Policy views on conservation and management of wetlands

Wetlands provide a range of ecosystem services, not the least of which is water security to vast regions housing millions of people in India. The variability in climatic conditions and changing topography has been attributed to significant biological diversity in the wetlands distributed in different geographical regions ranging from the Himalayas to the Deccan Plateau. Across land use, paddy cultivation contributes 70% of the wetlands that constitute 18.4% of the country's area. Despite their immense use to human well-being, wetlands are the most threatened and rapidly degrading ecosystems globally due to both biotic and abiotic threats such as habitat destruction and encroachments through drainage and landfill, over-exploitation of fish resources, discharge of waste water and industrial effluents, uncontrolled siltation and weed infestation, ill-effects of fertilizers and pesticides and other such anthropogenic pressures. Reports reveal that one-third of Indian wetlands has already been wiped out or severely degraded and warrant policies and framework mechanism for management of this critical ecosystem.

Several existing legislations that have relevance to wetland conservation include Indian Forest Act, 1927; Forest (Conservation) Act, 1980; the Wildlife (Protection) Act, 1972; the Air (Prevention and Control of Pollution) Act, 1974; the Water Cess Act, 1977 and the umbrella provision of Environment (Protection) Act, 1986. Nonetheless, there is no specific legal framework for conservation of wetlands and its biodiversity. India has set up over 505 wildlife sanctuaries and 100 national parks, 14 biosphere reserves, 6 heritage sites, projects on the conservation of tigers, elephants and marine turtles with the objective of effective conservation of wetlands, and floral and faunal wealth in forested areas.

The Wildlife (Protection) Act, 1972, which extends to all states in India, except Jammu and Kashmir, has a provision for the establishment of sanctuaries (Section 18) and national parks (Section 35) and thus, offers protection to wetlands (territorial waters) which fall within their boundaries. Although there is strict ban on grazing vis-à-vis management restrictions, unauthorized entry of people makes wise use of the wetlands virtually impossible in the wildlife sanctuary or national parks. In addition, the National Wetlands Conservation Programme (NWCP) is operational since 1985–86, under which 115 wetlands have been identified across different states by the Ministry of Environment and Forests, for conservation and management interventions. In 1993, the National Lake Conservation Plan was carved out of NWCP to focus on lakes, particularly those located in urban areas which are subjected to anthropogenic pressures.

Recognizing the value of wetlands and taking cognizance of the fact that there does not yet exist a formal system of Wetland Regulation, the National Environment Policy 2006, as approved by the Cabinet in May 2006 envisioned to set up a legally enforceable regulatory mechanism for the identified valuable wetlands to prevent their degradation and enhance their conservation, apart from routine inventory. In pursuance of the policy resolution a Multi-Disciplinary Expert Group held a series of meetings to formulate a regulatory framework for the wetlands that gave forth the Regulatory Framework for Wetlands Conservation and has been published in the Gazette of India, Part-II, Section-3, Sub-section-II.

In 1971, the Ramsar Convention, an ecosystem-specific convention was instituted that describes not only the conservation of wetlands, but also their management and wise use. In addition, the convention encourages its Contracting Parties to frame and implement their planning so as to promote the conservation of the listed wetlands as far as possible (Article 3.1). Presently, India has 25 wetlands listed under the Ramsar Convention. Amongst these, some are also covered by other environment protection laws concerning wildlife and forests. Like other protected areas, wetland reserves (e.g. Bangajang wetlands in Arunachal Pradesh, Rann of Kutch marshes in Gujarat, Pallikaranai marsh and Suchindram–Theroor wetlands in Tamil Nadu) exclusively for protection of wetlands and its associated biodiversity, needs to be set up considering the ecological fragileness and ecosystem services.

Progressively, a well-considered regulatory framework based on consultative process will receive high priority in wetland management. It is also hoped that a combination of promotional and regulatory measures backed by financial and administrative commitment will result in the generation of optimal efforts in the direction of conservation of the freshwater and marine aquatic entities of various types which are collectively known as the 'wetlands' that provide food-chain linkages from single-celled algae to large mammals and continuum with air and soil through water process.

