

Role of higher education in the sustainability of water resources: an assessment of institutions in India

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Abstract

The motivation behind this paper is to understand the status of water resources management education provided in higher education institutions (HEIs) in India and decipher gaps between what is taught and what is needed in the field. The assessment has been carried out based on the information available on the respective websites of the HEIs using keywords. The authors have also reached out to faculty members and final-year students in universities/HEIs in India. There are a good number of HEIs in India, which offer educational programmes in water-related subjects, though their distribution is skewed and there seems to be a clear bias in favour of the technological aspects of water. Relatively fewer HEIs engage themselves in social, economic and gender-related issues. It is imperative to popularise research in the social, economic and regulatory aspects of water management. Not all HEIs have provided information about the areas of research they engage in, on their websites. Further, a limited number of faculty members and students have responded to the questionnaires. The preparedness of any country in addressing its current challenges can be gauged from the incorporation and subsequent entrenchment of these roles into the fabric of HEIs. This article can be looked upon as reference documents which will go a long way to enabling the identification of synergies, interlinkages and collaboration opportunities to find solutions for a plethora of challenges.

Keywords: Education; Higher education institutions (HEIs); India; Water resources management

Introduction

As the population of the world increases and economies continue to develop, water will be needed in ever increasing amounts. It is not be wrong to say that the imperativeness and importance of research in this field has been earnestly appreciated by academia, industry, utilities and governments alike in many parts of the world, over the last decade (Venkatesh, 2018). From a sustainability perspective, water can be understood from a triple bottom line perspective – social, economic and environmental.

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The social dimension can be described in greater detail by defining sub-dimensions, of which education is one (Venkatesh, 2019). OECD *Principles on Water Governance* emphasised the urgent need to make society a responsible partner in solving problems related to water (OECD, 2015). It recommended the sharing of responsibilities by different actors, along with the policy-makers, to maximise the benefits of good water governance. Given the demographic advantage that many developing countries enjoy, the younger generation constitutes an extremely important segment in this endeavour. Educational institutions have to play a crucial role in nurturing interest, being the bedrocks of good ideas and channelising the energy of the youth towards addressing and surmounting challenges that the water sector is facing today and is likely to face in the years to come.

Education, of course, begins at home, with parents shouldering the responsibility in this case before the baton passes on to teachers in primary and secondary schools. Thereafter, students with an aptitude for specialising in water studies, opt for higher education either in their respective home countries or abroad. There has been a tendency among Indians (the second author being one example), till a few years ago, to look abroad for post-graduation and doctoral research opportunities, in general, and more so, in fields related to water and sustainability. There will, hopefully in the future, be a paradigm shift with Indian universities being among the top choices for higher education.

HEIs, globally, are engaged in offering formal educational programmes, as well as skill-enhancement modules for employed professionals. Research conducted in such institutions is unbiased and not tailor-made to please the funding agencies (industry or government bodies). Municipal, provincial and national governments look upon these centres of learning and research as think-tanks they can take recourse to when decisions need to be made and alternatives for change evaluated. They also serve as neutral platforms for diverse stakeholders to use for congregating to brainstorm and chalk out strategies for interventions, to promote sustainable development of anthropospheric systems in general. Therefore, the preparedness of any country in addressing its current challenges can be gauged from the incorporation and subsequent entrenchment of these roles into the fabric of higher educational institutions. As far as the primary duty and role of educational institutions are concerned, to quote India's former President Dr APJ Abdul Kalam, 'Educationists should build capacities of the spirit of inquiry, creativity, entrepreneurial and moral leadership among students.'

Water is central to many other challenges *Homo sapiens* are facing. This is particularly true in South Asian subcontinent. The nexuses – of varying degrees of tightness – with poverty alleviation, regional development, gender issues, health, food, energy and environment, conflicts and geo-political relations are well understood (Kerr, 2002; Hope, 2007; Datta, 2015). Integrated socio-economic, environmental and sectoral policies, which respect both the geographical and temporal scopes, are indispensable for the attainment of the Sustainable Development Goals (SDGs), the Paris agreement or the Sendai Framework, for instance (OECD, 2018). Water resources are thereby top priorities in central government planning. On date, there are six ministries in the central government of India, which have flagship programmes related to water resources management – Ministry of Environment, Forest and Climate Change, Ministry of *Jal Shakti* (Hindi word that means water power, this new ministry has been formed recently in June 2019 by merging two earlier ministries, namely Ministry of Water Resources and Ministry of Drinking Water and Sanitation), Ministry of Earth Sciences, Ministry of Housing and Urban Affairs, Ministry of Science and Technology, and the Ministry of New and Renewable Energy. Universities and research institutions, as mentioned earlier, need to play a stronger role in the years to come, in the generation, sharing and dissemination of knowledge about the sustainable management of water resources, formulation of effective policies and implementation of best practices.

In India, water resources management has traditionally been under the domain of *Civil Engineering* and allied post-graduate programmes (irrigation engineering, hydrology, water resources management and environmental engineering generally offered by Civil Engineering departments in universities). The obvious explanation is the narrow focus on infrastructure-related issues to overcome challenges in the water sector. The adjective ‘narrow’ can be justified by referring to [Kaushal \(2015\)](#), in which one of the authors was interviewed after the publication of a book of poems titled ‘Water for All and Other Poems’. The three major water issues which the world faces today, in the opinion of the interviewee were water wastage (social aspect), corruption and lack of proper use of public money to provide services (governance aspect) and non-appreciation of the value of water in most parts of the world, owing to the fact that it comes cheap (economic aspect). Scarcity problems have made some stand-up and think, but a great deal more needs to be done, as there are new demands now. It is the end-consumer who needs to play a key role. He/she needs to assume responsibility and start using water optimally; think about others before wasting water ([Kaushal, 2015](#)). It is, thus, crystal clear that water has multiple tentacles which link it to several influencing and influenced aspects in societies, economies, governments and the environment. There is an urgent need for multi-disciplinary/transdisciplinary approaches, the active and conscious involvement of the end-users (social aspect), and a decentralised water planning (governance and infrastructure aspects) and awareness of the impact of global climate change on local water resource availability (environmental aspect). These approaches are emphasised in the Water Governance Indicator Framework of the OECD along with coherent bottom-up and multi-stakeholder dialogue ([OECD, 2018](#)).

