climate change

REPORT OF THE CHAOPHRAYA DIALOGUE TASK FORCE

A collaborative evaluation
by Jinnah Institute and Australia India Institute

Acknowledgements

Authors:

Shafqat Kakakhel

Ahmad Rafay Alam

Rohan D'Souza

Mohan Guruswamy

Shakil A. Romshoo

Javed Iqbal

Peer Reviewers:

Dr. Adil Najam

Rohan D'Souza

Australia India Institute

JINNAH INSTITUTE

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JINNAH INSTITUTE

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The Australia India Institute (AII) is a leading centre for the study of India. Through its teaching, research, public policy, and outreach programmes, it is building Australia's capacity to understand India. AII is also a hub for dialogue, research, and partnerships between India and Australia. Based at the University of Melbourne, the Institute hosts a growing range of programmes that are deepening and enriching the relationship between the two countries.

The University of Melbourne established the Australia India Institute in October 2008. In 2009, funding for the Institute was provided by the Australian Government Department of Education, Employment, and Workplace Relations. The University of New South Wales and La Trove University were also founding partners. In 2012 the Department of Industrial Innovation, Science, Research, and Tertiary Education and the State Government of Victoria provided additional core funding. The Ministry of Culture, Government of India, is funding a Tagore Centre for Global Thought at AII - one of three Centres globally that are being funded by the Government of India. AII will host a Chair in Indian Studies, funded by the State Government of Victoria and the University of Melbourne and a Visiting Chair in Indian Studies sponsored by the Indian Council for Cultural Relations.

CLIMATE CHANGE

Report of the Chaophraya Dialogue

"You can partition land, but you cannot partition the monsoons, aquifers, the Himalaya or consequences of climate change."

The Task Force on Climate Change was established by the conveners of the Chaophraya Dialogue, a joint India-Pakistan Track II initiative, and from a realization of the critical impact of the adverse impacts of climate change and environmental degradation on the existing regional fault-lines in South Asia.

Over the years, the Chaophraya Dialogue has primarily aimed to give informed members of the strategic communities in both India and Pakistan an opportunity to interact with each other on a sustained basis. Undertaken by the Melbourne-based Australia India Institute (AII) and Islamabad-based Jinnah Institute (JI), the process has so far led to twenty rounds of dialogue and is now completing its seventh year.

The idea to convene two policy Task Forces was first raised in 2014. Given South Asia's natural vulnerability to the pressures of changing monsoon patterns, rising sea-levels and other effects of climate-change, the need for a sustained working group of climate change experts from India and Pakistan to devise policy recommendations was keenly felt. Ahead of the 21st U.N. Conference on Climate Change in Paris in December 2015, the mainstay of this Task Force was to identify shared challenges of trans-boundary water sharing, aquifer protection, food insecurity, glacial melt, and wildlife conservation; bypass strategic differences to find common ground; and to generate recommendations for potential collaboration that could gradually be mainstreamed into public discourse and taken up by policymakers on either side in a bid to bolster South Asian responses to climate change.

The Climate Change Task Force brought together a senior body of experts from India and Pakistan over the course of eight months to meet and engage in Bangkok and Colombo, and work on their respective chapters geared towards addressing climate change challenges in both countries.

EXECUTIVE SUMMARY

The fourth and fifth assessment reports of the Inter-Governmental Panel on Climate Change (IPCC) issued in 2007 and 2013-14 respectively and a number of studies carried out by UN agencies, multilateral financial institutions and climate research projects have highlighted the growing vulnerability of the South Asian region, especially India and Pakistan to all the major negative impacts of climate change. These findings have been corroborated by scientific studies produced by relevant Indian and Pakistani institutions.

Population growth, widespread poverty, huge dependence on agriculture, natural resources, and ecosystems for economic growth and livelihoods, critical reliance on the Himalaya glaciers and monsoons for surface and groundwater, and fiscal and human resource constraints inhibiting development and deployment of newly developed technologies for mitigation and adaptation to climate change are just some of the common factors facing the subcontinent. India and Pakistan are therefore highly vulnerable to the impacts of climate change. Climate change impacts are expected to further exacerbate the existing hydraulic endowments and patterns in the historical use of water resources in South Asia: in particular a) rising sea levels; b) rapid ice and snow melt in the high altitude glaciers; c) disruption in monsoon patterns and d) more frequent and longer lasting extreme events such as floods, droughts, heat waves, cyclonic storms and higher temperatures. The impact of climate change will arguably also fatally amplify several of the existing economic and political fault-lines of the region.

India and Pakistan have yet to comprehensively respond to the current and anticipated effects of climate change. Both countries have however, adopted several climate change policies and prepared action plans for mitigation and adaptation. High-level inter-ministerial bodies on climate change have been established, and are being headed by the countries' respective Prime Ministers. Domestic and external financial resources have also been mobilized to implement specific climate action plans. Efforts are underway to develop climate-friendly technologies particularly in the field of renewable energy. Disaster risk reduction and management capacities for coping with climate-induced natural disasters are also being sought to be augmented. Moreover, governments and civil society organizations are also trying to enhance public awareness of the risks posed by climate change. However, these measures fall far short when it comes to addressing the entire spectrum of impacts that climate change might have on the region.

Climate change poses some of the most profound challenges to water, food, and energy security in India and Pakistan. The human, ecological, and monetary costs of climate change have the potential to make or break trajectories of economic growth in both India and Pakistan, and leave a lasting impact on the quality of life available to the region's teeming millions. The climate change narrative in the subcontinent is therefore an alarming one, which calls for more urgent policy interventions in both countries on an individual as well as bilateral basis.

The vulnerabilities shared by India and Pakistan offer opportunities for both countries to jointly address the impacts of climate change. The measures undertaken by them to mitigate climate change impacts provide a framework of cooperation. The accident-prone bilateral dialogue between India and Pakistan has all along focused on resolving differences and disputes rather than exploring areas of mutually beneficial cooperation, although the agenda of the joint ministerial commission provided possibilities of moving beyond conflict resolution. Given the immediacy and urgency to work on the effects of climate change, and the possibility of cooperation and mutual interest, the two countries should immediately pursue an appropriate mechanism and commence working together on this issue.

The following are some of the themes that offer immense scope for potential collaborative efforts between institutions, governments, and communities in India and Pakistan, where the nature of the problem is familiar, solutions similar, and cooperation both possible and mutually beneficial.

WATER

Water connects India and Pakistan rather than divide them. This is because the basin hydrology of the Indus Basin aquifer does not respect the concept of sovereign nation states.

India and Pakistan represent almost all of the demands on the resources of the Basin, which in turn supplies the needs for approximately 300 million people within and millions more outside its catchment. However, unlike India, which has other water sources and river basins, Pakistan is critically dependent on the Basin as its only major water source. Nevertheless, the India Central Electricity Authority has identified as much as 33,828 MW of hydropower potential in its part of the Basin alone; With this potential, a major component of India's plans for economic development is intended to be met.

Growing populations, increasing water withdrawals, and increasing water scarcity in the Basin is expected to have long-term impacts on food production and livelihoods inside and outside the Basin.

Water management in the Basin is a State/Provincial responsibility and thus the water- and food-security impacts and corresponding plans and policies of these intra-State stakeholders will play out on completely different and unconnected scales to the Indus Waters Treaty, 1960 (IWT) or the Delhi-Islamabad centric Composite Dialogue. These new areas offer fresh opportunities for both countries to develop a "peace constituency" that can support formal dialogue between the two countries.

The subject of water in the Indus Basin has been restricted to bilateral discussion around the IWT, which is primarily a surface water document negotiated at a time before issues such as climate change became mainstream, and before technologies could help understand the conjunctive flow of surface and ground water in the basin.

