

indicator, and Q to be the zeroth-order indicator of performance, then it is possible to combine this to obtain a first-order indicator of performance, qQ and a second order indicator of performance, $X = q^2Q$. This means that we are in fact simplifying the interpretation of the *SIR* and Leiden data to imply that a quantity term (Q) and a quality term (q) will lead to a single composite term, $X = q^2Q$, that serves as the best proxy for total performance in the research context.

Table 1 is a league table using the X indicator based on the quantity and quality proxies used by Leiden and Scimago.

The Leiden Ranking covers only four top Indian higher education institutions. We compare the performance of these four institutions with that of the leading higher education institution in the world, namely Harvard University and four other Western institutions with comparable output.

From Table 1 it becomes clear that the publication output of Harvard is nearly an order of magnitude larger than that of the top-ranking Indian institutions. The quality proxy put Harvard about three to four times ahead of the top Indian counterparts. The net effect is that in terms of

the second-order indicator of performance, Harvard is typically about 100 (Leiden data) to 200 times (*Scopus* data) ahead of the top Indian institutions. Even institutions with comparable output perform at higher quality levels than our top technical institutions.

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Plant invasion researches in India: how long do we have to wait for appropriate management options?

The problem of plant invasion is increasing at a great pace worldwide and in India as well. Significant efforts have been invested in invasion-related research with respect to money and time, which have lead to a substantial increase in publications in the field in recent years. In this study we report the progress of plant invasion researches in India and how it is evolving in terms of the stages of plant invasion process (comprising introduction–establishment–naturalization–invasion success continuum) in the last two decades. We also aim to address the challenges associated with the management and control of the impacts of invasion. In India, the first milestone in the field of plant invasion ecology was the ‘International workshop on ecology of biological invasion in the tropics’ sponsored by the Special Committee On Problems of Environment (SCOPE) and Govind Ballabh Pant Institute of Himalayan Environment and Development

(GBPIHED) held in 1989 at Nainital¹. Thus 1989 could be considered as the beginning of plant invasion research in India and continuous literature on plant invasion biology has been added thereafter.

A bibliometric analysis was performed to find out the research articles and all papers dealing with the aspect of plant invasion ecology in India starting from 1989. The documents were searched for papers using the term invasion and its derivatives^{2,3}, and the results refined with ‘ecology’ as ‘subject area’ and ‘address’ as ‘India’ using the on-line database of the *Science Citation Index (SCI)* retrieved from the *ISI Web of Science*, Philadelphia, PA, USA from 1989 to 2010. A similar search was also performed on the *Google Scholar*. These searches cumulated 122 hits (or 122 articles on plant invasion biology related to India).

The results suggest that the number of papers published in individual years

increased drastically after 2005 (with 7 papers in 2005 to 34 papers in 2010). Content analysis of all the 122 articles was carried out and the articles were grouped into six categories³, viz. establishment, spread, impact, control, management and multidisciplinary with 29, 36, 36, 3, 8 and 10 hits obtained in each category respectively (see Table 1). We divided two decades into four time slots, each slot consisting of a five-year time-span. Articles in each time slot were segregated into the above-mentioned categories. Total number of articles in each category was quantified for each time slot. During the content analysis of the researches published in each slot, it was found that most of the researches in the initial time slot of 1989–1995, 1996–2000 and 2001–2005 focused on the spread, impact, establishment and invasive success of the non-natives. However, during the 2006–2010 time-slot few articles considering management and control

Table 1. Description of categories in Indian plant invasion researches, including percentage of publications in each category

Category	Description of category	Publication (%)
Establishment	Focus on establishment and mechanisms of species establishment	23.7
Spread	Discuss the spatial spread of species	29.5
Impact	Discuss the impact of invasives on native flora or fauna	29.5
Control	Discuss strategies for controlling invasives, but which have still not been implemented at larger ground level	2.5
Management	Discuss management of invasives, but which has still not been implemented at the ground level	6.6
Multidisciplinary	Focus on the definitions, concepts, mechanisms, new introductions, distribution, abundance, demography and synergistic effects, etc. caused by invasives (i.e. research largely confined to classical invasion biology)	8.2

issues related to invasives appeared. Out of 122 articles, only 2.5% and 6.6% of publication discussed about control and management of plant invasive species respectively.