Water sector challenges in India

The issues in the management of water resources are chiefly of inefficiency and inequitable access, resource degradation, the increasing gap between availability and demand, overexploitation of groundwater, under-pricing, poor conservation, fragmented approach and weak legal framework ([Prabhu, 2012](#)). For instance, overexploitation of groundwater in some areas (mainly the north-west region) has pushed up the cost of extracting. Moreover, the unreliability of power makes farmers pump water whenever it is available regardless of whether their crops need it ([Prayas, 2018](#)). The groundwater management is thus crippled with these wide range of concerns and require focus beyond physical depletion of this resource. Again, from the point of institutional set-up, it is seen that several functions are duplicated, while many others are unclear ([Saleth, 2004](#)). For instance, the focus has been on pollution from industries and domestic sources, while agricultural pollution has been overlooked. Surface water in all its entirety is treated as State property. This has led to many conflicts and litigation with individuals asserting that they are losing their rights to the State when irrigation projects are developed ([Saleth, 1996](#)). Water pollution and associated health implications are a serious concern. River cleaning programmes were started with Ganga Action Plan in the mid-1980s; however, there has not been any improvement in water quality of rivers over these years, and the initiatives are successful only so far that they helped in preventing further deterioration ([Tarannum et al., 2018](#)). Agriculture is the largest user of water and the irrigation departments have focused mainly on creating and constructing irrigation works. Most irrigation departments have their origins as Public Works Departments. This has caused a bias in favour of civil works construction, resulting in very limited attention to water planning and management ([TERI, 1998](#)). Irrigation water use efficiency is as low as 35%, which accounts for over 80% of water consumed ([Pachauri & Sridharan, 1998](#)). Fragmentation by purposes also hinders

effective inter-sectoral allocation of water, e.g. from agriculture to industry. The National Water Policy (2012) urges states to set up multi-disciplinary units for the management of water (Ministry of Water Resources, 2012). Many states are yet to set up, while some others have re-designated their irrigation departments as water resources departments. Moreover, as much as 60% of the country's net sown area is still rainfed, which is an indicator of the country's high vulnerability to impacts of climate change (Sathyan *et al.*, 2018). Abysmally low industrial tariffs and inadequate wastewater treatment capacity further compound the problem of water quality and availability. As reported in the NITI Aayog SDG India Index report (NITI Aayog, 2018), 32% of the districts in India are open defecation-free, 82.7% rural households have individual household toilets (100% target for 2030), 71.8% of the rural population in India has access to safe and adequate drinking water (100% target for 2030) and 62% of the net available groundwater in India is withdrawn annually, and the current sewage treatment capacity is 37.58% of the sewage generated (the target for the year 2030 is 68.8%). NITI Aayog, using target-setting, normalising and rescaling and equi-weighting, calculated indices (on a scale of 0–100) for selected targets within 13 chosen SDGs, and thereafter for every SDG, before arriving at composite indices for each State and Union Territory in the country. (Readers may refer to the report to understand the methodology and delve deeper into the results thereof.) The SDG Index score for the goal of Clean Water and Sanitation ranged between 31 (the worst, for the state of Bihar) and 100 (the best, for the state of Gujarat). The other states, which were categorised as front-runners (scoring 65 or greater), include Goa, Tamil Nadu, Mizoram, Uttarakhand, Sikkim, Haryana, Maharashtra, Himachal Pradesh and Chhattisgarh in the increasing order of score.

So far, India has focused on large-scale engineering solutions for enhancing the supply of water. Not only do some of these solutions entail huge externalities, but more importantly, these solutions do not acknowledge the potential in water conservation and more efficient resource management. The civil engineering-based nature of water resources management education cannot do justice to the multi-pronged epistemological nature of water. The realisation of this fact led to the mushrooming of different water education-related programmes in Indian higher educational institutions, in the 21st century. On date, however, there has not been any systematic assessment of the degree of fulfilment of the requirements of practitioners in the Indian water sector, attained by the HEIs. This article attempts to guide planners and decision-makers in the water sector in India to understand the status of water resources management education provided in higher education institutes in the country and decipher gaps between what is taught and what is needed out there in the field. This article can be looked upon as reference documents which will go a long way in enabling the identification of synergies, interlinkages and collaboration opportunities; and institutions which can potentially be involved in research to find solutions for a plethora of challenges. The authors have also reached out to faculty members and final-year students in universities/HEIs in India to glean more about the suitability of the *status quo* of water resources management studies and research to the challenges which India is facing and will face in the years to come.

Methodology

Analysis. It will be appropriate to understand the education system in India, at the outset. It is basically classifiable into three successive levels: primary, secondary and higher secondary schools (12 years), graduation (which awards a bachelor's degree) and post-graduation (which includes both a Master's degree and a doctoral degree or a PhD). Colleges (which are affiliated to universities) and universities

(both will be referred to as institutions hereafter in the article) conduct graduation and post-graduation educational programmes in general, though there are some institutions like the one the first author hails from (TERI School of Advanced Studies, New Delhi), which offer only Master's degree and Doctoral degree programmes. For the sake of this article, a *Higher Education Institution* (HEI) is defined as one which offers the post-graduation programme with or without the preceding graduation level programmes. The assessment, however, restricts itself to the post-graduate programmes only.

To comprehend the diversity of water studies in HEIs, some classification criteria have been developed and used in this paper for ease of understanding. There are four questions which guide the authors in this classification exercise, and they are as follows:

(a) How prominent is water education in any of the post-graduate programmes of the HEI?