There is no scientific understanding, leave alone legal agreement, on how the aquifer of the Basin is to be utilized. Ground water comprises approximately half of the water resource tapped in the Indus Basin, yet because of the hegemonic and securitized discourse around the treaty, many subjects such as better irrigation practices, crop productivity, and most importantly, food security have been ignored. A framework of action centered on a better understanding of the aquifer is necessary for policy formulation and moving forward.

The joint management of shared water resources between India and Pakistan - involving regional or basin-basin approaches for equitable and sustainable initiatives - have yet to be meaningfully explored.

Identification of basin aquifers, especially transboundary aquifers, the mapping of their spatial distribution and monitoring thereof will be a major step in understanding the groundwater hydraulics of the Basin.

Such identification etc. should be undertaken by joint academic studies, and findings should be made the basis for better groundwater regulation in both countries. In addition, the findings of such studies will aid operationalization of Article VI and VII of the IWT that call for regular exchange of data between India and Pakistan as well as the "optimum development of the rivers."

More study needs to be undertaken on the relationship between energy and water, especially in the context of subsidized electricity tariffs for tube wells in both countries.

Joint hydropower development projects in Jammu & Kashmir will help build trust between the two countries as well as exploiting the hydropower potential of the basin for economic development.

AGRICULTURE AND FOOD SECURITY

Agriculture plays a vital role in India's economy. Over 58 per cent of the rural households depend on agriculture as their principal means of livelihood. Agriculture, along with fisheries and forestry, is one of the largest contributors to the Gross Domestic Product (GDP) of the country.

Agriculture is the biggest employer by far, as revealed in the 2011 Census, whereby 118.9 million cultivators across the country comprised 24.6 per cent of the total workforce of over 481 million. In addition, there are 144 million persons employed as agricultural labour. If we add the number of cultivators and agricultural labourers, it would be around 263 million or 22 per cent of the population of 1.2 billion.

With 157.35 million hectares, India occupies the world's second largest agricultural land area. However, the average size of operational holdings has almost halved since 1970 to 1.05 ha. Over two thirds of Indian agriculturists are small and marginal farmers.

According to the 2001/2002 Agriculture census, only 58.1 million hectares of land was actually irrigated in India. The total arable land in India spans 160 million hectares, of which only about 35 per cent of total agricultural land is reliably irrigated. India's irrigation is now mostly groundwater and well based, which accounts for 39 million hectares (or 67 per cent of its total irrigation).

The ultimate sustainable irrigation potential of India has been estimated in a 1991 United Nations' FAO report to be 139.5 million hectares, comprising 58.5 mha from major and medium river-fed irrigation canal schemes, 15 mha from minor irrigation canal schemes, and 66 mha from groundwater-well fed irrigation.

The total food grains production in India reached an all-time high of 251.12 million tonnes (MT) in the Financial Year 2015 (as per 3rd Advance Estimates).

By the year 2050, India's population is expected to reach 1.7 billion, which will then be equivalent to nearly that of China and the US combined. A fundamental question then is: can India feed 1.7 billion people properly? If the food availability is bad now, what is likely to be the situation in 2050 when India will have an additional 430 million mouths to feed and also a much higher per capita income?

The agricultural industry of Pakistan is the backbone of its economy. It provides food to consumers and fiber for the domestic industry; it also provides livelihood and employment to the majority of the country's population, and is the major source, directly and indirectly, of the country's export earnings.

About 45 per cent of Pakistan's labour force is employed in the industry. More importantly, 66 per cent of the country's population living in the rural areas is directly orindirectly dependent on agriculture for its livelihood. Additionally, almost 68 per cent of the country's exports are agro-based. With that, it is safe to say that Pakistan's economy depends largely on agriculture.

The world's largest canal irrigation system also lies within Pakistan, with the total length of canals in the country spanning 56,073 km. Pakistan's surface flow in the Indus basin system is 145 MAF annually. The water mined from underground aquifers, which is around 40 MAF annually, is not a renewable water source. Pakistan is rapidly sprinting from a water-scarce country to becoming a water-stressed country, on the cusp of becoming being hit by a water-famine. Since the majority of land holdings are of less than five acres, the income patterns of households owning them become highly vulnerable to the vagaries of weather and economic shocks.

Pakistan's population is expected to exceed 300 million by the year 2050. Currently, its population stands at 188 million. In order to successfully meet the hunger needs of its forecasted population growth, Pakistan will by then need to produce at least 50 per cent more food than what it does today.

India and Pakistan need to dramatically increase food production to meet the demands of a growing population.

India and Pakistan are inefficient producers of food grains and agro-commodities like sugar and cotton. Since they share agro-climatic zones, both can mutually benefit by sharing their knowledge and experience. Exchange of research and experience-derived knowledge should be routinely exchanged.

Both countries are increasingly facing the stresses of water shortages and are increasingly dependent on aquifers for irrigation. Both share the waters of the Indus basin, which is also Pakistan's only river basin. The aquifers of Punjab, Rajasthan and Sindh, are also jointly shared. It is vital that both India and Pakistan jointly map the aquifers, and jointly plan on how best to use these resources and to replenish them.

India and Pakistan have both rendered agriculture largely uneconomic with exorbitant subsidy regimes at a large cost to the rest of their economies. Their proximity makes them susceptible to emulation of bad practices. For instance, electricity and water are provided free of cost, and production sustained by minimum support prices in the Punjab provinces of both countries. Since the two countries need to retain a price equilibrium, it would make sense for them to jointly understand how to make agriculture commercially viable in a freer market environment.

Due to a complementarity in the production of commodities like cotton, sugar, fruits, and vegetables, India and Pakistan could vastly improve efficiencies of production by allowing a freer import/export regime.

CRYOSPHERE

In the past few decades, global climate change has had a significant impact on the high mountain environment including snow, glaciers and permafrost that are particularly sensitive to the changes in the atmospheric conditions because of their fragility. The Intergovernmental Panel on Climate Change (IPCC) reports that the glaciers in the Himalaya are receding faster than in any other part of the world since 1850, and the receding and thinning of the Himalayan glaciers can be attributed primarily to global warming due to anthropogenic factors such as the emission of greenhouse gasses, aerosols with black carbon and dust, deforestation, forest fires, and human-induced pollution. Concern has been raised that climate change may reduce the glaciers and their capacity to store water, as well as the amount of seasonal snow available for melting. It has been observed that a majority of the glaciers in the mountainous Himalayan region are losing mass in response to the climate change. Glaciers in much of the Himalaya are declining, some at higher rates compared to the global averages and the receding trend of these glaciers is expected to continue during the 21st century. With the melting of the Himalayan glaciers, climate related risks are expected to increase in near future in the entire south Asian region. In the long term, there can be no replacement for water provided by glaciers that could result in water shortages on an unparalleled scale in the region, and adversely affect livelihoods and economy.

The glacier cover in the entire Himalayas is about 40,000 km^2. Nearly 11.5 per cent of the total area of the Upper Indus Basin (UIB) is covered by perennial glacial ice including most of the largest valley glaciers, the largest area outside the polar and Greenland regions. Serious concerns have been raised about the impact of climate change on the Himalayan Cryosphere, based on an assessment of given temperature changes in line with global climate change projections, and subsequent expectations of significant decreases in river flow in those originating from the Himalaya. Reports of significant retreat and depletion of glacier volume across the Hindu Kush Himalayan region have supported these concerns. It is pertinent to mention here that the two countries share the waters emanating from the Himalaya under a cooperative mechanism outlined in the Indus Water Treaty (IWT). There are however, significant gaps in knowledge about the effects and impacts of climate change on Himalayan glaciers and other water resources and that has given rise to several myths and misunderstandings. The effects of climate change are quite visible in the region, with its notable adverse impacts on the cryosphere, hydrology, land system practices, forestry, and even the livelihood of the communities inhabiting the catchment areas of the rivers originating from Himalayas. It is therefore necessary that the two countries, India and Pakistan, should work on developing a mechanism for cooperation for understanding the impacts of chaning climate on various sectors that are dependent on the Himalayan Cryosphere.

