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Mapping Institutions, Research and Funders in India within the Water-Energy-Food Nexus Research Area
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## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AFPRO</td>
<td>Action for Food Production</td>
</tr>
<tr>
<td>AIBP</td>
<td>Accelerated Irrigation Benefit and Flood Management Programme</td>
</tr>
<tr>
<td>AKRSP</td>
<td>Aga Khan Rural Support Programme</td>
</tr>
<tr>
<td>AMU</td>
<td>Aligarh Muslim University</td>
</tr>
<tr>
<td>BEE</td>
<td>Bureau of Energy Efficiency</td>
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<tr>
<td>CCA</td>
<td>Climate Change Adaptation</td>
</tr>
<tr>
<td>CGIAR</td>
<td>Consultative Group on International Agricultural Research</td>
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<tr>
<td>CSSRI</td>
<td>Central Soil Salinity Research Institute</td>
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<tr>
<td>DEDS</td>
<td>Dairy Entrepreneurship Development Scheme</td>
</tr>
<tr>
<td>DFID</td>
<td>Department for International Development</td>
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<tr>
<td>FAO</td>
<td>Food and Agricultural Organization of the United Nations</td>
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<tr>
<td>FYP</td>
<td>Five-Year Plan</td>
</tr>
<tr>
<td>GBP*</td>
<td>Great Britain Pounds</td>
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<tr>
<td>GCF</td>
<td>Gross Capital Formation</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GoI</td>
<td>Government of India</td>
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<tr>
<td>IARI</td>
<td>Indian Agricultural Research Institute</td>
</tr>
<tr>
<td>ICAR</td>
<td>Indian Council of Agricultural Research</td>
</tr>
<tr>
<td>ICI</td>
<td>Indian Citation Index</td>
</tr>
<tr>
<td>ICRISAT</td>
<td>International Crops Research Institute for the Semi-Arid Tropics</td>
</tr>
<tr>
<td>IISc</td>
<td>Indian Institute of Science</td>
</tr>
<tr>
<td>IIT</td>
<td>Indian Institute of Technology</td>
</tr>
<tr>
<td>INR</td>
<td>Indian Rupee</td>
</tr>
<tr>
<td>IRRI</td>
<td>International Rice Research Institute</td>
</tr>
<tr>
<td>ISI/BIS</td>
<td>Indian Standards Institute /Bureau of Indian Standards</td>
</tr>
<tr>
<td>ISA</td>
<td>Indian Science Abstracts</td>
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<tr>
<td>IWMI</td>
<td>International Water Management Institute</td>
</tr>
<tr>
<td>MGNREGS</td>
<td>Mahatma Gandhi National Rural Employment Guarantee Scheme</td>
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<td>NABARD</td>
<td>National Bank for Agriculture and Rural Development</td>
</tr>
<tr>
<td>NGBRA</td>
<td>National Ganga River Basin Authority</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
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<tr>
<td>NWP</td>
<td>National Water Policy</td>
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<td>PDCSR</td>
<td>Project Directorate Cropping Systems Research</td>
</tr>
<tr>
<td>PPP</td>
<td>Public Private Partnership</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>RIDF</td>
<td>Rural Infrastructure Development Fund</td>
</tr>
<tr>
<td>SCAMPIS</td>
<td>Scaling up Micro-irrigation Systems in India, Madagascar and Guatemala</td>
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<tr>
<td>SDC</td>
<td>Swiss Agency for Development and Cooperation</td>
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<tr>
<td>SHP</td>
<td>Small Hydro Power</td>
</tr>
<tr>
<td>SRI</td>
<td>System of Rice Intensification</td>
</tr>
<tr>
<td>SUBACS</td>
<td>Sustainable Development of Sugarcane-based Cropping System</td>
</tr>
<tr>
<td>TERI</td>
<td>The Energy and Resources Institute</td>
</tr>
<tr>
<td>UPJVNL</td>
<td>Uttar Pradesh Jal Vidyut Nigam Limited</td>
</tr>
<tr>
<td>UPNEDA</td>
<td>Uttar Pradesh New and Renewable Energy Development Agency</td>
</tr>
<tr>
<td>UPPCL</td>
<td>Uttar Pradesh Power Corporation Limited</td>
</tr>
<tr>
<td>UPPTCL</td>
<td>Uttar Pradesh Power Transmission Corporation Limited</td>
</tr>
<tr>
<td>USAID</td>
<td>US Agency for International Development</td>
</tr>
<tr>
<td>WRCRC</td>
<td>Water Resources Control and Review Council</td>
</tr>
<tr>
<td>WEF</td>
<td>Water-Energy-Food</td>
</tr>
<tr>
<td>WUE</td>
<td>Water use efficiency</td>
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*Note: Conversion rate GBP 1 = INR 92.5*
Executive Summary

The interconnection of energy, water and food sectors has been globally recognized and supported by various research studies across the globe. The Water-Energy-Food (WEF) Nexus approach is essential as actions related to one sector can impact one or both of the remaining sectors.

Research into the Nexus areas of water, energy, and food sectors has been evolving in terms of its interdisciplinary nature. Government ministries and organisations play a major role in activities pertaining to the WEF Nexus areas with support from international organisations and private bodies. During the 11th and 12th Five-Year Plan periods (i.e. 2007-2012 and 2012–2017), the research, development, and implementation schemes of the Government of India have stressed more on sustainable and equitable growth.

There is an increasing trend towards measuring research quality and effectiveness through publication-based metrics and their effects on scholarly communication. Publication metrics exercise a strong influence on science communication and directly affect the different actors of the process (mainly authors, readers, funding agencies, and institutions).

In India, issues related to the WEF Nexus have been addressed through various policy measures and schemes across the domains of agriculture, conventional and non-conventional energy sources, water management, environment, and rural development. The Government’s research and development (R&D) spending is driven by the need to support policy objectives. Agriculture sector, being the source of livelihood for the country’s vast rural population, remains the backbone of the economy. The provision of electricity subsidies that supports agricultural growth has a considerable impact on the ground water use in the country. As a result, agriculture, ground water, and electricity sectors are now inextricably linked with each other wherein the growth of the agriculture sector is being supported by unsustainable trends in the other two sectors in most parts of India.

Publication matrix

The publication matrix was developed based on the weighting assigned to following indicators of measuring and analysing research papers:

1. **Author and institute research productivity (weighting 20 per cent)**. The volume of research papers produced by an individual or a research organisation is considered as an indicator of research activity.

2. **Citations of papers (weighting 70 per cent)**. Citation counts are recognised as a measure of impact, which can be used to index the excellence of a research paper.

3. **Journal (publication) standing (weighting 10 per cent)**. The databases that index journal/research papers follow certain criteria to ensure the quality of research papers indexed. Parameters like peer-review, impact factor, and timeliness of the publication are pointers to the publication quality.
A comprehensive search was carried out in narrow subject domains developed in consultation with the subject experts, considering the High Level Research and Innovation Objectives of the UK–India Partnership. The search output was reviewed in terms of WEF Nexus issue and selected for publication matrix. The search output was then classified subject wise, institution wise, and author wise to develop the publication matrix.

In the Publication Matrix (Annexure 1), a total of 848 Indian authors/researchers contributed 366 papers in different capacities (primary authors and co-authors), originating from 272 Indian and about 30 centres of Consultative Group on International Agricultural Research (CGIAR) located in India and overseas institutions. An increasing trend of the number of research papers is noticed since 2007 and this trend reached the peak in 2013; i.e. during the 11th and 12th Five-Year Plans when the Government started according due priorities in these areas (Figure I).

**Figure I** Total number of papers published during study period

The leading institutions were identified based on the publication matrix in each of three sectors of the Nexus areas—water, energy, and food. The leading and emerging researchers in the Nexus areas were evaluated based on the scientometric methodology of measuring and analysing research papers. The mapping of leading researchers in the WEF Nexus research areas highlights that only a handful of researchers are publishing regularly in the areas of WEF Nexus. Some Nexus research areas, like emerging efficient technologies, need more attention by the Indian research community to meet the challenges faced by the interlinked components of the Nexus.
Research priorities of funding organisations

Research and development funding and fund allocation mechanisms are powerful instruments of research policy formulation in India as well as across the globe. During the 11th and 12th Five-Year Plan period, the Government of India has recognized the close interrelationship of energy-water-food sectors that is reflected in fund allocation trends. In India, most research funding comes from government sources — where expenditures are primarily carried out by the central and state governments through different planned schemes, universities, and specialized government agencies like research councils. Apart from research, the funding support is also provided for various implementation schemes. Several implementation schemes have research components that are not always obvious. For conducting this study, such implementation schemes have also been considered.

In the recent Union Budget 2015-2016, although several of the ministries fall in line with the WEF Nexus areas, primarily four ministries, namely Ministry of Agriculture, Ministry of Water Resources, Ministry of Earth Sciences, and the Ministry of New and Renewable Energy have fund allocation under the R&D budget head. Besides, out of the total R&D budget about 85 per cent is for the Ministry of Agriculture. The budget allocation pattern in the three sectors of water, agriculture, and renewable energy, underlines the focus of the Government on issues concerned with the agriculture sector. In the Nexus areas, agriculture sector receives maximum government funding and therefore, research and development in the Nexus areas revolve mostly around agriculture, irrigation, and allied activities.

The role of multi-stakeholders, both national and international, has been pivotal in promoting research in the topics concerned with the priority theme. The private sector involvement in R&D on the Nexus theme is increasing rapidly due to corporate efforts in social responsibility and business sustainability. Foundations and trusts like Arghyam, Concern India Foundation, Sir Dorabji Tata Trust and the Allied Trusts, and Sir Ratan Tata Trust have been actively engaged in civil society and community participation in various projects in the Nexus areas. Corporates like Adani Foundation, Axis Bank Foundation, Hindustan Coca Cola Beverages Private Limited, and PepsiCo Foundation undertake projects that broadly seek to address business sustainability.

International cooperation has played a significant role in developing and strengthening the research system in India. The international agricultural research centres under the CGIAR system have contributed extensively to the cause of agricultural research and the interlinkages with water and energy for sustainable food systems. International funding organisations are actively collaborating with the research and academic institutions as well as non-governmental organisations in India on various sustainable development topics. Notable among these are GIZ, International Development Research Centre, Department for International Development of UK Government (DFID), US Agency for International Development (USAID), Food and Agricultural Organization of the United Nations (FAO), Swiss Agency for Development and Cooperation, and several others. The agriculture sector attracts most of the international funding. Water and energy interventions in the agricultural
sector are the focus of several such projects. The details of schemes and projects of the funding organisations are provided in Annexures 5, 6 and 7.

The mapping exercise reveals that Indian research in the WEF Nexus areas shows an increasing trend from 2007. In the Nexus areas, agriculture receives most government funding and dominates research and development as this sector plays a vital role in the Indian economy. Most of the research is focused on interventions in the water and energy sectors to augment the food production and supply situation. A more coherent and integrated approach is required to meet the growing challenges regarding the availability, accessibility, distribution, and sustainability of water, energy and food for all.
1 Introduction

The challenges faced by the world in general and India, specifically, in respect of energy, water, and food sectors are increasingly becoming interlinked. Subsequently, strategies for tackling one or the other aspect of this integrated challenge would require consideration of critical aspects of managing supply and demand for energy, water, and food in a manner that ensures security in each of these. Global projections indicate that demand for freshwater, energy, and food will increase significantly over the next decades under the pressure of population growth and mobility, economic development, international trade, urbanisation, diversifying diets, cultural and technological changes, and climate change (Hoff 2011).

Water is an essential input for generating agricultural products in the fields and along the entire agro-food supply chain. Energy is required to distribute water and food—to pump water from water sources, to power tractors and irrigation equipment, and to process and market agricultural goods. As actions related to one sector can impact one or both of the remaining sectors, it is necessary to adopt a Nexus approach.

With the world population projected to reach 8.66 billion by 2025, the demand for the three resources—water, energy, and food—is going to increase manifold. Management of these resources poses a serious challenge to mankind. In India, research in WEF Nexus is predominantly centred on issues related to the agricultural sector as this sector plays a decisive role in the socio-economic development of the country. The core issue in the energy sector is improvement of efficiency in supply and consumption of energy. In respect of water, the challenge is associated with sustaining the increasing demand with decreasing water availability through water harvesting, supply mechanism, and community participation. Connected to this is the unit consumption of energy as there is a great potentiality in rationalizing set unit consumption in all consumption sectors, be it industry, agriculture, or domestic sector. The three resources, i.e. food, energy, and water are thus very critically important and their optimisation through efficiency and preservation would warrant sustained and innovative policy measures as also vigorous implementation of the same. In the pages to follow, we cover the current research studies in respect of the Nexus areas that include these three resources.

The research output in the form of published literature is a mirror of research progress and outcomes. Publication metrics have become intrinsically linked with research, both in terms of evaluation and communication. The publication outputs of any institute are a standard measure of its expertise in the fields of research and innovation. A study prepared for the UK’s Department of Business, Innovation and Skills shows that India has achieved substantial growth in overall research articles output, increasing from 54,000 in 2008 to 93,000 in 2012 at an annualized growth rate of 14.4 per cent (Elsevier 2013).
2. Scope of the study

2.1 Objectives

This study maps the research publication outputs, from 2005 to 2014, of the increasingly critical interface of water, energy, and food, and their intertwined relationship in Indian research. The report also examines the research and development priorities on these areas for Indian funding organisations and the existing international collaborations.

The objectives of the study are to identify:

- Leading research institutions and universities based on their publication matrix
- Leading and emerging researchers based on their publications matrix
- Research priorities for Indian funders in Water-Energy-Food Nexus

2.2 Challenges and limitations

The publication matrix takes into account the explicit occurrence/coverage of the identified nexus topics in the content of the data sources. While the study area covers an intersection of three major areas in the Water-Energy-Food Nexus, we have noticed a number of papers covering only two of the three areas. We have considered only those research papers which fall in the explicit intersection of WEF Nexus. There were limitations to access research papers that have less circulation/are not available in databases as mentioned in the methodology section or published in non-English languages. Limited numbers of books and conference proceedings have been considered whose citations were readily available. The study, therefore, captures only a part of the total output of India’s research output over the period. This part is usually recognized as the most relevant and impactful contribution to research.

Citation patterns of research papers have been found to differ among data sources depending on the quality and coverage of the journals. To achieve comprehensive coverage of research literature, citations have been sourced from multiple databases, including Google Scholar. However, as data formats of these databases are different, we have encountered a serious data integration issue, which was later resolved manually. In the Google Scholar, we have taken only the valid references/citations which were available in the open access.

The information on donor financing available in the public domain is limited. Many organisations that offer grants do not provide specific information about the overall amount they have provided for a particular project. The project team has studied all possible sources, from online to print, to gather the required information. Further to this, data from many private sources were not accessible, despite our utmost efforts.
2.3 Policy context

In India, issues related to the WEF Nexus have been addressed through various policy measures and schemes across the domains of agriculture, conventional and non-conventional energy sources, water management, environment, and rural development. The Government’s research and development (R&D) expenditure is driven by the need to support policy objectives. Several policies and schemes by the central and state governments like the National Policy on Biofuels, National Action Plan on Climate Change, National Water Policy 2002, Clean Ganga Fund, National Clean Energy Fund, Agriculture Demand Side Management, state renewable energy, and power subsidy policies have a direct or indirect impact on the Nexus areas.

The agriculture sector remains the backbone of the economy being the source of livelihood for the country’s vast rural population. The provision of electricity subsidies that supports agricultural growth has a considerable impact on the ground water use in the country. As a result, agriculture, ground water, and electricity sectors are now inextricably linked with each other where growth of the agriculture sector is being supported by unsustainable trends in the other two sectors, in most parts of India. The thrust areas of select national plans and policies, by the nodal ministries, that have a direct or indirect bearing on the interlinked Nexus issues are detailed in Table 2.1.

<table>
<thead>
<tr>
<th>Government ministries</th>
<th>Policies /Schemes</th>
<th>Thrust areas</th>
</tr>
</thead>
</table>
| Ministry of New and Renewable Energy     | National Policy on Biofuels        | • The policy calls for blending at least 20% biofuels with diesel and petrol by 2017.  
                                           |                                    | • The policy endeavours to facilitate and bring about optimal development and utilisation of indigenous biomass feedstock for production of biofuels.  
                                           |                                    | • The development of biofuels will have an impact on water, food, energy, and the environment.                                          |
| Ministry of Power                         | National Electricity Policy        | • The policy aims at laying guidelines for accelerated development of the power sector, providing electricity to all areas, and protecting interests of consumers and other stakeholders.  
                                           |                                    | • The policy allows the state electricity regulatory commissions to establish a preferential tariff for electricity generated from renewable sources to enable them to be cost-competitive. |

Table 2.1 National government policies and plans
| Ministry for Water Resources, River Development and Ganga Rejuvenation | National Water Policy 2002 | • The thrust areas of the policy include integrated water resources management for sustainable utilisation of the available surface and ground water; and participatory approach in water resources management.  
• Irrigation planning either in an individual project or in a basin as a whole should take into account the irrigability of land and cost-effective irrigation options possible from all available sources of water and appropriate irrigation techniques for optimizing water use efficiency. |
| --- | --- | --- |
| Department of Agriculture & Cooperation, Ministry of Agriculture | National Policy For Farmers 2007 | • The policy aims to protect and improve land, water, biodiversity and genetic resources essential for sustained increase in the productivity, profitability and stability of major farming systems.  
• The policy also aims to foster community-centred food, water and energy security systems in rural India and to ensure nutrition security for all. |
| Ministry of Agriculture | National Agricultural Policy | • The policy propagates rational utilisation of country’s water resources for optimum use of irrigation potential.  
• Application of frontier sciences like energy saving technologies, biotechnology, and other technologies through national research as well as proprietary research will be encouraged. |
| Ministry of Environment, Forest and Climate Change | National Action Plan on Climate Change | • The plan identifies eight core national missions, each of which is a sectoral response to the impacts of climate change.  
• Three of them—on solar energy, afforestation, and energy efficiency—seek to slow down the growth of India’s emissions. Another three—on agriculture, water, and Himalayan ecosystems—are about initiating measures to adapt to the effects of climate change. The remaining two—on sustainable habitat and strategic knowledge—are service missions and aim to create more knowledge on useful climate responses. |

Agriculture, water, and electricity—all the three sectors are state subjects according to the Constitution of India. Farmers and other agricultural workers, who comprise about 56.6 per cent of India’s total workforce, maintain significant pressure on politicians to avoid raising agricultural energy tariffs, which would in turn increase irrigation costs (Government of India 2001). Some state governments are now evolving alternative irrigation methods and reforms to such subsidies. For instance, the energy subsidy reform, the Jyotigram scheme, in the state of Gujarat, is showing signs of success. The scheme has helped significantly reduce farm electricity subsidies and ground water withdrawals in Gujarat (IWMI 2011). The central government has recently indicated that the Jyotigram scheme would be implemented throughout the country. Similarly, the Surya Raitha programme of Karnataka government is perceived as a step towards the welfare of farmers in the field of irrigation through solar power development. Table 2.2 provides the thrust areas of select state-level plans and polices that have an impact on the Nexus area.