Based on the prominence of water education in the PG programme, HEIs are classified into *high*, *moderate* and *less prominent* categories. 'High' is interpreted as the existence of a dedicated department/school/centre/division focusing only on water studies, with the word 'water' being explicitly mentioned in the names of the PG degree programmes offered (for example, Master's in Water and Gender Issues). 'Moderate' includes HEIs in which the PG programme/s have a significant coverage of water topics (more than 30% credit allocation) but are marked by the absence of the word 'water' in the names of the programmes. The 'Less prominent' HEIs which bring up the rear are those in which there is a conspicuous lack of water-related subjects (<30% of total credits in a programme).

Table 1 gives a list of keywords which were used to search for water-related subjects/programmes. In cases where water-related subjects/programmes are not mentioned or are very sparse, such cases as water topics are sparingly mentioned or not mentioned at all, the authors have decided to exclude the HEIs concerned, from their survey.

Table 1. List of keywords to search water-related subjects/programmes.

Main discipline	Keywords
Science and Technology	Water and sanitation; water energy hydro, current, wave, tides; industrial water, water pollution assessment and impact; water treatment technologies; bioremediation and biodegradation; contaminated site management; contaminant transport; flood modelling and forecasting; hydro-informatics; water distribution systems; water modelling; water recycling; sewage treatment; wastewater; hydrology; water power; water demand; optimisation; RS&GIS in water resources; infiltration; water quality; irrigation systems; river ecosystem; urban hydrology; agriculture water; rainwater; aquaculture; fisheries; glacier
Social Studies	Equity, gender and social justice, water access, feminisation of agriculture, behavioural aspects of water use; water security; water rights
Economics	Water economics and financing; water market; water nexus
Law and Regulatory	Water governance; hydro-diplomacy; water laws; legal framework on water; water (pollution and control of pollution) act; water policies
Management	River basin planning and catchment management; climate change and water; integrated impact assessment; watershed management; wetland management

(b) What is the nature of HEI in terms of their activities?

Ideally, all HEIs have to fulfil the two main functions expected of them – imparting education and carrying out pure and/or applied research. For the sake of an ordered classification, in this article, the authors have defined three categories: HEIs Primarily in Education, HEIs Primarily in Research and HEIs in both Education and Research. An HEI classifiable under ‘Primarily in Education’ is one which is involved basically with educating professionals and has undertaken, on average, less than one water-related project per annum over the last 5 years. To be categorised under ‘Primarily in Research’, an HEI must be actively involved in research and consultancy work in the water sector and must have undertaken over five funded projects annually, over the last 5 years. Some of these HEIs may also be offering academic degrees (mainly PhDs) in collaboration with other universities/academic institutes. The last category (the hybrid one – *Education and Research*) includes those HEIs which offer academic programmes related to water and which have undertaken more than one funded research project related to water per annum (average) during the previous 5 years. It must be clarified here that this classification is based on water-related projects only. It is possible that an HEI, which has been classified as ‘Primarily in Education’ in this article, may be involved in both education and research in some other field of learning – say energy for instance.

(c) What types of degree is offered by the HEI?

Based on the types of post-graduate degree in water-related subjects which are offered, HEIs are classified as *Science* (Master of Science degrees), *Social Science* (Master of Arts degrees), *Engineering/Technical* (Master of Engineering or Master of Technology degrees) and *PhD* (doctoral degree). The Master of Business Administration (MBA) programme was also considered, but the search did not yield any HEI offering MBAs in the domain of water resources management. (This leads the authors to suggest this option for HEIs which would like to be trendsetters in including water resources management as a possible optional module in the MBA degrees they offer).

(d) What aspects related to water resources management are accorded importance by the HEI currently and what are the gaps which can thereby be identified?

Courses related to oceanography have been kept out of the analysis. New keywords like aquaculture (water–food nexus), glaciers (water resources), etc., popped out during the course of the search, in addition to the ones which were considered at the outset. Classification on the basis of the aspects related to water resources was done under the following subject categories:

1. Water Economics (WE)
2. Water Governance and Policy (WGP)
3. Water Laws (WL)
4. Water Quality and Health (WQH)
5. Agriculture and Water (A&W)
6. Water Disaster (WD)
7. Water Nexus (WN)

8. Hydro-diplomacy (HD)
9. Climate and Water (C&W)
10. Technology in Water Application (TWA)
11. Inland Aquaculture, Fisheries, etc. (OW)
12. Glacier Hydrology (GH)
13. Watershed and Hydrological Flow (WHF)
14. Resource Assessment, Modelling and Impact Evaluation (RAMIA)

The aforesaid classification is done after considering the courses offered in the post-graduate programmes, funded research activities and the profiles of the faculty members.

The assessment described above has been carried out based on the information available on the respective websites of the HEIs, between 15 March 2018 and 10 April 2018. The HEIs were surveyed for each state in India, in order to minimise the chances of accidentally excluding any HEI.

Interviews. The first author used the contacts in his academic network within India, with two sets of questionnaires: one targeted at faculty members and the other at final-year students in programmes related to water resource management studies. The *modus operandi* involved contacting the faculty members with both sets of questionnaires and requesting them to answer one and exhort their final-year students to answer the other one. Tables 2 and 3 present the information requested from prospective respondents. The e-mails were sent out in the third week of July 2019, and the respondents have been acknowledged both in the List of References and the Acknowledgements at the end of this paper. The HEIs in the loop, as far as the surveys were concerned, were the TERI School of Advanced Studies (New Delhi and Hyderabad), the Bajaj Institute of Technology (Wardha), the Indian Institute of Technology (Kharagpur), the Visvesvaraya National Institute of Technology (Nagpur) and the Central University of Jharkhand. In all eight faculty members responded to the questionnaire, 50% of them from the HEI to which the first author belongs. Detailed responses were also elicited from nine students from the TERI School of Advanced Studies (New Delhi). While the preponderance of responses from the TERI-SAS can be explained by the affiliation of the first author, the spread of the HEIs when it comes to responses from faculty members can be considered to be diverse enough to encompass the length and breadth of the country.

Table 2. Questionnaire sent to faculty members in universities.

