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EVALUATION INDEX SYSTEM (EIS) FOR THE ECOLOGICAL- ECONOMIC- SOCIAL PERFORMANCES OF OUSTERI WETLAND ACROSS PUDUCHERRY AND TAMIL NADU

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Zareena Begum Irfan, Venkatachalam. L, Jayakumar S and Satarupa Rakshit

Abstract

Wetlands play a key role in the ecological conservation, in environmental quality improvement, and in human habitat environment improvement. Primer field investigations, primary survey and series of stakeholder meetings were utilised to evaluate the performance of the wetland. It was done using the complex index system covering wider aspect to correlate the comparative status of both Tamil Nadu and Puducherry zone of the Ousteri wetland. Compared with the researches applying the ecosystem service evaluation method, the proposed scoring method in this study can evaluate on some important performance indices (aquatic vegetation coverage, plant community integrity, integrity of management operating system, stakeholders feedback on the wetland protection, public satisfaction) that cannot be ignored and unable to be transformed to a monetary form. The Delphi method was used to screen preset 35 sub-indicators prior to evaluation. By using Delphi and Analytic Hierarchy Process method, as well as the weighted linear combination model, the ecological-economic-social performances were obtained. This indices system was applied to the case of Ousteri wetland with respect to Puducherry and Tamil Nadu scenario separately. With the help of the Evaluation Index system (EIS) established in this study, decision makers can obtain more omni-visual information so that an ecological subsidy policy by incorporating rewards and punishments mechanisms according to the performance evaluations can be formulated to enable the greatest returns on investment in the wetland conservative measure.

Keywords: *Wetland, Performance Evaluation, Evaluation Index System, Conservation*

JEL Codes: O13, Q15, Q56, N55, R11

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INTRODUCTION

Wetland provides a wide range of ecosystem goods and services for human well-being through hydrologic, geochemical, and biological functions functions (Costanza *et. al.*, 1997; Molnar and Kubiszewski, 2012; Trabucchi *et. al.*, 2012). Among these goods and services, the mjor ones are habitat provision, biodiversity conservation, water purification and recreation (Li *et. al.*, 2008). Unfortunately, rapid urbanization and growing population have brought excessive anthropogenic influences to the wetland ecosystem (Mensing *et. al.*, 1998). As a result, the wetland ecosystem is facing disturbance, thus gradually losing its original functions, goods and services.

Conservation scientists, national governments, and international conservation groups seek to devise conservative measures to manage the damaged and being damaged wetland ecosystems. However, what should be emphasized is that the pre-set goals would not be certainly achieved by following the planned ecological approaches needing repeated modifications according to the follow-up evaluations of the performance based on the conservative measures adapted. Lack of performance evaluation would lead to wastage of scarce financial resources and a risk of poorly designed and ineffective conservation programs (Chow-Fraser, 1998). It is in urgent need to develop a framework to evaluate the performance of the ecosystem services provided by the ecosystem presently and to find the way of achieving successful conservative method to improve the quality and the status of an ecosystem goods and services.

The evaluation should involve indices with which a comprehensive evaluation framework could possibly be built. Moore and Hunt (2012) proposed a framework focusing on carbon sequestration, vegetative diversity and cultural ecosystem service to evaluate the efficiency of a wetland hydrology and its water quality.

Chang *et. al.* (2013) developed a systematic indices system to quantify the performance of constructed wetlands' functional capacity by using DPSIR model (driving force, pressure, state-impact and respond). In China, there were also some cases addressing the ecosystem services provided by the goods of wetland ecosystem. For example, based on system dynamics, a comprehensive model is proposed in order to evaluate the performance of Qilihai Wetland, Tianjin City (Guoetal, 2011). Zheng *et. al.* (2012) developed an indices system to protect efficacy of national wetland reserves in China. Additionally, there were other case studies to conduct performance evaluation of wetland in light of ecosystem service (Horwitz and Finlayson, 2011; Jenkins *et. al.*, 2010; Liquete *et. al.*, 2013). However there is a lack of indices system for evaluation on the economic, ecological and social performances of wetland.

