Chennithala
		42. Thazhakkara
	Ambalapuzha	43. Karuvatta

District-2, Block-8, Panchayath-40, Municipalities-3
**Municipalities

Sustainability indicators

Climate change

Climate change is a global level phenomenon which can also be local level indicator of sustainability. The overall climate and weather changes of Onattukara region in general and the eight blocks in particular were observed for the different seasons of cultivation and the changes were observed by comparing with the climate data available for the (Alappuzha and Kollam district) Onattukara region (Table 3).

Table 3 Weather data during the cropping period (April 2017 to March 2018)

Months	R.H (%)	Max. Temp. (°C)	Min. Temp. (°C)	Rainfall (mm)
April-2017	92	29.3	24.0	339.4
May-2017	92	30.3	23.9	116.9
June-2017	85	31.2	23.9	184.9
July-2017	85	32.1	22.5	7.3
August-2017	71	33.3	21.7	19.5
September-2017	77	33.5	22.3	15.4
October-2017	72	33.4	23.7	25.2
November-2017	79	33.2	24.2	86.1
December-2017	86	32.1	24.6	27.9
January-2018	83	30.4	22.5	28.7
February-2018	90	29.5	24.3	18.4
March-2018	92	31.6	23.9	20.5

Soil type and soil loss

The soil type of Onattukara is fairly rich Alluvial Soil. Selected Locality under the Block wise differences were observed and noted. Suitability of the soil for rice cultivation is analyzed and changes as a result of border cultivation and inter cultivation were observed. Soil texture, soil pH etc. were analyzed (Table 4).

Water quality and usage

Water quality for the cultivation was assessed based on the parameters such as Dissolved Oxygen (DO), Biochemical Oxygen demand (BOD), pH of the water etc. (Table 5). Availability of water for the cultivation, its sustainable presence throughout the growing season (water logged condition), water usage, water loss etc. were also analyzed.

Land use

Land use for the rice cultivation and associated borderline cultivations were observed. Impact of border cultivation and inter cultivation on rice fields was assessed.

Rainfall

Most of the rice fields in the area are rainfed and '*Virippu*' and '*Mundakan*' cultivation is the main type of paddy cultivation in Onattukara region. Changes in the pattern and availability of rainfall and its storage were analyzed. The relationship between rainfall and water usage was also observed.

Table 4 Soil quality of Onattukara region

Name of Padasekaram	pH (1:2.5)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Ca (ppm)	Mg (ppm)	S (ppm)	WHC (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Soil texture
(CVA-LP)	6.1	12.54	12.35	22.288	513.45	15.70	11.20	24.51	103.29	6.17	2.04	Loamy sand
(CVA-SP)	4.8	13.5	10.86	24.864	531.40	20.45	15.22	31.59	33.78	6.70	2.06	Loamy sand
(OCR-LP)	4.4	11	6.67	87.696	513.25	34.83	314.92	35.49	347.52	15.38	2.65	Loamy sand
(OCR-SP)	5.0	13	81.49	33.152	203.00	15.88	22.93	25.58	328.14	9.75	2.65	Loamy sand
(SCA-LP)	5.4	19	22.23	33.04	518.05	16.93	24.94	27.30	275.72	12.61	3.37	Sandy loam
(SCA-SP)	5.2	26	56.05	24.752	636.45	17.15	639.10	28.59	293.63	9.05	3.06	Sandy loam
(MKM-LP)	4.1	35	1.32	419.216	517.80	262.85	210.66	49.56	539.58	43.73	7.52	Loamy sand
(MKM-SP)	4.1	37	13.85	48.608	525.80	21.80	359.85	30.30	295.12	14.51	2.94	Loamy sand
(HPD-LP)	4.8	46	0.95	366.24	617.75	170.28	694.08	37.82	732.48	68.78	15.02	Loamy sand
(HPD-SP)	4.3	38	1.38	311.024	608.80	221.00	346.10	36.12	681.89	74.19	14.17	Loamy sand
(BKV-LP)	4.5	34	1.80	51.968	534.15	30.38	161.05	44.90	539.65	20.47	6.67	Loamy sand
(BKV-SP)	4.6	39	62.93	61.6	523.05	26.93	95.01	30.10	319.12	15.14	4.16	Loamy sand
(MVK-LP)	4.6	41	11.75	395.472	554.10	48.15	118.81	40.52	392.49	19.78	6.54	Loamy sand
(MVK-SP)	4.4	36	2.78	26.208	523.30	27.03	63.83	24.86	238.12	9.09	2.27	Sandy sand
(AMP-LP)	3.5	51	0.79	110.656	657.20	397.85	135.91	39.23	256.00	48.11	3.90	Sandy loam
(AMP-SP)	4.0	47	1.85	66.864	536.25	64.45	841.59	31.62	247.40	9.92	2.34	Sandy loam