**Table 2.2 State governments’ policies and plans**

<table>
<thead>
<tr>
<th>States</th>
<th>Policies/Schemes</th>
<th>Thrust areas</th>
</tr>
</thead>
</table>
| Karnataka state government | Karnataka Solar Policy 2014-2021                    | • The policy provides incentives to farmers to set up solar plants on farms and facilitates liberalisation of norms for buying farm land for investors to set up power plants.  
  • The Surya Raitha programme, a part of the policy aims to ensure that solar panels are placed to generate electricity for running irrigation pump sets, and will also enable farmers to sell excess power generated to the Government. |
| Haryana state government | Scheme on Energy Conservation in Agriculture Sector | • This scheme provides subsidy on energy efficient 4-star and above-rated agricultural pump sets to the farmers.  
  • Farmers who are taking a new tube well connection or opting for higher capacity pump sets will be encouraged to install at least 4-star rated(BEE Star rating) pump sets and will be eligible for the state subsidy. |
<p>| Himachal Pradesh state government | Efficient use of energy and its conservation | • The programme stipulates mandatory use of ISI/BIS marked motor pumps sets, power capacitors, foot/reflex valves in the agriculture sector |
| Chandigarh government | Mandatory use of energy efficient appliances | • The programme stipulates mandatory use of ISI/BIS marked motor pumps sets, power capacitors, foot/reflex valves in the agriculture sector |</p>
<table>
<thead>
<tr>
<th>Gujarat state government</th>
<th>Jyotigrarn scheme</th>
</tr>
</thead>
</table>
|                         | • The scheme ensures regulated but improved quality power supply towards agriculture-enabled efficient and optimum use of water, which in turn contributes to the conservation of ground water resources.  
• Feeders contain specially designed transformers to supply power to farmers residing in scattered farm houses. |

*Source: Website of Indian Renewable Energy and Energy Efficiency Policy Database*  
<http://ireened.gov.in/>
3. Methodology

A systematic process was followed to extract appropriate data and resources from various databases and sources. A schematic representation of the methodology is given in Figure 3.1.

Figure 3.1 Schematic representation of the methodology

3.1 Identifying subject domains

Energy, water, and food systems are subject to a diversity of risks. They face the same agro-economic and social adversities, and are determined by cross-scale interactions. The Nexus is where all the three systems, i.e. food, water, and energy, intersect. The Nexus interactions are complex and dynamic and sectoral issues cannot be viewed in isolation from one another. After studying relevant papers (Hoff 2011; RCUK India 2013; TERI 2014; Rasul 2014) and extensive consultations with subject domain experts from TERI, RCUK India, and Science and Innovation Network, the subject areas were identified and matched with the Research and Innovation Objectives of the UK–India Partnership (Table 3.1).
<table>
<thead>
<tr>
<th>High Level Research and Innovation Objectives of the UK–India Partnership</th>
<th>Research areas covered in the mapping exercise</th>
</tr>
</thead>
</table>
| **1** Developing efficient energy storage solutions for mini/off-grid renewable energy.  
- Ground water management and energy requirement - irrigation systems  
- Energy efficient water technologies – irrigation pumps | • Mini/off-grid renewable energy applications  
• Energy efficient measures  
• Battery storage |
| **2** Developing affordable and water-efficient energy technologies.  
- Water for power generation – biomass  
- Energy recovery from biomass, organic waste, wastewater, and water quality  
- Water stress due to climate change - food and energy demand | • Water use efficiency  
• Energy efficient measures  
• Irrigation technologies |
| **3** Small modular thermal power plant designs that use 50 per cent less water for cooling.  
- Water efficiency for power generation  
- Waste heat recovery and power plants | • Water use efficiency  
• Organic Rankine Cycle |
| **4** Improving the scientific understanding of eco-hydrological system, including uncertainties and climate change, at the level of river catchment.  
- Water stress due to climate change - food and energy demand  
- Water stress in river catchments and processing – energy and water | • Ecohydrological systems  
• Ground water  
• Surface water  
• Climate change |
| **5** Developing better understanding of changing water demand from different sectors (industry, domestic, energy, agriculture) in pilot river catchments.  
- Efficiency of water use in agriculture – different paddy varieties  
- New technologies and food and water resources  
- Crop production and processing – energy and water  
- Energy subsidies – power consumption in irrigation | • Water use efficiency  
• Water security |
| **6** Developing better understanding of the governance, political economy and public participation in decision-making on water resource allocation in pilot river catchments.  
- Energy subsidies – power consumption in irrigation  
- Water stress due to climate change - food and energy demand  
- Water allocation  
- Bioenergy production, bioenergy competition with food and water uses | • Water security  
• Water governance  
• Energy demand and consumption  
• Energy pricing and subsidies  
• Climate change |
7. Developing innovations to increase sustainable agricultural productivity
   - Ground water management and energy requirement -- irrigation systems
   - Energy efficient water technologies -- irrigation pumps
   - Virtual water footprint along the food production and supply chain -- energy and water footprint of food products
   - Crop production and processing -- energy and water
   - Water desalination for irrigation -- if energy is consumed for desalination

8. Developing innovations to reduce waste
   - Efficient waste technologies
   - Energy recovery from biomass, organic waste, wastewater, and water quality
   - Food processing technologies

9. Developing innovations to increase nutritional value
   - Crop production and processing -- energy and water
   - New technologies -- food and water resources

10. Developing innovations to increase tolerance to biotic/abiotic stresses
    - Innovations in energy and water sector

11. Encouraging multi-functional use of land to deliver a range of goods and services.
    - Bioenergy production, bioenergy competition with food and water uses

12. Developing low-cost technologies to reduce post-harvest losses across agri-food lifecycle including infrastructure technologies such as storage and refrigeration.
    - Crop production and processing -- energy and water
    - Food marketing -- transportation and storage

   - Agricultural productivity
   - Sustainable agriculture
   - Water use efficiency
   - Food production and processing
   - Nutritional value
   - Food security
   - Water security
   - Bioenergy and biomass
   - Food security
   - Irrigation technologies
   - Food production and processing

Once these research areas were identified, exhaustive search was conducted based on these areas in multiple databases to locate relevant research papers, conference papers, reports, and books.

3.2 Data sources

After deliberations with the subject domain experts, the search strategy was decided by arriving at search terms to be used for the retrieval of research papers on the Nexus issues. (Figure 3.2).
Mapping Institutions, Research and Funders in India within the Water-Energy-Food Nexus Research Area

Figure 3.2 Search Strategy: An intersection of three sectors

The mapping exercise required collection of two different data types:

i) Research type data for the creation of publication matrix, and
ii) Funding type data of funding institutions

Data collection was augmented by visiting libraries, conducting searches in leading databases, personal visits to meet experts in some of these organisations, and through telephone calls.

A. Research type data

It was evident from our domain knowledge that for development of a desired publication matrix, one would require research paper citations and authors’ listing along with their affiliations. Citations of journal articles, conference proceedings, books, etc., can only be available if they are indexed within the database. To ensure a comprehensive coverage of research papers for the study, various databases established by businesses, or by public or private institutions, have been used to map the research papers on the priority theme, i.e., WEF Nexus. These databases index journals and to some extent, conference proceedings. Most of these are specialized databases and include citations. Table 3.2 details the databases identified for carrying out search and retrieval of data based on keywords primarily based on the identified subject topics of the priority theme as given in Table 3.1.

Table 3.2 Database matrix

<table>
<thead>
<tr>
<th>Name of database</th>
<th>Subject coverage</th>
<th>Publisher</th>
<th>Number of records collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web of Science</td>
<td>Sciences, social sciences, and arts &amp; humanities</td>
<td>Thomson Reuters</td>
<td>111</td>
</tr>
<tr>
<td>Scopus</td>
<td>Science, technology, medicine, social sciences, and arts &amp; humanities</td>
<td>Elsevier</td>
<td>151</td>
</tr>
<tr>
<td>CAB Abstracts</td>
<td>Applied life sciences including agriculture, environment, veterinary</td>
<td>CABI</td>
<td>94</td>
</tr>
</tbody>
</table>
Data collection also entailed communicating with various Indian and CGIAR research institutes, IITs, IISc Bengaluru, and universities that included Delhi University, New Delhi; Indian Agricultural Research Institute, New Delhi; Govind Ballabh Pant University of Agriculture and Technology, Uttarakhand; Aligarh Muslim University, Uttar Pradesh; Punjab Agricultural University, Punjab; and University of Agricultural Sciences, Bengaluru, Karnataka.

### B. Funding type data

Research funding and mechanisms for fund allocation are significant instruments of research policy in India and elsewhere. In India, most research funding comes from government sources, primarily from the central and state governments through universities and specialized government agencies such as research councils. A number of charitable foundations, private sector, and industry also provide significant funding for a wide variety of research activities.

Most public funding in India takes the form of block grants, i.e., direct institutional allocations, to fund R&D. However, as in more developed nations, some appear to be shifting towards more competitive funding to improve the effectiveness of the research system through linking funding to clients' needs, and to the performance of scientists/institutions in addressing the issues (National Centre for Agricultural Economics and Policy Research 2000). In some cases, corporates, foundations, and multilateral, bilateral...
organisations are also involved in the research through public-private partnerships. The study team has, therefore, concentrated on assessing the government bodies, followed by private sector partnerships.

3.3 Data retrieval and collation

As per the objective of the study, the publication matrix and the research priorities of funding organisations were mapped drawing inputs from the available data.

A. Publication matrix

The following search criteria have been considered while developing publication matrix for the time period of 2005 to 2014:

- Only, the papers written by authors on the WEF Nexus subjects were considered.
- All papers were categorized under broad subject disciplines based on the subject coverage of the papers.
- Any paper written by the same author on subject areas not relevant to WEF Nexus was not considered.
- Papers written by Indian authors and affiliated to Indian organisations were considered.
- As per the information science domain knowledge, journal papers which are indexed in major databases have higher citation value. If the journal is not indexed in any of the databases, it will have less citation value due to low information access. Keeping this in mind, we have included journal papers, books, and conference proceedings which are indexed in databases.

Each of the records collected from the databases, journals, and organisations visited was considered as an individual record and given priority while recording the number of citations, authors, affiliations, publishing year, and other relevant information. Each research paper was assigned with one or more research areas focusing on the WEF Nexus areas as detailed in Table 3.1. Table 3.3 presents the template of the publication matrix.

<table>
<thead>
<tr>
<th>Table 3.3 Template of publication matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search keywords</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

During preparation of the publication matrix, several challenges were faced such as non-availability of specific papers, unavailability of authors’ affiliations, and low citations for recent papers primarily due to complexity associated to the Nexus themes. Further to this, we have noticed that there was no database that exhaustively covered Indian periodicals and their papers. Hence, search was extended to several databases as listed above. Once data
were collected, following steps were taken during data inputs in order to streamline the datasets:

- Collection of each author’s affiliation including co-authors;
- Checking for duplicates as the same paper is included in many databases;
- Removal of duplicate and incorrect citations;
- Standardisation of data was a major task as each database has its own format;
- Google Scholar was searched extensively for maximizing citations of each article;
- CAB Abstracts do not provide any citations and author affiliations; hence, each of the articles were re-searched in other databases; and
- Except some noted journals, impact factors were not available for others. Hence, we have decided to consider ‘journal standing’ among the databases as a criterion.

The study, therefore, takes into account the following indicators for the publication matrix:

i) **Author’s and institute’s productivity**: Research potential ultimately rests on human potential. The volume of research papers produced by a researcher or a research organisation during the study period of 2005–2014 can be used as an indicator of research activity.

ii) **Citation-based metrics**: Research publications accumulate citation counts when they are referred by more recent publications. Citations reflect the value placed on a work by later researchers. A highly-cited work is recognized as having a greater impact and high citation rates are correlated with other qualitative evaluations of research performance, such as peer review. Citation counts are, therefore, recognized as a measure of impact, which can be used to index the excellence of the research from a particular group, organisation, or country.

iii) **Journal (publication) standing**: All the major databases that index journals and papers follow certain guidelines such as peer review process, timeliness of publication, etc. The indicator of journal (publication) standing is based on these parameters of databases. In the absence of availability of journal impact factor for every journal, we have gone deep into the perceived quality of the databases and journals, and categorized the databases as shown in Table 3.4 based on the following attributes:

- Impact value of indexed journals
- Coverage of peer-reviewed research papers
- Timely publication of papers
- Frequency of updating of records in the database
- User-friendly interface and exhaustive search facilities
- Advanced search options by controlled vocabulary
- Options for citation analysis of institutions
- Good coverage of Indian papers in national/international journals
Table 3.4 Categories of journal (publication) standing

<table>
<thead>
<tr>
<th>Category</th>
<th>Weighting scale 10%</th>
<th>Databases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>Web of Science</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>Scopus, CAB Abstracts, SpringerLink, Science Direct, Wiley Online</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>Google Scholar, Indian Science Abstracts, Indian Citation Index, J-Gate</td>
</tr>
</tbody>
</table>

Based on the methodology given above, leading researchers and research organisations were identified for achieving the following objectives:

1. **Leading institutions**

The institutions were segregated based on the coverage of the identified research areas focusing on WEF Nexus and categorized under the three main sectors of the priority theme as given below.

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Research areas</th>
</tr>
</thead>
</table>
| **Water** | ▪ Ecohydrological systems  
▪ Ground water  
▪ Surface water  
▪ Water governance  
▪ Water security  
▪ Water-use efficiency |
| **Energy** | ▪ Battery storage  
▪ Bioenergy and biomass application  
▪ Energy demand and consumption  
▪ Energy efficient measures  
▪ Energy pricing and subsidies  
▪ Mini/off-grid renewable energy applications  
▪ Organic Rankine Cycle |
| **Food** | ▪ Agricultural productivity  
▪ Food production and processing  
▪ Food security  
▪ Irrigation technologies  
▪ Nutritional value  
▪ Sustainable agriculture |

In the three sectors, leading institutions were identified based on a revised weighting formula where each author was listed under the affiliated institutions (if authors published research works under different research organisations, their names came under different organisations).

- The total number of papers published from each of the institutions is a measure of their research activeness in the three sectors of WEF Nexus.
To further analyze the publication matrix of these institutions, the average of the citations received by the institutions was considered.

2. Leading researchers

The scientometric formula was devised to identify the leading researchers, i.e., 70% for total citations received +20% for the number of papers published by the author under WEF Nexus areas during the study period +10% for journal standing average as per their categories in which these papers are published (Figure 3.3). While calculating their citations, each author in a multi-authored paper was given same weighting, according to the standard practice. From the resulting matrix, leading researchers were identified.

Figure 3.3 Author scientometric measure

The researchers have been mapped based on the research areas pertaining to the WEF Nexus.

Emerging researchers: Once the authors were identified, they were sorted as per the year of publications of their papers to prepare the list of emerging authors who have contributed most in recent years.

B. Mapping of funding organisations with research priorities

For identifying and mapping the funding pattern of organisations in the country and international collaborators, discussions were held with government officials of a few nodal ministries as well as key scientists/researchers who are conducting research in the priority theme. This was supplemented by studying their reports that included Working Group Reports for 12th Five-Year Plan (FYP), Annual Plans, Outcome Budgets, Union Budget documents for the last two years, research reports, policy briefs, and books published by these ministries. The references of these sources are cited both within the text wherever necessary and also listed as References at the end.

After an intense study, it was noticed that there are several schemes under different ministries, which may be included under the Nexus areas and a huge sum of money is invested regularly to improve central and state specific activities in these areas. Most of
these schemes are found to be implementation schemes rather than research schemes. While implementation schemes indicate policy focus of the funding organisations in these cases mainly government ministries, each ministry working in the areas of the Nexus has identified priority areas for research. Details of the research priority areas are given in Results chapter of the report (Refer to 4.2 Research priorities of funding organisations in India).

While conducting the analysis, it was observed that in most cases, ministries have worked in isolation till recently; however, slowly their research and implementation schemes are converging. Although there is no specific policy on WEF Nexus in place at the central or state level, policies in the areas of agriculture, water, environment, and energy to some extent cover the priority theme. Therefore, we have identified relevant schemes and drawn inputs from these policies to understand research and funding priorities of Indian funding bodies in this Nexus theme. We have also taken policy context of some of the Indian states to show that at the state level research and policies are now being framed considering the Nexus issues.

In order to summarize the research priorities, the major government funding organisations, their programmes, and schemes in the Nexus areas were tabulated. Similarly, research initiatives of private funding organisations, foundations, and international organisations in Nexus areas have also been covered. However, barring some specific instances such as irrigation schemes, sustainable livelihood, etc., private funding in the Nexus areas remains low. The details of these findings are covered in the relevant chapters of this report.
4. Results

4.1 Publication matrix

WEF Nexus is an important and complex area of research at the global level. While conducting the mapping exercise, it has been observed that from the Indian perspective, not many studies have been carried out so far. Most of the studies revolve around interlinkages between two sectors of the Nexus, i.e., water and food, or food and energy, or water and energy. Consequently, while mapping the research literature, it was found that the coverage of all the three sectors is ambiguous in certain cases. For this study, only those articles were derived which were falling exclusively in the WEF Nexus (Annexure 1).

Once all the major subject themes were identified, an intensive search strategy was framed and query formulation done using permutations and combination for the last 10 years (2005–2014) for 10 national and international databases as majority of these papers are listed in these databases (as indicated in the Methodology chapter). Besides, we have also come across a few conference proceedings and books published in the Nexus areas. However, since most of them are not cited in any of the published databases or other available sources, some of such sources had to be deleted to bring about uniformity into the publication matrix.

After several rounds of duplicate entry checking, followed by data standardisation, 366 unique Indian records were identified, which have been published during the years under consideration. Figure 4.1 indicates the paper publication trends in the Nexus areas.

Figure 4.1 Number of papers published during study period
The data revealed that during the years 2005 and 2006, a less number of research papers in WEF Nexus areas was published perhaps due to the Nexus areas being of lower research priorities to the funding bodies including the Government of India. An increasing trend is noticed from 2007 onwards, which reached its peak in 2013, i.e., during the 11th and 12th FYPs, when the Government started giving priority to these areas. The trend also depicts that, in 2014, less research papers were published in the Nexus areas. This is not an indicator of decline of published papers for the year. For inclusion of a paper in some databases (like, Google Scholar, Indian Science Abstracts, and Indian Citation Index) it takes few months for indexing and processing. This indicates that some papers published in later half of 2014 are yet to be covered in the databases; hence, a decline in number of papers is observed during 2014.

The research papers were categorized according to broad range of subject disciplines as depicted in Figure 4.2. The broad subject disciplines of Economics and Engineering and technology together constitute more than 50% of the total number of the research papers. Comparatively, there are lesser papers in the streams of Social sciences and Life sciences.

**Figure 4.2 Total number of papers based on broad subject disciplines**

In the publication matrix, it is noticed that a total of 1152 authors/researchers contributed the papers in different capacities (primary author, secondary author, etc.) from 272 Indian and about 30 CGIAR research centres located in India and overseas institutions. The quality of these papers were analysed based on the criteria defined in the methodology section, which includes average number of citations or total citations, number of papers per researcher and per institution, and the WEF research areas.

Based on the methodology, it can be considered that barring approximately 30 papers which have been published during 2014, rest of the papers have got sufficient time for peer
acceptance and been cited in the research that is being undertaken. Table 4.1 shows that over 40% of the papers have not been cited and another over 30% received a low level of citation. However, about 11% papers received high citations showing that the research in WEF areas in Indian context is drawing global attention in recent years.

Table 4.1 Citation trend of papers in WEF Nexus areas

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Citation range</th>
<th>Number of papers</th>
<th>Paper %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>152</td>
<td>41.71</td>
</tr>
<tr>
<td>2</td>
<td>1–10</td>
<td>119</td>
<td>32.42</td>
</tr>
<tr>
<td>3</td>
<td>11–20</td>
<td>38</td>
<td>10.62</td>
</tr>
<tr>
<td>4</td>
<td>21–30</td>
<td>17</td>
<td>4.63</td>
</tr>
<tr>
<td>5</td>
<td>31–50</td>
<td>17</td>
<td>4.63</td>
</tr>
<tr>
<td>6</td>
<td>&gt;50</td>
<td>23</td>
<td>6.26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>366</td>
<td></td>
</tr>
</tbody>
</table>

4.1.1 Mapping of institutions and research in Indian institutions

A. Leading institutions

Using the criteria of number of research papers, the mapping exercise intended to find out the leading institutions in India in the research areas under the Nexus theme. As citation matrix is considered as a measure of research impact, the average citations of leading institutions were analysed to assess their quality research output. The Institutional Matrix lists all the institutions mapped with corresponding Nexus research areas of the research papers contributed by researchers affiliated to the institutions (Annexure 2).