A lack of credible data and studies poses a major limitation to accurately assessing the impacts of climate change on the cryosphere and various dependent parts of the environment. The two countries need to cooperate to bridge the gaps in knowledge about the status and health of the cryosphere under changing climate conditions in the region.

There are indications to suggest that there is an increase in the incidence of glacial lakes and outburst floods in the Himalayas that could be associated with glacial retreat. The emerging glacial lakes have potential to damage infrastructure and threaten human life, in the event of a lake outburst. There is merit for the two countries to cooperate on jointly monitoring and assessing the development of glacial lakes in the higher reaches of Himalaya.

The increasing frequency of flooding is a shared concern in both countries. The flooding phenomenon can be better understood through the quantification of the hydrological and fluvial processes that operate at the basin scale, and beyond. There is a need for scientific and administrative collaboration between the two countries for the development of a basin-wide hydrological model with real time forecasting and early warning interface with the involvement of the relevant experts from both India and Pakistan.

There is a scanty network of observation stations in the entire mountainous Himalayan region for monitoring and understanding the land surface and atmospheric processes. The two countries need to join efforts to strengthen the network of observatories.

The two countries should facilitate the exchange of academics for establishing long-term cooperation in studying the issues of common concern in the region including cryosphere dynamics and its impacts on water availability. The two countries share water in the Indus under the IWT and it is important that a credible knowledge base about the impacts of climate change on waters emanating from the glaciers is generated. This shared information and knowledge on climate change and water concerns under a collaborative and joint ownership will help the two governments to deal effectively and appropriately with the policy issues governing the sharing of waters between the two countries.

ENERGY

Energy is an essential input in the production of any good or service, and is pertinent for the sustained growth and operation of economies. An important goal of any country should thus be to provide its citizens with an adequate, affordable, and secure supply of energy. The threat of climate change, however, has added a new dimension to energy policy. In 2015, energy production and use accounted for two thirds of global greenhouse gas (GHG) emissions. Energy policy therefore lies at the heart of global efforts to tackle climate change.

The energy sectors in India and Pakistan still have to close the supply-demand gap of energy. India has a further burden of shifting to cleaner energy sources. Pakistan on the other hand is facing an energy crisis and is focused entirely on increasing its energy supply, and making its energy mix affordable. It also has plans for integrating renewables in the current energy sector, but this goal remains as yet, secondary.

WILDLIFE CONSERVATION

Wildlife is an important indicator of ecosystem health and plays a signifiant role in grappling with the impacts of climate change. Wildlife, especially found along the line of control such as the Snow Leopard, faces a genuine threat of extinction: mainly due to habitat loss, human-wildlife conflict, and habitat degradation. The snow leopard is listed on the endangered list of the International Union for Conservation of Nature. As the potential habitat of the animal lies on both sidesof the border, it offers reasonable scope for both India and Pakistan to cooperate on efforts towards the conservation of the Snow Leopard. This should contribute towards the conservation of the entire mountain ecosystem and thus help to mitigate some of the impacts of the changing climate in the region.

There is no sufficient study and data on the trans-boundary wildlife habitats in the Indian sub-continent. The line of control cuts through several wildlife habitats and the zone is full of military activities including military movements, firing practices, exchange of shell firings, resulting in the immense destruction to the habitat of the snow leopard. These activities disturb the ecological balance and thus lead to a displacement of wild animals from their habitat. The landmines on the border further result in the killing of the snow leopard. Territorial security measures like border fencing in certain areas restrict the movement of animals across its habitat, thus disorienting animals towards human settlements.

India and Pakistan should consider setting up trans-boundary nature heritage sites/trans-boundary biodiversity conservation demarcations to protect the habitats of the snow leopard and other wild animals. The two countries can learn from various Nordic examples, which provide valuable lessons for trans-boundary cooperation for joint wildlife conservation efforts.

Both the countries should launch academic/research exchange international fellowships for joint research on wildlife and its habitat conservation.

India and Pakistan should also consider setting up a wildlife conservation consortium, South Asia Wildlife Conservation Research Centre wildlife to encourage and facilitate joint research between wildlife experts, activists, academic institutions, and government organizations.

The governments must also help build a network of stakeholders through organizing regular joint conservation workshops and conferences. These interventions can make a significant contribution for generating trans-border research on wildlife conservation.

The wildlife academic institutions in both the countries should sign MoUs to initiate joint degree programs through regular or distant learning on wildlife conservation. These institutions can also explore opportunities to launch special courses, for example, on the Snow leopard and its mountain ecosystem.

India and Pakistan should develop special training and wildlife sensitization programmes for front-line staff especially armed personnel. The armies stationed on the border can play a vital role in the protection of wildlife and its habitat.

There is tremendous scope in both countries to promote the snow leopard and other wildlife species as potential economic development agents in the immediate population areas of wildlife habitat. One of those initiatives could be Snow leopardEnterprises in eco-tourism sectors.

CONCLUSION

Both India and Pakistan face serious shortages of energy resources that are essential for sustainable development and poverty eradication. The Paris Climate Agreement at COP21 calls for a global transition away from fossil fuel based energy to cleaner, renewable sources as a means of curbing carbon emissions and stabilizing the climate. It is, therefore, imperative for India and Pakistan to consider cooperation in the development of renewable energy resources that are abundantly available in both countries, such as hydro, solar and wind,including the exchange of best practices, joint research and technology development.

Energy-related cooperation should be taken up as a priority topic in the resumed Comprehensive Bilateral Dialogue.

The special meeting of Environment Ministers in Dhaka in 2008 and the 16th SAARC Summit held in Thimpu (Bhutan) in 2012 agreed on measures for concerted regional responses to reduce the negative impacts of climate change in SAARC member countries. Cooperation between India and Pakistan will also go a long way in strengthening regional initiatives with the other member countries of SAARC.

The proposed recommendations envisage the exchange and sharing of information and expertise, close coordination, and frequent interactions among the various stakeholders from the two countries. The proposed cooperation on climate change and water issues has thepotential for generating the required goodwill and trust for addressing bilateral issues between the two countries. It is hoped that credible data and research outcomes generated from joint initiative(s) shall inform policy and decision makers in the two countries.

INDIA, PAKISTAN, WATER, AND THE INDUS BASIN: OLD PROBLEMS, NEW COMPLEXITIES

AHMAD RAFAY ALAM

1. INTRODUCTION

The Partition of British India in 1947 through the Radcliff Line divided the largest contiguous gravity flow irrigation system on the planet by creating a new riparian context between India and Pakistan over the Indus Basin. Whilst the Indus Waters Treaty of 1960 has been successful in defining the rights of the riparians for the Indus basin rivers for the past six decades, new challenges such as climate change and unsustainable groundwater mining are raising water- and food-security concerns that the Treaty was neither intended to nor envisioned to deal with. In this paper, the emerging challenges of the Indus Basin are set against the application of the Treaty. In examining the Treaty's limitations, new trans-boundary water management challenges, and opportunities, emerge.

2. CHARACTERISTICS OF THE INDUS BASIN

The Indus River rises in China and runs 3,200km across parts of India and the length of Pakistan before emptying into the Arabian Sea. The Indus Basin encompasses 1.12 million kilometers^2 with 47 per cent of this area falling in Pakistan, 39 per cent in India, eight per cent in China and six per cent in Afghanistan. The Basin counts 27 major tributaries, with six of the most significant branches, the Rivers Chenab, Ravi, Sutlej, Jhelum and Indus itself, flowing westwards from India to Pakistan. A seventh major tributary, the River Kabul, rises in Afghanistan and flows eastwards into Pakistan.

