7
Water Sustainability and Power Generation in INDIA

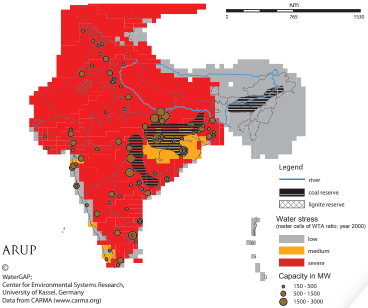
7.1 Local water challenges

7.1.1 Water availability

Growing water scarcity is evident in India due to falling groundwater tables and declining river discharge. This is despite annual utilisable resources of 1,122,000 gigalitres (GL).[45] Seasonal and regional precipitation patterns, such as the South West Monsoon, compound water management challenges. For example, many areas experience localised severe water shortages before the summer rains and are then subject to flooding during the monsoon period. Water resource development across India is also highly variable due to climatic and social factors. Experiences in the semi-arid west are, for instance, very different to those in the wetter eastern areas. **Figure 7** shows that across India, all river basins are water stressed with the exception of areas of eastern India and isolated pockets in the South West.

Figure 7:

Overview of the water withdrawal-to-availability ratio calculated by WaterGAP. This shows low, medium and severe water stress in river basins across India. The location of selected power stations (>150 MW) is also indicated.

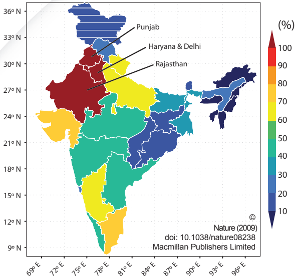


Water use in India is often unsustainable; the most significant cause is the overexploitation of groundwater, which is clearly illustrated in **Figure 8**. These groundwater resources underpin irrigated agriculture across India and occasionally conflicts arise with the power sector using groundwater resources for boilers and associated processes. **It is vital for financial institutions to understand that limited water availability and potential conflicts with competing users may affect the business operations of (newly planned) power utilities.**

See PI-TP 5 & 10

Figure 8:

Groundwater withdrawals as a percentage of recharge. The map is based on state-level estimates of annual withdrawals and recharge as reported by the Indian Ministry of Water Resources.[46,47]



Water stresses in the country are already having a significant impact on power generation. For example, in 2008, the National Thermal Power Corporation's Sipat plant was shut down due to lack of water supply from the Chattisgarh state, and thermal plants currently under construction in Orissa state are undergoing delays due to water allocation issues.[48] Furthermore, in June 2009, country widehydropower output dropped by over 9% due to the low availability of water.[49]

7.1.2 Climate change impacts

By 2050, freshwater availability, particularly in large river basins, is projected to decrease. In part, this will occur as a result of the continued shrinking of Himalayan glaciers and the discontinuation of their critical function: the storage of water and its gradual and uniform release over long and potentially dry periods of time. Studies also indicate that India will reach a state of water stress before 2025 when the availability is projected to fall below 1'000 m^3 per capita.[50] Additionally, increased temperatures alone will have an impact on electricity sector, as can be seen by the 2007 heat wave in Maharashtra which led to power shortages of 20% in the state and 9% across the country.[51] An outlook on how water availability (shown in **Figure 3**) is expected to change is provided by the University of Kassel.[52]

7.1.3 Water quality

Deteriorating water quality from untreated industrial and domestic effluent and municipal pollution limits available water supplies. Naturally occurring water quality problems can also impact on availability; high fluorine in Rajasthan and arsenic content in West Bengal are cases in point.

7.1.4 Institutional/regulatory context

Water resources are traditionally managed at the state level; however, the Ministry of Water Resources is responsible for policy guidelines and regulation of water at the federal level. In India, the use, management and ownership of water is often linked to land or irrigation structures, rather than the resource itself; hence property rights to water are poorly defined.[53] This lack of clarity contributes to the complexity and high cost of legal disputes over water. There is growing recognition that these laws need to be amended and international attention is beginning to focus on this issue.

Given the pressing need to manage demand, and re-allocate water in closed basins, uncertainty with regards to institutional responsibility, water policies, environmental regulation and property rights requires attention.

