ganize various activities such as annual symposia, workshops, seminars, etc. along with the publication of their own disciplinary journals/proceedings. PAs are an important component of the R&D system because they provide an opportunity outside the public system and assume a role which is complementary to the well-defined and well-structured role of the public R&D. They are different from other organizations in the R&D sector as their central concern is about furthering the interests of the profession and its social relevance, and are not tied to any patron (state/private/civil/legal entity), and can legitimately reflect upon the status/evolution of the profession, in order to strengthen their professional identity. This voluntary nature of PAs gives them the inherent convening power and drive, a unique position and flexibility to play a key role in innovations with broader goals relevant to the society.

Most scientists are part of one or more PAs/societies in India. But they have hardly been mentioned as important actors in the larger R&D system. Scientists, who are part of PAs, mostly get coloured by the organizational and disciplinary constraints of the R&D system and do not use the flexibility they can have due to their position. These scientists can work proactively through the PAs and use them as a platform to contribute to the public domain. This will help in bridging the gap between science and its public understanding and bringing its social relevance to the society. The disconnect between the science that they pursue and its societal relevance is quite evident through the absence in public debates on relevant issues.

These PAs are present in almost all the fields of science, but have played little role in linking the knowledge that they have with societal issues. It is important to recognize their role and leverage their roles and capacities. For example, there are more than 50 PAs in agricultural sciences, but they have hardly contributed to the public domain. These PAs often work independently and mostly in strict disciplinary modes. Organizations like the National Academy of Agricultural Sciences, like the academies in America or other parts of the world, could facilitate networking among PAs in agricultural sciences and other relevant stakeholders to help facilitate ongoing scientific disciplinary goals as well as broader societal goals to enlighten the public domain. There is a need now to recognize at least the presence of PAs as important actors in R&D and intervention points that could leverage their roles.

1. Raval, U., *Curr. Sci.*, 2007, **93**, 1335–1336.

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Virtual water trade

The article on 'Status of virtual water trade from India' by Vijay Kumar and Jain (*Curr. Sci.*, 2007, **93**, 1093–1099) gives a table, according to which the virtual water content of crops like millet, sorghum, lentil and oilseeds is higher than that of paddy and sugarcane. The authors define virtual water as, 'The amount of water consumed in the production process of an agricultural or Industrial product'. In simple terms, I guess virtual water indicates water-efficiency of a crop or a product. The authors further mention that the virtual water content of a product tells something about the environmental impacts of consuming the product.

According to conventional wisdom, paddy and sugarcane are more water-intensive than crops like millets, sorghum, lentils and oilseeds. The latter category crops can grow with little water and are called dry-land crops. Nutrition and agricultural scientists urge farmers in the dry-land area to diversify from paddy and sugarcane to horticulture, millets and pulses, since these crops are more nutrient-dense and consume less water. The farmers mindlessly use bore-well water to cultivate paddy, which the authors refer to as a 'water-guzzling crop'. Would such a diversification strategy mean more stress on the water system? Are we justified in advocating diversification from paddy and sugarcane to dry-land crops (sorghum, millets, oilseeds) in the hope of saving precious groundwater? It is also interesting to note how water-intensive coffee is compared to tea, and maybe coffee drinking should be discouraged in a water-stressed country like India. Not a palatable thought for South Indians, who relish coffee.

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Response:

For an agriculture crop, virtual water is calculated as the ratio of the water required (m/crop period) to the crop yield (t/sq. m). Note that the virtual water content of a crop is not the same as water-efficiency of a crop. The crop water requirement, crop yield and the resulting virtual water content of paddy, wheat, millet, sorghum and sugarcane is given in Table 1 (ref. 1).

As shown in Table 1, the water requirement is high for sugarcane followed by paddy, wheat, sorghum and millet. Sorghum and millet have low water requirement compared to sugarcane and paddy, but as their yield is less, the virtual water content is high.

As also mentiond in our article, Chapagain and Hoekstra[1] have calculated the water requirement using the CROPWAT model of FAO and considering a country's average climate data. Some of the data used are of the capital city of the country (e.g. New Delhi for India). Since there are large variations in climatic conditions and crop yields in India, there will be significant intra-country variations in virtual water content of various crops. Recently, we have done more literature survey on this topic and have

Table 1.

