Assessment (white-space mapping) of Indian effort in climate research

Periodic and quantitative assessment of research activities in a given area is an essential step to ensure identification of priority and niche areas. White-space, a term borrowed from spectrum analysis, in this context refers to areas of research (frequency bands) that are less explored. Thus white-space mapping or analysis identifies relative strength of research, and enables us to uncover opportunities that are not obvious or less explored.

In electromagnetic spectrum analysis, white space is defined as the temporary or local frequency voids unoccupied by the primary signals. Essentially, the use of white spaces allows a secondary network to coexist with a primary network in a way that the two systems are orthogonal. White-space modelling is essentially a problem of spatial spectrum sharing (or spatial reuse), which is a well investigated subject for both cellular (planned)[1] and ad hoc networks[2,3]. Drawing this analogy, research areas of high potential and importance often remain neglected (white) due to fixed and old planning and lack of fidelity and flexibility of the system. In the context of patents and research, white-space mapping or analysis is an in-depth analysis of research publications belonging to a particular research topic. In addition, in-depth white-space analysis can also enable identification of future potential research areas.

A quantitative measure of status of research in a country is its *Science Citation Index* (*SCI*) research publications. To define an unbiased measure among different countries, we normalize the number of research publications by the respective GDP values. The publication data for different countries are obtained from the *Web of Knowledge*; the GDP values (USD) are obtained from the World Bank data portal.

One area of primary interest is climate sciences, climate change and related areas. Apart from the knowledge that they provide, reasearch in these areas is of strategic importance as assessment and international policy discussions are often guided by published work in these areas. It could be argued that quality of the publication, such as impact factor and citation, should be taken into account in such evaluation. However, the important question here is of presence rather than of quality.

The data utilized are year-wise and country-wise number of *SCI* research publications collected from the *Web of Knowledge* in the areas of research related to climate change (Table 1). Here we define climate change in a broad sense to also include the 'global warming' string. For the sub-classifications, we use the string climate change and the 'Sub research area' as shown in Table 1.

The annual total number of research publications per trillion of USD shows steady growth for China and the world as a whole during the period 1986–2010 (Figure 1). The GDP values (in USD) are obtained from the World Bank data portal. While India has maintained research publications close to the global average till 2000, it has fallen far short since then China, with a value smaller than the global average up to around 2000, now shows values much higher than the global average.

The spatial distribution (Figure 2) shown in green colour indicates that the number of publications per GDP is greater than 25; white colour represents the less explored area, while red colour indicates no data. The bar diagram shows the number of research publications by each country in the research area of climate change along with the sub-research area. The spatial distribution shows that there is less focus on research in India, Pakistan, Afghanistan and North African countries.

Figure 1 shows that beginning with nearly equal *SCI* publications (normalized to GDP) of about ten in the year 1990, the world output in climate research has grown steadily to about 150 in recent times. What is most striking is the growth in research output from China, with a sudden three-fold increase around 1990, and reaching now 325, with no sign of saturation (Figure 1). The

Table 1. Search areas and search strings for white-space mapping in climate and climate change research

Research area	Research topic/search strings
Climate change/global warming/environmental change	+ Agriculture/forest + Hydrology/water + Biodiversity/pollution + Sustainability + Adaptation/mitigation + Vulnerability/natural disaster/hazard + Energy + Health/diseases

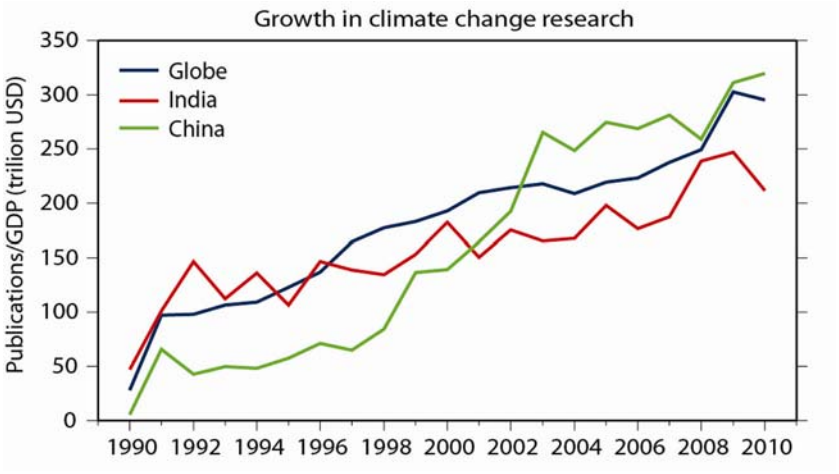

Figure 1. Year-wise comparison of growth in climate change research in terms of *SCI* publications as a function of GDP for the world, China and India.