Name of the institution/university	_____
Department	_____
Name of faculty (optional)	_____
Designation	_____
Working since	_____
<i>Which programme are you associated with and which are the subjects you teach?</i>	
<i>Do you have prior industry/water sector experience?</i>	
<i>How would you honestly rate your ability to contribute to churning out what the real-world out there needs from graduate students? On a scale of 1 to 5; 1 = highly capable of delivering the goods; 5 = incapable of doing so; working on it at the time of responding</i>	
<i>Do you split your time at work between research and pedagogy?</i>	
<i>Your personal opinions of the lock-ins which have introduced gaps between academia and industry in India?</i>	
<i>Do you have prior industry/water sector experience?</i>	

Table 3. Questionnaire sent to final-year students in universities.

Name of the institution/university	_____
Department	_____
Name of the student (optional)	_____
Name of the programme	_____
Year of admission	_____

On a scale of 1 to 5 (1 being very good and 5 being not satisfactory at all), how would you rate the education you are being imparted, with respect to relevance to your career in the future?

Briefly state the reason why you have chosen this programme – in 3 sentences at the most

On a scale of 1 to 5, how would you rate your teachers/professors with respect to their awareness of what the real-world economy needs from graduate students in universities when they go out to work (1 = Highly aware; 5 = totally unaware)

Results and discussion

Of the assessment

Refer to the Supplementary Information for a detailed inventory of HEIs offering programmes (study and/or research). India has 895 universities offering higher education, of which 337 are relevant for the current survey owing to their close engagement with the water sector. About 155 of the 895 universities are engaged in research and offer PhD degrees. Of the 337, a good chunk (289; 86%) is categorised under ‘Primarily in Education’ (refer to question (a) in the previous section), while 24 each (7% each) belong to the other two categories (Figure 1).

If one looks at the regional distribution of these HEIs (Figure 2), it is observed that the northern region dominates with 146, followed by the southern region (70). It is ironic that among the other

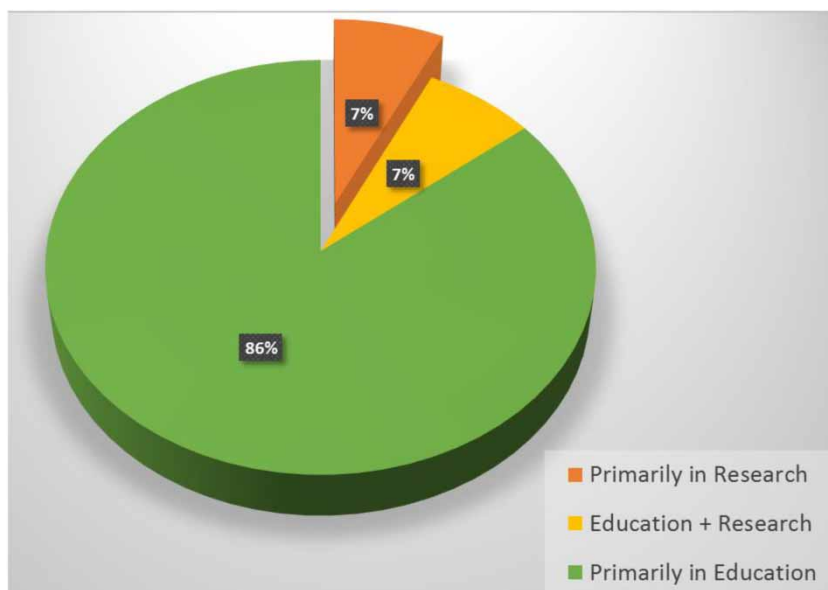


Fig. 1. Distribution of water relevant HEIs based on the focus area of activities.

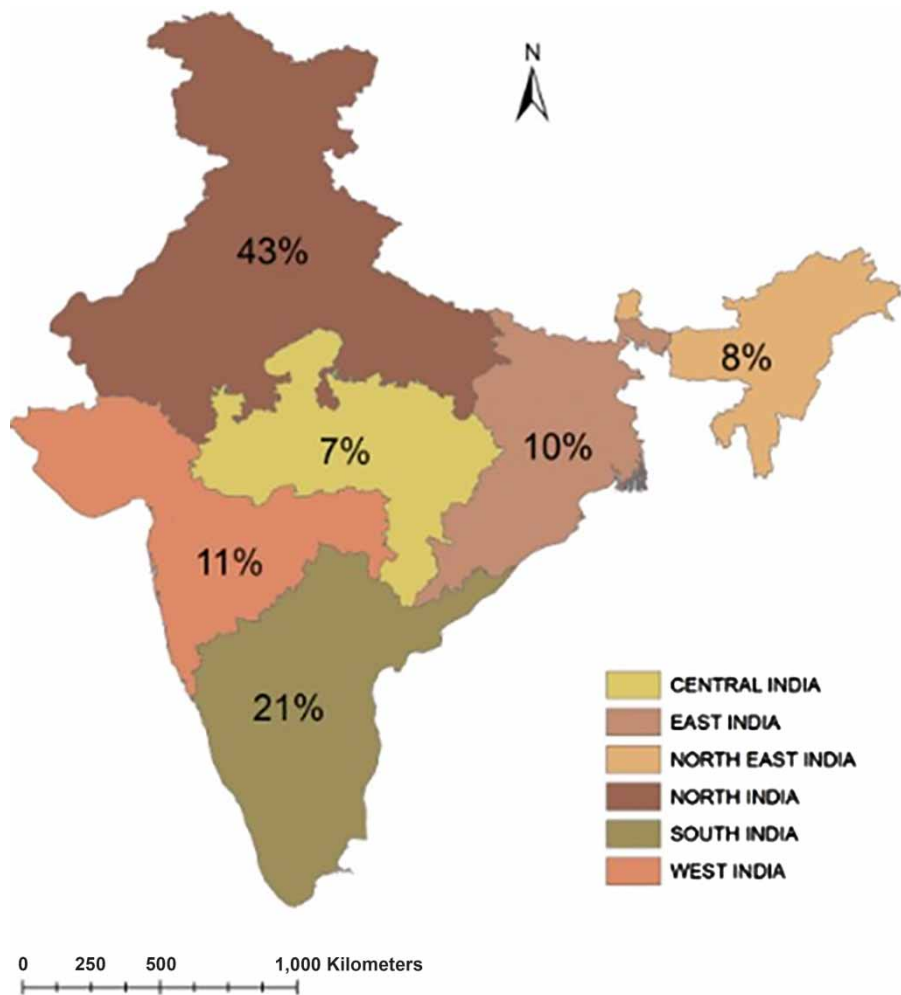


Fig. 2. Region-wise distribution of HEIs engaged in water resources management education and research.

regions (less than 40 HEIs each), the central and central-western parts are meteorologically drought-prone, and the eastern parts are meteorologically flood-prone. An interesting observation which can be made from this distribution is that regions with water problems due to anthropogenic (population growth and water wastage, *inter alia*) or climate change-related (more recent temperature spikes) factors have more HEIs, vis-à-vis those which have been meteorologically affected owing to their topography (location on the surface of the earth).