Although the Indus Basin comprises of four riparian states, there is only one legal arrangement related to the sharing, division or trans-boundary management of water therein: the Indus Waters Treaty (IWT), executed with the assistance of the World Bank in 1960. The IWT, however, is between India and Pakistan only but clarifies the rights of these upper and lower riparians over six of the twenty-seven tributaries of the River Indus rather than share the use of the same. Under the IWT, India has exclusive use of the waters of the Eastern Rivers, namely the Beas, Ravi, and Sutlej, while Pakistan has use – subject to limited Indian rights to develop, inter alia, certain types of non-consumptive run-of-the-river hydropower projects subject to detailed criteria – of the waters of the Western Rivers, namely the Rivers Indus, Jhelum and Chenab.

Map of the Indus Basin

The mean average of the annual flow of the Indus Basin is about 168 million acre feet. Approximately 69 per cent of the flow originates in India and Indian administered Kashmir, 19 per cent from Pakistan and 12 per cent from China and Afghanistan collectively. India and Pakistan represent almost all of the demands on the resources of the Indus Basin. Pakistan draws 63 per cent of the water used in the Basin and India draws 36 per cent. The Basin supplies the needs of approximately 300 million people living in the basin and helps feed and employ millions more beyond its boundaries. With agriculture accounting for 93 per cent of water withdrawn from it, the Basin is the major source of employment, food and cash crops in both countries. In Pakistan, agriculture employs 40 per cent of the labour force, contributes up to 22 per cent of GDP; in India it produces a quarter of the country's grain supply. However, unlike India, which has other water sources and river basins, Pakistan is critically dependent on the Basin as its only water resource.

The surface water flows in the Indus Basin are not regular and depend on variables such as precipitation (from June to September) and glacial melt. Local river flow in upper sub-basins derives mainly from the surrounding catchment while upstream discharges are the major source of local river flow in lower sub-basins. The variability in flow and its composition raises significant challenges for, but ultimately proves the need and importance of integrated water management of, the Basin. Some have argued that nothing short of large storage dams can harness the variability of water flows for ensuring water- and food-security throughout the year.

The Indus Basin also represents an extensive groundwater aquifer, covering a gross command area of 16.2 million hectares. Before the introduction of the canal irrigation system in the 19th and 20th centuries, the aquifer was in a state of hydrological equilibrium, with recharge from rivers and rainfall balanced by outflow and crop evapotranspiration. The irrigation system, the largest contiguous gravity flow irrigation system in the world, resulted in increased percolation to the aquifer in irrigated areas, causing salinity and waterlogging issues. While the higher water tables in fresh water-zones have been used by wells and tube wells, today groundwater extraction exceeds recharge and these aquifers are under increasing pressure.

3. CLIMATE THREATS AND VULNERABILITIES

Basin hydrology does not respect the concept of the sovereign nation state. Neither does climate change. And while glacial melt is a real and present threat, one of the most pronounced aspects of climate change in South Asia has been the variation in the timing and intensity of the Monsoon and, consequently, floods in the Indus Basin. Since 2010, both countries have experienced flooding every Monsoon, with Pakistan suffering a devastating "1000-year" flood in 2010 that submerged nearly 20 per cent of its landmass.[1] The trans-boundary nature of climate and basin hydrology challenges test the existing legal and institutional frameworks in the riparian states.

The variations in the Monsoon have, in this decade alone, produced devastating floods, brought about draught conditions and adversely impacted crop production.[2] The human and economic loss of this is impossible to quantify. Commercial activities and human settlements in low-lying flood-plains constantly face the risk of heightened flows during periods of heavy precipitation.

Existing Indus Basin supplies, both surface and groundwater, have been adversely impacted by a variety of human causes: industrial and agricultural pollution that renders water supplies unusable, water withdrawals that result in unsustainable environmental flows, and storage and hydroelectric dams that impact every scale of a river's ecology from mouth to delta.

These climate risks and environmental challenges are straining existing and future water supplies. So are the water demands of growing populations and increasing development within the Indus Basin.

Country	India	Pakistan	Total
Average long-term available renewable water supplies in the IRB	97 km3/year	190 km3/year	287 km3/year
Estimated renewable surface water supplies in the IRB	73 km3/year	160-175 km3/year	239-258 km3/year
Estimated renewable groundwater supplies in the IRB	27 km3/year	63 km3/year	90 km3/year
Estimated total water withdrawals in the IRB	98 km3/year	180-184 km3/year	275-299 km3/year
Estimated total surface water withdrawals in the IRB	39 km3/year	128 km3/year	
Estimated total groundwater withdrawals in the IRB	55 km3/year	52-62 km3/year	

Note: Figures for surface and groundwater supplies may not sum evenly to figures for total renewable water resources because a large fraction of groundwater and surface water resources overlap, so that separate supplies cannot be absolutely distinguished.

Source: Derived from FAO, *Irrigation in Southern and Eastern Asia in Figures: AQUASTAT Survey 2011*, Karen Frenken ed. (Rome: FAO, 2012); A.N. Leghari et al., "The Indus basin in the framework of current and future resources management," *Hydrology and Earth Systems Sciences* 16, no.4 (2012); Bharat R. Sharma et al., "Indo-Gangetic River Basins: Summary Situation Analysis," International Water Management Institute, New Delhi Office, July 2008.

Renewable Water Resources and Withdrawal Levels in the Indus Basin [3]

Taking growing populations and increasing water withdrawals into account, water availability in the Indian part of the Indus Basin is expected to slide from 2,109m^3 per capita in 2000 to 1,732m^3 in 2050 and in Pakistan from 1,332m^3 to 545m^3. The future of the subcontinent is water scarce or water stressed.

Increasing water scarcity has long-term implications on food production and livelihoods within and outside the Indus Basin. Variations in the Monsoon and climate patterns have an impact on crop productivity and corresponding livelihoods from the farm to the market. Changing lifestyles within the Basin are also driving water demand for food production as an emerging middle class displays a preference for meat and dairy. The unreliability and inefficiency of the irrigation network has led farmers to use tube wells to irrigate crops with ground water. Poor ground water regulations and politically motivated electricity tariffs have resulted in unsustainable withdrawals from the Indus Basin aquifer, and pollution risks compromising existing renewable freshwater resources.

development. Economic development in the Indus Basin is often linked to the development of large storage dams or hydropower dams to regulate the flow and availability of water and to generate electricity. The Central Electricity Authority of India has identified 33,832 MW and the Water and Power Development Authority of Pakistan has identified 25,000 MW of hydropower potential in their respective parts of the Basin. The amount and type of hydroelectric infrastructure constructed in the future will have major implications for water users in the Basin.

Whilst the climate challenges in and to the Basin can be discerned through a water-based analysis, the differing dependences of Pakistan and India on the Indus Basin have resulted in vastly differing responses to climate change and food- and water-security issues. The different roles, stances and negotiating positions taken by both countries at the U.N. Conference on Climate Change in Paris in December 2015 is evidence of this differing response at the international level. But even at the domestic level, climate adaptation and mitigation plans and strategies in place in either country prescribe vastly differing agendas. This is a lost opportunity for some, like Roland D'Souza, who has pointed out the different geomorphological points occupied by India and Pakistan in the Indus system is precisely the reason for thinking of the Indus Basin as a holistic and integrated ecological system. Post-devolution, water management in South Asia, in law, is also a State/Provincial responsibility. The water- and food-security related plans and policies of these intra-State stakeholders play out on a completely different and unconnected scale to the IWT, or the official bilateral dialogue between Islamabad and New Delhi. It is difficult, therefore, to identify existing legal and institutional frameworks, including the framework provided by the IWT that can allow both sides to work together on trans-boundary water issues related to the Indus Basin.