Crop	Water required (mm/crop period)	Crop yield (t/ha)	VWC† (cubic m/t)	Global average VWC (cubic m/t)
Sugarcane	1101	69.0703	159	175
Paddy	852	2.9892	2850	2291
Wheat	438	2.6482	1654	1334
Sorghum	320	0.7895	4053	2853
Millet	264	0.8075	3269	4596

†VWC, Virtual water content. Source: Chapagain and Hoekstra[1].

come across a range of estimates of crop yield and water requirements for sorghum. The yield for sorghum varies from 400 to 1200 kg/ha and virtual water content is found to vary from 400 to 4100 cubic m/t. There are similar variations in the estimates of yield and virtual water for pulses and oilseeds. Thus, we are of the opinion that it is high time that the virtual water estimates for various agricultural products are computed state-wise or agro-climatic zone-wise. This can be done easily provided requisite data are available.

We are in agreement with the views of the discussor regarding crop diversification. The present practices with little or no regard to the implications on water resources are leading to rapid lowering of groundwater levels at many places and are not sustainable.

1. Chapagain, A. K. and Hoekstra, A. Y., Water footprints of nations. Value of Water Research Report Series No. 16, UNESCO-IHE, Delft, The Netherlands, 2004.

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Science in the wilderness

This note is with reference to the article titled 'Science in the wilderness: The predicament of scientific research in India's wildlife reserves' by M. D. Madhusudan *et al.*[1].

The issue of scientific inquiry in wildlife reserves is undoubtedly gaining momentum in recent years. From the time when scientifically conducted wildlife research was unheard of (pre-independence) it has certainly experienced a tremendous leap forward with at least the major species (large mammals especially) been studied in the last 40 years[2]. For the authors, who have put in their past experience of fieldwork in the paper under reference, it is indeed worth the effort that will have a long ranging impact if not a pathbreaking one.

Without denying or putting forth arguments just for the sake of argument, it would also be necessary to ponder over the difficulties and challenges that a protected area (PA) manager faces within the wheels of this huge and efficient but perhaps a little rusted machine that we attribute to as the Government. If the authors have addressed the 'why', I would also like to bring to attention the 'how' by which the processes can be streamlined.

The entire debate emanates from the Wildlife Protection Act 1972, which is even today perhaps one of the best legislations for wildlife conservation in the world. A look at the various wildlife enactments from across the world indicates that no other country has such an exhaustive legislation that covers the entire gamut of biodiversity[2]. It is fairly recent enacted in 1972, and has seen several amendments, the most recent one being in the year 2006 (with recommendations of the Tiger Task Force) which has enabled the constitution of the National Tiger Conservation Authority, thereby reinstating the Government's willingness to change according to the times. The policing roles have been defined and as compared to the Draconian laws such as the Indian Penal Code, 1860 which is used against criminal offences, it is still the best for the penalty it imposes for a crime within the scope of the Act. True, it is more prohibitive in nature rather than permissive, but that is the way legislations are meant to be. Moreover, the scope of the Act is to cover a wider and generalized theme leaving much to be interpreted at the state level. This is a blessing in disguise, because it enables the implementer (the state forest department) to suitably adapt the Act according to the local and currently prevailing conditions (e.g. Declaration of Sanctuary, National Park, Conservation and Community Reserves under Section 26A and Section 35, Section 36A and Section 36C respectively). Also, it provides enough safeguards in the form of Section 26A(3), Section 33 and Section 35(5) and (6) which essentially prevents any alteration to protected area boundaries, permanent construction and other such activities by the state without the prior approval of the National Board, the highest advisory body headed by the Prime Minister of the country himself. This has given enough protection over political interference at the local level such as in autonomous councils, unclassed state forests and community-owned forests, particularly in the northeastern region of the country.

Within this context, research is also entirely the mandate of the State Government (Section 28), but the Act also envisages the constitution of a State Wildlife Advisory Board and advisory committee Section 6(l) and Section 33(b) respectively, which has members none other than the Chief Minister, members of the state legislature, representatives of NGOs, ten eminent people with contribution to conservation science and representatives from ZSI, BSI, WII and others.

Besides these, a Research Advisory Committee is also constituted in several states (e.g. Assam) wherein the research proposals submitted are examined. It has