While the northern region accounts for the biggest share of the pie, and the southern region follows in second place, if the states are ranked on the basis of the number of HEIs within their boundaries, Uttar Pradesh tops the list with 42, followed by Rajasthan (28) and Tamil Nadu (22). As can be seen from Figure 3, most of the HEIs in these three leading states in the country belong to the category ‘Primarily in Education’, and mostly offer Master’s degree and PhD programmes in water-related topics. It is

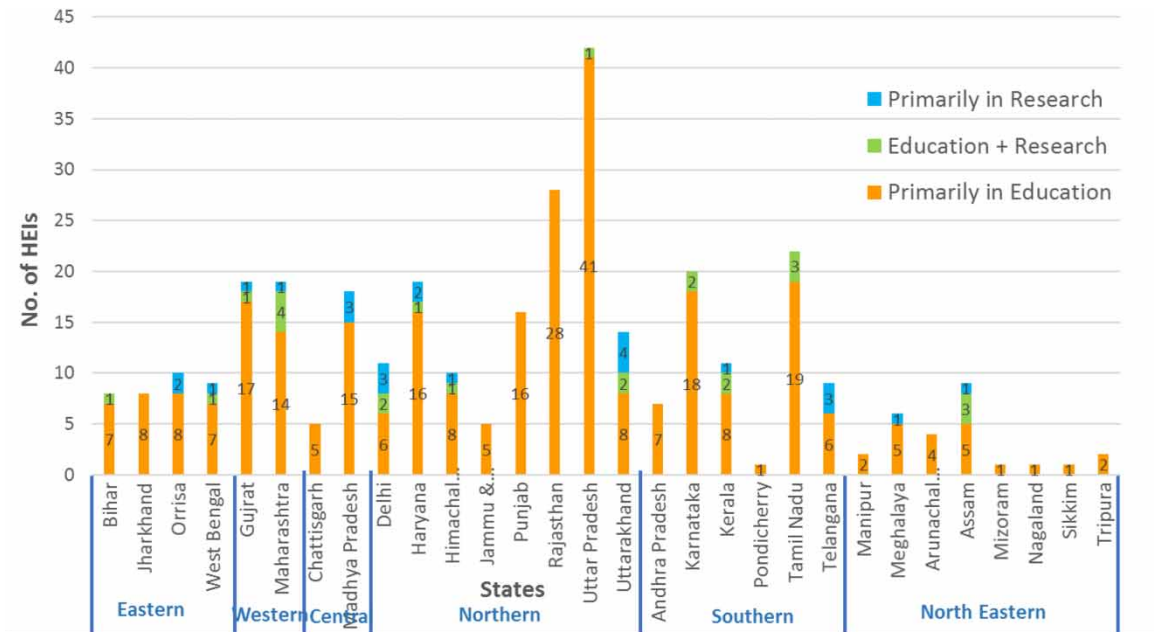


Fig. 3. State-wise distribution of HEIs offering programmes in water-related subjects.

interesting to note that the small state of Uttarakhand in north India has more HEIs belonging to the ‘Primarily in Research’ category, than any other state in the country.

Prominence of water in education

Around 10% of the HEIs accord high prominence to water. Of these, 23 belong to the ‘Primarily in Research’ category, while 9 are hybrids (both education and research). These have ongoing exclusive water-related degree programmes or a dedicated division/department/centre offering water-related degree programmes and engaging closely with the water sector. Prominent topics covered by these institutions include agriculture efficiency, water treatment technology, water resource management and hydrology. A case in point here, however, is the strong and perceptible bias towards the ‘engineering and technological’ aspects – treatment technologies, hydro-projects, drainage infrastructure, etc. There are only two HEIs in this category offering courses on economic and social aspects of water resources – the Tata Institute of Social Sciences (TISS) and TERI School of Advanced Studies (TERI-SAS).

About 29% of the HEIs accord moderate prominence to water-related programmes. These, in general, offer degrees (Master’s degrees, PhD) in Civil Engineering or Environmental Science/Engineering and have few mandatory water-related courses in their curriculum. The ‘low prominence’ category dominates the mix, with 61% of the HEIs, as seen in Figure 4.

It is also observed that HEIs according to high prominence to water-related subjects are primarily engaged in research, as seen in Figure 5. The nine ‘high prominence’ HEIs, which are actively

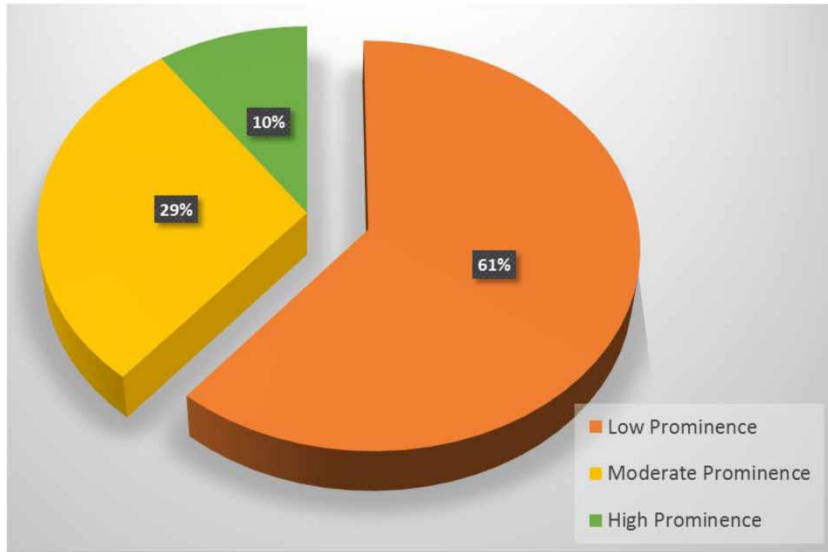


Fig. 4. Distribution of HEIs based on the level of prominence accorded to water-related studies/research.