In the present paper, an evaluation index system (EIS) has been established to assess the performance of the Ousteri lake to mainly address the following issues: (1) which ecosystem service is better performing in the aspects of economic, social and ecological benefit attained by local residents (2) discussions on the implications of performance evaluation on ecological subsidy policy (3) recommending approaches for enhancing ecological-economic-social performances. This study will provide some useful information for decision makers to improve the effectiveness of wetland conservative measure. The aim of this analyses was to provide an indices system covering full ecological, economic and social performances of wetland. The complex evaluation was performed based on the inputs attained from the primary and secondary survey along with the series of stakeholder meetings conducted across various clusters of participants associated with the benefits and loss attained from the Ousteri lake both directly and indirectly.

Establishment of Evaluation Index System and Weighting

In purpose of evaluating the economic, social and ecological performances of Ousteri wetland, the Delphi methods (Austen and Hanson, 2008; Sagoff, 2011) were applied to screen the major indices from 35 pre-set indices and Analytic Hierarchy Process (Wattage and Mardle, 2006; Ouyang *et. al.*, 2011; Guuo *et. al.*, 2011; Cools *et. al.*, 2011) were used to weighting each index. The criteria to select the major indexes are based on integrity, representativeness, and suitability for comparable evaluation. In this study, we established two evaluation indices system for the Ousteri wetland across the Puducherry and Tamil Nadu region indicated as EIS I and EIS II, respectively. 15 indices were selected and measured for EIS I (Table 1 and Figure 1(a)), while 7 indices were measured for EIS II (Table 2 and Figure 1(b). Since wetland across the Puducherry zone provides more benefits than across Tamil Nadu, EIS I needs to be developed with more indicators than EIS II, eight additional indices (botanic biodiversity, wetland tourism value, increase of house price in the surrounding area of wetlands, public awareness on wetland protection, public satisfaction, scientific education service and job provision) were included in the indices system for evaluating the performance of EIS I.

Index Explanation, Calculation and Scoring

The definition, explanation and calculation of 15 indices were described as follows. The scoring criteria for each of the 15 indices are summarized in Table 3.

Water Quality (WQ)

The integrated water quality assessment was adopted to measure the water quality after implementing the conservative measure of the Ousteri wetland. Water quality indicator was used to measure the function of water purification provided by the conservative method. Five pollution indicators were involved, including total phosphorus (TP), chemical oxygen demand (COD_{Mn}), Arsenic, Lead and dissolved oxygen (DO). The

inde of water quality (P) was calculated as follows:

$$P_i = \frac{1}{n}\sum_{i=1}^{n} Pi$$

where n is the number of pollution indicators; P_i is the integrated pollution index for pollutant i.

The P_i of TP, As, Pb and COD_{Mn} were calculated by

$$P_i = C_i / S_i$$

where Ci is the concentration of pollutant i (mg/l); S_i is national water quality standard of pollutant i in India (mg/l).

The Pi of DO was calculated by

$$Pi = \frac{DOf - DOi}{DOf - DOs} when\ DOi \geq DOs$$

$$Pi = 10\text{-}9 \times \frac{DOi}{DOs} \text{ when } DO_i < DO_s$$

$$DO_f = \frac{468}{(31.6+T)}$$

where DO_f is the concentration of saturated DO (mg/l); DO_s is the national water quality standard of DO is India (mg/l); T is water temperature (°C).

The 5-points –scoring criterion for P is shown in Table 3.

Aquatic Vegetation Coverage (AVC)

Aquatic plants supply oxygen and provide shelter to aquatic animals, and can be food for fishes. Aquatic vegetation coverage, defined as the percentage of the total aquatic vegetation occupying the total wetland area, was one of important indicators for measuring the aquatic habitat (Zhao *et. al.*, 2013); in this study we used this indicator. According to Abbasi (1997), the maximum documented aquatic vegetation coverage of natural wetland in Ousteri wetland was 60 percent. Meanwhile, according to statistics, greening coverage in built-up area was 40 percent, which

was taken as a pass threshold reference. The 5-points-scoring criterion of AVC for conservation to EIS Iis shown in Table 3. Since the EIS II were mainly built for filtering out cyanobacteria and absorbing nutrient pollutants, the plants with strong function of absorbing nutrient pollutants such as reed were used for EIS II. Aquatic vegetation coverage of 80-90 percent were recommended and preferred, which enable better realizing the function of absorbing nutrient pollutants; so the aquatic vegetation coverage for EIS II might require a greater degree than EIS I. The 5-points-scoring criterion of AVC for EIS II is also shown in Table 3. The aquatic vegetation coverage for each of the conservation was obtained through site observation and through the feedback provided by stakeholders.

