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Assessing Cost Effective Management Options of *Eichhornia Crassipes* in Ecotourism Ramsar Sites, Nepal

[1*]Ram Asheshwar Mandal., [2]Pramod Kumar Jha., [3]Nir Krakaue., [4]Ajay Jha and [5]Tarendra Lakhankar
[1]Central Department of Botany, Tribhuvan University Kirtipur, Nepal., [2]Professor of Central Department of Botany, Tribhuvan University Kirtipur, Nepal., [3,5]City College, CUNY, New York, NY, USA., [4]Institute of Global Agriculture and Technology Transfer (IGATT), Fort Collins, CO, USA., Email Corresponding Author: ram.mandal@gmail.com

Abstract

Ecotourism is growing business in Nepal due to domestic and international visitors. Specifically, natural lakes in Ramsar sites are very potential avenues for boating, scenic beauty and study the aquatic ecosystem. However *Eichhornia crassipes* has been threatening the beauty, ecosystem and eco-tourism business. This research was objectively carried out to explore income generation from ecotourism and determine socio-economic management of *Eichhornia crassipes* for manure or biobriquette. Four Ramsar sites namely Beeshazari, Maipokhari, Lakes Clusters of Pokhara and Jagdishpur Lakes were selected for the study. Data were collected through expert consultation organizing four workshops, direct observation and sampling. Meanwhile record of manpower, removal cost and utilization of *Eichhornia crassipes* were also collected. Affected sites of *Eichhornia crassipes* were calculated analyzing the current image of Google earth pro using ArcGIS. Samples were collected establishing sixty plots of 1m×1m and these were analyzed. Altogether about US$ 785260 was earned from tourism business between 2011 to 2015. The highest income was generated about US$ 397500 between 2011 to 2015 from visitors of Lakes of Pokhara. Removal cost of *Eichhornia crassipes* was the highest about US$ 108.09 ha^{-1} of Beeshazari Lakes in 2015. Farmers could save cost about US$ 31931 using *Eichhornia crassipes* as manure and that could be nearly US$ 38315 for biobriquette in 2015. The B/C ratio, NPV and Profit Index could be nearly 6.13, 96059.91 and 7175.11 using *Eichhornia crassipes* of Beeshazari Lakes as manure while 4.81, 105868.50 and 12415.63 using it as biobriquette. The study could contribute design the ecotourism policy.

Keywords: Ecotourism, Economic analysis, Water hyacinth, Manure, Biobriquette

1. Introduction

Globally, billions people depend on wetland ecosystem services like rice growing, selling water, construction, fishing, weaving, medicine, transport and ecotourism etc (Levin et al, 1997, Mack and Wrase 2017). Valuing these scopes, numerous lakes, ponds, waterfalls, rivers and other water bodies have been listed under Ramsar sites to conserve and promote them (IUCN, 2015). The record showed that over 2,200 Ramsar sites were listed of 169 Ramsar contracting parties across the world. Out of that United Kingdom listed the highest number of sites with 170 (JNCC, 2015), and Bolivia recorded the greatest area of wetlands with over 140,000 square kilometers (WWF, 2013). There are twenty six Ramsar sites in India and ten sites in Nepal (RSIS, 2016). In reality, Ramsar sites are natural home for important floral species like *Trapa quadrispinosa*, *Ludwigia adscendens*, *Azolla imbricate*, *Lemna spp*, *Ceratophyllum demersum*, *Hydrilla verticillata* and *Najas minor* as well as faunal organisms namely *Aythya nyroca*, *Leptotilos javanicus*, *Lutra lutra*, *Crocodylus palustris* and *Varanus flavescens* and *Aythya nyroca* and *Kachuga kachuga* (MoFSC, 2014).

The infestation of obnoxious weed like *Eichhornia crassipes* (water hyacinth) is threatening the indigenous species (Simpson and Sanderson, 2002, Tobin et al., 2011, Mironga, 2014) and also ecotourism business. Though, scope of ecotourism business is expanding as a key source of income, the income trends of ecotourism from these sites were

not explored yet in Nepal. Since these Ramsar sites are seriously affected due to infestation of water hyacinth (EEA, 2012), the governmental, nongovernmental institutions and local communities have been paying high cost to remove the weed every year but these costs were unrecorded and not explored yet. On the other hand, if the removed water hyacinth could be used as manure or biobriquette production, the removal cost could be economically compensated. In this circumstance, such studies were significant to explore the income generation from ecotourism business of Ramsar sites in tropical and subtropical Nepal and determine the economic management of water hyacinth for manure or biobriquette production.