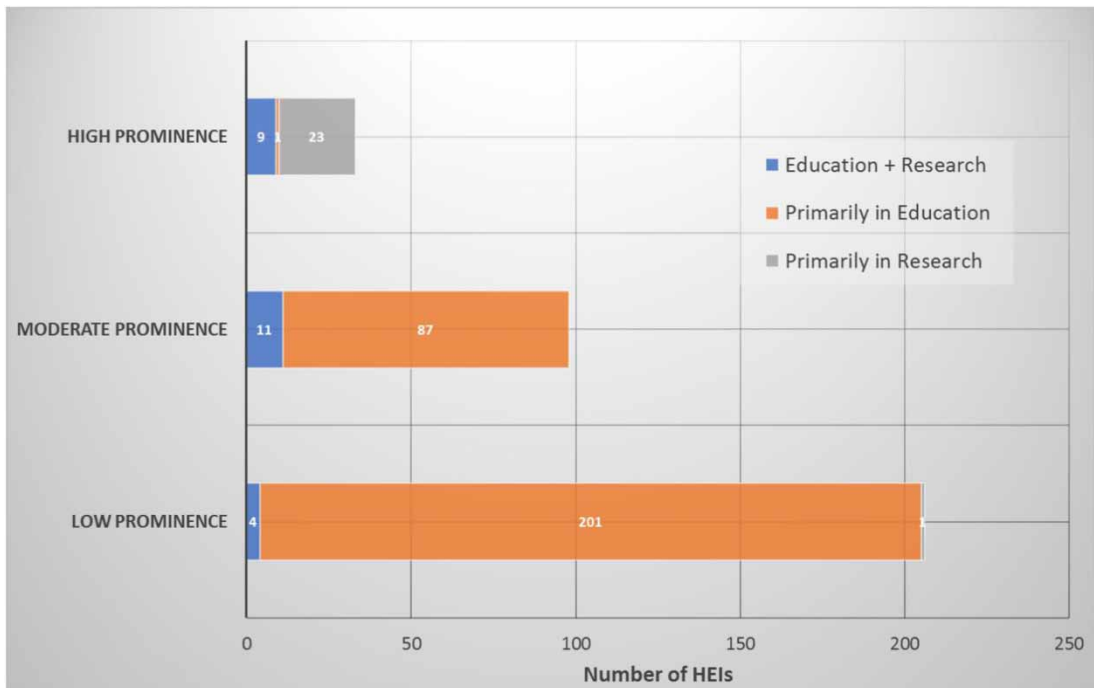


Fig. 5. Distribution of HEIs based on the prominence accorded to water and the nature of activity/activities.

engaged in both imparting higher education and conducting research for and in the water sector, are as follows:

1. The School of Water Resources, Indian Institute of Technology (IIT) Kharagpur, West Bengal (Eastern region)
2. Water Resource Development & Management, IIT Roorkee (Eastern region)
3. Centre for Water Resources (CWR), Anna University, Tamil Nadu (Southern region)
4. Interdisciplinary Centre for Water Research (ICWaR), IISc, Bengaluru (Southern region)
5. Coca-Cola Department of Regional Water Studies, The Energy Research Institute's School of Advanced Studies (TERI-SAS), New Delhi (Northern region)
6. Tata Institute of Social Sciences (TISS), Maharashtra (Western region)
7. Centre of Water Resources Engineering (WRE), Visvesvaraya National Institute of Technology, Maharashtra
8. Central Institute of Fisheries Education, Maharashtra (Western region)
9. Tamil Nadu Agricultural University, Tamil Nadu (Southern region)

Types of degree offered by HEIs

Figure 6 depicts the distribution of degrees offered by HEIs. Based on the availability of information, the authors found out that PhDs in water-related research themes are offered by 155 HEIs, Master of Engineering (ME) and Master of Technology (MTech) degrees by 157 of them and Master of Science (MSc) degrees by 107 HEIs. Two institutions stand out by virtue of the multi-disciplinary programmes they offer – TERI-SAS in New Delhi with its *Water Science and Governance* programme (since 2014)

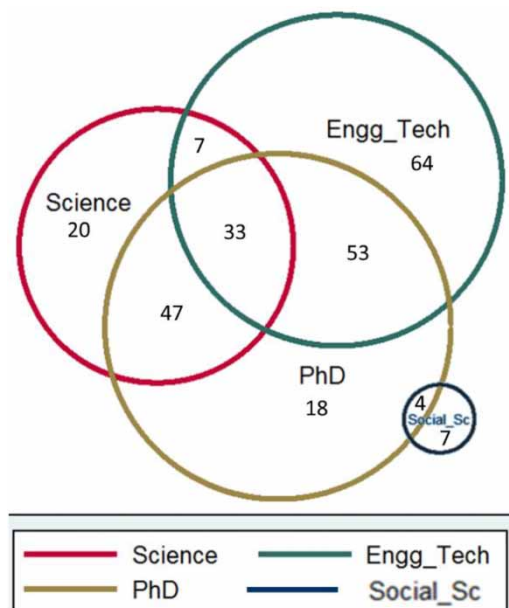


Fig. 6. Distribution of HEIs based on the nature of degrees offered in the water domain.

and the Shiv Nadar University in Noida with its *Water Science and Policy* programme (since 2016). There are 53 HEIs which offer both MTech/ME and PhD degrees, and an almost equal number offers both MSc and PhD degrees. The intersection set of the three big sets in the Venn diagram in Figure 6 – Engineering/Technology, Science and PhD, has a value of 33, which, depending on one’s perspective may seem less or enough for a country the size of India.