Aquatic Botanic Biodiversity (ABB)

According to the Chari and Abbasi, 2003, there are 220 different kind of aquatic species in Ousteri lake. After the conservative measure, the aquatic botanic biodiversity is expected to increase. The increase in aquatic botanic biodiversity provided more suitable habitat for aquatic animals, thereby increasing aquatic animal biodiversity (Kentula, 2000). In this study, we used aquatic botanic species expected to be attained by conservative measure to the total documented botanic species in the Ousteri lake, to measure the aquatic habit after the implementation. The 5-point scoring criterion of ABB is shown in Table 3.

Plant Community Integrity (PCI)

The integrity of wetland plant community indicated the health of its ecosystem (Raab and Bayley, 2012). The integrity of plant community should include five typical wetland plant communities, namely, the submerged plants, the floating plant, the emerged plant, the helophyte and the hygrophyte. In this study, as Table 3 shows, the score of plant community integrity depends on the variety of plant community in the present condition of the wetland.

Achievement of Buffer Function (ABF)

Buffer zone is the lake land ecotone which is adjacent to the rivers, lakes, reservoirs and has certain buffering capacity for the pollutants, sediments and floods (Natural Resources Conservation Service, 1998). Mauscutt *et. al.* (1993) and Parkyn (2004) pointed out a narrow buffer zone (5-6 m) in the subsurface can remove 80 percent of nitrate nitrogen. Hefting *et. al.* (2003) reported that 10 m grass buffer zone can remove 96 percent of nitrate nitrogen through the undercurrent water. Yang (2008) showed that ammonia nitrogen purification rate was increased along with the increase of the width of vegetation zone, and the purification rate was approximately 75.2 percent if the width of buffer zone was 20-40 m. In this study, the buffer function was the buffering capacity for the pollutants and the achievement of buffer function was measured by the width of buffer zone. The 5 points scoring criterion of achievement of buffer function is shown in Table 3.

Habitat Protection and Improvement for Faunal Species

Faunal habitat function is one the wetlands fundamental ecological services. Wetland provides shelter and food to wild animals, especially to the migrants (Paulo and van den Bergh, 2011). In this study, the index of habitat protection and improvement for fauna was measured by whether there were core conservation zones for wildlife and the abundance of the faunal species that could be gained after implementing the incentive mechanism; abundance of wild life in the Ousteri lake was characterized by the proportion of wildlife species observed to the whole information documented of Ousteri lake. The 5 point scoring criterion of the habitat protection and improvement for faunal species is shown in Table 3. From the present study sampling and site investigation, it was inferred that currently there are 166 bird's species, 63 butterflies' species, 9 frog species, 3 turtle species, 10 lizard species, 15 snake species, 24 fish species and 14 mammals found around the lake.

Intensity of Anthropogenic Disturbance Activities

Anthropogenic influences pose significant threats to wetland. In this study, the anthropogenic disturbance activities mainly include extracting surface and ground water, building but having nothing to do with the ecological conservation, destructive way of fishing, illegal exploitation on wetland flora and fauna and pollutant discharge. In this study, we use the index of intensity of anthropogenic disturbance activities. As Table 3 showed, the intensity of anthropogenic disturbance activities varied with 0-5 different types of anthropogenic disturbance activities observed in the Ousteri lake.

Output Value of Wetland Products

Wetland production contributes to the output value (Costanza *et. al.*, 1997; de Groot *et. al.*, 2012). In this study, using the direct market pricing method, we calculated the economic value of wetland products as follows:

$$OV = \sum_{i=1}^{n} Qi \; x \; Pi$$

Where OV is the total value of material goods provided by wetland ecosystem annually (dollar /yr); Qi is annual output of product I (kg/yr); Pi is the unit price of product I (dollar/kg).