APPLICATION OF THE INDUS WATERS TREATY: RIGID PAST POSITIONS AND UNCERTAIN FUTURE COMPLEXITIES

Trans-boundary water in the Basin is regulated by the Indus Waters Treaty, 1960. Before further discussion, it is helpful to summarise the significant incidents where the IWT has been invoked:

1) WULAR BARRAGE CONTROVERSY

The Wular Lake is located in the Bandipora district in the Indian state of Jammu and Kashmir. It is fed by the River Jhelum (a Western River under the IWT). In 1984, the Indian government began work on the Tulbul Project – a navigation lock-cum control structure on the mouth of Wular Lake – that would help keep the minimum draught of 4.5 feet in the river for navigation purposes and provide an additional 0.3 MAF of storage. Pakistan objected to the Project in 1987 by approaching the Indus Waters Commission, alleging it was in violation of the IWT, and construction was halted thereafter. Pakistan's apprehensions were based on the following reasons:

a) A barrage may damage Pakistan's own triple-canal project linking Jhelum and Chenab with the Upper Bari Doab Canal;

b) A barrage would be a security risk enabling the Indian Army to make crossing the river either either easy or difficult, at will, by the controlled release of water;

c) After constructing the dam, India would control the flow of water into the Jhelum, creating drought and flood situations at will in Azad Kashmir and Pakistan; and

d) It would ruin Pakistan's agriculture.

The issue has been taken up by the two Governments, who have held repeated rounds of talks, without any resolution or progress. Most recently, following the visit of Prime Minister Narindra Modi to Pakistan in December 2015, the Wular Barrage/Tulbul Project has been included in the list of subjects that form the "comprehensive bilateral dialogue" to be carried out at the Foreign Secretary level in early 2016.

2) BAGLIHAR DIFFERENCE

In 2005, Pakistan approached the World Bank under the IWT, asking it to appoint a Neutral Expert to address a "difference" which had arisen in relation to the Baglihar hydropower plant which was under construction by India on the River Chenab (a Western River). Pakistan claimed the design of the run-of-the-river, 450MW, hydropower plant did not conform with the criterion stipulated in the IWT. Behind these technical differences was Pakistan's belief that the plant would give India the ability to easily withhold water during shortages and release water during excess.[4] India's response was to point out that doing so would damage its own downstream Salal hydropower project.

The difference was decided by the Neutral Expert in 2007, accepted by both countries and even touted as victory by both. The decision addressed the six issues of concern ("differences", in the language of the Treaty that require resolution by a Neutral Expert) raised by Pakistan. According to Salman[5] :

Two observations are worth making with regard to the process and the decision of the Neutral Expert:

Firstly, as appeared from the composition of the two delegations, Pakistan seemed to have viewed the difference as largely a legal one, involving the interpretation of the Treaty, while India seemed to have viewed it mainly as an engineering one, regarding hydropower plants (Executive Summary, 2007).

Secondly, the Neutral Expert opined that the rights and obligations of the parties under the Treaty should be read in the light of new technical norms and new standards as provided for by the Treaty. This meant that the Baglihar difference was addressed bearing in mind the technical standards for hydropower plants as they have developed in the first decade of the twenty-first century, and not as perceived and thought of in 1950s when the Treaty was negotiated. The reference to modern technical standards is particularly clear in the discussion and analysis by the Neutral Expert of the issue of gated or ungated spillway summarised earlier.

Climate change and its likely effects is another example of contemporary concerns not prevalent or thought about during the 1950s which was taken into account by the Neutral Expert in his decision. It should be added that, along the same lines, the International Court of Justice in the Danube dispute between Hungary and Slovakia (the Gabcikovo-Nagymaros case) required that the current standards must be taken into consideration when evaluating the environmental risks of the project.[6] This manner of interpretation will most likely influence future interpretation of the Treaty, as well as other international water treaties.

3) KISHANGANGA ARBITRATION

The Kishanganga Hydroelectric Plant is part of a run-of-the river hydroelectric scheme designed to divert water from the River Kishanganga to a power plant in the Jhelum Basin. It is located in the state of Jammu and Kashmir (J&K) and will have an installed capacity of 330MW. Construction on the project began in 2007, but was halted by The Hague's Permanent Court of Arbitration in October 2011 due to Pakistan's objection that it would affect the flow of the River Kishanganga and thus the River Jhelum (a Western River).

In 2010, Pakistan instituted arbitral proceedings against India under the IWT and approached the International Court of Arbitration (ICA) against violations of the Treaty. Pakistan's alleged plant design would increase the catchment of the River Jhelum and deprive it of its water rights. In a partial award delivered in February 2013, the ICA ruled India could divert water of the Western Rivers for non-consumptive manner for optimal generation of power. In a "final award" given in December 2013, the ICA specified that $9m^3/s$ of natural flow of water must be maintained in the River Kishanganga at all times to maintain the environment downstream.

A common feature of these three examples is the manner in which Pakistan and India framed their initial positions versus the final outcome of the dispute resolution process. In all three incidents discussed, proceedings were initiated by a rights-based allegation i.e. Pakistan alleging its rights were being violated. The Indian reply, in all three cases, has also been rights-based: that Pakistan is seeking to restrict its rights to develop limited hydropower potential subject to detailed criterion in a manner so as to defeat such right.

In the dispute resolution process followed in the Baglihar and Kishanganga incidents, the dispute resolution mechanisms of the IWT stressed needs-based solutions based on changing technical standards, climate change challenges, environment flow and development of hydropower potential.

The shift from rights-based claims to needs-based resolutions is, in Wescoat's view, indicative of the need to shift the emphasis from defining generalized principles to encouraging treaty negotiations be based on the special circumstances and needs of each basin.[7] On the other hand, it can also be said that the IWT allows its basin states to engage in rights-based rhetoric, full of martial assertions of absolute territorial sovereignty, safe in the knowledge that the Treaty's dispute resolution mechanism's technical requirements ensure a needs-based resolution.

One of the unique characteristics of the Treaty is that rather than dividing or sharing the waters of the Indus Basin between the two countries, it divides the six major rivers comprising the Indus rivers system. Under Article II(1) of the Treaty, "All the waters of the Eastern Rivers shall be available for the unrestricted use of India except as expressly provided . . . ." Article IV of the Treaty allows Pakistan to "receive for unrestricted use all those waters of the Western Rivers which India is under obligation to let flow under the provisions of Paragraph (2)". Paragraph (2) thereof stipulates India shall let flow all the waters of the Western Rivers and shall not interfere with these except for, inter alia, domestic use, non-consumptive use, agricultural use and limited hydro-electric power.

Another characteristic feature of the Treaty is its dispute resolution process. To date, despite the political differences between Pakistan and India, all differences and disputes that have arisen during the operation of the Treaty have been resolved, with each country accepting the determination of decision of Neutral Expert or the ICA.

The Treaty defines the Eastern Rivers as the Sutlej, Beas, and Ravi, and the Western Rivers as the Indus, Jhelum, and Chenab. The Eastern and Western Rivers include connecting lakes, if any, and all their

Tributaries. Tributaries of a river, in turn, are defined as “any surface channel . . . whose waters in the natural course would fall into that river” (emphasis added). By limiting itself to the “waters” of the “rivers” of the Indus Basin and their tributaries, the Indus Waters Treaty does not envisage the regulation of ground water. This contention is reinforced by the following observations.