Based on the coverage of WEF Nexus research areas in the papers contributed by researchers affiliated to these institutions, three lists of leading Indian institutions were generated in each of the three sectors; i.e., water, energy, and food (see Tables 4.2, 4.3, and 4.4, respectively).
Table 4.2 Leading institutions: Water sector

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Banaras Hindu University, Varanasi, Uttar Pradesh</td>
</tr>
<tr>
<td>2</td>
<td>Bharathi College, Bharathi Nagar, Karnataka</td>
</tr>
<tr>
<td>3</td>
<td>Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand</td>
</tr>
<tr>
<td>4</td>
<td>ICAR Research Complex for Eastern Region, Patna, Bihar</td>
</tr>
<tr>
<td>5</td>
<td>Indian Agricultural Research Institute, New Delhi</td>
</tr>
<tr>
<td>6</td>
<td>Indian Institute of Technology Delhi, New Delhi</td>
</tr>
<tr>
<td>7</td>
<td>Institute for Resource Analysis and Policy, Hyderabad, Andhra Pradesh</td>
</tr>
<tr>
<td>8</td>
<td>Panjab University, Chandigarh</td>
</tr>
<tr>
<td>9</td>
<td>Punjab Agricultural University, Ludhiana, Punjab</td>
</tr>
<tr>
<td>10</td>
<td>University of Mysore, Mandya, Karnataka</td>
</tr>
</tbody>
</table>

While scrutinizing the involvement of leading research organisations in the WEF Nexus focusing on water sector (Figure 4.3), it is noted that Punjab Agricultural University, Ludhiana and Indian Agricultural Research Institute, New Delhi are leading both in terms of research papers and average citations. About 40% of these organisations are agri-based research organisations. This underlines the fact that much of the WEF research in the country is due to a great extent centred on agricultural research. Further to this, research conducted in these sectors is receiving global acceptance as per the high average value of citation.
Figure 4.3 Leading institutions: Publication indicators (Water sector)

Govind Ballabh Pant University of Agriculture and Technology, Pantnagar
- Average citations: 6.33
- Total no. of papers: 3

Punjab University, Chandigarh
- Average citations: 11.33
- Total no. of papers: 3

ICAR Research Complex for Eastern Region, Patna
- Average citations: 1.25
- Total no. of papers: 4

University of Mysore, Mandya
- Average citations: 3.00
- Total no. of papers: 4

Bharathi College, Bharathi Nagar
- Average citations: 3.00
- Total no. of papers: 4

Banaras Hindu University, Varanasi
- Average citations: 3.80
- Total no. of papers: 5

Indian Institute of Technology Delhi
- Average citations: 4.40
- Total no. of papers: 5

Institute for Resource Analysis and Policy, Hyderabad
- Average citations: 4.17
- Total no. of papers: 6

Indian Agricultural Research Institute, New Delhi
- Average citations: 15.60
- Total no. of papers: 10

Punjab Agricultural University, Ludhiana
- Average citations: 22.06
- Total no. of papers: 16
### Table 4.3 Leading institutions: Energy sector

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anna University, Chennai, Tamil Nadu</td>
</tr>
<tr>
<td>2</td>
<td>Banaras Hindu University, Varanasi, Uttar Pradesh</td>
</tr>
<tr>
<td>3</td>
<td>Indian Agricultural Research Institute, New Delhi</td>
</tr>
<tr>
<td>4</td>
<td>Indian Institute of Science, Bengaluru, Karnataka</td>
</tr>
<tr>
<td>5</td>
<td>Indian Institute of Technology Delhi, New Delhi</td>
</tr>
<tr>
<td>6</td>
<td>Indian Institute of Technology Roorkee, Uttarakhand</td>
</tr>
<tr>
<td>7</td>
<td>Institute for Resource Analysis and Policy, Hyderabad, Andhra Pradesh</td>
</tr>
<tr>
<td>8</td>
<td>Project Directorate for Cropping Systems Research, Meerut, Uttar Pradesh</td>
</tr>
<tr>
<td>9</td>
<td>Punjab Agricultural University, Ludhiana, Punjab</td>
</tr>
<tr>
<td>10</td>
<td>Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, Jammu and Kashmir</td>
</tr>
</tbody>
</table>

When we compare leading energy research organisations in WEF Nexus with reference to the number of papers published and average citations received by each paper, it reveals that about 40% of the leading organisations focus on agriculture sector; rest are multidisciplinary in nature. The average citations received per paper for the energy sector in the Nexus areas show a high scientometric measure for Indian Institute of Science, Bengaluru; Punjab Agricultural University, Ludhiana, and Indian Institute of Technology Delhi (Figure 4.4).
Figure 4.4 Leading institutions: Publication indicators (Energy sector)

<table>
<thead>
<tr>
<th>Institution</th>
<th>Total no. of papers</th>
<th>Average citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banaras Hindu University, Varanasi</td>
<td>4</td>
<td>4.75</td>
</tr>
<tr>
<td>Indian Institute of Technology Roorkee</td>
<td>4</td>
<td>12.50</td>
</tr>
<tr>
<td>Anna University, Chennai</td>
<td>4</td>
<td>14.00</td>
</tr>
<tr>
<td>Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu</td>
<td>5</td>
<td>10.00</td>
</tr>
<tr>
<td>Indian Institute of Science, Bengaluru</td>
<td>5</td>
<td>21.00</td>
</tr>
<tr>
<td>Institute for Resource Analysis and Policy, Hyderabad</td>
<td>6</td>
<td>4.17</td>
</tr>
<tr>
<td>Indian Agricultural Research Institute, New Delhi</td>
<td>6</td>
<td>7.33</td>
</tr>
<tr>
<td>Project Directorate for Cropping Systems Research, Meerut</td>
<td>7</td>
<td>10.00</td>
</tr>
<tr>
<td>Indian Institute of Technology Delhi</td>
<td>9</td>
<td>16.78</td>
</tr>
<tr>
<td>Punjab Agricultural University, Ludhiana</td>
<td>10</td>
<td>17.80</td>
</tr>
</tbody>
</table>

Table 4.4 Leading institutions: Food sector

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bharathi College, Bharathi Nagar, Karnataka</td>
</tr>
<tr>
<td>2</td>
<td>ICAR Research Complex for Eastern Region, Patna, Bihar</td>
</tr>
<tr>
<td>3</td>
<td>Indian Agricultural Research Institute, New Delhi</td>
</tr>
<tr>
<td>4</td>
<td>Indian Institute of Technology Delhi, New Delhi</td>
</tr>
<tr>
<td>5</td>
<td>Institute for Resource Analysis and Policy, Hyderabad, Andhra Pradesh</td>
</tr>
<tr>
<td>6</td>
<td>Project Directorate for Cropping Systems Research, Meerut, Uttar Pradesh</td>
</tr>
<tr>
<td>7</td>
<td>Punjab Agricultural University, Ludhiana, Punjab</td>
</tr>
<tr>
<td>8</td>
<td>Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, Jammu and Kashmir</td>
</tr>
<tr>
<td>9</td>
<td>Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu</td>
</tr>
<tr>
<td>10</td>
<td>University of Mysore, Mandya, Karnataka</td>
</tr>
</tbody>
</table>
Figure 4.5 shows that the Indian Institute of Technology Delhi, Punjab Agricultural University, Ludhiana, and Indian Agricultural Research Institute, New Delhi have high average citations per paper that demonstrates the high research impact these institutions have on the food-related topics in the Nexus areas.

**Figure 4.5 Leading institutions: Publication indicators (Food sector)**

![Bar chart showing leading institutions in the food sector]

Figure 4.5 also depicts that nearly 50% of the leading food research organisations in the WEF Nexus areas are from agricultural sector. While looking at the research strengths of the leading organisations in India, it is evident that greater emphasis has been put on agri-based research organisations in conducting research in WEF Nexus areas.

Many of the leading institutions in the three sectors are common that depicts an integrated approach of research in the WEF Nexus areas. It is observed that while majority of the impactful research in the Nexus areas are being conducted in universities (56%) comprising agricultural and multidisciplinary universities, research institutions and IITs also play an important role in creating and disseminating knowledge on the WEF Nexus areas (Figure 4.6). The Institutional Dossier provides more details about these leading institutions (Annexure 3).
Figure 4.6 Profile of leading research organisations

- Universities: 56%
- Research institutes: 31%
- IITs: 13%
B. Leading and emerging researchers in India

A publication matrix was used to identify the Nexus researchers across India from different institutions. Out of the total dataset, 848 authors of research papers were identified that were affiliated to institutions of Indian origin. A detailed analysis of the papers and subsequent authors’ analysis revealed that out of these authors from different organisations, only 18 authors have published at least 3 papers in WEF Nexus areas over the period of last 10 years. A productivity matrix of researchers is appended in Table 4.5. The table highlights that only a handful of researchers are publishing regularly in the area of WEF Nexus. This trend indicates that the research in WEF Nexus areas is concentrated among a few researchers only.

Table 4.5 Researchers’ productivity in the Nexus areas

<table>
<thead>
<tr>
<th>Total number of papers</th>
<th>Researchers with multiple papers</th>
<th>Year range</th>
<th>Number of researchers</th>
<th>Researchers % vis-à-vis total number of researchers</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Kumar, M Dinesh</td>
<td>2010-2014</td>
<td>2</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>Singh, O P</td>
<td>2009-2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Chandraju, S</td>
<td>2008-2011</td>
<td>3</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>Chaudhary, V P</td>
<td>2006-2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chidankumar, C S</td>
<td>2008-2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Behera, U K</td>
<td>2011-2014</td>
<td>4</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Buttar, G S</td>
<td>2006-2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pandey, D K</td>
<td>2006-2014</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Vasudevan, P</td>
<td>2009-2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Gangwar, B</td>
<td>2006-2014</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gangwar, K S</td>
<td>2009-2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Murugan, D</td>
<td>2009-2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Palanisami, K</td>
<td>2008-2009</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sethi, V P</td>
<td>2007</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sharma, S K</td>
<td>2007-2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sivamohan, M V K S</td>
<td>2010-2014</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Identification of leading authors is quite complex as we have encountered following challenges:

- Several researchers have changed organisations in between and published papers while conducting research at both the organisations.
- The problem was further aggravated when compilation of data was done from databases that do not follow a standard author naming practice.
However, through intense data analysis, searching, and communications with these researchers, problems were solved. The institutions of affiliation as provided in the published research papers have been considered for the mapping of researchers and institutions.

Based on the methodology, the Author Scientometric Measure was derived to evaluate the researchers. The *Researcher Matrices* 1 and 2 provide the following details (Annexure 4):

1. **Researchers of leading institutions.** Researchers affiliated to the leading institutions of the three WEF sectors (i.e., water, energy, and food) are listed alphabetically with their focus areas of research in the Nexus.

2. **Leading researchers of other institutions.** Researchers affiliated to the institutions other than the leading ones are listed alphabetically with their focus areas of research in the Nexus.

While mapping the research papers for WEF Nexus areas for the last 10 years, it was noticed that research intensity in these issues has increased from 2007 onwards. In order to assess the quality of emerging researchers, the publication matrix has been used in a different way. Authors who have started research in the Nexus areas recently (approximately five years ago) and have published their first research paper in the Nexus areas by 2010 were considered under emerging researchers’ category as detailed in Researchers Matrix 3 (Annexure 4). The same logic and criteria were followed to identify the emerging researchers as it is done for the other researchers.

Analysing the areas of research of over 200 leading researchers (affiliated to leading as well as other institutions) shows high research dispersion on issues related to agricultural productivity, water-use efficiency, and water security (Figure 4.7). On the other hand, although research in climate change has been growing at a steady pace in India, there appears to be lacunae in the research into aspects of climate change mitigation, adaption, and vulnerability that focus on the WEF Nexus. Research and development of resource-use efficient technologies like Organic Rankine Cycle need to consider the scarcity of interlinked natural resources such as water, energy, and land.
It is evident from the above figure that while most of the researchers are agricultural scientists, efficient water use and security/governance issues also get priority in the research framework. Hence, a clear water–food Nexus is emerging out. However, a lower number of researchers in energy domain working on WEF Nexus areas indicates that energy is a weak link in the Nexus area. Besides, bringing sustainability to agriculture, deploying advanced...
technologies in irrigation, energy efficiency in food sector, and maintaining balance of ecohydrological systems are also recognized as priority research areas. Application of renewable energy technologies, battery storage and assessment of climate change mitigation and impacts in the context of WEF Nexus are still under-researched areas that need to be focused more in the research framework.

4.1.2 Significance of CGIAR research centres in India

International cooperation has played a significant role in developing and strengthening the research system in India. It was observed from the Publications Matrix that the international agricultural research centres under the Consultative Group on International Agricultural Research (CGIAR) System have contributed extensively to the cause of agricultural research in India. The mapping of research institutes based on the WEF Nexus areas depicts that these institutes have high value of scientometric indicators in terms of number of papers (Table 4.6).

<table>
<thead>
<tr>
<th>S No.</th>
<th>Name of CGIAR research institutions</th>
<th>Total no. of papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>International Rice Research Institute, India Office, New Delhi</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>International Water Management Institute, New Delhi</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>International Water Management Institute, Patancheru, Andhra Pradesh</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>International Water Management Institute, Vallabh Vidhyanagar, Gujarat</td>
<td>8</td>
</tr>
</tbody>
</table>

4.2 Research priorities of funding organisations in India

Research and development funding and fund allocation mechanisms are powerful instruments of research policy formulation in India as well as across the globe. During the 11th & 12th Five-Year Plan period, the Government has recognized the close interrelationship of energy–water–food sectors which is reflected in fund allocation trends. At present, separate agencies under different union and state governments, typically perform the funding and policy-making process for WEF Nexus areas, however, coordination in both state and central level is lacking in most cases.

In the Indian context, water, food and electricity sectors come under State subjects and, hence, funding for research & development and implementation of different schemes have
both state and national level dimensions. From the derived results, it has been observed that in most cases, central government funding is passed to different union ministries as well as state governments for implementation of various schemes. Separate funds are allocated under each scheme. Increasingly, state governments are poured in with more budget to be spent under these sectors. This is more evident in the current fund allocation pattern announced in the Budget for 2015-2016.

In India, a major portion of research funding comes from government sources—where expenditures are primarily carried out by the central and state governments through different planned schemes, universities, and specialized government agencies like research councils. Apart from research, the funding support is also provided for various implementation schemes. Several implementation schemes have research components that are not always obvious. For conducting this study, such implementation schemes have also been considered. In the past, except dairy and poultry sectors, private spending in research and development expenditure in comparison to government funding was very less. However, in recent years, a number of charitable foundations, private sector and industry provided significant funding for a wide variety of research activities.

The role of multi-stakeholders, both national and international, has been pivotal in promoting research in the topics concerned with the priority theme. For instance, the involvement of WWF-ICRISAT project, Sir Dorabji Tata Trust, and NABARD has been vital in promoting System of Rice Intensification (SRI). The benefits of SRI are multi-fold, especially in resource conservation (water, land, energy, seeds, and labour), rice production and addressing the challenges of climate change.

A. Government ministries and bodies

Most of the funding support to research areas under the WEF Nexus comes from government sources (central ministries and state government departments) as mentioned earlier. The following central ministries support research and development activities in the Nexus areas.

Ministry of Agriculture, Government of India

The ministry focuses on sustaining the current momentum by stabilizing foodgrain production to ensure food security. The share of total investment in gross capital formation (GCF) in agriculture and allied sectors has been going up in recent years. GCF, i.e., investment in agriculture and allied sectors relative to GDP in this sector has been showing a steadily increasing trend from 13.5 per cent in 2004–05 to 20.1 per cent in 2010–11 (Government of India, 2012).

India’s agriculture funding is led by the Government rather than the private in contrast to many developed and developing countries (e.g., Brazil). The government expenditure in agriculture research and education has continued to move upward to INR 63,430 million (GBP 685.7 million) in 2009-2010. In the past, agricultural research spending grew with an impressive 6 per cent in the 1980s, slowed down to 3 per cent in the 1990s, which was considered seriously, as agricultural R&D expenditure is highly capital intensive. According
to Planning Commission, Government of India, the agricultural research intensity, i.e., share of agricultural research and education expenditure (Ag GDP) is 0.58 per cent in 2009, showing a moderate increase from 0.45 per cent in the early 1990s. This spending on R&D is relatively lower than most developed (2.35 per cent) and developing countries (1.04 per cent) (Government of India, 2012). State-wise research intensity indicators show higher spending in hilly and southern states as compared to eastern and Northeastern states. Besides, three major agrarian states, Uttar Pradesh, Odisha and West Bengal, spend on the lowest on agricultural research indicating that penetration of newer agri-based technologies is far less in these states.

The Government of India has felt that there is an urgent need to increase public investment in agri-R&D to the level of 1 per cent of Ag GDP, and hence 12th Five-Year Plan has witnessed a total budgetary allocation of INR 650,000 million (GBP 7,027 million) as against the half of the amount budgeted for 11th Five-Year Plan. Since ICAR is a leading institution in agricultural research in India, the 12th Plan working group has recommended INR 550,000 million (GBP 5,945.9 million) for ICAR to carry out further research.

The research priorities of the Department of Agricultural Research and Education, Ministry of Agriculture, cover crop husbandry, soil and water conservation, animal husbandry, and fisheries. Based on the data of Government of India’s Expenditure Budget 2015-2016, the financial budget allocation to agricultural research over the last three years shows an upward trend (Table 4.7 and Figure 4.8).

**Table 4.7 R&D expenditure of Ministry of Agriculture**

<table>
<thead>
<tr>
<th>Ministry</th>
<th>R&amp;D Expenditure in recent Years (INR in million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total allocation for the Ministry</td>
</tr>
<tr>
<td>Ministry of Agriculture (Department of Agricultural Research &amp; Education)</td>
<td>170,043.5 (GBP 1,838.3 million)</td>
</tr>
<tr>
<td>*Research priority areas</td>
<td>The allocation includes expenditure of the Department, contribution to international bodies, payment to ICAR for their research expenditure in different research institutes and implementation of national agricultural innovation project. The ICAR is engaged in conducting research in the field of agriculture, soil and water conservation, animal husbandry, fisheries, dairying, forestry, agricultural education, and extension research.</td>
</tr>
</tbody>
</table>

*Source: Expenditure budget 2015-2016 (Volume 2), Government of India. 2015*
Animal husbandry is an integral component of Indian agriculture supporting livelihood of more than two-thirds of the rural population. Livestock sector grew at an annual rate of 5.3 per cent during the 1980s, 3.9 per cent during the 1990s and 3.6 per cent during the 2000s. Despite deceleration, growth in livestock sector remained about 1.5 times larger than in the crop sector which implies its critical role in cushioning agricultural growth. Between 1983 and 2004, the share of animal products in the total food expenditure increased from 21.8 per cent to 25.0 per cent in urban areas and from 16.1 per cent to 21.4 per cent in rural areas. However, the research priorities as well as fund allocation by the Government are not commensurate with this growth.

The Working Group on Animal Husbandry of the 12th Five-Year Plan recommended that the share of animal husbandry in agricultural credit should be increased at least to 10 per cent and interest rate on animal husbandry credit should be at par with crop loan. The facility of the Kisan credit cards should be extended to all livestock farmers. Livestock insurance coverage should be expanded to all types of production systems and species with appropriate incentive framework. Further to this, the group recommended that a minimum of 35–40 per cent of the allocation under the flagship scheme of *Rashtriya Krishi Vikas Yojana* must be earmarked for animal husbandry and dairy sector activities. A budgetary outlay of INR 315,600 million (GBP 3,411.9 million) is recommended for animal husbandry and dairy sector to achieve growth rate of 6 per cent (Government of India, 2012). The budgeted allocations for the last 3 years are given in Table 4.8.