In this study, we considered the reed and fish as the major goods gained presently. In this study, according to local market investigation, the price of reed and fish was $0.063/kg and $1.59 /kg, respectively. The annual outputs of products were obtained from local agricultural administration. As shown in Table 3, the score of output value of wetland products depended on the proportion of annual output value of wetland products per unit area accounting for the conservation of the Ousteri wetland.

Wetland Tourism Value

Due to the biodiversity and pretty scenery, the wetland parks are often a destination for tourists. Tourists need to pay for their visits to wetland parks. Therefore, those payments and traveling time they took during the visit could be regarded as the ecosystem services value (Costanza *et. al.*, 1997). In this study, in order to simply calculate, we used the annual tourism income to measure the index of wetland tourism value. As shown in Table 3, the scores for each of the wetland system's were classified by comparison with the average of annual tourism income per scenic area in the Ousteri lake and the annual tourism income for each of the wetland systems were all obtained from the tourism administration and through primary survey.

Increase of House Price in Surrounding Area of Wetland

The availability of wetland system's especially the rehabilitation of wetland could stimulate the house price in surrounding area of wetland (Kaza and BenDor, 2013). In this study, the score of the increase of house price presently and attained after implementation of the wetland system (Table 3). The house price in surrounding area of wetland was obtained from local housing authority.

Integrity of Management Operating System

The management of Ousteri wetland plays a significant role in the realization of wetland's ecological service. A full integrity of management operating system should include four components: administration of wetland, effective implementation of administration, adequate organizers and managers, and sufficient funds for the sustainable management of the wetland. As shown in Table 3, the score of the integrity of the management operating system varied with the presence of the four components of management operating system.

Stakeholder's Feedback on Wetland Protection

The information on the opinion of bureaucrats, academicians, politicians,

local communities and non-governmental bodies was obtained through the six round of stakeholder meetings conducted from October 2014 to February 2015 across the Puducherry and Tamil Nadu region of the Ousteri lake. These meetings were focused in order to collect the details and feedback of stakeholders with regards to the conserving of wetland and adopting the incentive mechanism to conserve the lake. In this study, the information was segregated across five disciplines: well known issue which needs to resolve through with mutual colloraboration, issue across Puducherry alone, issue prevails because of Tamil Nadu, issue prevails because of anthropogenic activities and no problem faced. Then the scores of stakeholder's feedback on wetland protection were measured by the percentage of respondents who were in level of which category of opinion (Table 3).

Public Satisfaction

Through face-to face interviews, we measured the public satisfaction by calculating the percentage of interviewers who were satisfied with the Ousteri wetland system across Puduchery and Tamil Nadu labelled as ES I and ES II, respectively. In this study, the five point scoring creiteria was used to rate the public satisfaction (Table 3).

Scientific Education Service

The wetlands can serve as educational spot for students and scientific research locations for researchers. For the Ousteri wetland system, the ecological education areas with the function of popularization of wetland conservation knowledge were preferred to be built for visitors. In this study, as shown in the Table 3, the score of scientific education service depended on whether there were ecological education areas or not, and the percentage of scientific researchers accounting.

Weighted Linear Combination and the Final Performance Categorization

Finally, the weighted linear combination (WLC) was applied for calculating the ecological-economic-social performances of the Ousteri wetland system. The combination of the components, according to the WLC model, is carried out as the following equation

$$\text{FEESP} = \sum_{i=1}^{n} Weighti\ x\ Indicator\ i\ x\ 20$$

where FEESP was the final score of the ecological-economic-social performance: indicatori was the score of indicator i of the evaluated wetland system. Weighti was the weight corresponding to the ith indicator.

The final ecological-economic-social performances ranged from 0 to 100. The results of evaluations were finally divided into five levels with a centesimal grade (Table 3).