Our analysis shows that the trajectory of the plant invasion literature in India follows the stage-based pattern of invasion process with exponential growth in terms of publication. The inference derived from the study is that we need to reorient our research focus from the trivial invasion process, like spread, establishment and impacts (although important), towards more applicable researches for the control and management of invasive plants. This warrants further efforts for

authoritative decision to reallocate research interest and funds towards researches focusing on the applied aspects of plant invasion control and management so that conservation efforts can be initiated instantaneously.

1. Ramakrishnan, P. S. (ed.), *Ecology of Biological Invasion in the Tropics*, International Scientific Publications, New Delhi, 1991.
2. Gaertner, M., Fisher, J. L., Sharma, G. P. and Esler, K. J., *NeoBiota*, 2012, **12**, 57–75.
3. Esler, K. J., Prozesky, H., Sharma, G. P. and McGeoch, M., *Biol. Invasions*, 2010, **12**, 4065–4075.

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Mandu sacred grove in Upper Ganga Ramsar site, Uttar Pradesh

Ramsar sites are wetlands of international importance recognized under the Ramsar Convention, 1971. The Upper Ganga Ramsar site in Uttar Pradesh, one of the 25 sites in India, extends along 85 km stretch of the holy river Ganga, from Brij Ghat to Narora. The region is endowed with special attributes related to religious traditions, spiritual knowledge and cosmological beliefs depicting the cultural heritage of humanity and a source of aesthetic inspiration adorned with important local traditions. It also serves as a pilgrimage centre since ancient times, but is completely unexplored in terms of floristic riches with few eclipsed and naturally conserved forest patches that have evaded degradation during modernization. These forest patches are immune from human interference for ages, on grounds of staunch religious beliefs and comprise physically diverse patches of natural, primary forested enclosure of sacred trees and connected life-forms, supporting climax vegetation representative of their particular locality and hence emerge as sacred groves.

The small Mandu forest is one such undisturbed and naturally conserved patch which has twofold significance of being a sacred grove and a naturally conserved ecological entity of Ramsar site. It is embedded within a mantle of dense vegetation, on the northeastern flank of the Ganga, at 28.3700°N lat. and 78.2700°E long., 6 km from Unchagaon Fort in District Bulandshahr. The grove

spreads in about 9 ha area with 3 ha core zone (Figure 1a) of primary forested patch surrounded by 6 ha buffer zone, with an admixture of primary and secondary vegetation. On the southern boundary of the core zone flows the river Ganga and all other sides are bordered by the buffer zone. A twin *Ficus benghalensis* L. tree thrives at the centre of the core with two main stems, one of which is slightly damaged.

The grove is endowed with luxuriant vegetational cover and dense canopy of trees, mostly 10–30 m tall, the dominant 11 species being *F. benghalensis* L., *Ficus religiosa* L., *Ficus racemosa* L., *Cassia fistula* L., *Azadirachta indica* A. Juss., *Delonix regia* (Bojer ex Hook.) Rafin., *Albizia lebbek* (L.), *Aegle marmelos* (L.) Correa, *Callistemon lanceolatus* DC., *Acacia nilotica* (L.) Willd. ex Delile and *Bauhinia variegata* L. There are 10 species of important medicinal herbs – *Catharanthus roseus* (L.) G. Don, *Murraya paniculata* (L.), *Bacopa monnieri* (L.) Pennell, *Ocimum gratissimum* L., *Desmodium gangeticum* (L.) DC., *Acalypha indica* Forsk., *Adhoatoda vasica* Nees, *Achyranthes aspera* L., *Boerhavia diffusa* L. and *Calotropis gigantea* (L.) R.Br., as sustainable medicinal resources of the local clans. The occurrence of *Manilkara hexandra* (Roxb.) Dubard, a species of high economic value but restricted distribution, is of special interest. The forest is also rich in woody climbers of which the five prominent species are

Tinospora cordifolia (Willd.) Hook.f. & Thoms., *Clitoria ternatea* L., *Hemidesmus indicus* (L.) R.Br., *Cissampelos pareireia* L. and *Cocculus hirsutus* (L.) Diels. The entire vegetation of the grove is therefore of much significance in terms of original gene pool of economical and medicinal importance.

At present the groves are revered by the endogamous clans, the Jatas and Gujjaras, and completely secluded from anthropogenic disturbances. Hence these



Figure 1. Mandu sacred grove. **a**, Entrance to the core zone. **b**, Ancient Mandu temple.