2. Materials and methods

Six Ramsar sites specifically Beeshazari, Ghodaghodi and Mai Pokhari Lakes, Jadishpur reservoir, Koshitapu wildlife reserve (WR) and Lakes of Pokhara were selected for the study (Table 1).

Primary and secondary data were collected to meet the research objectives applying the following methods and they were analyzed using economic analysis.

Consultation: The hotel professional, business men, boater, local people, administrative staff particularly army and arm force, local eco-club, buffer zone community (Chitwan – Beeshazari Lake and Koshitapu Wildlife Reserves), social worker and environmentalists were invited to participate in the workshop. Experts who involve in biobriquette and manure preparation business were also consulted. The workshop focused on finding the number of manpower required, times needed to remove water hyacinth, labour cost. Expert consultation was done to assess the raw materials required to produce the biobriquette and manure and their management and production cost and selling price.

Workshops: Six workshops were organized with stakeholders involve to remove the water hyacinth manually at Ramsar sites namely Beeshazari and Associated Lakes, Ghodaghodi Lake, Jagadishpur Reservoir, Koshi Tappu Wildlife Reserve, Pokhara and Mai Pokhari to know about the manpower needed.

Estimation of water hyacinth affected area: The currently available image of Ramsar sites was downloaded from Google earth pro (Albright et al., 2004). The image was analyzed using ArcGIS to find the affected areas of water hyacinth in Ramsar sites.

Observation and sampling: Disturbed areas of water hyacinth in the Lakes were verified by the field observation. Altogether sixty samples were collected from Lakes to know the quantity of water hyacinth per unit area having 1m×1m plot size. The collected samples were dried in laboratory and recorded.

Cost estimation: The removal cost of water hyacinth and ecotourism was estimated asking with participants of the workshop. The removal cost was varied US$ 30 to 50 ha^{-1}. The cost of manure and biobriquette preparation was also varied US$ 10 to15 and 12 to 17 per ton respectively.

Calculation of B/C ratio, NPV and PI

B/C = Benefit/Total management cost

NPV = Total present value − Total management cost

$$= \left[\frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \cdots + \frac{CF_n}{(1+r)^n}\right] - \text{Total management cost,}$$

PI = Total present value – Net cash outlay

Table1. Geographical description of Ramsar sites of Tarai, Nepal

Name	Location (districts)	Latitude degree N	Longitude degree E	Altitude m	Ramsar site ratification	Area ha
Beeshazari and Associated Lakes	Chitwan	27.61912	84.470415	286	August, 2003	3,200
Koshi Tappu Wildlife Reserve	Sunsari, Saptari, and Udaypur	26.5626	85. 56	75	1987	34800
Lake Cluster of Pokhara Valley	Kaski	28.2026	83.985	827	February, 2016	26106
Mai Pokhari	Ilam	27.025	87.55	2150	October, 2008	90

3. Results and discussion

3.1 Income from ecotourism

Altogether about US$ 785260 was generated from the tourism business in five years between 2011 to 2015. The highest income was generated about US $ 397500 between 2011 to 2015 from tourists of Lakes of Pokhara. Generally income depends up on the number of tourists visited, days stayed, mode of transports used, goods and services purchased (Kunwar, 1997). Globally, about US$ 7.6 trillion (10% of Gross Domestic Product: GDP) earned and 277 million jobs created in 2014 from tourism

business in and around the wetlands. About US$ 0.68 million paid for staff at Sauraha, Chitwan in 2012 (Banskota, 2012).

3.2 Description of water hyacinth affected area

The density and affected areas of water hyacinth in Ramsar sites were varied from place to place. The water hyacinth was about 25.21 t ha^{-1} in Beeshazari Lake which was about 26.21 t ha^{-1} in Lakes of Pokhara. The affected area was 80.1 ha in Lakes of Pokhara valley and quantity of water hyacinth was nearly 1705.96 t. About 4000- 6000 ha area of Victoria Lake was affected due to infestation of water hyacinth between 1996 to 2001 (Albright et al., 2004).

3.3 Removal cost of water hyacinth

The removal cost of water hyacinth was the highest about US$ 108.09 ha^{-1} of Beeshazari Lakes in 2015 which was about US $ 80.89 ha^{-1} of Lakes of Pokhara valley. There are 4.52 million t of water hyacinth in Thailand which needs roughly US$ 0.27 million annually to eradicate it at the rate of US$ 2.68 t^{-1} (Na, 2015). The cost was about US$ 2800 to control water hyacinth from Lagoon Creek in 2006 (Veitch et al., 2007).