Amongst the responsibilities of the Permanent Indus Commission established by the Treaty is the exchange of data. Article VI of the Treaty provides daily flow, withdrawal, escapages and delivery from link canals information shall be exchanged regularly between the parties. By restricting the exchange of data to surface water of the rivers, the Treaty indicates it does not envisage ground water. Article VII of the Treaty provides for future cooperation and states both Parties “recognize they have a common interest in the optimum development of the Rivers . . .” and agree to cooperate to the fullest possible extent, but in particular on the establishment of hydrologic and meteorological observation stations, and drainage and engineering works. Again the Treaty restricts itself to the waters of the Indus Basin’s major rivers and does not specifically apply to the Indus Basin aquifer.

There are, however, arguments that the Treaty may be revised or upgraded to include issues that have arisen in relation to proper implementation of the Treaty but which were not considered by it at the time. Such arguments can be extended to include provisions regarding ground water or climate change. The Indus Basin Working Group report on the Indus Basin encapsulates these arguments as follows:

Since 1960, the IWT has stood through the 1965, 1971 and 1991 wars between the two countries and survived numerous lesser clashes. Yet, marked dissatisfaction with the IWT exists in both India and Pakistan. A significant body of opinion in India regards persistent Pakistani objection to planned Indian infrastructure projects on the Western Rivers as unfairly stalling India’s legitimate development programs. Many in Pakistan, in turn, fear that – though individual Indian proposals generate substantial cumulative impacts downstream. In the wake of continuing controversies, voices in both countries suggested revising the IWT terms – or even scrapping the accord and starting over. Ultimately, some mutually agreed alternation to the IWT in the future might improve the scope for effective international cooperation and integrated resource management across the basin. Presently, however, moves to renegotiate the IWT would almost certainly provide more contentions that current confidence levels between the parties could bear.[9]

At present, nothing short of a revisit of the Indus Waters Treaty to include provisions with respect to ground water would allow for it to be called in aid of better trans-boundary aquifer management. The existing provisions of the Treaty restrict its scope to surface water alone.

Despite the Treaty being negotiated between India and Pakistan using the “good offices” of the World Bank, and despite the existence of SAARC as a regional body, bilateralism has been the guiding principle of Indian foreign policy towards Pakistan since at least the Simla Agreement of 1972. The consequence of such a policy, an assertion of the now-aging concept of territorial sovereignty, has been to limit trans-boundary water relations of the Indus Basin to India and Pakistan alone and not to extend them to a region or Basin States such as China and Afghanistan. Bilateralism also allows India the ability to maintain differing negotiating positions with other trans-boundary riparians such as China, Nepal, and Bangladesh. There is no agreement between Pakistan and Afghanistan on the Kabul River. It remains to be seen whether this bilateral framework – as opposed to, for example, a regional, basin or hydrological framework – can withstand the aggressive and increasing water demands of these regional, basin, or hydrological riparians as well as present and future climate risks.

Pakistan's repeated objections that hydropower development by India in its portions of the Indus Basin are not in line with the IWT (and are said to "violate the spirit of the Treaty"), over and above the individual objections to specific projects, essentially stems from a food- and water-security argument that underscores the Pakistani economy's existential reliance on the waters of the Basin. And while Pakistan and India continue to dispute the provisions of the IWT, the government of J&K has repeatedly claimed the Treaty has deprived it of the ability to develop hydropower and has plans to assess the "loss" caused to it by the Treaty.

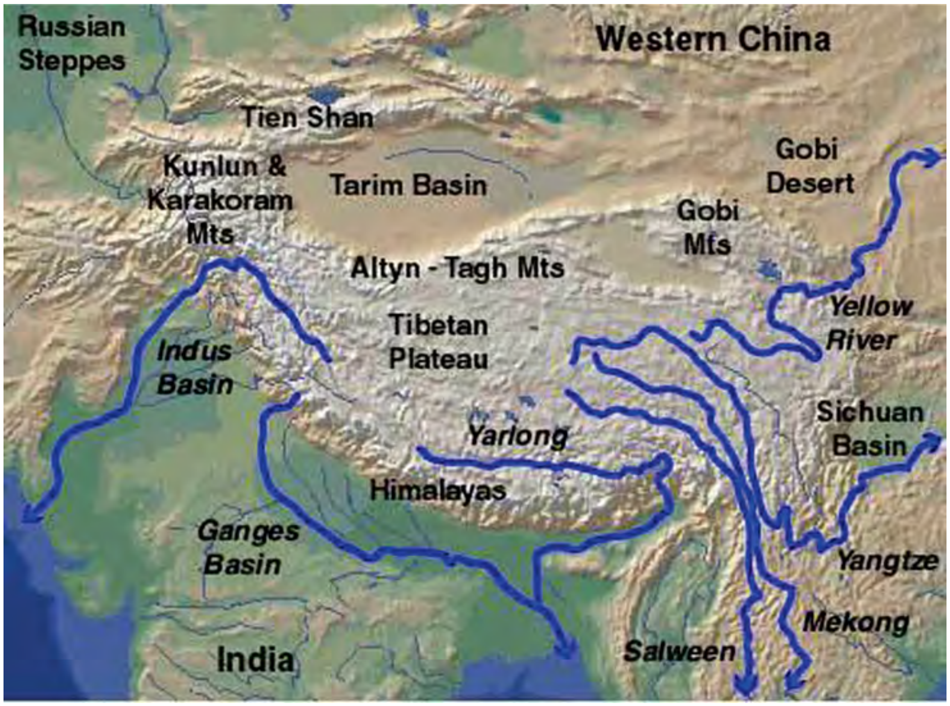
4. CONCLUSIONS

Peace is defined not just as the absence of war, but also the conditions for a just and sustainable state of peace. With water relations in the Indus Basin defined at this point solely by the Indus Waters Treaty, this ageing legal document singularly bears the brunt of the climate-, water- and food-security issues arising in the Basin. What remains to be seen is whether future water-related challenges can be met with modifications to the Treaty or through other means of negotiation and interaction – whether the Treaty can continue to provide conditions for a just and sustainable relationship between the two countries.

For reasons that appear evident but which cannot be explained or justified other than as an accident of history, the management and operation of the IWT, through the offices of the Permanent Commissioners, is dominated by security establishments operating in New Delhi and Islamabad. In India, for example, information relating to river flows in upper catchment areas of the Indus Basin is classified. In Pakistan, development of hydropower resources by India is viewed as a threat to the entire economy. The heavily securitised discourse on water in the Indus Basin, reinforced in Pakistan by the fact that at present the Ministries of Defence, and Water & Power are held by the same officer, makes it difficult to advocate other water-related Basin issues. Issues such as climate-, water- and food-security, all security issues in their own right, are brushed aside in preference for issues related to the Treaty. Additionally, as stated above, the Treaty allows both riparian States to make rights-based claims founded on the concept of territorial sovereignty while its dispute resolution process allows for needs-based adjudication. By not being flexible, the parties are not leveraging the possibility of further needs-based adjudication that would take into consideration climate- water- and food-security issues in the Indus Basin.

One limitation of the IWT is that it does not address ground water or the shared Indus Basin Aquifer. Ground water accounts for 48 per cent of all water withdrawals in the Indus Basin, and current withdrawals are forecasted to deplete these resources. There is no agreement between Pakistan and India over groundwater; the Treaty is not a document that regulates the conjunctive use of surface and ground water; and since ground water, in both countries, is subject to laws, rules and policies set predominantly by the States/Provinces of either country – entities that otherwise do not perform any trans-boundary interaction – ground water related issues do not find a place in the securitised discourse of the Treaty. Yet ground water issues – better irrigation practices, rationalized electricity tariffs for tube wells, water quality and availability – are ultimately the same water- and food-security issues that underpin the securitised discourse of the IWT.