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'Champion works': a second-order analysis

Mahesh[1] presents a first-order analysis of how different countries perform from the point of view of 'champion works' – papers that have received 1000 or more citations. India appears at the 23rd position out of 84 countries that have had one or more papers with 1000 or more citations.

Two tiny countries, Finland and Norway, rank ahead of India, even when a first-order indicator of performance like the number of 'champion works' is used.

Table 1. GDP-based second-order performance indicator for some countries

Sl. no.	Country	Champion works *C*	GDP in million US$	Works/GDP in trillion US$	*X* (GDP)
1	The United States	4635	14,447,100	320.83	1,487,026.81
2	England	1090	2,070,802	526.37	573,739.11
3	Switzerland	336	527,920	636.46	213,850.58
4	Canada	501	1,577,040	317.68	159,159.56
5	Sweden	246	458,725	536.27	131,922.18
6	Scotland	145	215,368	673.27	97,623.60
7	France	475	2,559,850	185.56	88,139.93
8	The Netherlands	255	779,310	327.21	83,439.20
9	Israel	134	217,445	616.25	82,577.20
10	Germany	502	3,280,334	153.03	76,822.67
…	…	…	…	…	…
16	Finland	79	238,731	330.92	26,142.39
…	…	…	…	…	…
21	Norway	52	413,056	125.89	6,546.33
…	…	…	…	…	…
30	Russia	39	1,479,823	26.35	1,027.83
31	South Africa	17	363,704	46.74	794.60
…	…	…	…	…	…
33	India	36	1,722,328	20.90	752.47
…	…	…	…	…	…
37	Brazil	30	2,088,966	14.36	430.84
…	…	…	…	…	…
39	China	43	5,739,358	7.49	322.16

Table 2. Population-based second-order performance indicator for some countries

Sl. no.	Country	Champion works *C*	Population in millions	Works/per million of population	*X* (Population)
1	The United States	4635	314.91	14.72	68,220.86
2	England	1090	53.01	20.56	22,411.48
3	Switzerland	336	8.00	42.00	14,112.00
4	Canada	501	35.00	14.31	7,171.01
5	Sweden	246	9.54	25.79	6,343.35
6	Scotland	145	5.25	27.59	4,001.10
7	The Netherlands	255	16.77	15.20	3,876.68
8	France	475	65.35	7.27	3,452.56
9	Germany	502	81.87	6.13	3,077.95
10	Denmark	120	5.60	21.43	2,571.58
…	…	…	…	…	…
15	Finland	79	5.43	14.56	1,150.17
…	…	…	…	…	…
18	Norway	52	5.05	10.29	535.11
…	…	…	…	…	…
33	Russia	39	143.30	0.27	10.61
…	…	…	…	…	…
36	South Africa	17	51.77	0.33	5.58
…	…	…	…	…	…
38	Brazil	30	193.95	0.15	4.64
…	…	…	…	…	…
40	China	43	1,347.35	0.03	1.37
…	…	…	…	…	…
43	India	36	1,210.19	0.03	1.07

Therefore, for a more meaningful comparison, a second-order indicator should be used. For this purpose, it is required to define the zeroth-order indicator for ‘size’. In the context of country-level comparisons, this could be the population, or the gross domestic product (GDP) of the country. Let us now look at the top 50 countries from table 1 of Mahesh[1] to see how they pan out if second-order indicators are used. Population data are retrieved from http://en.wikipedia.

org/wiki/List_of_countries_by_population and GDP data from http://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal).

Both sources were accessed on 10 December 2012. If *C* is the number of 'champion works' and *P* is the zeroth-order indicator of size (we use here population in millions and GDP in trillions of US dollars respectively), then the second-order indicator[2] is $X = C^2/P$. Tables 1 and 2 show GDP-based and population-based second-order performance indicators for the top 10 in each list, as well as Finland, Norway, South Africa and the BRIC countries.