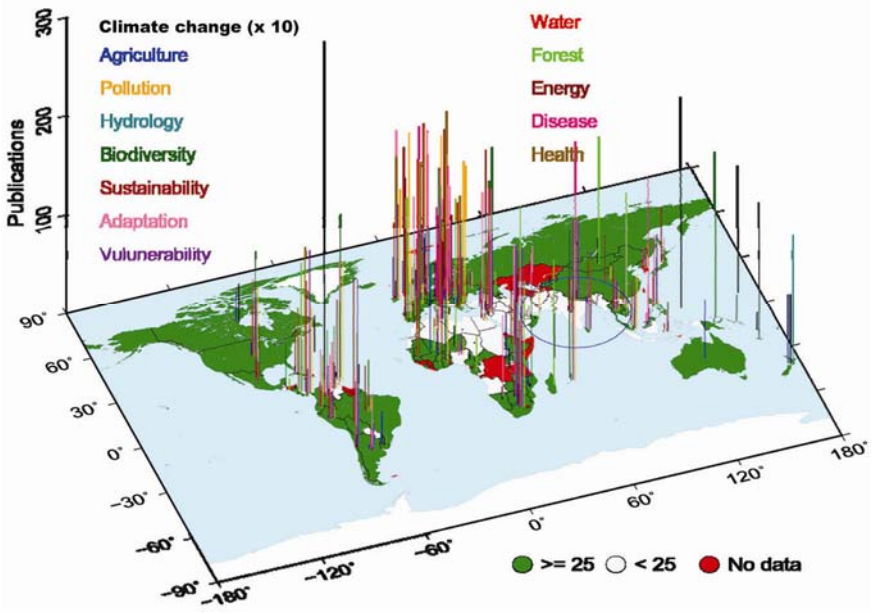

Figure 2. White-space mapping: country-wise distribution and number of *SCI* publications in climate change as a function of GDP. Countries with 25 or more publications per 100 billion USD are shaded with green and others are shown in white (source: *Web of Knowledge*).

implications of such a presence in the international techno-policy forums are obvious. It is likely that, recognizing the obvious advantages of such a presence, a conscious effort has been made by the Chinese policy-makers. It is worth noting that India appears to be essentially white, with less than 25 publications per 100 billion USD, while most of the countries, except for a few in Africa, are shaded green, indicating more than 25 publications per 100 billion USD (Figure 2).

It is clear that India with its climatic diversity and vulnerability to climate change[4–6] needs to put urgent efforts to create a meaningful knowledge presence to support its policy. It is encouraging that significant and long-term efforts are being planned by the Ministry of Earth Sciences, Government of India, in the form of its Climate Research Centre, Monsoon Mission, etc. Similarly, the Council of Scientific and Industrial Research (CSIR) and the Department of Science and Technology continue to support basic and applied research in earth sciences. The Indian Council of Agricultural Research also has a significant effort allocation for climate change. However, many of these initiatives may have to divide efforts in application, outreach and science; thus the contribution of programmes to the filling up of the white space in research remains to be seen.

More importantly, however, concerted and well-planned efforts are needed to enhance cross-sectoral research to quantify and assess impact of climate change through integrated approach. A notable effort in this direction is the 11th Five Year Plan project of CSIR on Integrated Analysis for Impact Mitigation and Sustainability (IAIMS), a network initiative among a number of institutions and academia to develop a multidisciplinary platform in climate change research. It is also encouraging to note that the Planning Commission of India, in March 2012, had recommended the formation of an inter-agency network for cross-sectoral research and outreach in sustainability and climate adaptation (Network Initiative on Sustainability, Climate Adaptation and Mitigation: NISCAM). Such a sustained inter-agency network will go a long way to colour the research space of India in climate research.

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Identification of invasive plant species using field spectro-radiometer and simulated Hyperion spectra – a rapid mapping of invasiveness

'Invasiveness is establishment of self-sustaining plant populations that are expanding within a natural plant community with which they had not previously been associated.'[1] Invasive species are described as a 'catastrophic wildfire in slow motion' as they cross geographic boundaries, spanning landscapes, land ownerships and jurisdictions[2]. Presence of invasive plant species alters the structure and function of terrestrial ecosystems by changing the species composition and resource availability[3,4]. These ecological effects frequently impact population dynamics and impose selective pressure