CVA-Chavara, OCR-Ochira, SCA-Sasthamcotta, MKM-Muthukulam, HPD-Harippad, BKV-Bharanickavu, MVK-Mavelikkara, AMP-Ambalappuzha, LP-Large padasekaram, SP-Small Padasekaram

Table 5 Water quality of Onattukara region

Name of padasekaram	pH	DO	BOD
(CVA-LP)	7	4.8	1.7
(CVA-SP)	7.4	3.9	1.6
(OCR-LP)	7.2	4.6	1.7
(OCR-SP)	7.9	4.2	1.6
(SCA-LP)	7.5	4.6	1.9
(SCA-SP)	7.3	4.2	1.7
(MKM-LP)	7.4	3.9	0.7
(MKM-SP)	7	3.2	0.9
(HPD-LP)	7.1	5.2	1.7
(HPD-SP)	7.6	5.9	1.8
(BKV-LP)	7.6	5.1	0.9
(BKV-SP)	7	4.6	1.1
(MVK-LP)	7.4	2.9	1.9
(MVK-SP)	7.1	4.3	1.9
(AMP-LP)	6	3.9	1.7
(AMP-SP)	7.3	4.6	1.6

CVA-Chavara, OCR-Ochira, SCA-Sasthamcotta, MKM-Muthukulam, HPD-Harippad, BKV-Bharanickavu, MVK-Mavelikkara, AMP-Ambalappuzha, LP-Large padasekharam, SP-Small Padasekharam

Biodiversity and habitat value

Rice fields offer a unique ecosystem inhabited by a variety of flora and fauna specific to such periodic environments. Many of these plant and animal species are ecological indicators whose disappearance itself indicates a substantial change in the system and also an indication of the sustainability of the system. The habitat value of rice field is the ability of the system to inhabit the plants and animals specific to these environments.

Habitat value was assessed by listing the plants present in the rice fields and their period of presence in the fields and these were compared with the standard flora of rice fields. Change in the floristic pattern was taken as the indication of sustainability.

RESULTS AND DISCUSSION

Climate change

The analytical and empirical results of the study are shown in the (Table 3). Climate change was observed for a particular duration with respect to the rice cultivation and compared with the climate graph of Onattukara region. In all the Onattukara locations rice cultivation is done twice a year during June to August and October to February. The climate during the period begins with rainy season and ends in summer. The maximum rainfall april-2017 in 339.4 mm and minimum rainfall reported in july-2017 in 7.3 mm (Fig 4). The relative humidity is reported in maximum april-2017 in 92% and minimum reported august-2017 in 71% (Fig 5). The average precipitation during the two seasons is not varying much when compared to that of the climate graph. Similarly, the mean temperatures and relative humidity data were also in agreement with the available data. However, the onset of summer early in January with corresponding reduction in rainfall during January to March and the narrow difference between the maximum and minimum temperatures suggest an unfavourable change in the climate compared (Fig 6) to that of the past and a forward shift in hotness that may adversely affect the rice cultivation especially in these Onattukara areas and other similar lowland rice fields.