1. Mahesh, G., *Curr. Sci.*, 2012, **103**, 1260–1261.
2. Prathap, G., *Curr. Sci.*, 2010, **98**, 995–996.

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Bt brinjal: a risk assessment worth taking?

The *Bt* brinjal debate seems to have regained momentum. Several new reports and articles have been made available[1–4], and an FAO e-mail conference on GMOs[5] has attracted a number of participants who have voiced ideas and opinions on *Bt* brinjal. Concern over the potential consequences for biosafety if this transgenic crop is commercialized, is a recurrent theme in many of the views put forward.

In a recent article, Gupta[3] outlines the major environmental risks which are generally perceived to be associated with the commercialization of genetically modified crops. These include transfer of transgenes to wild species due to pollen transfer (or pollen-mediated transgene flow). The view that certain environmental risks, including pollen transfer, have no scientific basis, is put forward. In this light, he suggests that the appropriate regulatory tests can therefore be dispensed with. In stark contrast, the Thirty-seventh Report of the Committee on Agriculture[1] recently noted that there were strongly expressed concerns over the scope and adequacy of the evaluation of certain environmental hazards associated with the release of *Bt* brinjal. Such hazards include risks to wild relatives (which can arise as a consequence of pollen-mediated transgene flow).

In the course of the on-going international crop improvement programme for brinjal, over 50 different sexual hybridization studies have been undertaken. These have employed pollen transfer techniques, with the majority looking at the potential for hybridization between brinjal and its wild relatives. Some studies reported an extremely high crossing success rate, e.g. in the cross between brinjal and *Solanum violaceum* Ortega (a common weed); this gave a successful two-way cross, producing vigorous, highly fertile F_1 hybrids[6]. A number of other studies have looked at hybridization between brinjal and cultivated relatives, such as *S. aethiopicum* L. and *S. macrocarpon* L. (sometimes cultivated in India and other parts of Asia). These are relevant considerations in our understanding of potential transgene transfer from *Bt* brinjal during outcrossing, and several useful summaries of the hybridization studies are available[7–9]. At this point it is important to note that six wild-relative species and four cultivated *Solanum* species found in India are known to be able to cross with brinjal to produce reproductively fit hybrids[2].

It has been suggested that the chances of natural hybridization (as opposed to artificial hybridization via hand-pollination, described above) taking place are low. However, pollination in brinjal may consist of up to 47% natural cross-pollination, with up to 70% of fruit set arising as a consequence of pollination by insects – many trials indicate that insects play a major role (see Quagliotti[10]). Brinjal has thus been described as 'an often cross-pollinated crop'[11]. Some pollen leaves the apical pores of the anthers on its own accord upon dehiscence, but physical contact is known to facilitate the exit of pollen. In spite of this, some reports have described the role of insects in pollination of *Solanum* flowers as 'insignificant'[12]. Cross-pollination of brinjal in Asia is by insects such as bees and, regionally, may be as high as 48% (ref. 13). Pollen is collected and transferred by bee species using 'buzz-pollination'[14]. The release of pollen from the anther pores of one flower is thereby encouraged by vibrations set up by rapid beating of the bee's wings. It is then transferred to the stigmas of other flowers as the bee moves on. It seems that where buzz-pollinating bees are present, pollen transfer is virtually inevitable. It is not surprising then, that there is a considerable body of opinion that adheres to the idea that brinjal and its closest wild relatives can freely interchange genes by natural hybridization (e.g. refs 15 and 16).

It is of note that two main studies were undertaken to determine the risk of pollen transfer from *Bt* brinjal hybrids to non-*Bt* brinjal. These took place in 2003 and 2009 on experimental farms in Karnataka, Maharashtra and Andhra Pradesh, and studied the incidence of outcrossing from spiny *Bt* brinjal lines to spineless untransformed varieties. It was discovered that almost 3% outcrossing was possible, with pollen transferred up to 30 m away from the transgenic plants[11]. In both studies, honey bees were used as an integral part of the methodology and

Figure 1. Details of brinjal flower, showing the yellow, poricidally dehiscent anthers (photograph by the author).