Any interaction or negotiation on trans-boundary ground water in the Indus Basin would have to be preceded by shared and reliable scientific data on the nature and characteristics of the Indus Basin Aquifer. Both research and subsequent interactions will take place amongst actors on the State/Provincial level – constituencies removed from the Islamabad-Delhi stakeholders involved in the IWT. Given the often toxic level of discourse on the IWT, these constituencies are an immense opportunity to create new water relations between India and Pakistan.



Rivers of South Asia

A limitation imposed by bilateralism on water relations in the Indus Basin is that regional or basin-based approaches to just and sustainable water management have not and cannot be explored. This is tantamount to attempting to solve a thousand-piece jigsaw puzzle with only a handful of pieces. Due to the securitised nature of the discourse on the IWT, it shall remain in force until a new security architecture rewrites the relationship between India and Pakistan. At present, the only possibility of such a rewrite is if China were to takes steps to secure its relations or future investments in the region. Ideally, a new architecture would involve all the Basin States – Afghanistan, Pakistan, China, and India – operating under a framework where water was managed justly and sustainably. ing the possibility of further needs-based adjudication that would take into consideration climate- water- and food-security issues in the Indus Basin.

ENERGY NARRATIVE IN INDIA AND PAKISTAN

ROHAN D'SOUZA

INTRODUCTION

Energy is a necessary input in the production of any good or service, and is essential for economies to operate and grow. Therefore an important goal of any country is to provide its citizens with an adequate, affordable, and secure supply of energy. The threat of climate change, however, has added a new dimension to energy policy. In 2015, energy production and use accounted for two thirds of global greenhouse gas (GHG) emissions. Energy policy therefore lies at the heart of global efforts to tackle climate change.

In the run-up to COP21 in Paris, 184 out of 196 Parties to the UN Framework Convention on Climate Change (UNFCCC) put forth their pledges. These pledges, termed as intended nationally determined contributions (INDCs) detail actions on climate change mitigation and adaptation that a country plans to undertake to reduce GHG emissions by 2030. All INDCs submitted covered energy sector emissions, and many included targets and actions to reduce emissions. About half of all INDCs emissions reduction submissions contain explicit energy-focused targets, either alongside a GHG target or as a stand-alone goal. The most common energy-related measures planned to be undertaken are those relating to increased renewable energy deployment (~40 per cent of the INDCs) and improved energy efficiency (~33 per cent of the INDCs).

A complete analysis of the INDCs by IEA revealed that from 2014, to 2030, fossil fuel demand growth will considerably slow down and the share of renewables in the world's energy mix will rise from less than 20 per cent in 2015 to about 25 per cent in 2030. The annual growth in global energy emissions will slow down to 0.5 per cent by 2030. At the same time, electricity demand is expected to increase by more than 40 per cent by 2030. This means that for the first time, a relative decoupling of electricity demand and emissions will be seen at the global level.

How does the energy sector in India and Pakistan compare with the global average? In what direction are the energy sectors of these two countries moving?

ENERGY SECTOR IN INDIA

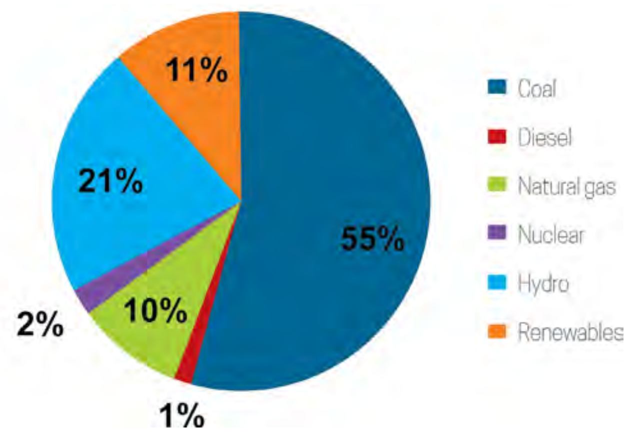
India, home to one sixth of the world's population, with the third largest economy, (when GDP is adjusted for inflation and purchasing power) accounts for only 6 per cent of global energy usage. Despite energy use having doubled since 2000, energy consumption per capita is still only around one third of the global average, and one in five of the population lacks access to electricity.

The rate of economic growth has been faster than the rate of energy demand between 2000 and 2013, implying a partial decoupling between economic growth and energy consumption. This is in part due to a shift away from bioenergy consumption, the increasing importance of the services sector in the Indian economy, and greater efforts to improve energy efficiency.

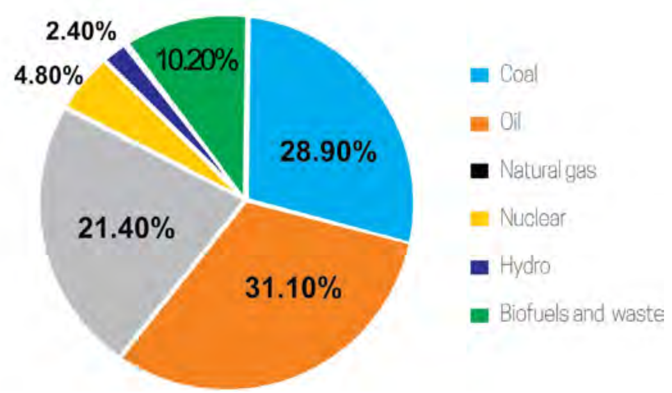
The amount of energy required to generate a unit of GDP (on a PPP basis) in India is slightly lower than the global average. This can be greatly reduced if India tackles transmission and distribution losses in the electricity grid, as well as improve efficiencies in generation equipment.

Let us now compare India's energy mix to the world average.

This is India's energy mix in 2012:



Compare this with the world energy mix in 2013:



The difference between India and the world's energy mix needs to be interrogated.

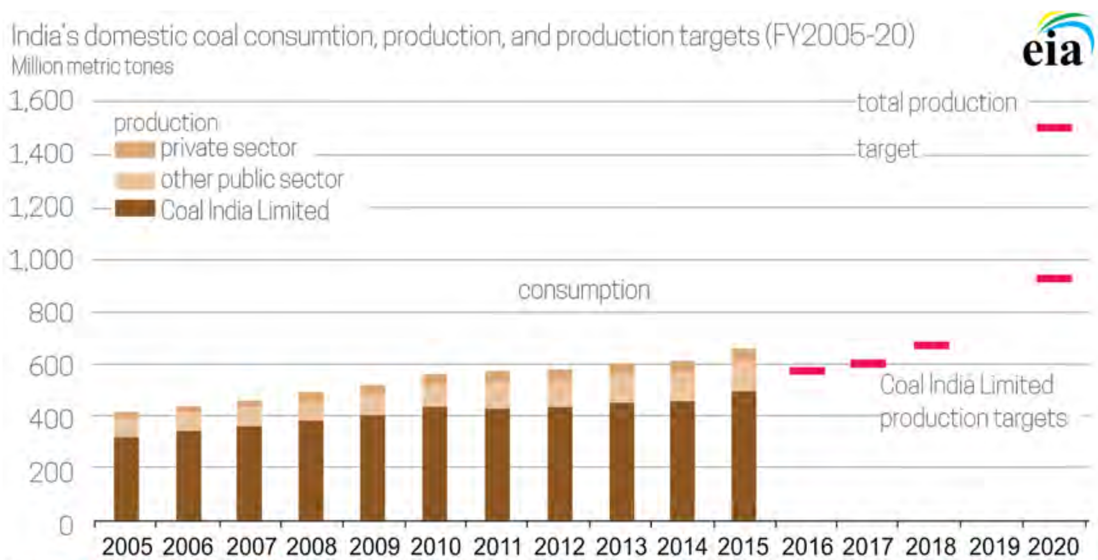
COAL

It can be clearly seen that coal contributes far more to the Indian economy than on a global average. India is the world's third largest producer of thermal coal. Most of India's coal has low to medium calorific values and a high ash content, and thus produces more emissions per unit of electricity generated when burnt. The availability and affordability of coal relative to other fossil fuels has contributed to its usage particularly in the power sector.