**Table 4.8** Budget allocation in animal husbandry

<table>
<thead>
<tr>
<th>Year</th>
<th>Animal husbandry budget (INR in million)</th>
<th>R&amp;D budget (INR in million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-2014</td>
<td>18,260.1 (GBP 197.4 million)</td>
<td>6,554.8 (GBP 70.9 million)</td>
</tr>
<tr>
<td>2014-2015</td>
<td>18,865.7 (GBP 203.9 million)</td>
<td>6,349.1 (GBP 68.6 million)</td>
</tr>
<tr>
<td>2015-2016 (Provisional)</td>
<td>15,854.3 (GBP 171.4 million)</td>
<td>7,485 (GBP 80.9 million)</td>
</tr>
</tbody>
</table>

*Source: Expenditure budget 2015-2016 (Volume 2), Government of India, 2015*
Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India

This ministry is responsible for laying down policy guidelines and programmes for the development and regulation of country’s water resources. As the ministry responsible for overall policy formulation, planning and guidance in respect of minor irrigation, command area development and development of ground water resources, it plays a vital role in the funding of the relevant programmes and projects relevant to Nexus theme.

Recognizing the scarcity of water, the Government has taken steps towards ensuring water security through formulation of policies, considering water as commodity, etc. The National Water Policy (NWP) of India was first introduced in 1987. The prioritisation was as follows:

- Drinking water
- Irrigation
- Hydropower
- Navigation
- Industrial and other uses

The research priorities in India are evolving as per the policy prioritisation of the Government. The NWP 2002 gave emphasis for the first time to ecological and environmental aspects of water allocation. However, the new NWP 2012 calls for a common integrated perspective to govern the planning and management of water resources. Such perspective should consider local, regional, national contexts and be environmentally sound. The policy states that water needs to be managed as a common pool community resource to ensure equitable and sustainable development for all. NWP 2012 has done away with water allocation prioritisation mentioned in 1987 and 2002, but has emphasized on treating water for safe drinking and sanitation and considered water as an economic good. Consideration of irrigation comes next (TERI, 2014). The R&D criteria were defined accordingly. Table 4.9 displays expenditure made in recent years for development of water sector.
Table 4.9 R&D expenditure of Ministry of Water Resources, River Development and Ganga Rejuvenation

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<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total allocation for the Ministry</td>
<td>R&amp;D programme*</td>
<td>Total allocation for the Ministry</td>
<td>R&amp;D programme*</td>
<td>Total allocation for the Ministry</td>
</tr>
<tr>
<td>Ministry of Water Resources, River Development and Ganga Rejuvenation</td>
<td></td>
<td>42,324.3 (GBP 457.6 million)</td>
<td>300 (GBP 3.2 million)</td>
<td>60,093.2 (GBP 649.6 million)</td>
</tr>
</tbody>
</table>

*R&D programme for water sector

Major research priorities include:
1. Find solutions to water resources related problems so as to improve available engineering, technology, and procedures
2. To collect information across Indian organisations and access the knowledge gap and devise strategies to bridge the knowledge gap between national and international organisations
3. Prepare, coordinate and recommend funding of research to be undertaken by various Indian water research organisations
4. Disseminate information and stimulate thought process through publications, events, etc.
5. Promotion of training and human resource development in water sector

Source: Expenditure budget 2015-2016 (Volume 2), Government of India. 2015

The research priorities of the Ministry of Water Resources, River Development and Ganga Rejuvenation include finding solutions to water resources related problems; improving technology and engineering methods; and collecting information, identifying knowledge gap, preparing and implementing suitable strategy for bridging gaps. Figure 4.9 shows the trend of budget allocation for this sector over the past three years.

Figure 4.9 R&D programme in water sector: Annual Plan outlay

Source: Expenditure Budget 2015-2016 Volume 2, Government of India. 2015
**Ministry of Rural Development, Government of India**

The ministry has two departments namely Department of Rural Development and Department of Land Resource. Through its various schemes and programmes, the ministry aims at sustainable and inclusive growth of rural India through a multipronged strategy for eradication of poverty by increasing livelihood opportunities, providing social safety net, and developing infrastructure for growth.

**Ministry of Environment, Forest and Climate Change, Government of India**

The ministry is the nodal agency for the planning, promotion, coordination and overseeing the implementation of India’s environmental and forestry policies and programmes. The ministry has been funding research through grant-in-aid projects to many research institutions in different areas under the broad ambit of environment protection and management. The R&D projects particularly aim at attempting solutions to the practical problems of resource management and provide necessary inputs for development and formulation of action plans for conservation of natural resources, and restoration and improvement of environmental quality, while promoting sustainable development.

**Ministry of Earth Sciences, Government of India**

The ministry conducts scientific and technical research activities related to earth system science for improving forecasting of weather, monsoon, climate and hazards, exploration of polar regions, seas around India, and develop technology for exploration and exploitation of ocean resources (living and non-living), ensuring their sustainable utilisation. The ministry, jointly with the Natural Environment Research Council of UK, funds the Sustaining Water Resources for Food, Energy & Ecosystem Services programme with a focus on research contributing to an improved understanding of water resources and its role in food, energy and ecosystem services, and through this support the economic development and welfare of India. An MoU has been signed in 2010 with the UK Government, valid for an initial period of 5 years, for undertaking specific collaborative projects for the Changing Water Cycle under the themes – Land-Ocean-Atmosphere interactions; Regional scale precipitation; Detection and attribution of changing water cycle; Consequences of the changing water cycle; and Research inputs for adaptation strategy. Two significant operational services of the ministry—Agrometeorological Advisory services and Hydrometeorological services—have an impact on the WEF Nexus areas.

**Ministry of Power, Government of India**

The ministry is concerned with perspective planning, policy formulation, processing of projects for investment decision, monitoring of the implementation of power projects, training and manpower development and the administration and enactment of legislation in regard to thermal, hydropower generation, transmission, and distribution. The R&D has two dimensions:

i. R&D for industry manufacturing electrical equipment for generation/transmission and distribution of power.
ii. Applied research involving improvement of efficiency and effectiveness of various techniques, procedures, processes, maintenance and upkeep of equipment from technical, techno-economic and technological point of view.

**Ministry of New and Renewable Energy, Government of India**

The broad aim of the ministry is to develop and deploy new and renewable energy for supplementing the energy requirements of the country. The Ministry has been supporting research, design and development in new and renewable energy.

The budget allocation by the ministry for research, design and development is depicted in Figure 4.10. The research priorities of the ministry are towards renewable energy technologies and schemes/projects under the National Clean Energy Fund.

**Figure 4.10** Research, design and development in renewable energy: Annual Plan outlay

![Diagram showing budget allocation for renewable energy from 2013-2014 to 2014-2015 in INR million]

*Source: Expenditure Budget 2015-2016 Volume 2, Government of India. 2015*

The budget allocation in the three sectors of water, agriculture, and renewable energy underlines the focus of the Government on issues concerned with the agriculture sector. This emphasizes the vital role of agriculture in the socio-economic development of the country.

As part of the central ministries, several public sector bodies comprising research institutes (such as Indian Council of Agricultural Research), development banks (such as NABARD), coordinating government bodies (such as National Rainfed Authority) support various programmes that have research components. Most public funding to agricultural research and education in India takes the form of block grants to ICAR and the state agricultural universities, with allocations determined by five-year plans that were developed and monitored by the now defunct Planning Commission (replaced by NITI Aayog in 2014). ICAR is the apex body for coordinating, guiding and managing research and education in agriculture including horticulture, fisheries, and animal sciences in the entire country. With 100 ICAR institutes and 70 agricultural universities spread across the country, this is one of the largest national agricultural systems in the world. The priorities of select programmes of central ministries and other government bodies that are related to the Nexus theme are detailed in Annexure 5.
B. Private sector, donor agencies, and corporates

The private sector involvement in research and development on the Nexus theme is increasing rapidly, partly due to corporate efforts in social responsibility, but also due to the commitment of corporates to business sustainability. They actively engage in civil society participation and community participation. Arghyam is one such institution whose programmatic approach focuses on broad themes on ground water and sanitation. Arghyam has made grants to recipients in 22 states of India since 2005. Out of the total projects, those on sustainable methods of water utilisation through surface and ground water management have a direct impact on agricultural productivity. Arghyam has partnered with several non-governmental organisations such as Gram Gaurav Pratishthan, Advanced Centre for Water Resources Development and Management and several others.

Several corporate bodies (such as the Adani Foundation, Axis Bank Foundation, Hindustan Coca Cola Beverages Private Limited, and PepsiCo Foundation) are actively involved in sustainability issues and philanthropic activities whereby they seek to minimize the environmental footprints. Adani Foundation supports the project on Building Social Capital-Drip Irrigation Project that aims to bring more and more land under drip irrigation at villages in Mundra, Gujarat; facilitate high crop productivity with limited water resources; and reduce weeding requirements. Axis Bank Foundation supports the conservation of small-scale irrigation tanks that is working to improve the performance of traditional water commons in four drought-prone blocks in Tamil Nadu. Hindustan Coca Cola Beverages Private Limited supports the Water Stewardship Initiative that endeavours to bring down the overall usage of water in agriculture to help conserve ground water through drip irrigation. PepsiCo Foundation, through its partnership with Earth Institute at Columbia University, focuses on water security through water harvesting, recharging, watershed management, and innovative irrigation practices that can lead to ‘more crop per drop’.

Sir Dorabji Tata Trust and the Allied Trusts and Sir Ratan Tata Trust are amongst the oldest philanthropic institutions in the country that have been fostering sustainable livelihood and management of natural resources. Sir Dorabji Tata Trust has undertaken several projects on enhancing sustainable livelihoods through action research on Diversion Based Irrigation System and System of Rice Intensification. IWMI Tata Water Policy Research Programme is an important programme supported by the Sir Ratan Tata Trust. The programme is now in its second phase and has resulted in several research outputs on areas on intersection of water sector with agriculture and energy management. Evolving farmer-led agriculture extension system, increasing agricultural productivity of farming systems through participatory research-cum-demonstrations, and sustainable ground water use are some of the other thrust areas of the research priorities of Sir Ratan Tata Trust. More details about the private funding institutions and their projects are given in Annexure 6.

4.3 International collaborations

International funding organisations are actively collaborating with the research and academic institutions as well as non-government organisations in India on various sustainable development topics. Agriculture, being one of the backbones of the Indian...
Mapping Institutions, Research and Funders in India within the Water-Energy-Food Nexus Research Area

The economy, attracts much of international funding among the Nexus sectors. Water and energy interventions in agriculture sector are focus of some of such projects. Consultative Group on International Agricultural Research and FAO are two major international donors.

Projects that are directly related to the Nexus theme include Water–Food–Energy—Urban nexus from local perspective in Nashik, Maharashtra; Protecting food, energy, and livelihoods in Punjab through water-efficient agriculture; and Resource scarcity, food security, and climate change—that is funded by GIZ and International Development Research Centre, Canada, and DFID respectively. International Fund for Agricultural Development’s (IFAD) strategy in India centres on improving poor rural people’s access to economic and social resources. The strategic objectives of the new Country Strategic Opportunities Programme 2010-2015 include increased access to agricultural technologies and natural resources, efficiency use of water in agriculture and innovations in renewable energy sector for farming communities. This demonstrates the significance of the Nexus theme in their research priorities for providing funding.

Climate change has been an area of concern for international funding organisations. Projects that study the impact on food and water resources and adaptation through water efficient and energy efficient agricultural practices have been supported by FAO, Ministry of Foreign Affairs in Norway, Rockefeller Foundation, and Swiss Agency for Development and Cooperation. The Swiss Agency for Development and Cooperation has set up the Rural Innovation Fund that supports sectors which include dryland/ rainfed farming, innovative rainwater harvesting, rural energy from biomass/ agricultural wastes, techniques for increasing the value of crop residues and non-crop biomass, community regulation of distribution and use of water and energy, storage devices for agricultural and rural products, and others. Other international donors that support rural development (with components related to the Nexus theme) are Aga Khan Foundation and The Andheri Hilfe Bonn.

The Government of UK has been providing bilateral development assistance to India since 1958. The aid agency of UK is the Department of International Development (DFID). Of the various programmes and projects being supported by DFID in India, the following two funds are targeted at multi-sectoral infrastructure development:

1) **Infrastructure Equity Fund** — Investment in small infrastructure projects in India’s poorest states
2) **Infrastructure Loan Fund** — Small loans to bridge the infrastructure gap for the poor

The sector-wise project budgets for both these funds demonstrate a greater share for agricultural services related projects as depicted in Figure 4.11.
The UK and India have established strong research collaborations that include the Sustaining Water Resources for Food, Energy & Ecosystem Services programme, conducted jointly by the Natural Environment Research Council of UK and Ministry of Earth Sciences, Government of India, which provides an opportunity to further develop this successful partnership and lay the foundations for future joint activities in WEF Nexus areas.

The US Agency for International Development (USAID) had announced a grant to the Centers for International Projects Trust (affiliated with the Earth Institute at Columbia University, USA) to implement the Water–Agriculture–Livelihood Security in India programme. The programme seeks to improve farmers’ livelihoods and food security in Punjab, Gujarat, and either Bihar or Jharkhand. The programme will support local farmers to test and scale up innovative and integrated water and energy saving technologies and practices—all important components of the Nexus theme.

The partnership between WWF and ICRISAT aims for producing more foodgrain with less water and has good potential for improving the water productivity in agriculture by making interventions at the farm level and developing policy frameworks to scale up such approaches to have an impact at national and river basin levels. The World Bank, in partnership with state governments, has funded the Assam Agricultural Competitiveness Project and Rajasthan Agricultural Competitiveness Project for improving agricultural productivity by integrating technology, organisation, institution, and market innovations. More details about the international collaborations are given in Annexure 7.
5. Conclusions

Research in the Nexus areas of water, energy and food sectors has been evolving in terms of its interdisciplinary nature. The mapping exercise reveals that Indian research in the Nexus areas shows an increasing trend from 2007. This could be attributed to the Government of India’s priorities during the 11th and 12th Five-Year Plans (2007-2012 and 2012-2017) that stresses sustainable and equitable growth. Within the Nexus areas, agriculture receives most government funding and, therefore, research and development in the Nexus areas is revolving mostly around agriculture, irrigation, and allied activities.

Water, a crucial part in the Nexus, is receiving major attention in recent times due to its scarce nature and increasing future demand. As nearly 85 per cent of the country’s fresh water resources is being utilized in agriculture, this aspect used to get due focus in the earlier National Water Policies (NWPs). However, presently water is considered as a scarce commodity, and the Government focus has therefore shifted towards making drinking water available to all, followed by community participation for water conservation, sanitation and then irrigation, as evident from the NWP 2012.

Agriculture and water are very closely related areas under the WEF Nexus and are presently dealt together in many schemes, projects, etc. Energy continues to remain as a weak link in the nexus, which is clearly evident from the policies framed at state and national level. However, views are changing very fast with use of more and more energy efficient technologies in irrigation, water supply and conservation, and renewable energy applications. A brief understanding of such change can be observed in the publication matrix with substantial contribution of energy research conducted and reported in recent years.

In the publication matrix, it was observed that a total of 1152 researchers contributed in the papers in different capacities (primary author and co-authors) representing 272 Indian and about 30 CGIAR research centres located in India and overseas organisations. The top organisations comprising research institutions and universities were based on the methodology of scientometric assessment of research papers. Analytically, we have derived the leading institutions based on the indicators that include total number of papers and average citations per research paper (Table 4.2, Table 4.3, and Table 4.5).

The leading institutions were derived based on sectoral focus of the WEF Nexus theme. Several of the leading institutions in the three sectors are common depicting an integrated approach of research in the WEF Nexus areas. Agricultural universities and agricultural research institutions are producing impactful research in the Nexus areas as the Indian agricultural research system has a long and distinguished history that advanced from a decentralized, imperial system into a centralized one created to respond to the food crisis in the 1960s. The significance of the challenges faced in the WEF Nexus can be judged from the fact that institutes that were established in the beginning of the century (like Indian Institute of Science) as well as those established in recent decade (like Institute for Resource Analysis and Policy) feature in the lists of leading institutions. While majority of the impactful research in the Nexus areas are being conducted in universities (56 per cent) comprising
agricultural and multidisciplinary universities, research institutions (31 per cent), and IITs (13 per cent) also enhance the country’s research impact.

The identification of leading researchers was derived based on scientometric indicators that include total citations received, author’s productivity, and journal (publication) standing. An in-depth analysis of the research papers and subsequent authors’ analysis revealed that out of a total of 848 researchers/authors from different organisations in the country, only 18 researchers/authors have published three or more papers exclusively in the WEF Nexus areas over the period of last 10 years. Emerging researchers were assessed based on the research papers being published after 2009.

The research dispersion of the leading researchers shows a greater inclination towards research in topics related to agricultural productivity, water use efficiency, and water security (Figure 4.8). Research on sustainable agriculture, irrigation technologies, energy efficient measures, biomass, and bioenergy received moderate attention.

Although there has been a steady growth of climate change literature in the recent years in India, the research dispersion of leading Nexus researchers depicts a need for research into aspects of climate change that focus on the WEF Nexus issues. Research and development of resource-use efficient technologies like Organic Rankine Cycle requires consideration of scarcity of interlinked natural resources. Capacity development of the Indian research fraternity is, therefore, required on solutions-oriented research to facilitate technologies and approaches that support increased resource efficiency in an integrated way.

There are several research institutes in the country like TERI; Council on Energy, Environment, and Water; Centers for International Projects Trust; Centre for Development Studies, etc., that are carrying out extensive research and policy analysis on the Nexus issues. These institutes publish technical reports and other such grey literature on the subject. However, as there is no standard publication metric to measure the impact of the grey literature, it is outside the scope of this study to assess such literature.

The issues concerning WEF Nexus have been addressed through various policy measures and schemes across the domains of agriculture, conventional and non-conventional energy sources, water management, environment and rural development. Research in WEF Nexus areas is still in primary stage in the country due to the absence of an umbrella policy framework and also these sectors are primarily considered as state subjects. Hence, research priorities are also localized, scattered, and are difficult to assess.

In general, the Government provides most of the funding in the Nexus areas. The funding pattern shows that government research based organisations like IARI and select universities carry out most of the research in the Nexus areas. The Government’s research and development outlay are driven by the need to support policy objectives. Despite the interrelationship of energy, water and food sectors, separate government bodies typically perform the funding and policymaking of these resources. We have, therefore, assessed the research priorities of these individual ministries and government organisations and identified a consolidated list of research priorities. As indicated earlier, in India, most research funding comes from government sources, hence funding under different schemes
could be considered as an indication of research priorities of the sector. The schemes and programmes of government ministries as well as the annual budget allocation in the three sectors of water, agriculture and energy underline the fact that research in the country is predominantly centred on issues related to agriculture as this sector plays the most decisive role in the socio-economic development of the country. It was also noted that not all sectoral ministries have dedicated research fund, rather they are part of different implementation schemes. Corporate endeavours in social responsibility have led to the private sector involvement in research and development on the Nexus theme. Such research projects actively engage civil society and community participation.

International funding organisations from different parts of the world are actively collaborating with the research and academic institutions in India as well as non-government organisations in India on various sustainable development topics. Besides, several WEF Nexus schemes have received supports from international organisations. Agriculture sector attracts most of the international funding; water and energy interventions in agriculture sector being the focus of some of such projects.

As has been indicated above, while there are innumerable research projects for energy, food and water, the Nexus issues between the three is brought out, if at all, only incidentally. It is clear that the WEF Nexus needs to be understood and researched more than in the past to evolve a holistic approach for development. This is possible if the funding agencies, including the Government, work in a more cohesive manner to support resource efficiency. With a greater understanding of sustainable development, it is hoped that more papers and reports clearly bring out the concerns and implications wherever there is such connectivity between the three Nexus sectors.
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About TERI

A dynamic and flexible not-for-profit organisation with a global vision and a local focus, TERI is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to tackling issues of global climate change across continents and advancing solutions to growing urban transport and air pollution problems, TERI’s activities range from formulating local- and national-level strategies to suggesting global solutions to critical energy and environmental issues. With over 1,000 employees drawn from diverse disciplines, the Institute’s work is supported by ministries and departments of the government, various bilateral and multilateral organisations, and corporations of repute.