Table 1: Indices System for Evaluating the Performance of Ousteri Wetland Along the Puducherry Region

Components Hierarchy	Weights	Indices Hierarchy	Weights
Ecological Performance	0.428	Water Quality	0.240
		Aquatic Vegetation Coverage	0.028
		Aquatic botanic biodiversity	0.033
		Plant Community Integrity	0.015
		Achievement of buffer function	0.021
		Habitat protection and improvement	0.004
		Intensity of anthropogenic disturbance activities	0.087
Economic Performance	0.096	Output value of wetland products	0.068
		Wetland tourism value	0.017
		Increase of house price in the surrounding area of weltands	0.011
Social Performance	0.476	Integrity of management operating system	0.020
		Stakeholders feedback on wetland protection	0.242
		Public satisfaction	0.013
		Scientific education service	0.201

Source: Author Interpretation from the research work.

Table 2: Indices System for Evaluating the Performances of Ousteri Wetland Along the Tamil Nadu Region

Components Hierarchy	Weights	Indices Hierarchy	Weights
Ecological Performance	0.364	Water Quality Aquatic Vegetation Coverage Plant Community Integrity Achievement of buffer function Intensity of anthropogenic disturbance activities	0.031 0.099 0.029 0.165 0.040
Economic Performance	0.096	Output value of wetland products	0.096
Social Performance	0.540	Integrity of management operating system Stakeholders feedback on wetland protection	0.105 0.435

Source: Author Interpretation from the research work.

Table 3: Scoring Criteria

Indices	Score				
	5 point	**4 point**	**3 point**	**2 point**	**1 point**
Water Quality	P< 0.2	0.2 ≤ P < 0.4	0.4 ≤P <0.7	0.7 ≤P <1.0	P ≥ 1.0
Aquatic Vegetation Coverage ES I	≥ 80 percent	65-80 percent	45-65 percent	25-45 percent	≤ 25 percent
Aquatic Vegetation Coverage ES II	≥ 65 percent	45-65 percent	35-45 percent	25-35 percent	≤ 25 percent
Aquatic botanic biodiversity	≥40 percent	30-40 percent	20-30 percent	10-20 percent	≤ 10 percent
Plant Community Integrity	All of the 5 typical wetland communities	4 typical wetland plant communities	3 typical wetland plant communities	2 typical wetland plant communities	1 typical wetland plant communities
Achievement of buffer function	Width of buffer zone ≥ 30 m	Width of buffer zone 20 -30 m	Width of buffer zone 10-20 m	Width of buffer zone 5-10 m	Width of buffer zone ≤ 5 m
Faunal Habitat protection and improvement	Having core conservation zone and abundance of fauna in the Ousteri wetland ≥ 60 percent	Having core conservation zone and abundance of fauna in Ousteri wetland 30-60 percent	Having core conservation zone and abundance of fauna in Ousteri wetland ≤ 30 percent	Having core conservation zone, but few fauna observed in the Ousteri wetland	Lack of core conservation zone and few fauna observed in the Ousteri wetland
Intensity of anthropogenic disturbance activities	No human disturbance activities in the Ousteri wetland	1 type of human disturbance activities in the Ousteri wetland	2-3 types of human disturbance activities in the Ousteri wetland	4 types of human disturbance activities in the Ousteri wetland	5 types of human disturbance activities in the Ousteri wetland
Output value of wetland products	Annual Output value of wetland products per unit area if more than 2 percent of Ousteri wetland	Annual Output value of wetland products per unit area is 1.5 - 2 percent of Ousteri wetland	Annual Output value of wetland products per unit area is 1-1.5 percent of Ousteri wetland	Annual Output value of wetland products per unit area is less than 1 percent but >0 of Ousteri wetland	No Output value of wetland products as of Ousteri wetland

(Table contd…)

(Table contd…)