Aspects of water issues covered by HEIs

Not all HEIs have provided information about the areas of research they engage in, on their websites. However, based on the limited information available, the research areas were categorised into 14 themes, which were listed in the Methodology section. It goes without saying that an HEI generally would engage itself in more than one thematic area of research in water resources management. This explains the fact that the number of HEIs which one can count in Figure 7 is greater than the actual number of institutions surveyed for this paper and is an important piece of information necessary to interpret the graph correctly. It must also be mentioned at this juncture that owing to the aforesaid limitation in the availability of comprehensive information about all the surveyed HEIs, the results presented are not complete.

The state-wise distribution of the HEIs based on their focus research areas, depicted in Figure 8, is rich with information. From this graph, one can conclude that about 20% of HEIs engaged in research in collaboration with the water sector in India focus on Resource Assessment and Impact Assessment (RAMIA, in the figure). The theme ‘Technology for Water (TWA)’ follows with 19%. Technical aspects include runoff/hydrological/hydraulic modelling, water & wastewater treatment/recycling, water power engineering, design and development of water-related infrastructure, optimisation techniques for water demand application, *inter alia*. Research on themes like watershed & hydrology and agriculture & water are the fortes of 12.2% and 11.7% HEIs, respectively. HEIs like IISc, Bangalore,

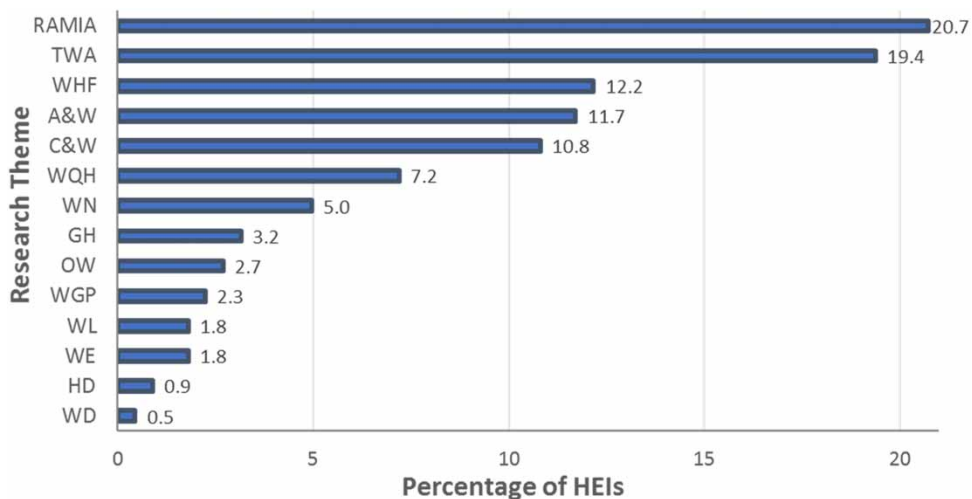


Fig. 7. Distribution of HEIs based on the 14 major research themes considered in this report (refer to the Methodology section for definitions of the acronyms on the Y-axis).

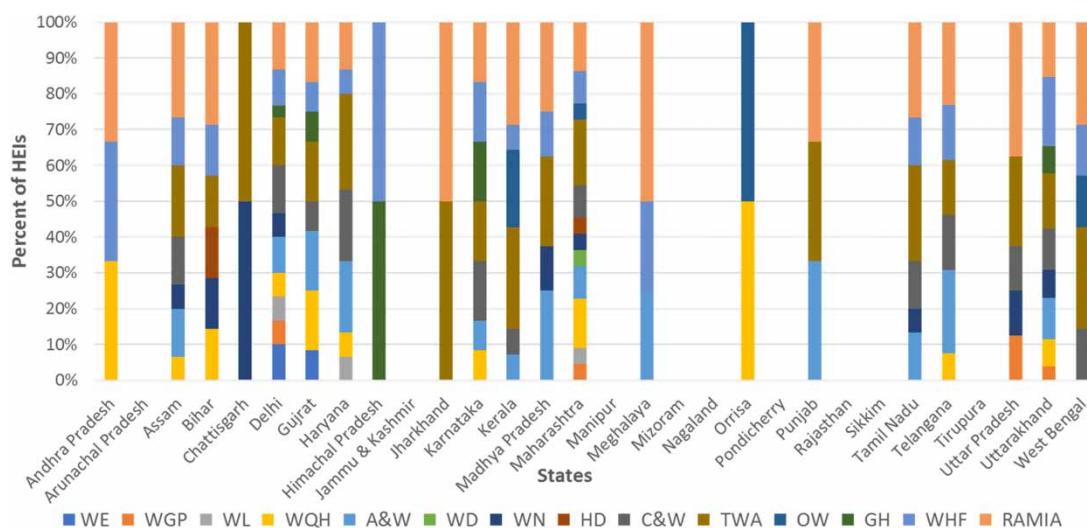


Fig. 8. Thematic distribution of HEIs in different states.

Anna University, Chennai and the Benaras Hindu University, Varanasi (all three in the hybrid ‘Education + Research’ category); Space Application Centre, Ahmedabad, Indian Institute of Remote Sensing, Dehra Dun and TERI-SAS, New Delhi (all three in the ‘Primarily Research’ category) engage themselves in water research associated with climate change impacts.

Delhi University, Nalanda University, TISS, CMR University and South Asian University are among the few which are engaged in research in conflict resolution and management of transboundary issues. Of these, only TISS offers a specialised programme related to the socio-economic challenges associated with water.