TERI, being a research organisation, emphasizes on knowledge creation and global dissemination of its research on sustainable development. TERI’s Knowledge Management Division was created to meet the challenges of the knowledge acquisition, management, and outreach demands of research community. TERI’s knowledge management activities are enriched through: (i) internal learning from operational practice, and (ii) external learning from long-term strategic partnerships with other organisations and academic institutions of repute. These objectives are fulfilled through the provision of library, information, documentation, and publication services. The Division manages databases of TERI’s research activities through a well-designed state-of-the-art knowledge management system, besides bringing together in digital, print, audio, and video media with cutting-edge technology; and providing state-of-the-art information resources and value-added services, which address societal needs at both global and national levels.
## Publications Matrix

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The areas of *Climate change* and *Water/Air pollution* affect all the three WEF sectors, hence are kept separately.
| Institutions                                                                 | Total no of papers | RA 01 | RA 02 | RA 03 | RA 04 | RA 05 | RA 06 | RA 07 | RA 08 | RA 09 | RA 10 | RA 11 | RA 12 | RA 13 | RA 14 | RA 15 | RA 16 | RA 17 | RA 18 | RA 19 | RA 20 | RA 21 |
|------------------------------------------------------------------------------|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Aarupadai Veedu Institute of Technology, Chennai                             | 2                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| AFPRO Task Force, Raipur                                                   | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Agricultural Engineering College and Research Institute, Coimbatore          | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Alagappa University, Karaikudi                                              | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Aligarh Muslim University, Aligarh                                           | 3                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Amar Agro-Industries, Ludhiana, India                                        | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       | Y     |
| Anand Agricultural University, Anand                                         | 3                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Anna University, Chennai                                                   | 4                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Anna University, Coimbatore                                                 | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Annamalai University, Annamalai Nagar                                       | 3                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Arulanandar College, Karumathoor                                            | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Institutions                                                                 | Total no of papers | RA 01 | RA 02 | RA 03 | RA 04 | RA 05 | RA 06 | RA 07 | RA 08 | RA 09 | RA 10 | RA 11 | RA 12 | RA 13 | RA 14 | RA 15 | RA 16 | RA 17 | RA 18 | RA 19 | RA 20 | RA 21 |
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| Assam Agricultural University, Jorhat                                     | 2                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| B V B. College of Engineering and Technology, Hubli                       | 1                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Baba Saheb Bhimrao Ambedkar University, Lucknow                           | 1                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Baddi University, Solan                                                    | 1                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Banaras Hindu University, Varanasi                                        | 6                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Basaveshwar Engineering College, Bagalkot                                  | 1                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Bhabha Atomic Research Centre, Mumbai                                     | 1                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Bhakra Beas Management Board, Punjab                                      | 1                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Bharath University, Chennai                                                | 1                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Bharathi College, Bharathi Nagar                                           | 5                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |

Note: The table contains data regarding the total number of papers and their distribution across different institutions.
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| Miranda House, Delhi University, Department of Geography, Delhi            | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| MKSSS’s Cummins College of Engineering, Pune                               | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Mohamed Sathak Polytechnic College, Kilakarai                               | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Moradabad Institute of Technology, Moradabad                                | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Motilal Nehru National Institute of Technology, Allahabad                   | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| N V Patel College of Applied and Pure Sciences, Vallabh Vidyannagar        | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Narmada Hydroelectric Development Corporation Ltd., Bhopal                   | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| National academy of Agriculture Research and Management, Hyderabad          | 2                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| National Botanical Research Institute, Lucknow                              | 2                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| National Centre for Agricultural Economics and Policy Research, New Delhi  | 2                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |</p>
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| Sri Venkateswara College, University of Delhi, Delhi              | 1                  |       | ❑     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| SSN College of Engineering, Electrical and Electronics, Chennai   | 1                  |       |       | ❑     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Sugarcane Breeding Institute, Coimbatore                          | 1                  |       |       | ❑     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
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| Suresh Gyan Vihar University, Jaipur                              | 1                  |       |       | ❑     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| SVS’s Dadasaheb Rawal College, Dhule                              | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Symbiosis Centre for Management and Human Resource Development, Pune | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Tamil Nadu Agricultural University, Bhavanisagar station          | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Tamil Nadu Agricultural University, Coimbatore                    | 5                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Tamil Nadu Agricultural University, Paiyur station               | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Tata Research Development and Design Centre, Pune                  | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
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| Tehri Hydro Development Corporation Ltd.         | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Tetra Tech., Gurgaon                            | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Tezpur University, Tezpur                        | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| The Arvind Mills Ltd, Ahmedabad                  | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| The Energy and Resources Institute, New Delhi    | 2                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| The Science Ashram, Vadodara                     | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Thermax India, Pune                              | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Uma Lele team, New Delhi                         | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| University of Agricultural Science, Dharward     | 1                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
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# Institutional Dossier

## Anna University, Chennai

Website: [https://www.annauniv.edu](https://www.annauniv.edu)

### Overview

Anna University was established in 1978 as a unitary type of university in Tamil Nadu. The university imparts higher education in engineering, technology and allied sciences relevant to the current and projected needs of the society. Besides promoting research and disseminating knowledge gained therefrom, it fosters cooperation between the academic and industrial communities.

### Selected Research Projects

- Bioenergy conversion technologies and thermal energy storage systems
- Rainfall runoff modelling and ground water dynamics of irrigation tank clustered catchments in a semi-arid region
- Regional capacity building on integrated water resources management
- Preparation of detailed project report of agro-fuel fired hot air generator
- Water and wastewater processing/recycling

### Institutional Strength

Anna University comprises four departments and 32 central facilities. The Institute for Energy Studies aims to provide sustainable support for the integration of higher engineering education with its energy related research activities. The Centre for Environmental Studies contributes towards sustainable management and utilization of natural resources, enhances technical management knowledge and develops and promotes technology for sustainable management.
Banaras Hindu University, Varanasi

Website: [http://www.bhu.ac.in/](http://www.bhu.ac.in/)

**Overview**

Banaras Hindu University (BHU) is a public central university located in Varanasi, Uttar Pradesh. Established in 1916, BHU is one of the largest residential universities in Asia, with over 20,000 students. One of the main objectives of the university is to advance and diffuse scientific, technical and professional knowledge, combined with the necessary practical training to help in promoting indigenous industries and in developing the material resources of the country.

**Selected Research Projects**

- Impact and vulnerability of agriculture in different agro-climatic regions to climate variability and changes
- Studies of agriculturally important microorganisms to develop effective microbial consortium in soil to enhance sustainable agriculture
- Research on drip irrigation and resource conservation technology
- New land use system developed for better agriculture resource management through diversification

**Institutional Strength**

BHU is organized into four institutes, 16 faculties, 140 departments, four advanced centers and four interdisciplinary schools. The Centre of Energy & Resources Development promotes research activities for the exploitation of solar based energy systems- active and passive collectors, photovoltaic cells, solar dryers, and biomass based devices. The Institute of Agricultural Sciences has 10 All India Coordinated Research Projects involving multi-disciplinary approach on land use management practices, crop improvement, crop-weather interaction, on farm research in participatory mode, integrated pest management, mechanization etc.
Bharathi College, Bharathi Nagar

Located in Karnataka

Select Research Project (*based on research paper*)

- Impact of irrigation of distillery spentwash on the nutrients

*More details not available*
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar

Overview

Govind Ballabh Pant University of Agriculture and Technology is the first agricultural university of India. It was inaugurated in 1960 as the "Uttar Pradesh Agricultural University". Later the name was changed to "Govind Ballabh Pant University of Agriculture and Technology" in 1972. The University, located in Uttarakhand state, is regarded as the harbinger of Green Revolution in India.

Select Research Projects

- Farming system-diversification, income, employment, capital requirements, energy needs, risk and sustainability
- Economics of resource use/conservation
- Characterization of agro-climate and crop-weather relation for productivity of major crops.
- Agro-techniques for site specific problems of small and marginal farmers under constraints of input supply
- Breeding of crops for high yield; biotic and abiotic stresses; value addition and industrial utilization.

Institutional Strength

The main focus of research is on agriculture and engineering. A total of 340 projects have been undertaken during the year 2014-2015. Research is coordinated by a Directorate of Experiment Station and carried out through about 70 subject-matter departments spread across colleges, 14 specialized research centres located in the campus, 7 dedicated off-campus research stations and 10 off-campus horticultural research-cum-extension centres. The College of Technology is a Centre of Excellence for “Energy studies in industries and agro-systems of Uttarakhand (Energy Management)".
Indian Agricultural Research Institute, New Delhi

Website: [http://www.iari.res.in/](http://www.iari.res.in/)

**Overview**
Indian Agricultural Research Institute (IARI), popularly known as Pusa Institute, began in 1905 at Pusa (Bihar). After the country’s independence, the institute has been renamed as Indian Agricultural Research Institute with its headquarters in New Delhi. The institute conducts basic and strategic research with a view to understanding the processes, in all their complexity and to undertake need based research that lead to crop improvement and sustained agricultural productivity in harmony with environment.

**Selected Research Projects**
- Policy, investment and inclusive agricultural growth
- Micro-irrigation and fertigation
- Water resource management in rainfed areas
- Groundwater assessment and augmentation planning
- Climate-induced water and food security analysis
- Alternative renewable energy source exploitation
- Extension of improved equipment / technology

**Institutional Strength**
The Institute has 20 divisions and five multidisciplinary centres situated in Delhi, eight regional stations, two off-season nurseries, three All India coordinated research projects with headquarters at IARI and 10 national centres functioning under the All India coordinated research projects. The School of Natural Resource Management conducts studies on integrated nutrients, water management in food sector; investigations on biomass production, use of bio-fertilizers and agro-energetics with emphasis on recycling of crop and effective utilization of agricultural wastes, integrated approach for efficient utilization of rainwater and nutrients, and contingent crop planning for rainfed areas, weather based crop management using medium range weather forecasts, assessment of soil, water, climate and crop resources using remote sensing, GIS, nuclear and other allied techniques.
ICAR Research Complex for Eastern Region, Patna

Website: http://icarrcer.in/

Overview
The ICAR Research Complex for Eastern Region, Patna was established towards the end of Ninth Five Year Plan, with a mandate to address diverse issues relating to agricultural production in eastern states of India. The institute came into existence in 2001 with its headquarter at Patna and its regional stations at Darbhanga, Bihar and Ranchi, Jharkhand.

Selected Research Projects
- Application of optimization techniques in planning and management of land, water and other resources
- Development of location specific integrated farming system
- Modules for rainfed eco-system for Eastern Plateau Hill Region
- Evaluation and development of drought tolerant rice for Eastern Region
- Water saving technology under Farmers Participatory Action Research Programme
- Impact of elevated carbon dioxide and temperature on growth and yield of rice-wheat cropping system under predicted climate change scenario.

Institutional Strength
System mode research, integrating crop-livestock-fish-agroforestry-horticulture is the priority of the institute. The institute has six research centres focusing on land and water management, crop, horticulture, aquatic crops, fishery, livestock and poultry, agro-processing and socio-economic aspects for agricultural development in the region so as to improve the livelihood of resource poor farmers.
Overview
The Indian Institute of Science (IISc), founded in 1909, has become the premier institute for advanced scientific and technological research and education in India. Interdisciplinary research has emerged as a crucial part of the research landscape of IISc. The Institute also offers undergraduate Bachelor of Science programme, in addition to Master’s degrees, Integrated PhD, and PhD programmes.

Selected Research Projects
- Land use and land cover dynamics
- Alternate energy systems and energy conservation
- Impact of climate change on the water cycle and ecosystem of functioning at the river base
- Development and dissemination of fuel efficient wood burning devices and agro-processing driers
- Assessing groundwater storage changes and sustainability due to climate change in the semi-arid watersheds of South India

Institutional Strength
IISc has 39 departments, units, or centres, 3500 students, and about 500 academic and scientific staff, supported by 600 administrative personnel. The Interdisciplinary Centre for Energy Research conducts research on various fields, such as concentrating solar power, next-generation solar photovoltaics, high storage density battery, green buildings, sustainable technologies, combustion science and technology.
Indian Institute of Technology Delhi, New Delhi

Website: http://www.iitd.ac.in/

Overview

Indian Institute of Technology Delhi is a public research university located in New Delhi. The College of Engineering & Technology established in 1961 and was later renamed "Indian Institute of Technology Delhi ". IIT Delhi conducts various programmes including bachelor's degree in technology, the dual degree bachelor-cum-master of technology programme, integrated master of technology programme and other postgraduate level programmes on technology, science, business administration and industrial design. The institute offers PhD programme for research in basics sciences such as biological sciences, chemical sciences, physical sciences as well as interdisciplinary research including but not limited to nanoscience and nanotechnology, bioengineering, etc.

Select Research Projects

- Design and development of bullock drawn electricity generator
- Design and development of micro hydraulic turbo pump for canal based irrigation systems
- Investigations on standalone solar photovoltaic and wind energy conversion systems
- Designing an optimal system for soil fertility management in sustainable agriculture
- Integration of fodder production with agriculture and forestry involving rural women
- Development of plant based, ecofriendly formulations for insect and fungi control

Institutional Strength

The institution also has 13 department and 11 multidisciplinary centres. The Centre for Energy Studies has been contributing to fulfill the need of trained manpower as well as research and development activities in the area of energy engineering. The Centre for Atmospheric Sciences undertakes research on climate dynamics and renewable energy resource assessment.
Indian Institute of Technology Roorkee

Website: http://www.iitr.ac.in

Overview

Indian Institute Technology Roorkee is the oldest engineering college in India located in Uttarakhand. It was started as Roorkee College and later renamed as Thomason College of Civil Engineering in 1853. The Institute offers Bachelor’s Degree courses in 10 disciplines of engineering and architecture and postgraduate’s degree in 55 disciplines of engineering, applied science, architecture and planning.

Select Research Projects

- Water security for hilly regions of North-East through rainwater harvesting
- Conjunctive use planning of water resources considering spatial variation in cropping pattern using remote sensing and GIS MOW-433- WRC.
- Preparation of action plan for important of irrigation water work efficiency
- Development of spatial water climate information system for Uttarakhal
- General purpose software development for water resources information and decision support systems
- Biofortification of wheat for micronutrients through conventional and molecular breeding approaches

Institutional Strength

IIT Roorkee has 21 academic departments covering engineering, applied sciences, humanities & social sciences, and management programmes, one academic centre, three centres of excellence, five academic service centres and three supporting units. The Institute has contributed to all sectors of technological development and has been considered a trend-setter in the area of education and research in the field of science, technology, and engineering.
Institute for Resource Analysis and Policy, Hyderabad

Overview
The Institute for Resource Analysis and Policy (IRAP) is a non-profit research organization that was established in 2009 with the goal to promote sustainable systems for management of natural resources and their related services, particularly land and water resources, for improved food security, livelihoods and environment. The institute advocates strategies and policies for sustainable natural resource management systems that are people-centered and based on principles of equity, productivity and resource sustainability through the help of targeted policy briefs, popular media, existing knowledge exchange networks and participation in policy dialogue forums.

Selected Research Projects
- Multiple-use water services to reduce poverty and vulnerability to climate variability and change
- Social economic and environmental impacts of Sardar Sarovar Project in Gujarat
- Study on natural resource management for strengthening agro-based livelihood in fragile regions of Gujarat and Rajasthan
- Sustaining rice-wheat productivity through integrated nutrient supply system. Godavari River Basin in Maharashtra
- Development of an indigenous automated micro irrigation system

Institutional Strength
The institute undertakes research on physical, social, economic, institutional, legal and policy aspects of natural resources and their linkages with environment and livelihoods, of practical relevance. IRAP focuses on multi-disciplinary and inter-disciplinary research and consultancy projects on natural resources, comprising their assessments, interactions and interdependence.
ICAR- Indian Institute of Farming Systems Research, Meerut (formerly, Project Directorate for Cropping Systems Research)

Website: [http://pdfsr.ernet.in/](http://pdfsr.ernet.in/)

Overview
The Project Directorate, renamed as ICAR- Indian Institute of Farming Systems Research during the 12th Five Year Plan, aims to develop efficient, economically viable and environmentally sustainable integrated farming system models for different farming situations. Significant contributions have been made on various aspects of region-specific system-based technologies for crop-diversification and intensification, integrated nutrient management, farm mechanization, tillage and crop establishment, precision farming, organic farming, farming systems and resource characterization, delineation of cropping systems zones, on-farm technology assessment and refinement and development of agricultural resources information system for crops and cropping systems.

Selected Research Projects
- Identification of bio-intensive, complementary cropping systems for high productivity and efficient resource use
- Sustaining rice-wheat productivity through integrated nutrient supply system
- Development of suitable resource conservation modules to mitigate the ill effects of climate change
- National Initiative on Climate Resilient Agriculture
- Global yield gap and water productivity

Institutional Strength
In addition to campus based research at Meerut, the Project Directorate is operating through All India Coordinated Research Project on Integrated Farming Systems with 42 on-station, 32 on-farm and five voluntary research centers spread throughout the country in five major ecosystems, i.e., arid, semi-arid, sub-humid, humid and coastal representing 15 agro-climatic zones to develop location specific system-based technologies.
Panjab University, Chandigarh

Website: http://puchd.ac.in/

Overview
The university, established in 1882 at Lahore (now in Pakistan), is a public autonomous university. By virtue of its age, experience, achievements and philosophy, the Panjab University is a University of national character and international stature and draws both faculty and students from all over the country and different parts of the globe.

Selected Research Projects
- Development of an active heat exchanger for latent heat thermal energy storage
- Development and evaluation of thermal energy storage materials
- Evaluation of seasonal thermal storage in aquifers for heating and cooling
- Elemental analysis of ground water using PIXE and PIGE techniques

Institutional Strength
The Panjab University, with its 78 teaching and research departments besides four chairs for the research on the main campus at Chandigarh, has 188 affiliated/constituent colleges spread over Punjab and Chandigarh besides Regional Centres at Muktsar, Ludhiana, Hoshiarpur and Kauni. The Energy Research Centre promotes R&D and extension activities in the emerging field of renewable energy.
Punjab Agricultural University, Ludhiana

Overview

Punjab Agricultural University, Ludhiana was established in 1962 and is the nation’s oldest agricultural university, after Govind Ballabh Pant University of Agriculture & Technology, Pantnagar. The university, located in Punjab, pioneered the Green Revolution in India in the 1960s. The university performs the integrated functions of teaching, research and extension in agriculture, agricultural engineering, home science and allied disciplines.

Select Research Projects

- Mitigating effect of climate change on crop productivity under PURSE Programme
- Management of sewage sludge and treated sewage water for use in agriculture
- Resource conservation technologies for improving water productivity
- Water productivity, economics and energetics of rice- wheat under different methods of crop establishment

Institutional Strength

The university has 28 departments in the four constituent colleges and 10 research stations, with 866 teaching and research faculty. The university has made landmark achievements in the development of improved crop varieties and their production-protection technology package, saline-alkaline soil reclamation technology, cropping-system and agro- ecology based input application, etc.
Overview

Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu (SKUAST, Jammu) came into existence in 1999. The university is mandated to address the basic, strategic and applied research related to enhanced production in agriculture and allied sectors (livestock health improvement and quality based products). SKUAST, Jammu strives to achieve high standards of excellence in education, research and extension for the betterment of farming community of the region.