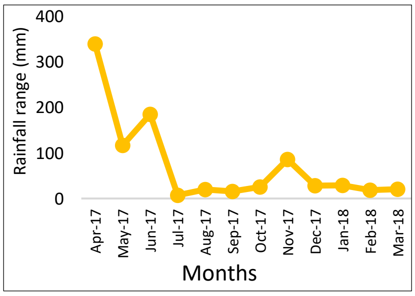

Fig 4 Rainfall source in Onattukara region

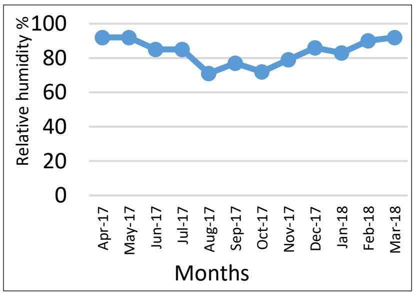

Fig 5 Relative humidity in Onattukara region

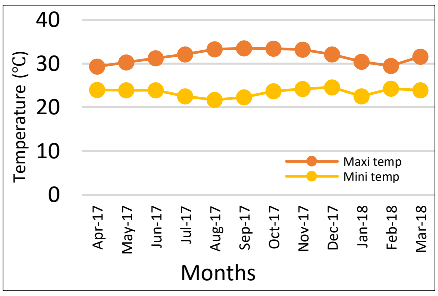

Fig 6 Temperature in Onattukara region paddy field

Soil type and soil loss

The soil type in the study area is Sandy loam of Laterite rather than loamy sand laterite typical of other areas. All most localities pH value reported extremely acidic (3.5-4.4) except four localities very strong acidic (4.5-5.0) in nature (Table 4). Potassium regulates many metabolic strategies required for increase, meals and seed development. Many vegetables and end result crop are excessive in Potassium which is important for animal and human nutrition [8]. The potassium values are below the standard the soil samples Chavara, Ochira, Sasthamcotta, Bharanickavu, Ambalappuzha. Sulphur content value ranges from 13.21kg/hectare to 520.09 kg/hectare. The soil sample Chavara are in between the standard values but the other soil sample values are exceeding the standard value. Deficiency causes plant stems are stiff, skinny and woody and growth price is retarded and maturity is delayed [3].

This may be due to the continuous addition of organic matter after every harvest and the deposition of soil from other areas through water streams. Inter farming of other crops such as Cassava, Banana and Pulses also seem to alter the soil texture and organic content. Water logged condition during the rice cultivation makes the upper soil clayish and becomes normally unsuitable for other crops.

Soil loss is not observed very much during cultivation as the paddy fields are well protected with border bumps in order to hold water and maintain the water-logged condition during '*Virippu*' and '*Mundakan*' cultivations. However, inter farming becomes a regular cultivation in between these two-rice cultivation which involves alteration of soil and manual Soil movement in and out of the rice fields. Thus, soil loss is not a critical indicator of rice field sustainability [9].

Water quality and water use

Water quality is a critical indicator of sustainability of any wetland ecosystem that determines the biodiversity of the system. Because rice is farmed in fields flooded with shallow water, the importance of good farming practices to water quality is evident. Water quality problems associated with other crops, such as soil erosion and sediment transport, saline drainage waters, and high concentrations of trace elements in subsurface drainage, are typically not a problem with rice farming because of the slow continuous rate of flow through rice fields and the controlled rate of water release [7]. The water quality was analyzed by measuring the Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and pH (Table 5). All the parameters indicate the good quality of water at all the Onattukara rice fields.

Water availability and usage depends upon the rainfall and pattern of rainwater harvesting since all the rice fields are rainfed types and the cultivations are of *Viruppu* and *Mundakan*. At all the localities irrigation facilities are almost nil. During the rainy seasons water is collected at large in the fields which are so prepared with raised border bunds and narrow canals along the borders. Frequent ploughing increases the water holding capacity of the soil and the water is logged throughout the period of cultivation. Because of the flooded nature of lowland rice, its water balance and water productivity are different from those of other cereals such as wheat and maize. Water inputs to lowland rice fields are needed to match the outflows by seepage, percolation, evaporation, and transpiration.

The major water quality challenges at all the localities are the enhanced application of pesticides, herbicides and chemical fertilizers which can adversely affect the sustainability of the system.

Land use

Paddy cultivation in Kerala has witnessed a steady decline since the 1980s. Over the years, large tracts of paddy fields in Kerala have been converted into land for the cultivation of crops such as coconut, banana and rubber [6]. The land use pattern has changed a lot in favour of other crops such as Banana, cassava and Rubber. The shrinking of rice fields all the localities was visible and it takes place largely in the form of border cultivation (Fig 7). At all localities rice fields were encroached by Banana and Cassava cultivation and sometimes *Mundakan* cultivation was replaced by Banana cultivation (Fig 8). The progressive encroachment and replacement of rice fields was in fact influenced by many climatic and socio-economic factors that may hamper the sustainability of the rice wetlands. Paddy fields are being progressively filled with soil transported from other places and converted in to building sites or sites for growing other crops.