7.1.5 Transboundary water management

See PI-TP 10

India has a number of transboundary rivers and shares water with Pakistan, Bangladesh and Nepal. The water-sharing agreements between these countries, particularly with Pakistan, can be a source of tension. Inter-state water conflicts are also prevalent due to the federal system in India and are exacerbated by uncertain rights to water at the State level. A notable example is the dispute between Tamil Nadu and Karnataka over the Cauvery River.

7.2 The electricity power sector in India

With a population in excess of 1.1 billion, rapid economic growth and rising per capita power consumption, the demand for energy resources in India is increasing markedly. Whilst power generating capacity is growing, it is outstripped by demand. Some 40% of households particularly in rural areas are without access to electricity.[54]

India's power sector is dominated by thermal power plants with an installed capacity of 93 GW, this accounts for over 80% of electricity provision[55] (with hydropower, natural gas and nuclear sharing the remaining 20%).[56] Coal fuels the majority of these plants (53%). Associated thermal power plants are often located close to coal deposits in central areas, **Figure 8** (above).[57,58]

Significant fuels sources other than coal are oil, which provides 30% of energy for electricity production followed by gas (8%), hydropower (6%), nuclear (2%) and other renewables such as solar power generation provide less than 1%.

7.2.1 Expansion

According to a recent WRI report, 79% of new generating capacity will be built in already water stressed areas,[59] implying numerous financial impacts. Future trends will include greater reliance on gas technology, and the development of a wider nuclear programme given recent agreements on nuclear cooperation with the United States and France. A further trend is the development of India's substantial hydropower capacity, of which only 20% has been developed to date.[60] Government policies and targets are set out in 5 year plans. For the current plan (2007-2012), the government has set a thermal capacity expansion target of 60 GW of new capacity, which represents an increase of approximately 60%. This will be achieved through the development of Ultra Mega Power Projects or large thermal power projects producing about 400 MW each.[61] However, any expansion is constrained by limited water resources. The location of current thermal power plants is dictated by available water resources with many power plants being built in coastal locations in order to use seawater for cooling purposes (see also case study on following page). **By asking the right questions, financial institutions can play a role in carefully identifying and therefore minimising risk exposure due to water availability. Financial institutions should ensure that company's are using climate and hydrological information to assess not only present day risk, but also take into account future risk from climate change on sensitive water resources.**

See PI-TP 4 & 6

7.2.2 Renewable energy (hydro)

India has great capacity to increase the levels of hydro-electricity produced and is ranked 5th in the world for usable potential for hydropower development. These sites are predominantly situated in the mountainous regions in the north and north east of the country (states such as Himachal Pradesh, Sikkim and Uttaranchal).[62]

See PI-TP 1 to 22

In addition neighbouring Nepal has the potential to generate hydroelectric power and export electricity to India. Implementation and development of these schemes has been hindered by concerns about the environmental and social damage caused by large dams, the possibility of seismic risk in earthquake zones and the long gestation and capital intensive nature of these projects.

There is also renewed interest in small scale hydro-power generation as this is associated with fewer environmental risks and will contribute to the Indian Government's goal of increasing rural electrification. As with large-scale projects, there are a number of recognised barriers to implement these schemes, including technical challenges and costs. [63]

7.2.3 Other

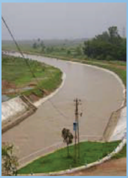
India's power sector is dominated by state companies and characterised by a lack of foreign investment. This limits the ability to source capital investment to improve basic infrastructure. In recent years, the government has attempted to revitalise the sector by introducing a number of policy measures aimed at encouraging private sector participation.[64] The most significant move to reform is the Electricity Act of 2003, an incremental piece of legislation aimed at liberalising the power generation sector. The reforms have hadmixed success, in part due to the sheer size and complexity of the sector and also the reluctance of the State Electricity Boards to accede to the new framework.[65] In addition to these reforms are the ambitious targets of the 11th and 12th Five Year plans, the latter calling for more than 100,000 MW of additional power generation between 2012-2017. There is optimism that these targets may be achieved, in part because the effects of policy reform and the expected increase in private sector participation by the 12th Five Year Plan (*ibid*).