Select Research Projects

- Improving the productivity of traditional agricultural system with scientific intervention
- Enhancement of livelihood security through farming systems and related farm enterprises in north-west Himalayas
- Scaling up of water productivity in agriculture for livelihoods through teaching-cum-demonstration, training of trainers and farmers
- Technology refinement in micro-irrigation and fertigation for improving quality and productivity on important crops in rainfed areas of Jammu
- Technology refinement and dissemination of ginger and turmeric in Jammu region

Institutional Strength

The institution has six research stations/sub-stations and six Krishi Vgyan Kendras in the university which are located in different agro-climatic zones of Jammu region for catering the location-specific needs of the farming community. The university pursues research of high standard through projects funded by various central and state agencies. Some of the specialized research centres includes Farming System Research Centre and Water Management Research Centre.
Overview

Established in 1868, the Tamil Nadu Agricultural University caters to the globalizing agricultural needs, research for innovative solutions and effective technology delivery functions. The university is currently offering 13 under graduate programmes, 38 master and 27 doctoral level programmes.

Select Research Projects

- Modelling urea transport for nitrogen scheduling in drip irrigation
- Irrigated agriculture modernization and water resource management
- Drip fertigation in high value crops under farmers action research programme
- Optimization of water utilization through wells and pumps
- Development of efficient water management practices in agricultural crops especially in rice (System of Rice Intensification)

Institutional Strength

Apart from the academic institutes, the University has research programmes at more than 32 stations, spread over in Tamil Nadu with more than 1200 scientists and teaching faculty. The Water Technology Centre plays a key role in making an assessment of the available resources of water and economic utilization for maximizing agricultural production with suitable on-farm water management practices developed for different situations.
University of Mysore, Mandya

Website: [http://www.uni-mysore.ac.in/](http://www.uni-mysore.ac.in/)

**Overview**
The University of Mysore was established in 1916 in Karnataka. The mission of the University aims at ‘promoting teaching and research in conventional and traditional domains of Arts, Humanities, Pure and Applied Sciences and Professional disciplines’.

**Selected Research Projects**
- Studies on rice bran proteins and their use in food formulation
- Agro-based industries development in Karnataka
- Evaluation of ground water potential zones in the sub-watersheds of north Pennar River basin around Pavagada, Karnataka, using remote sensing and GIS techniques
- Nutrition status of population and food behavior

**Institutional Strength**
The University has 42 postgraduate departments at the main campus, two postgraduate centres, with five postgraduate departments each and one satellite centre at Chamarajanagar with three postgraduate departments. It is providing higher education to about 85 lakhs students, of which over 10,000 are postgraduates. Government of India has considered University of Mysore as ‘Institution of Excellence’ and has awarded special grant for establishing Centre of Excellence in ‘Biodiversity, Bioprospecting and Sustainable Development’ and also to strengthen infrastructural facilities in the University.
### Research Matrices

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<td>Climate change</td>
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<td>Water/Air pollution</td>
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The areas of *Climate change* and *Water/Air pollution* effect all the three WEF sectors, hence are kept separately.
### Researchers Matrix 1. Researchers of leading institutions

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<td>Thapliyal, Alka</td>
<td>Indian Institute of Technology Delhi</td>
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<td>45</td>
<td>Chandrasekar, P</td>
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<td>Mallick, K</td>
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<td>50</td>
<td>Raj, Pradeep</td>
<td>Government of Andhra Pradesh, Groundwater Department, Hyderabad</td>
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## Schemes and programmes of government ministries and bodies

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<tr>
<th>Government ministries/bodies</th>
<th>Schemes/Programmes</th>
<th>Priorities (with respect to end-users)</th>
<th>Budget/12th Five Year Plan outlay*</th>
</tr>
</thead>
</table>
| Ministry for Water Resources, River Development and Ganga Rejuvenation | Clean Ganga Fund | • The fund, approved in 2014, will finance the control of non-point pollution and setting up of waste treatment and disposal plants along the river.  
• The fund will finance research and development projects and innovative projects for new technology and processes for cleaning the river.  
• The fund will accept voluntary contributions from residents, non-resident Indians, and person of Indian origin towards cleaning of the river Ganga. | Integrated Ganga Conservation Mission has been proposed to be set up and a sum of Rs 20,370 million (GBP 220.2 million) has been set aside for this purpose. |
| Ministry for Water Resources, River Development and Ganga Rejuvenation | National Ganga Plan | • The scheme has been included in the budget of Ministry of Water Resources during the financial year 2014-15.  
• The Budget provision, for cleaning of the Ganga river, is to be met from National Clean Energy Fund. | Rs 15,000 million (GBP 162 million) |
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<tr>
<td>• The mission is the implementation wing of National Ganga River Basin Authority (NGBRA).</td>
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<td>• The aim is to ensure effective abatement of pollution and rejuvenation of the river Ganga by adopting a river basin approach and to maintain minimum ecological flows in the river.</td>
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<td>• The government has approved projects for World Bank assistance to NGRBA for abatement of Ganga pollution. The Bank will support by providing technical assistance and financing of US $1 billion.</td>
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<td>• Japan International Cooperation Agency is supporting one project on Ganga in Varanasi on 85:15 basis.</td>
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<thead>
<tr>
<th>Ministry for Water Resources, River Development and Ganga Rejuvenation</th>
<th>Irrigation Management Programme</th>
</tr>
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<tbody>
<tr>
<td>• The programme is a new scheme introduced in the 12th Five Year Plan.</td>
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<tr>
<td>• The programme aims to identify the injudicious inter-sectoral and intra-sectoral distribution of water amongst various categories of water users, low water use efficiency, fragmented approach to water resources planning and development, low water user charges and meagre recovery as some of the major problems associated with the management of water resources in the country.</td>
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<tr>
<th>Ministry for Water Resources, River Development and Ganga Rejuvenation</th>
<th>National Water Mission</th>
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<tr>
<td>• The Mission is established under the National Action Plan on Climate Change launched by the Government of India.</td>
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<td>• The objective of National Water Mission is conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management.</td>
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<thead>
<tr>
<th>Ministry for Water Resources, River Development and Ganga Rejuvenation</th>
<th>Dam Rehabilitation and Improvement Project</th>
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<tr>
<td>• The Government has formulated the scheme for implementation of the project with the World Bank assistance under which rehabilitation of 223 dams in the states of Kerala, Madhya Pradesh, Orissa and Tamil Nadu are proposed to be taken up.</td>
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<td>• The programme has become effective from 2012, and the activities will be spread over 6 years.</td>
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<tr>
<th>Ministry for Water Resources, River Development and Ganga Rejuvenation</th>
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<td>Rs 100000 million (GBP 1018 million)</td>
</tr>
</tbody>
</table>
| Ministry for Water Resources, River Development and Ganga Rejuvenation | National River Conservation Plan | - The scheme has been included in the budget of Ministry of Water Resources during the financial year 2014-15.  
- The Budget provision is for greater efficiency in programme delivery, the programme has been shifted to the Ministry of Water Resources from Ministry of Environment and forest. | Rs 5370 million (GBP 58 million) |
| --- | --- | --- | --- |
| Ministry for Water Resources, River Development and Ganga Rejuvenation | Detailed Project Report for Interlinking of Rivers | - The scheme has been included in the budget of Ministry of Water Resources during the financial year 2014-15.  
- One of the components of interlinking of rivers is optimizing water resources required for irrigation purposes. | Rs 1000 million (10.8 million) |
- The budgetary support will be used to complete ongoing major, medium & minor irrigation/multipurpose projects in advanced stage of construction and which are beyond the resource capability of State Governments in a time bound manner with a view to (a) Create additional irrigation potential and (b) Derive envisage benefits from these projects. | Total AIBP: Rs 89922.2 million (GBP 972 million) |
| Ministry for Water Resources, River Development and Ganga Rejuvenation | AIBP: Command Area Development and Water Management Programme | - At least 10% of the total Culturable Command Area of each new project is to be covered under micro irrigation during 12th FYP. Quantifiable outputs are: (i) Irrigation Potential of 0.5 million hectares is targeted for creation. (ii) Development of adequate delivery system of irrigation water up to farmers’ field with an objective to enhance water use efficiency and production and productivity of crops for improving Socio-economic conditions of farmers. | --- |
| Ministry for Water Resources, River Development and Ganga Rejuvenation | AIBP: Repair, Renovation and Restoration of Water Bodies | • The fund will provide central assistance for restoration of about 10000 water bodies in 12th Plan.  
• The outputs will include (i) Restoration of irrigation potential. (ii) Ground water Recharge, (iii) All round socio-economic development of people, (iv) Enhancement of availability of drinking water. |  |
| Ministry for Water Resources, River Development and Ganga Rejuvenation | Farmers’ Participatory Action Research Programme | • The programme was sanctioned at 5000 demonstration sites and being implemented in 375 districts of 25 states/union territories with the help of 60 agriculture universities, ICAR, ICRISAT and NGOs to increase yield and income per drop of water.  
• The duration of the programme was 2008-2011. | **Rs 244.6 million (GBP 2.6 million)** |
| Ministry of Rural Development | Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) | • A very large proportion (80%) of the works under the scheme are focused on soil and water conservation on the lands of the small and marginal farmers  
• Several studies conducted by Indian Institute of Science, Indian Institute of Forest Management, etc have concluded that MGNREGS works have had a positive impact on agricultural productivity, water availability, soil fertility. |  |
| Ministry of Rural Development | National Rural Livelihoods Mission | • The Mission aims at creating efficient institutional platforms of the rural poor through sustainable livelihood enhancements and improved access to financial services. |  |
| Department of Land Resources, Ministry of Rural Development | Integrated Watershed Management Programme | • Launched during 2009-10, funds from this erstwhile scheme have been transferred to the new Pradhan Mantri Krishi Sinchai Yojana in the upcoming fiscal (2015-16).  
• The main objectives of the programme was to restore the ecological balance by harnessing, conserving and developing degraded natural resources such as soil, vegetative cover and water.  
• The outcomes are prevention of soil erosion, regeneration of natural vegetation, rain water harvesting and recharging of the groundwater table. | **Rs 35000 million (GBP 378.3 million)** |
| Ministry of New and Renewable Energy | Design and development of vacuum pyrolysis plant to process various agricultural and agro-industrial biomass to demonstrate its technical and economic feasibility | • To evaluate technical and economic feasibility of the pyrolysis units for implementing the pyrolysis technology.  
• Duration of project is 2010 to 2014  
• Funding support is Rs 137.77 lakh |
| Ministry of New and Renewable Energy | Demonstration of promising genotype of Jatropha in Chhattisgarh, Tamil Nadu, Karnataka and Rajasthan | • To study and assess the suitability and productivity of the promising genotypes of Jatropha in Chhattisgarh state.  
• Duration of project is 2010 to 2016  
• Funding support is Rs 34.10 lakh for each state. |
| Ministry of Power | Deen Dayal Upadhyaya Gram Jyoti Yojana | • The scheme focuses on feeder separation (rural households & agricultural) and strengthening of sub-transmission & distribution infrastructure including metering at all levels in rural areas  
• The earlier scheme for rural electrification has been subsumed in the new scheme as its rural electrification component |
| Ministry of Power/Bureau of Energy Efficiency | Agriculture Demand Side Management | - The scheme was initiated in the Eleventh Five year plan as a key strategy to address the existing inefficiencies in the end use segments of agriculture sector.  
- The scheme involves eleven DISCOMs of eight states (Maharashtra, Haryana, Punjab, Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh and Karnataka) which are agriculturally intensive and account for more than 70% of electricity consumption in this sector.  
Following instruments are planned to meet the proposed target:  
- Financing mechanism for promoting investments in Agricultural Demand Side Mechanical projects  
- Monitoring and verification protocol  
- Integrated water and energy conservation scheme – 100 Joint Demo projects implementation  
- Technical assistance & capacity development of stakeholders | Rs 3930 million (GBP 42.4 million) |
| Government of India | National Clean Energy Fund | - The National Clean Energy Fund will be used for funding research and innovative projects in clean energy technologies.  
- Funding research and innovative projects in clean energy technologies, and harnessing renewable energy sources to reduce dependence on fossil fuels constitute the objectives of the fund. | |
| Ministry of Environment, Forests and Climate Change | National Ganga River Basin Authority (NGBRA) | - The NGBRA was formed in 2009 under Section 3(3) of the Environment (Protection) Act, 1986.  
- The programme is a multi-disciplinary initiative involving multiple dimensions of Ganga clean-up and conservation, and therefore will span across many sectors, including but not limited to social, environment, urban development, water resources, agriculture, industries, and energy. | |
| Department of Agriculture and Cooperation, Ministry of Agriculture | National Food Security Mission | - The Mission was implemented to increase production of food grains.  
- Two major programmes were covered:  
  - Accelerated Pulses Production Programme  
  - Micro Irrigation Programme | |
| Department of Agriculture and Cooperation, Ministry of Agriculture | National Mission for Sustainable Agriculture 2010 | - The Mission seeks to transform Indian agriculture into a climate resilient production system through suitable adaptation and mitigation measures in the domain of crops and animal husbandry.  
- The mission caters to key dimensions of ‘Water use efficiency’, ‘Nutrient Management’ and ‘Livelihood diversification’ through adoption of sustainable development pathway by progressively shifting to environmental friendly technologies, adoption of energy efficient equipment, conservation of natural resources, integrated farming, etc. | Rs 1080,000 million (GBP 11675.6 million) |
| Department of Agriculture and Cooperation, Ministry of Agriculture | National Mission on Oilseeds and Oil Palm | - The mission envisages increasing in production of vegetable oils sourced from oilseeds and oil palm.  
- Mission funding will be in the ratio of 75:25 between the Central and the State Governments. | |
| Department of Agriculture and Cooperation, Ministry of Agriculture | Himachal Pradesh Mid-Himalayan Watershed Development Collaborating agency: World Bank | - This project aims at preventing degradation and protection of biodiversity, productivity of livestock, watershed development, etc.  
- The project envisages covering an area that includes 602 Gram Panchayats in 10 districts of the state. | Rs 5100 million (GBP 55 million) |
| Department of Agriculture and Cooperation, Ministry of Agriculture | Assam Agricultural Competitiveness Project Collaborating agency: World Bank | - The project aims at increasing productivity and market access of targeted farmers and community groups to stimulate growth in Assam’s agricultural economy.  
- The project area covers 23 districts in the state. | Rs 10,220 million (GBP 110.4 million) |
|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------|
| Department of Agriculture and Cooperation, Ministry of Agriculture | Bringing Green Revolution to Eastern India | - The programme aims to increase production and productivity of rice and wheat by adopting latest crop production technologies.  
- It promotes cultivation in rice fallow area to increase cropping intensity and to create water harvesting structures and efficient utilization of water potential. | |
| Department of Agriculture and Cooperation, Ministry of Agriculture | Sustainable Development of Sugarcane based Cropping System (SUBACS) (under Revised Macro Management of Agriculture Scheme) | - The scheme aims to transfer of improved production technology to the farmers through field demonstrations; supply of farm implements; enhancing production of planting materials; efficient use of water; etc | |
| Department of Agriculture and Cooperation, Ministry of Agriculture | National Mission on Micro-Irrigation | - The mission aims to increase the area under micro irrigation through improved technologies  
- It also aims to enhance water use efficiency; increase productivity of crops; establish convergence and synergy among on-going government programmes, etc. | |
| Department of Agriculture and Cooperation, Ministry of Agriculture | Mission for Integrated Development of Horticulture | - The mission promotes holistic growth of horticulture sector through area based regionally differentiated strategies, which includes research, technology promotion, and extension.  
- The mission seeks to improve productivity by way of quality germplasm, planting material and water use efficiency through micro Irrigation. |
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<tr>
<td>Department of Agriculture and Cooperation, Ministry of Agriculture</td>
<td>National Project on Organic Farming</td>
<td>- The project aims to promote organic farming in the country through technical capacity building of all the stakeholders including human resource development, transfer of technology, promotion and production of quality organic and biological inputs.</td>
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</tbody>
</table>
| Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture | Dairy Entrepreneurship Development Scheme (DEDS) | - The scheme aims to set up modern dairy farms for production of clean milk  
- The scheme seeks to upgrade traditional technology to handle milk on commercial scale |
| Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture | Development of Marine Fisheries, Infrastructure and post-Harvest operations in 2014-15 | - Development of marine fisheries; development of infrastructure and post-harvest operations, etc. |
| Department of Agriculture and Cooperation, Ministry of Agriculture | Pradhan Mantri Krishi Sinchai Yojana | - The scheme aims to provide assured irrigation to mitigate risk to the farmer.  
- The scheme promotes ‘per drop more crop’ i.e. farming through optimum utilization of water.  
- The scheme will provide end-to-end solutions in the irrigation supply |

The Union Budget 2015-16 has allocated Rs 53,000 million (GBP 573,000,000)
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<tr>
<th>Department of Agriculture and Cooperation, Ministry of Agriculture</th>
<th>Vegetable Initiative for Urban clusters</th>
<th>The initiative seeks to enhance vegetable production and productivity, improve nutritional security and income support to vegetable farmers. The initiative promotes, develops and disseminates technologies for enhancing production and productivity of vegetables in peri-urban areas of major cities, etc.</th>
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<tr>
<td>Department of Agriculture and Cooperation, Ministry of Agriculture</td>
<td>National Mission on Agricultural Extension and Technology</td>
<td>The mission aims to restructure and strengthen agricultural extension to enable delivery of appropriate technology and improved agronomic practices to the farmers; Sub-missions consists of sectors that include Agricultural Extension and Agricultural Mechanization.</td>
</tr>
<tr>
<td>Department of Agriculture and Cooperation, Ministry of Agriculture</td>
<td>Paramparagat Krishi Vikash Pariyojana</td>
<td>The scheme aims to promote organic farming and to develop potential markets for organic products The scheme promotes utilization of natural resources through eco-friendly cultivation</td>
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<tr>
<td>National Bank for Agriculture and Rural Development (NABARD)</td>
<td>Rural Infrastructure Development Fund (RIDF)</td>
<td>RIDF was instituted with the objective of giving low cost fund support to state governments and state owned corporations for quick completion of ongoing projects relating to medium and minor irrigation, soil conservation, watershed management and other forms of rural infrastructure. The guiding principle for the operation of RIPF is to support solely the programmes/activities that are carried out for promotion of rural infrastructure, which would directly or indirectly, facilitate agriculture</td>
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The cumulative allocation in the fund has reached Rs 2175,000 million (GBP 23513.5 million) including Rs 18,000 million (GBP 194.5 million) towards micro-irrigation.
and rural development.