3.4 Managing water hyacinth as Manure

The farmers could save cost to use the manure of water hyacinth in their field despite using chemical fertilizers. Specifically, farmers living near Lakes of Beeshazari could save about US$ 31931 utilizing water hyacinth as manure in 2015 and this saving could be about US$ 2212 of farmers of Lakes of Pokhara. The use of manure of water hyacinth helps to improve the soil fertility of degraded soil (Nyananyo et al, 2007, Cbukwuka and Omotayo, 2009, Vidya and Girish, 2014).

3.5 Managing water hyacinth as Biobriquette

If the water hyacinth of Beeshazari Lakes was used for biobriquette nearly US$ 38315 income could generate in 2015 while this could be US $ 3010 for Lakes of Pokhara. The biobriquette is very useful for cooking and heating (Frank and Akhihiero, 2013, Rezania et al., 2015). The government of Nepal has high priority to use the biobriquette as an alternative energy (KC et al., 2011).

The B/C ratio, NPV and Profit Index showed that nearly 6.13, 96059.91 and 7175.11 to use water hyacinth as manure which could be 4.81, 105868.50 and 12415.63 of Beeshazari Lakes to utilize water hyacinth for biobriquette. There is not only one use of water hyacinth significantly (EEA, 2012) so used it as manure and biobriquette are cost effective (Sanni and Adesina, 2012). Alternative use is more effective solution to manage water hyacinth (Njogu et al., 2015).

Table 2. Income (US$) from ecotourism of Ramsar sites, Nepal

Year	Income (US$) from Ramsar sites				
	Beeshazari Lake	Koshi Tappu WR	Lakes of Pokhara	Mai Pokhari	Total
2015	20250	23625	82500	675	148500
2014	27000	31500	90000	500	178000
2013	24000	29000	95000	457	174110
2012	16000	22000	75000	375	133000
2011	10000	18000	55000	321	151650
Total	97250	124125	397500	2328	785260

Table 3. Infestation of water hyacinth in Ramsar sites, Nepal

Description	Beeshazari Lake	Koshi Tappu WR	Lakes of Pokhara	Mai Pokhari
Ton/ha	25.21	22.89	26.21	19.21
Affected area ha	105.09	72.88	80.1	22.82
Total (t)	2649.32	1668.22	2099.42	438.37

Table 4. Removal cost (US $) of water hyacinth form Ramsar sites, Nepal

Year	Beeshazari Lake	Koshi Tappu WR	Lakes of Pokhara	Mai Pokhari
2015	108.09	76.89	80.89	20.82
2014	97.28	69.20	72.80	18.38
2013	87.55	62.28	65.52	17.75
2012	78.80	56.05	58.97	11.50
2011	70.92	50.45	53.07	10.41

Table 5. Value of manure of water hyacinth (US $)

Year	Value of manure prepared from water hyacinth (Us $)			
	Beeshazari Lake	Koshi Tappu WR	Lakes of Pokhara	Mai Pokhari
2015	31931	406	2212	466.4
2014	23539.5	40.5	1341	296.8
2013	20925.25	20.3	1174.6	237.55
2012	17213.93	77.36	854.22	258.75
2011	12612.23	100.21	409.32	160.05

Table 6. Value of biobriquette of water hyacinth (US$)

Year	Value of biobriquette prepared from water hyacinth (US$)			
	Beeshazari Lake	Koshi Tappu WR	Lakes of Pokhara	Mai Pokhari
2015	38315	805	3010	626
2014	28327.5	340.2	1939.5	416.5
2013	25186.95	286.2	1707.3	343.9
2012	20751.08	138.06	1296.72	347.8
2011	15265.33	34.164	1093.97	226.6

Table 7. Economic analysis showing water hyacinth using as manure or biobriquette

Using Water Hyacinth for manure				
Economic Analysis Tools	Beeshazari Lake	Koshi Tappu WR	Lakes of Pokhara	Mai Pokhari
B/C ratio	6.13	0.08	0.63	0.85
NPV	96059.91	5120.31	10446.23	2123.34
PI	7175.11	12096.56	13908.95	2373.24
Using water hyacinth for Biobriquette				
B/C ratio	4.81	0.20	0.85	1.03
NPV	105868.50	11720.70	18927.11	3604.92
PI	12415.63	12417.08	14610.53	2504.32

4. Conclusion and recommendations

Water hyacinth has been creating problems in Ramsar sites of Nepal, though these sites are high sources of income for ecotourism purposes. Local people and government pays very high costs every year to remove the water hyacinth from the Ramsar listed sites. However, if the weed is used for manure or biobriquette production removal cost could be economize. Therefore, It is recommended to find the alternative sustainable, social and economic cost effective management options of the weed.

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