Wetland tourism value	Atleast 10 percent less than the average annual tourism income per scenic area of Ousteri wetland	0-10 percent less than the average annual tourism income per scenic area of Ousteri wetland	Approaching the average annual tourism income per scenic area of Ousteri wetland	0- 10 percent more than the average annual tourism income per scenic area of Ousteri wetland	Atleast 10 percent more than the average annual tourism income per scenic area of Ousteri wetland
Increase of house price in the surrounding area of weltands	Annual growth on house price ≥ 15 percent per year	Annual growth on house price 10 - 15 percent per year	Annual growth on house price 5-10 percent per year	Annual growth on house price ≤ 5 percent per year	No annual growth on house price or negative impact of price of house per year
Integrity of management operating system	All of 4 components of management operating system	3 components of management operating system	2 components of management operating system	1 components of management operating system	No management operating system
Stakeholder feedback on wetland protection	The percentage of stakeholders who think that the conservation of the Ousteri wetland could be achieved only through mutual colloraboration between the Puducherry and Tamil Nadu government	The percentage of stakeholders who have public awareness on wetland protection $70-90$ percent	The percentage of stakeholders who have public awareness on wetland protection $50-70$ percent	The percentage of stakeholders who have public awareness on wetland protection $30-50$ percent	The percentage of stakeholders who have public awareness on wetland protection ≤ 30 percent
Public satisfaction	The percentage of stakeholders who are presently satisfied with Ousteri wetland conditions 90-100 percent	The percentage of stakeholders who are presently satisfied with Ousteri wetland conditions 80-90 percent	The percentage of stakeholders who are presently satisfied with Ousteri wetland conditions 70-80 percent	The percentage of stakeholders who are presently satisfied with Ousteri wetland conditions 60-70 percent	The percentage of stakeholders who are presently satisfied with Ousteri wetland conditions <60 percent

(Table contd…)

(Table contd…)

Scientific education service	There were ecological education areas and the scientific researchers accounted for more than 15 percent of the visitors	There were ecological education areas and the scientific researchers accounted to less than 15 percent of the visitors	No ecological education areas; but the scientific researchers accounted for more than 15 percent of the visitors	No ecological educations areas and the scientific researchers accounted for less than 15 percent of the visitors	No ecological education areas and no scientific researchers
Job provision	Very high job provision	High job provision	Many job provision	Low job provision	Very low job provision

Note:

The score ranged from 1 to 5; 5 point indicated the best performance, while 1 point indicated the worst performance

P is the index of water quality calculated by equation 1

Aquatic botanic biodiversity was measured by the percentage of aquatic botanic species which could be attained by conservative measure to the total documented botanic species in the Ousteri lake

The integrity of plant community should include 5 typical wetland plant communities; namely the submerged plants, the floating plants, the emerged plants, the helophyte plant and the hygrophyte

The aquatic fauna habitat protection and improvement was measured by whether there were core conservation zones, and the abundance of fauna which could be achieved by EIS I; abundance of fauna through conservative measure was characterized by the proportion of fauna species observed in the EIS II to the whole Ousteri wetland's documented faunal species

Source: Author Interpretation from the research work.

In this study, the anthropogenic disturbance activities mainly include extracting surface and ground water, building but having nothing to do with the ecological conservation, destructive way of fishing, illegal exploitation on wetland flora and fauna and pollutant discharge

We used the number of visitors to measure the index of wetland tourism value; the average tourism income per scenic area in Ousteri lake and the annual tourism income for each of the conservative measure were all obtained from the tourism administration and through primary survey.

A full integrity of management operating system should include four components, namely administration of wetland, effective implementation of administration, adequate organizers and managers and sufficient funds for sustainably managing the Ousteri wetland

Table 4: Final Categorization of Performance

Level	Very poor	Poor	Fair	Good	Excellent
Scores	0-30	30-60	60-70	70-85	85-100

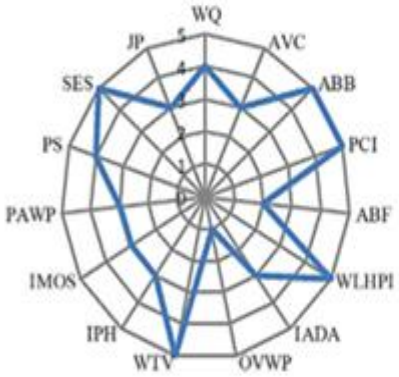
Source: Author Interpretation from the research work.