A further issue is that efficiency within the grid is low, with transmission and distribution losses averaging 26% of total electricity production. When non-technical losses such as energy theft are included in the total, average losses are as high as 50%; according to the Ministry of Power.[66]

Case study: Competing demands at the Hirakud reservoir

The Hirakud Reservoir is situated in the central zone of the Mahanadi river basin in the Eastern Indian State of Orissa. Completed in 1957, the dam has a multi-purpose function for flood control, irrigation and hydro-power generation. Recent increases in the allocation of water for industrial purposes and thermal power plants have resulted in a series of protests by farmers who are concerned about water shortages. The largest of these protests in November 2007 involved over 20,000 farmers and resulted in political turmoil at the State level.

See PI-TP 10



The government promised that 'not a drop of water for irrigation would be given to industry and water deficits would be met by reducing the water available for hydro-power generation.

This competition over water between different sectors of the economy has continued and in 2009, the State Government was forced to defer Mega-Power projects in the region due to farmer opposition. Those plants which have been given conditional permission have been asked to use seawater for cooling purposes rather than river water to avoid placing further pressure on the Mahanadi river basin.

Source: [67, 68]

8

Water Sustainability and Power Generation in BRAZIL

8.1 Water challenges

Brazil is a prime example of a region where water pressures and resulting financial risks are not solely a consequence of chronic water shortages or prolonged droughts, but also unsustainable water management and agricultural or industrial pollution of water resources.

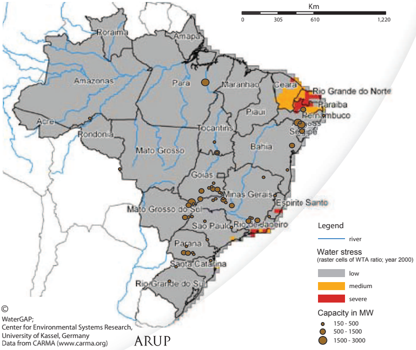
8.1.1 Water availability

Brazil has abundant water resources with approximately 12% of the world's available freshwater resources. Important sources of water include the Amazon River basin, Tocantins-Araguaia river basin and the São Francisco river basin.

While the average availability of water across the country is high, the North-eastern region has an arid climate with only 3% of the country's water resources, but almost 30% of the population. In this area river basins that are classified as water stressed are illustrated in **Figure 9**. Water stressed regions also exist in the south where much of Brazil's urban population is found. Competing uses in the area, further enforced by poorly maintained and managed water supply systems, have led to water conflicts.

Figure 9:

Overview of the water withdrawal-to-availability ratio calculated by WaterGAP. This shows low, medium and severe water stress in river basins across Brazil. The location of selected power stations (>150 MW) is also indicated.



8.1.2 Climate change impacts

A detailed assessment of different climate change scenarios and their impact on water resources and agriculture is beyond the scope of this briefing, however key issues are worth highlighting. For example, the potential consequence of changing rainfall patterns which may cause decreases in water availability and erratic rainfall patterns. In the semi arid north-eastern region, model simulations suggest that by the middle of the 21st century, annual average river runoff and water availability will decrease. An outlook on how water availability is expected to change (shown in **Figure 3**) is provided by the University of Kassel.[69] These changes to water availability will have direct consequences for the electricity power sector.

See PI-TP 6

8.1.3 Institutional/regulatory context

The *National Water Resources Policy* (Law 9.433/97) provides guidance on water sustainability issues. It introduced the following fundamental premises for water management in Brazil: (i) water as a public good; (ii) water as a limited resource, with economic value; (iii) priority for human consumption and watering livestock; (iv) use of water by several sectors (challenge of preventing conflicts on water use); (v) river basins should be the planning and management unit; and (vi) participative management.