Of insights from the survey

Faculty members. The HEIs from which the respondents hail have already been identified in the Methodology section. Of the eight respondents, five have provided information about the time periods of their stints as faculty members in the respective HEIs. The experience ranges between less than a year and 22 years. Prior industry experience is always a plus point for academicians, as that makes them more aware of the realities ‘on the ground’, and they can impart more meaningful education to their students. Singh (personal communication), Associate Professor from the Central University of Jharkhand, has worked in an irrigation company for a few months; Sherly (personal communication), Assistant Professor from TERI-SAS, has a combined industry experience of 5.5 years (split between the IT sector and the water sector); Prakash (personal communication) from TERI-SAS (Hyderabad campus) and Chaudhuri and Tarannum from TERI-SAS (Delhi) bring with them 2 decades, 15 years and 10 years of water sector work experience to their positions as faculty members in the said HEI (personal communication). Kanhe and Ghangrekar also come to academics from the industry (personal communication), while Tembhurkar (personal communication) states that he has not worked in the industry prior to his stint in the HEI he is affiliated to.

Self-rating is a challenging task, and when asked to rate their abilities to ‘contribute to churning out what the real world out there needs from graduate students’, on a scale of 1–5, with 1 representing a very

high ability and 5 inability, three respondents each rated themselves with a ‘1’ and ‘2’, respectively, while one each gave themselves a rating of 3 and 4. Curiously, there was no direct correlation between the extent of prior industry experience and the rating of personal ability. In fact, two respondents with no or minimal industry experience are confident of churning out students with the required capabilities the industry needs (they rate themselves right on top of the scale). All the eight respondents split their time (or at least try to) between pedagogy and research, and this clearly indicates the bridge between theory and practice which needs to be reinforced over time in India.

Change is often impeded by so-called lock-ins, and the authors wished to know from the respondents what they thought the lock-ins were which have introduced gaps between academia and industry – sometimes, yawning and conspicuous ones. The personal opinions expressed (regarding the lock-ins and/or suggested remedies) are summarised hereunder without naming the sources.

1. Regional industries should be compelled legally to tie up with HEIs.
2. Many HEIs do not take the industry internships so seriously, and there is no proper accountability for the time devoted and effort put in by the industry partner.
3. There is no well-defined platform for mutual exchange of knowledge (even using webinar) except for invited industry lectures.
4. The water sector relies on HEIs mainly for manpower, and there is a very limited role for an academic researcher imparting knowledge to the industry through invited talks and project collaborations.
5. Many international water consultancy organisations (Atkins, AECOM, Arcadis, Mott-MacDonald, WSP, etc.) that have offices in developing countries do not have a research wing in existence, at least in India.
6. Academicians are too obsessed with theory. There is a lack of understanding of how the theory works in real life. Students of the 21st century (especially those from a technical background) are more interested in applied knowledge. They want to change the world, and they look up to their teachers to help them to find solutions to contemporary local/national/global challenges.
7. The industry follows its preset manuals for design without giving much importance to the outputs that academic research generates.
8. The curriculum followed in HEIs is often not vetted by the industry. There is little or no focus on project-based/experiential learning.
9. The curriculum needs to be updated periodically. Teaching the basics is, of course, necessary but not sufficient. Students must be educated about the most recent advancements made and enlightened about relevant case studies. Industry visits must become an integral part of any curriculum.

Students. All the relevant responses originated from the same HEI – the one to which the first author belongs. All the nine students who responded began their respective Master’s programmes in 2018. Two different programmes were identified: one in Water Resources Engineering and Management and the other one in Water Science and Governance.

As far as the relevance of the education received to the professional requirements in the water sector in the real world is concerned, the opinions were markedly different. Four students ranked the relevance right on top of the scale with a ‘1’, while four others rated it with a ‘2’. There was a lone student who gave it a ‘3’ – a rating in the middle of the scale. There was another Likert scale question related to what

the students thought about the awareness their professors showed the practical and real-life challenges in the water sector. Most students rated their professors highly in this regard. Interesting reasons were put forth by the respondents for their choice of the said Master's programmes at TERI-SAS. These are listed as follows:

'I am keen on developing strategies for the sustainable use of water to achieve optimum productivity in agriculture in India.'

'As our country is staring at an uncertain future in which water will become a scarce resource in most parts of India, we as water experts can contribute meaningfully.'

'Water treatment happens to be an area of interest.'

'I have always had an abiding interest in water conservation.'

'The world needs water experts to deal with water crisis issues holistically.'

'I wish to be a part of the solution to the problems associated with water crisis and environmental degradation.'

Conclusion

There are a good number of HEIs in India, which offer educational programmes in water-related subjects and carry out research in close collaboration with the water sector in the country. However, as evidenced from Figures 2 and 8, the distribution is skewed (quite akin to water resources themselves which are unevenly distributed). There seems to be a clear bias in favour of the technological aspects of water. Relatively fewer HEIs engage themselves in social, economic and gender-related issues. There are few trendsetters when it comes to multi-disciplinary approaches to water resource management, and there is hope that these will entrench themselves in academia and research in general over time. In the western world, the realisation that sustainability challenges in the 21st century can only be solved if educational disciplines could cooperate and harness the benefits of a multi-disciplinary approach dawned a couple of decades ago and they became the global trendsetters. The Hobson's choice for Indian HEIs is to follow suit – and sooner the better, in the interest of the Sustainable Development Goals, which India intends to achieve by 2030.

Resource assessment, application of modelling software and RS&GIS tools, irrigation, and treatment technologies are preferred themes of research for most of the HEIs engaged in research. Some of them have dedicated centres for research in climate change-induced impacts on water resources, inland aquaculture, fisheries, etc. There is a need to popularise research in the social, economic and regulatory aspects of water management, which at the time of writing do not seem to be getting the importance they deserve.

The e-mail interviews conducted revealed a clear consensus among the faculty members regarding the gap between academia and industry which needs to be urgently bridged. The students who responded seem to be keen on applying the education they receive in the HEIs to solve the practical problems and real-life challenges they would be faced with when they take on assignments in the industry after graduating. This article presents an approach for carrying out similar studies in other regions to enable cross-regional comparison, finding collaboration opportunities and fostering regional champions of water governance.

Supplementary material

The Supplementary Material for this paper is available online at <https://dx.doi.org/10.2166/wp.2020.160>.

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