| NABARD                | Climate Change Adaptation Project in Maharashtra | NABARD is supporting climate change adaptation project in 25 villages of Akola and Sangamner Talukas of Ahmednagar district of Maharashtra in collaboration with Swiss Agency for Development and Co-operation. The project is being implemented by Watershed Organisation Trust.  
|                       |                                                   | The key interventions of the project include social mobilization, watershed structures, lift irrigation system, water budgeting, biodiversity, renewable energy and innovative activities. |
|                       |                                                   | 185,000 million (GBP 2000 million) under Bharat Nirman. |
| NABARD                | Farmers’ Technology Transfer Fund                | The fund was created out of the operating profit of NABARD to support technology transfer projects. 242 projects in 13 states involving assistance of Rs 91.3 million (GBP 0.98 million) were sanctioned during 2013-14 and cumulatively, 1524 projects were sanctioned with financial support of Rs 899.5 million (GBP 9.7 million).  
|                       |                                                   | Major programmes financed and implemented under the fund are Farmers’ Club Programme, Pilot Project on Augmenting Productivity of Lead Crops, System of Rice Intensification, and Village Development Programme |
|                       |                                                   | Rs 237.9 million (GBP 2.5 million) |
| NABARD                | NABARD-SDC Rural Innovation Fund                 | NABARD constituted the Rural Innovation Fund with the corpus of Rs 1399 million (GBP 15.1 million) in collaboration with the Swiss Agency for Development and Co-operation (SDC) in 2005-06.  
<p>|                       |                                                   | Sectors to be considered for support include dryland/ rainfed farming, innovative rainwater harvesting, rural energy from biomass/ agricultural wastes, techniques for increasing the value of crop residues and non-crop biomass, community regulation of distribution and use of |
|                       |                                                   | Rs 899.5 million (GBP 9.7 million) |</p>
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<tr>
<th>NABARD</th>
<th>Umbrella Programme on Natural Resource Management</th>
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<td>• NABARD has collaborated with KfW and GIZ for implementing the Umbrella Programme on Natural Resource Management.</td>
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<td>• The programme is being implemented since 2007-08 and aims to boost rural livelihoods by supporting community managed sustainable natural resource management projects.</td>
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<td>• It is a shift from project-based to programme based funding and grant-based to loan-based funding. The programme showcases financial business models in the fields of sustainable agriculture, organic farming, animal husbandry, agro-forestry, non-timber forest produce, medicinal plants, efficient irrigation and water management, System of Rice Intensification (SRI), etc.</td>
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<td>• The programme covers 228 projects sanctioned covering more than 2.53 lakh people across 19 states and one union territory of India.</td>
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<tr>
<th>NABARD</th>
<th>Watershed Development Fund</th>
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<td>• The Fund has been established with the objective of integrated watershed development in 100 priority districts of 18 States through participatory approach.</td>
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<td>• A number of externally aided projects are under implementation on watershed approach, which covers an area of about 1.5 lakh hectares annually.</td>
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<td>• Presently, the scheme is being implemented in Gujarat, Maharashtra, Uttar Pradesh, Uttarakhand, Karnataka, Tamil Nadu, Rajasthan, Chhattisgarh, Odisha, Jharkhand, Madhya Pradesh, Himachal Pradesh and West Bengal.</td>
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<tr>
<td>Organization</td>
<td>Project Title</td>
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</table>
| Indian Council of Agricultural Research | National Initiative on Climate Resilient Agriculture | - The main objectives are to enhance the resilience of Indian agriculture covering crops, livestock and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies.  
- The project seeks to enhance the capacity of scientists and other stakeholders in climate resilient agricultural research and its application. | 2011-2017 | Rs 3500 million (GBP 37.8 million) |
| Indian Council of Agricultural Research | Sustainable Rural Livelihood and Food Security to Rainfed Farmers of Orissa | - The objective of the project is to enhance farm productivity, profitability and employment opportunities six clusters of rainfed villages located in 3 disadvantaged districts of Odisha, viz., Kandhamal, Dhenkanal and Kalahandi to ensure sustainable rural livelihood and food security for about 3794 landless, small and marginal farm families.  
- This pilot project will serve as a model for future projects aiming at sustainable livelihood and food security to the entire state, particularly to the remaining 15 disadvantaged districts in the state. | 2008-2014 | Rs 61.7 million (GBP 0.66 million) |
| National Rainfed Area Authority | Bundelkhand Special Package | - The Bundelkhand Special Package was approved for implementing drought mitigation strategies in Bundelkhand region over a period of 3 years starting 2009-10.  
- The Government of India approved the continuation of the Bundelkhand Special Package during the 12th Plan period (2012-2017) under the Backward Regions Grant Fund with a financial outlay of Rs 44,000 million (GBP 475.6 million). | | |
| National Rainfed Area Authority | Kuttanad Package | - The Government of India implemented the Kuttanad Package with a total cost outlay of Rs 18,400 million (GBP 199 million) in 2008.  
- The objectives of this package are promotion of natural water flow, dilute pollutants and enhance ecological health; and promotion of better rice cultivation and reduction in cost of cultivation. | | |
Indian National Committee on Irrigation and Drainage

- The agency is involved in processing, coordination and monitoring of the R&D schemes funded by the Ministry of Water Resources.
- The agency works in collaboration with institutes like Centre for Water Resources Development & Management, IIT Roorkee, National Institute of Hydrology, IIT Bombay, Jadavpur University, North Eastern Regional Institute of Science and Technology, and several others. The following schemes are related to the nexus theme:
  - Impact of Implementation of an Irrigation Project on Water Resources and Cropping Pattern
  - Documentation and analysis of farmer’s practices on water management of plantation crops (Rs 10,97,000)
  - Action research on on-farm water management for paddy through farmer’s participation (Rs 8,03,000)
  - Jointly Managed and Farmer Managed Irrigation Systems in Kerala - A Study (Rs 5,65,000)
  - Development of integrated irrigation information systems (Rs 36,50,000)
  - Agrotechnical constraints analysis for improving water productivity in Upper Ganga Canal Command (Rs 5,57,000)
  - Aerobic rice - water saving method for southern dry zone of Karnataka (Rs 16,30,000)

Note. * The financial budgets for the various schemes and programmes are based on the envisaged budget allocated in the various reports of the Working Group / Steering Committees for the Twelfth Five Year Plan (2012-2017). The budget provides an indication of the government spending on these sectors.
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Mahatma Gandhi National Rural Employment Guarantee Scheme < http://www.nrega.ap.gov.in/Nregs/>
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Department of Agriculture and Cooperation, Ministry of Agriculture <http://agricoop.nic.in/>
Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture <http://www.dahd.nic.in/dahd/default.aspx>
Ministry of Power <http://powermin.nic.in/>
Ministry of Environment, Forests and Climate Change <http://envfor.nic.in>
NABARD < https://www.nabard.org>
ICAR < www.icar.org.in/>
National Rainfed Area Authority < http://nraa.gov.in/>
Indian National Committee on Irrigation and Drainage < http://www.cwc.gov.in/main/INCID/welcome.html>
## Schemes and programmes of private funders in the Energy-Water-Food Nexus areas

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<th>Funding organization</th>
<th>Highlights of research priorities</th>
<th>Project budget</th>
</tr>
</thead>
</table>
| **Action for Food Production (AFPRO)** | *Enhancing Livelihoods and Food Security through Diversion based Irrigation System*  
- Diversion based Irrigation Systems represents an innovative approach to the promotion of food security and livelihoods through the provision of protective irrigation to rainfed farmers based on the principle of gravity flow.  
- The system comprises identifying the right water sources and connecting these to the farmers fields through gravity based distribution channels to enable irrigation, both kharif and paddy crops that provides protective irrigation.  
- Implementation of DBIS across the five states (145 tribal villages in Orissa, Jharkhand, Assam Meghalaya and Tripura) has highlighted the need to further leverage the strengths of DBIS interventions comprising the use of traditional knowledge and proper use of water resources. | |
| **Adani Foundation** | *Building Social Capital- Drip Irrigation Project*  
- The project aims to bring more and more land under drip irrigation at villages in Mundra, Gujarat, facilitate high crop productivity with limited water resources, and reduce weeding requirements  
- Besides the 50% subsidy given by the Government, an additional 25% subsidy is also contributed by the Foundation with technical support till the micro irrigation becomes popular and well accepted by the | |
sustainable development. The foundation, since its inception in 1996, works in four broad working areas that are education, community health, sustainable livelihood development, and rural infrastructure development.

At other sites, drip-irrigation is propagated amongst farmers.

<table>
<thead>
<tr>
<th>Arghyam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arghyam grants funds to organisations, which implement and manage groundwater and sanitation projects in India. Arghyam has made grants to recipients in 22 states of India since 2005, the year of its founding. The total amount funded is Rs 474 million (GBP 5.1 million).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evolving water self-reliance through surface and groundwater sharing and management</th>
</tr>
</thead>
<tbody>
<tr>
<td>• In partnership with Gram Gaurav Pratishthan and Advanced Centre for Water Resources Development and Management, the project collaborated to help create access to groundwater resources and ensure sustainable management in a village in Pune district.</td>
</tr>
<tr>
<td>• Sustainable methods of water utilization were evolved, such as irrigation schemes, water allocation based on the family rather than size of land, cropping restriction to seasonal crops.</td>
</tr>
<tr>
<td>• Over 550 acres of land was irrigated with 250 direct beneficiaries.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Biotechnology Plant: An option for wastewater treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• This action research addressed the challenges of waste-water treatment in India by seeking to assess and consider Soil Biotechnology’s effectiveness in treating wastewater, through the analysis of the construction and operation of one such treatment facility at ACCEPT Society in Bangalore.</td>
</tr>
<tr>
<td>• The project supported the installation of a 15 kilolitre per day domestic wastewater treatment plant that provides water to support</td>
</tr>
</tbody>
</table>

| Rs 50.9 lakh |
the agricultural and horticultural activities on the campus.

| Improving agricultural livelihoods of marginalized tribal households through sustainable groundwater management |
|---|---|
| - Through the use of watershed interventions the project was able to improve sub-surface water availability. The project assessed utilisation potential and set up dug wells on the basis of hydro geological understanding. |
| - The interventions helped improve agricultural productivity through sustainable groundwater management and transfer of knowledge on appropriate agricultural practices. These outcomes led to a drop in distress migration and increased drinking water and livelihood security in two blocks in Ratlam district in Madhya Pradesh. |
| Rs 65.73 lakh. |

<table>
<thead>
<tr>
<th>Axis Bank Foundation</th>
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</thead>
<tbody>
<tr>
<td>The foundation is a registered public trust formed in 2006. Axis Bank Foundation Livelihood Programme in some of the poorest districts of the country aims to impart positive change in people’s lives by providing direct solutions to these issues. ABF’s partners work in some of the most socio-economic backward states to help improve irrigation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Conservation of Small Scale Irrigation Tanks</th>
</tr>
</thead>
<tbody>
<tr>
<td>- In partnership with Dhan Vayalagam Foundation the project identified four drought prone blocks in Tamil Nadu -- Kottampatti, Natham, South Pudur and Ponnamaravathy, working to improve the performance of traditional water commons viz. tanks and village ponds and rehabilitate them to their original hydrologic standards by organizing the community members into associations.</td>
</tr>
<tr>
<td>- The project involves reviving 625 irrigation tanks and 125 drinking water ponds in addition to various other site specific soil and water conservation interventions. Over the next five years, the project is expected to benefit around 30,000 small and marginal farming families and 30,000 landless labour families from over 500 villages.</td>
</tr>
</tbody>
</table>
through rain water harvesting, make various government schemes accessible, create market linkages and opportunities for small enterprises and provide credit linkages with banks.

**Creating livelihoods on a sustainable basis**

- In partnership with Dilasa Janvikas Pratishthan, the project aims to enable a 50% increase in the annual income of 50,000 families living in the Vidarbha region of Maharashtra.
- The project has introduction of a number of interventions to be implemented; these include creating irrigation facilities by building small check dams and tanks, soil erosion control measures, and promoting sustainable and lower risk agricultural practices.
- Over a period of five years (beginning 2011) the project is expected to reach out to around 51,325 families and bring about at least a 50% of increase in their annual income.

**Interventions in water infrastructure for livelihood improvement**

- Axis Bank Foundation has partnered with Samaj Pragati Sahyog in several inter-related focus areas over a period of five years to address the distress of the poorest, especially the tribal populations in Dewas and Khargone districts of Madhya Pradesh.
- Various interventions in water infrastructure will be used to build a whole range of livelihood opportunities, moving towards stimulating livelihood security for the most deprived.
- The overall goal of the project is to achieve livelihood security for 47,143 families from poor households in the study region and to achieve an overall increase in the income of the household by at least 50% through the various livelihood activities such as watershed development programs and dryland agriculture.
<table>
<thead>
<tr>
<th><strong>Concern India Foundation</strong></th>
<th><strong>Community irrigation scheme</strong></th>
</tr>
</thead>
</table>
| Set up in 1991, Concern India Foundation extends financial and non-financial support to grassroots projects working in the areas of education, health and community development. In 2013-14, the foundation extended support to over 270 NGOs across India, working at the grassroots level in the areas of education, health and community development reaching out to over 1,60,000 lives directly from the disadvantaged sections of society. | • The scheme is introducing lift irrigation technology in Udaipur by installing electric pumps that lifts water from perennial water sources to higher altitude places.  
• The scheme is implemented and managed by the Water User Association, a group comprising of all the farmers with land holdings in the proposed irrigation command area. Members avail benefits of receiving water by paying charges. The lift irrigation project prevents exploitation of ground water in water depleted areas. |

<table>
<thead>
<tr>
<th><strong>Hindustan Coca Cola Beverages Private Limited</strong></th>
<th><strong>Water stewardship initiatives: Drip irrigation</strong></th>
</tr>
</thead>
</table>
| The water stewardship initiatives of the company are based on the responsibility to safely return to nature an amount of water equivalent to what we use in all our beverages and their production and ensure continued support to water neutrality. | • The objective of the partnership is to facilitate the setting up of long term, economically sustainable infrastructure benefiting local stakeholders economically and bringing down the overall usage of water in agriculture to help conserve ground water.  
• Initiated the public-private community partnership to promote drip irrigation for better water management in Kaladera, Rajasthan.  
• Impacts of drip irrigation lead to water saving, savings on electricity, and economic benefits. Drip irrigation has led to a shift in the cropping pattern – from mono-cropping to inter-cropping and thereby improving quality and quantity of yield.  
• The initiative has reached to 410 farmers covering 205 hectares of agricultural land leading to significant water saving. |
<table>
<thead>
<tr>
<th><strong>PepsiCo Foundation</strong></th>
<th><strong>Water security and sustainable agriculture; Adaptive approaches to our changing climate</strong></th>
<th><strong>SABMiller India Ltd</strong></th>
<th><strong>Sustainable water resources for livelihood improvement</strong></th>
<th><strong>2008-2010: $1.15 million</strong></th>
</tr>
</thead>
</table>
| PepsiCo’s philanthropic anchor, PepsiCo Foundation is committed to developing sustainable partnerships and programmes that provide opportunities for improved health and inclusion and a better environment. | - The project, in partnership with Earth Institute at Columbia University, tests methods that deliver ‘more crop per drop’. This approach focuses on water security through water harvesting, recharging, watershed management and innovative irrigation practices.  
- It is envisaged that the project will empower private and public communities with practical new methods to use water more efficiently both now and in the future.  
- The project is developing research, tools, and strategies to improve agricultural income and water use through policy reform and private sector contributions to the agricultural value chain.  
- The project has reached 500 farmers across Punjab and Gujarat. | SABMiller is India’s second largest beer company. The company’s sustainability activities focus towards a resilient world where business, local communities and ecosystems share uninterrupted access to safe, clean water. | - SABMiller India, in partnership with ICRISAT, is implementing activities on sustainable water resources in the surrounding areas of Charminar Breweries located in Andhra Pradesh while contributing to improving the livelihoods of the people dependent of agriculture.  
- The objectives of the initiative are to provide technical backstopping to establish agricultural demonstration farm in the factory premises for addressing issues of low quality waste water from the factory, to improve agricultural productivity in selected two villages by adopting rainwater conservation and harvesting as well as its efficient use for improving livelihoods.  
- The duration of the project is 2009 to 2013. |
### Sir Dorabji Tata Trust and the Allied Trusts

Sir Dorabji Tata Trust was established in 1932. Now known as the Sir Dorabji Tata Trust and the Allied Trusts, the entity comprises the Sir Dorabji Tata Trust and other trusts set up by the Tatas. The Trusts support community-based and grassroots organisations to ensure that the human rights of marginalized communities are not violated and they are not denied access to public entitlements.

<table>
<thead>
<tr>
<th><strong>Combating land degradation and increasing productivity</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- The goal of the project is to minimize land degradation and improve the food security and livelihood opportunities for rural people in rainfed areas of India.</td>
</tr>
<tr>
<td>- Specific objectives of the project implemented in Madhya Pradesh and Eastern Rajasthan are to develop and apply a holistic participatory watershed-based model for the convergence of activities in the watershed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Enhancing livelihoods and food security through diversion based irrigation system</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- The Trusts, in partnership with Action for Food Production, initiated Diversion based Irrigation Systems that represents an innovative approach to the promotion of food security and livelihoods through the provision of protective irrigation to rainfed farmers based on the principle of gravity flow.</td>
</tr>
<tr>
<td>- Training to farmers on appropriate agricultural skills such as SRI, mixed farming, organic farming, crop rotation, and dryland farming facilitate them to grow successful crops for food security.</td>
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</table>

<table>
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<tr>
<th><strong>System of Rice Intensification (SRI)</strong></th>
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<tbody>
<tr>
<td>- The Trusts have been supporting the systematic extension of SRI among small-holder farmers who cultivate crops under rain-fed conditions.</td>
</tr>
<tr>
<td>- The programme has reached out to over one lakh farmers in more than 105 districts – via a network of over 153 implementation partners.</td>
</tr>
</tbody>
</table>
### Sir Ratan Tata Trust

Established in 1919, Sir Ratan Tata Trust is one of the oldest philanthropic institutions in India.

### IWMI Tata Water Policy Research Programme

- The IWMI-Tata Water Policy Programme was launched in International Water Management Institute (IWMI) in 2000 with the support of Trust. The second phase of the project was initiated in 2006 for a period of five years.
- The objective of the programme is to help policy makers at the central, state and local levels address their water challenges — in areas such as sustainable groundwater management, water scarcity, and rural poverty — by translating research findings into practical policy recommendations.
- A key area of focus is to undertaking research in organizational and institutional processes in the water sector, whilst exploring, understanding and incorporating the real constraints at improving policy formulation and implementation.
- Sanctioned grant amount is Rs 50 million.

### Strengthening, replicating and diversification of water centered livelihood for the rural and tribal community in western India – ensuring improved environment and ecosystem (phase III), under CINI

- The grant was operationalized in 2011 for a period of five years.
- Over the five years, the programme in partnership with Sadguru, proposes to further develop and strengthen land and water resources, along with concentrated market focused diversification of agriculture. It would also promote and strengthen collective action through institutional building. Sadguru would consolidate its program activities and cluster villages in blocks of Dahod, Garbada, Jhalod, Fatehpura, Dhanpur, Limkheda and Devgarh Bariya (all in Gujarat), where it covers almost 72 per cent of the total villages through various interventions.
- Sanctioned grant amount is Rs 156.33 million.
### Sustainable rain-fed agriculture and livelihoods improvement of tribal farmers

- The project, in partnership with Gramin Vikas Trust, addresses the livelihood needs of 2778 marginal tribal farmers in Jhabua district, Madhya Pradesh, through the promotion of improved rain-fed agriculture interventions, creation of water resources and promotion of optimum utilisation of these resources.
- The overall project area covers 19 most backward tribal villages spread over an area of 3,026 hectares, comprising of micro watersheds, which would be treated with various integrated soil and water conservation measures, with support from National Rural Employment Guarantee Scheme.
- The project duration is from 2008 to 2011; sanctioned grant is Rs 11.49 million.

### Increasing agriculture productivity in irrigated command through restoration of canal system and establishment of farmer-led agriculture extension system

- In partnership with Action for Social Advancement, the programme aims to increase agriculture productivity through the restoration of canal systems and establish effective irrigation management systems within the Participatory Irrigation Management Act of Madhya Pradesh.
- The focus of the project is towards promoting improved livelihood interventions in the command area of five select irrigation systems, which would cover 2,592 hectares having a canal network of 73.81 kilometres.
- The project duration is from 2008 to 2011; sanctioned grant is Rs 11.49 million.
**Increasing agricultural productivity of farming systems in parts of central India through participatory research-cum-demonstrations and knowledge sharing innovations**

- The project operates within select 20 benchmark villages (4 nucleus and 16 satellite), and is developing these as sites of learning in the East Singhbhum and Gumla districts in Jharkhand, and Jhabua and Mandla districts in Madhya Pradesh. The selected benchmark villages serve as training sites, and as sites for undertaking action research.
- The project provides regular technical inputs to ongoing field projects on crop and water management practices. Linkages with the state agriculture universities, research and academic institutions are being developed for the long-term qualitative extension support to the farmers.
- The project duration is from 2008 to 2013; sanctioned grant is Rs 42.46 million.

**Field projects to mitigate and prevent salinity ingress**

- In January 2002, the Trust supported Ambuja Cement Foundation, Ambujanagar, in implementing a pilot programme for three and a half years, which focused on 20 villages of Kodinar and Sutrapada talukas of Junagadh district in Gujarat.
- Phase 2 of the programme focused on cost effective and innovative demand and supply water management and agriculture model, for efficient utilisation of available water. Fresh projects were initiated in five villages of Jafarabad taluka of Amreli district.
- The project involved construction of water-harvesting structures for groundwater recharge and roof rainwater harvesting tanks, well sealing and percolation wells for drinking water, propagating horticulture and water saving technologies, such as drip irrigation and sprinklers.
- The duration of the second phase of the programme is from 2006 to 2009; sanctioned grant is Rs 17.67 million.