The regulation of water use in Brazil is based on a framework that promotes the "user pays" and "polluter pays" principle. For São Paulo state for example, law n°12.183/05 entitled "Disposition on charges for water use in São Paulo State" and its implementation decree n°50.667 of March 2006 provides regulation. **In light of sharpening federal regulation on water, financial institutions should encourage clients to comply with emerging regulation in Brazil before it becomes mandatory.**

See PI-TP 7 & 8

Watershed and basin committees have recently formed and have introduced voluntary water-user fees. In general, fees are collected by the local water management agency to redistribute a proportion to local watershed management committees. Similar schemes, based on payments for ecosystems services are increasingly common.[70]

See PI-TP 10

8.2 The electricity power sector in Brazil

Brazil's energy mix is characterised by renewable sources.[71] Hydropower plants represented the vast majority (77%) of Brazil's internal electricity production in 2007. The reminder of the national electricity mix consisted of thermal power (14.5%) and imported energy (8.5%).[72]

The largest hydropower station in operation is Itaipu, on the border with Paraguay at the Parana River. Itaipu, although not the world's largest hydropower plant, does generate the most electricity and has an installed capacity of 14 GW, with 20 generating units of 700 MW each. Other hydropower plants are concentrated in central-southern Brazil which is the most developed part of the country.

With regard to thermal power plants, their contribution to the electricity mix has increased over recent years. Thermal power stations have played an important role in providing electricity during peak demand periods and droughts when water levels in reservoirs are low. They also supply towns and communities that are not connected to the national electrical grid.[73] Thermal power plants are fired by biomass, natural gas, petrol derivates, nuclear and mineral coal. These sources of energy accounted for 4.1%, 3.3%, 2.8%, 2.6% and 1.6% respectively within the Brazilian electricity mix of 2007.[74]

8.2.1 Expansion

Brazil's hydroelectric potential is immense (more than 100,000 MW), yet estimates vary.[75] This potential includes small, medium, and large size dams. Brazilian's regulations define small dams as less than 30 MW, medium dams as less than 500 MW, and large above this limit. Approximately, 40% of the potential is located in the north of the country.[76]

Various dams are currently being assessed, funded or built and there are prospects for many others to be realised in near future.[77] However, a key requirement for new reservoirs and schemes under Brazilian Legislation is an Environmental and Social Impact Assessment.

See PI-TP 1 to 22

Financial institutions have the ability to influence the approaches used to realise the country's electricity generation capacity. Besides requirements of the statutory process, wider sustainability frameworks can help to assess the sustainability issues at stake.

Expansion of gas-fired thermal electric power is hampered by the limited pipeline network (availability of gas), in addition to the high cost of this fuel source.[78]

8.2.2 Renewable energy (biomass)

The use of biomass as a source of electrical energy has increased in Brazil, notably in co-generation systems belonging to the industrial and agricultural sectors. The term "biomass" includes many types of industrial and agricultural residues, such as sugar cane bagasse, black liquor (cellulosic pulp residue), wood waste, rice husk and biogas. Generally, few power plants with installed power capacity up to 60 MW use biomass as a fuel. . These are located close to industrial users, and are scattered across the agricultural hotspots.[79]

8.2.3 Other

Petrol derivates such as diesel, residual fuel oil, ultra-viscous oils or refinery gas are used to fuel thermal power stations.

Water permitting and water sustainability of a new Thermal Power Plant in Brazil

See PI-TP 10

The coal-fired plant President Medici (UTPM) in the State of Rio Grande do Sul is looking at an expansion scheme (Candiota III, new phase C) to deliver an additional capacity of 335 MW. The Brazilian environmental agencies have granted a Water Usage Permit (outorga) and the Installation License. On the basis of studies on water availability and water demand the outorga was granted for the Arroio Candiota River Basin. It outlines a maximum withdrawal rate of 292 L/s, operating 24 h/day, 365 days per year. According to the National Water Agency this rate will ensure a minimum flow of 187 L/s downstream of the dam supplying water to the power plant.

See PI-TP 2 & 7

No water user fee is established in the river basin where UTPM operates and the region is not classified as water stressed according to the WaterGAP analysis. (see Figure 4). The project plans the adoption of a semi-dry desulphurization system for coal, which is characterized by low water consumption and does not generate liquid effluent. The cooling system of the thermal engines is semi-open (evaporative cooling tower).

Sources: [80,81]