Fig 7-8 Border line cultivation, Mundakan cultivation was replaced by Banana cultivation Onattukara region

Table 6 Flora and fauna

Blue green algae	Nostoc
	Anabaena
	Rivularia
Algae	Volvox (Colonial free-floating)
	Chlorella
	Euglena (dinoflagellate)
Rooted hydrophytes	Hydrilla
	Isoetes
	Nilumbium(Water lilies)
	Nymphaea
Free floating forms	Azolla
	Pistia (Water lettuce)
	Wolffia
	Salvinia
	Eichhornia crassipes (Water hyacinth)
	Utricularia
Nektons and Neustons	Fishes
	Dragon fly nymphs (Odonata)
Birds	White breasted water hen
	Indian Pond Heron
	Little Egret
	Common Maina
	Paddy Field Warbler
Weeds	Monochoris vaginalis
	Echinochlora crusgalli
	Leptochlora chinensis
Pests	Rice stem borer
	Dieladispa armigera
	Rice swarming caterpillar
	Rice bug
Amphibia	Frog (Rana hexa dactyla)
Reptilia	Rat snake

Rainfall and its distribution pattern

Precipitation is a complex indicator which in combination with other factors such as temperature, land use pattern, water usage etc. can determine the very sustainability of rice fields. Onattukara collects on average 2700 mm of rainfall per year, or 74.18 mm per month. On average there are 132 days per year with more than 0.1 mm (0.004 in) of rainfall (precipitation) or 11 days with a quantity of rain, sleet, snow etc. per month. The driest weather is in January when an average of 28.7 mm of rainfall (precipitation) occurs. The wettest weather is in June when an average of 184.9 mm of rainfall (precipitation) occurs (Table 3). Decreasing duration of rainfall and the increased duration of hot condition from January to March severely affect the *Mundakan* cultivation and often farmers are compelled to replace *Mundakan* with other inter farming crops such as Banana. Moreover, the average precipitation during *Virippu* cultivation is very high (339.4 mm) while it is as low as 7.3 mm during July. Over the years a progressive decline in precipitation is observed in Kerala that contribute to the low sustainability of rice fields.

The average level of annual rainfall is quite high in the State, being in the neighborhood of about 2700 mm. It is significant that the State gets rainfall both from the south-west and the north-east monsoons. The former starts towards the end of May or the beginning of June and fades out by September while the latter commences in October, and continues up to middle of November and dry weather sets in by the end of December. Among the different districts of Kerala, Palakkad receives the minimum rainfall and the highest rainfall in the State occurs in the High Ranges of Kottayam district where it is over 3000 mm.

Biodiversity and habitat value

Traditional rice fields inhabit unique flora and fauna that account for the habitat value of the rice wetlands and stands as an important indicator of such ecosystems. Two major groups of organisms that rely on the rice paddy system for habitat are frogs and dragonflies. (Table 6) enlists some common plants that inhabit the rice fields under investigation. Blue-green algae and other edaphic algae are present abundantly in paddy fields and are important in maintaining fertility of rice fields through nitrogen fixation [1]. Owing to the various climatic factors and human intervention such as applications of chemicals and pesticides the habitat value of rice fields is fast depleting as evident from the low diversity of flora and fauna and disappearance of such critical species as frogs.

CONCLUSION

Paddy fields are wetland ecosystems that contribute not only to the enrichment of unique biodiversity but also to the socio-economic development of the state. Kerala is gifted with diverse rice field ecosystems, considering the seasonal differences in which rice is grown in the state, six significant paddy - agroecosystems are identified. In Kerala, rice has been grown in three seasons namely *Virippu, Mundakan, Puncha*. In the context of degradation and disappearance of these wetlands owing to various agro-climatic conditions over the years, the development of local sustainability indicators has become a primary concern in implementing and monitoring sustainability of these paddy fields. The onset of summer early in January with corresponding reduction in rainfall and the narrow difference between the maximum and minimum temperatures and persistence of hotness suggest an unfavourable change in the climate compared to that of the past that can adversely affect the rice cultivation in lowland rice fields. The water quality was analyzed by measuring the Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and pH and all the parameters indicate the good quality of water at all the blocks Onattukara rice fields. At all localities rice fields were encroached by Banana and Cassava border cultivation and sometimes *Mundakan* cultivation was replaced by them. Owing to the various climatic factors and human intervention the habitat value of rice fields is also decreasing as evident from the low diversity of plants. The preliminary investigations reveal that the indicators point towards an imminent threat to the sustainability of our rice filed wetlands, which in turn necessitates an immediate integrated action program for saving these wetlands.

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