**Sustainable groundwater use in semi-arid and arid regions: promoting improved farmer management of land and water**
- A third phase of support to the “North Gujarat sustainable groundwater initiative” towards ensuring sustainable groundwater use in semi-arid and arid regions through promotion of improved farmer management of land and water resources is proposed to consolidate gains in Banaskantha district that were achieved during the first and second phases of support, whilst also expanding activities to other areas of north Gujarat and Rajasthan.
- Phase III, which would be implemented by Society for Integrated Land and Water Management, would aim to design and pilot groundwater management strategies for new regions having different geo-hydrological and socio-economic conditions as compared to north Gujarat and western Rajasthan.
- Overall, around 5000 farmers are expected to be directly benefited. Further, the adoption of micro irrigation systems would indirectly benefit another 7500 farmers.
- The grant was operationalized in 2010 for period of three years; sanctioned grant is Rs 42.04 million.

**Drought Proofing in Rajasthan**
- Under the project, the Trusts have collaborated with His Highness Maharaja Hanwant Singhji Charitable Trust, Jodhpur, to create lasting solutions by evolving technological and organizational innovations for the integrated development of drought prone areas.
- Project Sahyog, as it is also called, has a four-pronged approach, with the following activities -- water resource development, agriculture diversification, animal husbandry and income generation.
<table>
<thead>
<tr>
<th>Jain Irrigation Systems Ltd</th>
<th>Establishing a Resource Centre for water use efficiency in agricultural sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>The company operates in three segments include hi-tech agri input products, industrial products and non-conventional energy. They conduct research and development in plant, in lab and on farm to improve their products. The research focus of the company includes collaborative research on fertigation and irrigation scheduling with national and international institutes and development of low energy, low pressure drip irrigation system.</td>
<td>The company signed a MoU with TERI in 2014 for establishing a Resource Centre for water use efficiency in agricultural sector. This resource centre will engage in research for conserving water resources and policy advocacy to ensure water for all.</td>
</tr>
</tbody>
</table>

- Initiated in September 2002, phase I of Project Sahyog ended in February 2007. It significantly enhanced the lives of people in 16 villages in Balesar block of Jodhpur district, over a four and a half year period.
- The project focuses on drought proofing through ground water recharging, supplementing drinking water, and diversifying and sustaining livelihoods.
- Phase 2 of the project was initiated in 2007 for period of four years; sanctioned grant is Rs 24.11 million.
Sources

Websites
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Arghyam <arghyam.org/>
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Concern India Foundation <www.concernindiafoundation.org/>
Hindustan Coca Cola Beverages Private Limited <https://www.hindustancoca-cola.com/>
PepsiCo Foundation <www.pepsicoindia.co.in/purpose/pepsico-foundation.html>
SABMiller India Ltd <www.sabmiller.in/>
Sir Dorabji Tata Trust and the Allied Trusts <www.dorabjitatatrust.org/>
Sir Ratan Tata Trust <www.srtt.org/>
Jain Irrigation Systems Ltd <www.jains.com/>
## Projects and programmes of international funders

<table>
<thead>
<tr>
<th>Funding organization</th>
<th>Project/Programme and Grantee institutes</th>
<th>Highlights of research priorities</th>
</tr>
</thead>
</table>
| Aga Khan Foundation, Switzerland | Aga Khan Rural Support Programme in India (AKRSP) | • AKRSP works to provide infrastructure for drinking water, technical know-how as well as infrastructure for generating alternative energy and fodder growth for cattle and improved governance: AKRSP encourages the formation of a range of organisations at the village, sub-village and multi-village level that are responsive to the needs of their communities and influence local governance structures; it also works at the state level to influence government policies regarding the rights of such groups.  
• AKRSP has reached over 500,000 beneficiaries in over 1100 villages in the states of Gujarat, Madhya Pradesh and Bihar. Over 4000 village organisations have been created. |
| Asian Development Bank, Philippines | Managing natural resources and increasing crop productivity through community watershed management  
*Grantee institute:* International Crops Research Institute for the Semi-Arid Tropics, Patencheru | • The overall objectives of the research were to enhance and sustain the productivity of the medium to high-water holding capacity soils in the intermediate rainfall eco-region of semi-arid tropical Asia (parts of India, Vietnam, and Thailand).  
• The specific objectives of the project were to: characterize natural resource base and identify physical and socioeconomic constraints to increased sustainable cropping in the target ecoregion; apply and refine integrated cost-effective soil, water, and nutrient management practices based on the natural resource endowments of the farmers.  
• The duration of the project was 2003-2006 |
| Consultative Group on Developing integrated science-stakeholder-policy approach to | | • This activity aims to analyze possible risks from climate change to farming systems in Peninsular India, and to examine actual adoption of |
| International Agricultural Research (CGIAR), France | Adaptation in Water and Agriculture sectors in Andhra Pradesh, and Tamil Nadu states of India. Analysis of production risk and farm technology adoption in climate change prone rainfed eco-systems of Karnataka, Andhra Pradesh and Tamil Nadu.  
*Grantee institutes:* International Water Management Institute, Acharya N. G. Ranga Agricultural University, Tamil Nadu Agricultural University, Water and Land Management Training and Research Institute | - adaptation strategies by farmers in the region.  
- The project focuses on climate smart agriculture and land/soil management.  
- Duration of the project is from January 2012 to June 2014. |
| --- | --- | --- |
| CGIAR, France | Research Program on Water, Land and Ecosystems  
*Grantee institute:* International Water Management Institute | - The programme is working to improve the food security, nutrition and livelihoods of smallholder farmers and the rural poor in three Ganges basin.  
- Priority areas include opportunities for improving degraded lands and improving groundwater management while tapping into new energy and fertilizer sources to boost agricultural yields in the plains and promising interventions to combat environmental variability and diversify agricultural and aquacultural systems in the delta. |
<table>
<thead>
<tr>
<th>Organization</th>
<th>Initiative Description</th>
<th>Details</th>
</tr>
</thead>
</table>
| CGIAR, France        | Assessing the combined impact of watershed interventions and projected climatic changes on surface and groundwater availability for agriculture and food security of vulnerable rural men and women in selected watersheds in India.                                                                                                                        | • The project focused on understanding climate impacts on availability of natural resources to rural poor, and on their livelihoods, which is an important part of developing national adaptation programs.  
• The duration of the project was from June 2011 to December 2012. |
| **Grantee institute:** International Water Management Institute |                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                           |
| COOPERNIC, Europe    | Scaling up micro-Irrigation Systems in India, Madagascar and Guatemala (SCAMPIS)                                                                                                                                                                                                                                                                             | • The goal of the scaling up micro-irrigation systems project in India, Madagascar and Guatemala is to improve the livelihoods and food security of 30,000 smallholder farmer households.  
• The project is using micro-irrigation systems and where appropriate uses liquid organic fertilizer systems to address the following challenges: water scarcity and low soil fertility which negatively impact productivity.  
• SCAMPIS aims to improve food security and water water availability for agricultural activities.  
• The complete project is expected to directly benefit 30,000 households.  
• The total budget is Euro 3.0 million.                                                                                     |
| **Grantee institutes:** International Fund for Agricultural Development, Rome; International Development Enterprises – India, New Delhi |                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                           |
| DFID, UK             | Resource Scarcity, Food Security, and Climate Change                                                                                                                                                                                                                                                                                                      | • The programme strives to build global public goods and share India’s lessons and expertise, in order to help to strengthen their approaches to food and nutrition security; and manage resources more efficiently at the food-water-energy nexus. |
| **Grantee institute:** Knowledge Partnership Programme |                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                           |
| DFID, UK | Infrastructure Equity Fund - Investment in small infrastructure projects in India’s poorest states | • The fund seeks to improve access to better quality transport, clean energy and basic urban services for households and businesses, by investing in equity to private sector-led infrastructure projects.  
• The fund is expected to benefit an estimated 280,000 people with improved infrastructure services.  
• Duration of the scheme is from January 2014 to May 2018  
• Project budget is £1,500,000 |
| DFID, UK | Infrastructure Loan Fund - Small loans to bridge the infrastructure gap for the poor | • The fund seeks to improve access to better quality transport, clean energy and basic urban services for households and businesses, by providing loans to private sector-led infrastructure projects.  
• This will benefit an estimated 280,000 people with improved infrastructure services.  
• Duration of the scheme is from October 2013 to 2018  
• Project budget is £37,000,000 |
| European Union | Community based sustainable groundwater management through social regulations and local governance  
*Grantee institute: Centre For World Solidarity Trust, Secunderabad* | • The over-all objective of the project is to ensure equitable and sustained access to water for the wellbeing and livelihoods of all people of selected Gram Panchayats of rural Andhra Pradesh, India.  
• The duration of the project is from July 2011 to June 2016.  
• The grant contribution is € 968,777.00 (89.80% of total). |
| European Union | Establish and demonstrate a people and panchayat led equitable water governance model for Sustainable Economic Development in three Agro-Ecological Zones of India  
Grantee institute: Vrutti Society Bangalore | • The specific objective of the project is to establish and demonstrate a people and Panchayat led model of equitable water governance in 3 agro-ecological zones of India.  
• The duration of the project is from May 2011 to April 2016.  
• The grant contribution is € 900,000.00 (90% of total). |
| Food and Agricultural Organisation (FAO) of UN | Reversing Environmental Degradation and Rural Poverty through Adaptation to Climate Change in Drought Stricken Areas in Southern India: A Hydrological Unit Pilot Project Approach  
Grantee institute: Bharathi Integrated Rural Development Agency, Nandyal, Andhra Pradesh | • FAO is the GEF agency for implementation of the project.  
• The development objective of the Strategic Pilot on Adaptation to Climate Change is to increase the knowledge and capacity of communities to adapt to climate change and climate variability in seven drought-prone districts of Andhra Pradesh.  
• Globally, the project aims to build on existing knowledge and document experiences in integrating climate change adaptation within sustainable land and water management in drought-prone areas.  
• The duration of the project was from 2011 to 2014. |
| GIZ, Germany | Water-Food-Energy: Urban Nexus from Local Perspective- Nashik, Maharashtra, India  
Grantee institute: ICLEI South Asia Secretariat, New Delhi | • The project aims to identify and establish mutually beneficial responses from the inter-linkages between the water, energy, food sectors  
• The project resulted in design and implementation of innovative solutions and programs for optimizing water, energy and land resources in peri-urban agricultural practices  
• The duration of the project was November 2013 to May 2014 |
| International Development Research Centre, Canada | Protecting food, energy, and livelihoods in Punjab through water-efficient agriculture
*Grantee institute:* Punjab Agricultural University, Ludhiana |
| --- | --- |
|  | • Since 2008, Punjab Agricultural University and Columbia University have worked together with farmers to address these unsustainable practices, while maintaining yields and livelihoods.
• The latest phase of research — launched in 2012 with funding from International Development Research Centre — links low-income farmers, corporations, the state development bank, and the state agricultural extension program in testing innovations that will reduce pressure on overused aquifers.
• This initiative is helping farmers use meteorological information to plan their water and energy use, while exploring how policy reforms and agricultural value chains might shift production toward more sustainable practices. |

| International Fund for Agricultural Development (IFAD) | Convergence of Agricultural Interventions in Maharashtra’s Distressed Districts Project
*Grantee institute:* Government of India and State Government of Maharashtra |
| --- | --- |
|  | • The project area includes 1200 villages in the districts of Akola, Amravati, Buldhana, Wardha, Washim and Yavatmal. T
• The project will address issues like low farmers’ productivity, food insecurity, partly as a result of inefficient water use, depleted soil fertility and indiscriminate use of fertilizers and hybrid seeds.
• The project duration is 2009 to 2017 and is expected to directly benefit 286,800 households.
• Total IFAD financing is US$ 41.1 million |

<table>
<thead>
<tr>
<th>IFAD</th>
<th>Integrated Livelihoods Support Project</th>
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</table>
|  | • This project will support poverty reduction in Uttarakhand, a predominantly rural hill state, by promoting sustainable livelihood opportunities for 143,400 rural households.
• Priority target groups include small rural producers, women, scheduled-caste households and young people.
• The duration of the project is 2011 to 2018
• Total IFAD financing is US$ 89.9 million |
<table>
<thead>
<tr>
<th>Organization</th>
<th>Program/Project</th>
<th>Description</th>
</tr>
</thead>
</table>
| Japan International Cooperation Agency | Ganga River Pollution Control | - Japan International Cooperation Agency is supporting one project on Ganga in Varanasi worth Rs 4969 million (GBP 53.7 million) on 85:15 basis.  
- The aim is to ensure effective abatement of pollution and rejuvenation of the river Ganga by adopting a river basin approach and to maintain minimum ecological flows in the river. |
| Ministry of Foreign Affairs in Norway, through the Royal Norwegian Embassy, New Delhi | ClimaAdapt | - The primary objective of ClimaAdapt is to improve the adaptive capacity of the farming communities and agriculture and water sectors in the states of Andhra Pradesh and Tamil Nadu in India.  
- The project was initiated in April 2012 and will be completed in May 2016. |
| Rockefeller Foundation, USA | Enhancing climate resilience of Gorakhpur city by buffering floods through climate resilient peri-urban agriculture | - The project focuses on demonstrating the importance of ecosystem services such as flood buffering for addressing climate change impacts in Gorakhpur city.  
- The key strategies being implemented under this project are to develop models of climate resilient integrated agriculture-horticulture-aquaculture-livestock systems in small marginal land holdings in the peri-urban context employing a diversity of water system.  
- The duration of the project is 2011-2015 |
<table>
<thead>
<tr>
<th><strong>Swiss Agency for Development and Cooperation (SDC), Switzerland</strong></th>
<th><strong>Extension Program on Climate Change Adaptation (CCA) in Rural Rainfed Areas of Maharashtra, Madhya Pradesh and Andhra Pradesh in India</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grantee institute:</strong> Watershed Organization Trust, Pune</td>
<td><strong>The project aims at enhancing the capacities of rural communities to adapt to climate change effects by adopting a comprehensive and integrated approach that aims at various Nexus issues, including ecologically friendly and weather-responsive agriculture, water budgeting to match water availability with demand, “precision farming” that optimizes land and water productivity in field conditions, and renewable energy for household cooking and lighting.</strong></td>
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<td><strong>It also aims at developing practical knowledge, tools and systems that can be widely adopted thus facilitating upscaling.</strong></td>
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<tr>
<th><strong>SDC, Switzerland</strong></th>
<th><strong>Rural Innovation Fund</strong></th>
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<td><strong>Grantee institute:</strong> NABARD</td>
<td><strong>The Fund was institutes with the corpus of Rs 1399 million (GBP 15.1 million) in 2005-06.</strong></td>
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<td></td>
<td><strong>Sectors to be considered for support include dryland/ rainfed farming, innovative rainwater harvesting, rural energy from biomass/ agricultural wastes, techniques for increasing the value of crop residues and non-crop biomass, community regulation of distribution and use of water and energy, storage devices for agricultural and rural products, and others.</strong></td>
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<td><strong>Cumulative disbursement as on 31 March 2014 stood at Rs 669.5 million (GBP 7.2 million).</strong></td>
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<tr>
<th><strong>The Andheri Hilfe Bonn, Germany</strong></th>
<th><strong>Rural development and resource management</strong></th>
</tr>
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<td></td>
<td><strong>The programme supports projects in which marginal farmers take their fate into their own hands: discuses measures to be taken on their fields to avoid erosion and to improve water management (e. g. watershed development: contour-bunding, re-charging water sources, rising ground-water table).</strong></td>
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<td><strong>Pesticides and chemical fertilizers are not used by these farmers but are replaced by self-produced biological alternatives like compost.</strong></td>
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<td><strong>Bio-gas installations and energy-saving stoves reduce the use of fire wood and contribute to achieve sustainability.</strong></td>
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</table>
| **The Bill and Melinda Gates Foundation, USA** | Agricultural water management for small-scale agriculture in sub-Saharan Africa and South Asia  
**Grantee institutes:** International Water Management Institute, International Food Policy Research Institute, Stockholm Environment Institute, Food and Agriculture Organization of the United Nations, International Development Enterprises, CH2M Hill Inc. | • The main objective of this project is to help design agricultural water management strategies for smallholder farmers in sub-Saharan Africa and in India.  
• In India, the project is implemented in Madhya Pradesh and West Bengal.  
• The goal of the project is to stimulate and support successful agricultural water management investment, policy and implementation strategies. |
| **US Agency for International Development (USAID), USA** | Promotion of off-grid renewable energy projects  
**Grantee institute:** Chhattisgarh Renewable Energy Development Agency | • As part of this initiative, USAID will help design and implement a state level off-grid fund, and support in the development and implementation of pilot programs including smaller micro-grids (localized and decentralized electricity grids) for irrigation and other energy use. |
| **USAID, USA** | Water-Agriculture-Livelihood Security in India program  
**Grantee institute:** Centers for International Projects Trust (affiliated with Columbia University) | • The programme will help improve farmers’ livelihoods and food security in Punjab, Gujarat, and either Bihar or Jharkhand – all significant contributors to India’s overall food security.  
• The programme will support local farmers to test and scale up innovative and integrated water and energy saving technologies and practices.  
• The grant amount is $1.7 million grant |
| World Bank, USA | Assam Agricultural Competitiveness Project | The objective of the Assam Agricultural Competitiveness Project is to increase the productivity, and market access of targeted farmers and community groups.  
*Grantee institute: Government of Assam*  
- Key indicators of success would be increased yields of crops, fish and livestock products - complemented by an increase in the proportion of marketed surplus.  
- The duration of the project is 2004-2015.  
- The grant amount committed is US$ 154.00 million. |
| World Bank, USA | Rajasthan Agricultural Competitiveness Project | The objective of the project is to demonstrate the feasibility of a range of distinct agricultural development approaches integrating technology, organization, institution and market innovations across selected regions of Rajasthan – each marked by different agro-ecological, climatic, water resource and social conditions – capable of significantly increasing agricultural productivity and farmer incomes.  
*Grantee institute: Government of Rajasthan*  
- The duration of the project is 2012-2019.  
- The grant amount committed is US$ 109 million |
| WWF, USA | Producing more food grain with less water- Promoting farm-based methods to improve water productivity | This partnership between WWF and ICRISAT is aims to find solutions to the most pressing issue – the water productivity in agriculture.  
*Grantee institute: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru*  
- The project works on two fronts: a) improving the water productivity in agriculture by making interventions at the farm level and b) developing policy frameworks to scale up such approaches to have an impact at national and river basin levels.  
- Due to efforts of the WWF-ICRISAT project and many other national partners, it is estimated that about 600,000 farmers are growing rice with all or most of the recommended System of Rice Intensification (SRI) crop management practices on about 1 million ha distributed across 300 districts of the country. |
Sources

Websites

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Embassy of the United States in New Delhi <http://newdelhi.usembassy.gov>
European Union <europa.eu/index_en.htm>
Food and Agricultural Organisation <www.fao.org>
International Development Research Centre <www.idrc.ca/>
International Fund for Agricultural Development <www.ifad.org/>
Ministry of Foreign Affairs in Norway, through the Royal Norwegian Embassy, New Delhi <www.norwayemb.org.in>
Rockefeller Foundation <www.rockefellerfoundation.org/>
Swiss Agency for Development and Cooperation <https://www.eda.admin.ch/sdc>
The Andheri Hilfe Bonn <https://www.andheri-hilfe.de/about-us-andheri-hilfe.html>
The Bill and Melinda Gates Foundation <www.gatesfoundation.org/>
USAID <www.usaid.gov/>
World Bank <www.worldbank.org/>
WWF <www.wwfindia.org>