The Performance of the Ousteri Wetland System ES I and ES II

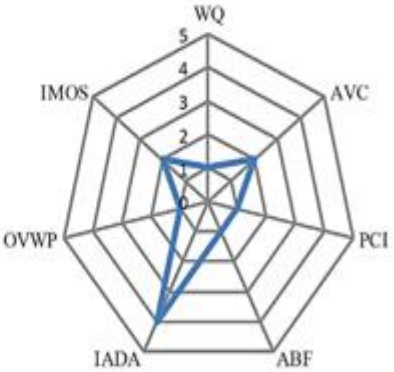
Puducherry Zone of the Ousteri Wetland ES I

According to our field investigation (Figure 1(a), primary survey and the stakeholder discussions, it was observed that the aquatic botanic biodiversity was high and wetland plant community in the Ousteri wetland across the Puducherry zone of the Ousteri wetland was relatively complete, making it a beautiful scenic spot and attracting a large number of visitors daily. However, due to lack of management operating system, the increasing human disturbance activities were observed, which posed severe threats to the wetland ecosystem and caused the low water quality. Though there was no conservation core zone, migratory birds can be found regularly. There were no ecological education areas that should be paid more attention in the future. The migrant birds were frequently observed and the biodiversity of aquatic animal ecosystem was high.

Therefore, it could be observed that in overall, the Ousteri wetland witnessed a nearly complete plant community and a wide buffer zone. However, strong human interruptions were observed in the Ousteri wetland; hence it was under severe threats and the water quality was low.



(a) Puducherry zone ES I



(b) Tamil Nadu zone ES II

Figure 1: The Results of Performance Indicators for the Puducherry Zone ES I and Tamil Nadu Zone ES II of the Ousteri Wetland System

[WQ, water quality; AVC: aquatic vegetation coverage; ABB: aquatic botany biodiversity; PCI: plant community integrity; ABF: achievement of buffer function; WLHPI: Wildlife /faunal habitat protection and improvement; IADA: intensity of anthropogenic disturbance activities; OVWP: output value of wetland products; WTV: wetland tourism value; IHP: increase of house price in the surrounding area of wetlands; IMOS: integrity of management operating system; PAWP: Stakeholders feedback on wetland protection; PS: public satisfaction; SES: scientific education service; JP: job provision]

Tamil Nadu Zone of the Ousteri Wetland ES II

As shown in the Figure 1(b), due to lack of conservation core zone, the abundance of the faunal species was low. The wetland was open access; so the wetland tourism was relatively low. This could be correlated to the downstream impact faced by the Tamil Nadu zone due to the anthropogenic activities produced by the Puducherry zone of the Ousteri wetland. Due to well management, there were very little human interruptions but the reduction in the aquatic vegetation coverage and the integrity of plant community were low.

CONCLUSION

Wetlands play a key role in the ecological conservation, in environmental quality improvement, and in human habitat environment improvement. Primer field investigations, primary survey and series of stakeholder meetings were utilized to evaluate the performance of the wetland. It was done using the complex index system covering wider aspect to correlate the comparative status of both Tamil Nadu and Puducherry zone of the Ousteri wetland. Compared with the researches applying the ecosystem service evaluation method, the proposed scoring method in this study can evaluate on some important performance indices (aquatic vegetation coverage, plant community integrity, integrity of management operating system, stakeholders feedback on the wetland protection, public satisfaction) that cannot be ignored and unable to be transformed to a monetary form.

The Delphi method was used to screen preset 35 sub-indicators prior to evaluation. After the survey, fifteen indexes were selected and measured for the wetland system ES I representing Puducherry while seven indexes were measured for the ES II representing the Tamil Nadu zone of the Ousteri wetland. By using Delphi and Analytic Hierarchy Process method, as well as the weighted linear combination model, the ecological-economic-social performances were obtained. This indices system was applied to the case of Ousteri wetland with respect to Puducherry and Tamil Nadu scenario separately.

With the help of the Evaluation Index system (EIS) established in this study, decision makers can obtain more omni-visual information so that an ecological subsidy policy by incorporating rewards and punishments mechanisms according to the performance evaluations can be formulated to enable the greatest returns on investment in the wetland conservative measure. By investigating the wetland system with good ecological, economic and social performances, the experience of successes included all of the management right (management right,

disposition right, and the right to benefit from wetland management) demised to the private, the development of management system, improvement in education level of managers, scientific wetland plant community composition and spatial patterns and the ticketing for entering the wetland park. It should be emphasized that the proposed indices system is not only applicable to this case study, but also suitable to be applied to conduct ecological, economic, and social performance for wetland in other areas.

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