(Note that: Current coal-fired electricity generation capacity is mostly based on subcritical technology. Although subcritical technology is relatively low cost compared with other available technologies, it uses more coal and generates more GHG emissions. From 2017, all new coal fired plants developed in India are required to use supercritical technology or better)

The demand for coal, however, is outstripping its supply. From 2005 to 2012, India's coal production grew by 4.7 per cent p.a. while the country's coal fired electric power capacity grew by 9.4 per cent p.a., reaching 150 GW. India has thus become increasingly more reliant on imported coal, with imports rising from 10 million tonnes in 2000 to 142 million tonnes in 2013. This led the government to launch plans in early 2015 to more than double coal production by the year 2020 in order to reduce dependence on imports. India is expected to be the largest driver of global coal usage in the future, surpassing even China.

Coal India Limited (CIL), responsible for producing more than 80 per cent of India's current production is ramping up production. However, as can be seen from the figures below, this is nowhere close to meeting its demand.



Source: Energy Statistics 2015 Government of India Ministry of Statistics and Programme implementation; Provisional Statistics 2013-14 Government of India, Ministry of Coal; news reports Note: India fiscal year is April to March. For example, FY 2005 represents April 1, 2004, to March 31, 2005. Data for 2015 are preliminary.

CIL is characterized by several inefficiencies, low productivity, and an over-reliance on surface mining which is dangerous to the environment. Since 2012, CIL has increased coal production by outsourcing production operations to private and foreign companies to improve mechanization and mining experience and meet its 2020 target. However, in August 2014, allegations of impropriety, hoarding of coal resources, lost government revenue, and a lack of transparency led to India's Supreme Court to cancel 214 coal licenses allocated to the public and private sector, representing 9 per cent of 2013's production. The Ministry of Coal quickly re-auctioned many of these properties to minimize disruption, but the impact on production is still uncertain.

OIL

The current percentage of oil is lower than the global average in India's energy mix. Despite this, India was the fourth largest consumer of crude oil and petroleum products in the world in 2013. It was also the fourth largest net importer of crude oil and petroleum products. Net imports of crude oil have increased from 99.41 MTs during 2005-6 to 189.24 MTs during 2013-14. EIA projects that India's oil demand will double by the year 2040, while domestic production will remain relatively flat.

The percentage of oil in the energy mix is projected to rise, fuelled by the growing number of vehicles on the road. Transport alone accounts for more than 40 per cent of the total amount of petroleum in the country. Such a high percentage is unique. In China for example, it is at 33.6 per cent, while in the US it is at 27.8 per cent. This is due to the high percentage of road freight traffic. It is imperative that India thus transition to more stringent fuel efficiency standards.

The upstream is still dominated by state owned companies: Oil and Natural Gas Corporation Limited (ONGC) and Oil India Limited (OIL). Together, these two companies account for two thirds of India's crude oil production. The New Exploration Licensing Policy was initiated in 1998 in order to attract international oil majors with deep water drilling experience to realise India's crude oil production. However, due to skepticism over government contracts and uncertain reserve levels, international oil companies have participated only to a limited extent in the New Exploration License Policy (NELP).

What is interesting is that India has excess refinery capacity. Refined petroleum products have become the country's biggest export, ahead of gems and jewellery. India had 17 public-sector refineries in 2013 owned by seven state owned companies, according to EIA. It had three private refineries owned by the country's two private refiners: Reliance Industries and Essar Ltd. In October, 2014, the government took advantage of low oil prices and deregulated the price of diesel. The cost of subsidies for the ten-year period prior to deregulation cumulatively amounted to USD $50 billion. These subsidies were only paid to public refineries. Private refineries were forced to export their products as they could not compete with the lower prices offered by public refineries. Now that the subsidies have been removed, it is expected that exports will decline as private refineries can sell their finished products on the domestic market. This will encourage public sector refineries to upgrade their facilities and modernize in order to compete effectively.

It is important to note that although current oil prices have dropped extensively due to the glut of oil on the market, diesel and fuel prices have not fallen commensurately in India due to the hike in excise tax on petroleum products. Revenues generated from the taxation of petroleum products are important sources of income to the Central and State governments.

The table below shows India's imports-exports of crude oil and petroleum products in Million Tons (MT). Most of India's imports come from the Middle East.

	Crude Oil			Petroleum Products		
Year	Gross Imports	Exports	Net Imports	Gross Imports	Exports	Net Imports
2005-06	99.41	0	99.4	13.4	23.4	-10.02
2006-07	111.5	0	1111.5	417.7	633.6	-15.86
2007-08	121.6	0	121.6	622.4	240.7	-18.32
2008-09	7132.7	0	7132.7	618.5	838.9	20.38
2009-10	8159.2	0	8159.2	214.6	50.9	-36.31
2010-11	6163.6	0	6163.6	616.8	759.0	-42.26
2011-12	171.7	0	171.7	215.8	860.8	-44.99
2012-13	3184.8	0	3184.8	515.7	463.4	-47.64
2013-14	189.24	0	189.24	716.72	167.86	-51.14

NATURAL GAS

The plateauing of India's oil production in the 1990s led to an increased focus on natural gas. The increased environmental friendliness on Natural Gas has also contributed to making it a fuel of choice in the recent years. Natural gas makes up a relatively small share of India's energy mix. It is used mainly for power generation (33 per cent), in the production of fertilizer (28 per cent), and the replacement of LPG in the residential sector (15 per cent). The government has labelled these as priority sectors for domestic programs.

India was self-sufficient in natural gas production until 2004, when it began importing liquefied natural gas (LNG) from Qatar. Policymakers have pursued two options for meeting shortfalls in gas: LNG imports and transnational pipelines.

India was the world's fourth largest LNG importer in 2013. LNG contracts in India are a mix of long-term, short-term, and spot contracts. LNG is effectively, the swing supplier of gas. The supply of gas can be raised indefinitely via LNG imports, however, a potential bottleneck is regasification capacity in India. Rating agency ICRA has stated in a report that India's regasification capacity is expected to double by the year 2025.

The success of the second longer term import option: transnational pipelines, is determined by two major geopolitical factors. First- is it feasible to lay gas pipelines in the north-west in politically volatile nations such as Afghanistan and Pakistan; And second, can India compete with the growing energy demands of other countries such as China for pipelines in the east.

India is currently investing in the Chabahar port on Iran's southern coast in order to build a trans Arabian sea pipeline that will be able to carry 1.1 billion standard cubic feet of gas to India a day, roughly doubling India's gas imports. The previous much talked about Iran-Pakistan-India pipeline failed to materialize despite much discussion about the same.

BIOENERGY

Bioenergy accounts for roughly a quarter of India's current energy consumption. The largest share of bioenergy is traditional biomass used for cooking in households. A biogas promotion program was started in India in 1981-82. The number of biogas plants in India have increased from 1.27 million in 1990 to approximately 4.54 million in 2012.

India has recognized the potential of more modern applications of bioenergy to become a larger part of the energy mix. In order to realise this potential it launched the National Bioenergy Mission.The more modern applications of biomass in the energy sector that have been promoted rely mainly on agricultural residues. There was around 7 GW of biomass power generation capacity in 2014, most of which came from bagasse (a by-product of sugar cane processing). A smaller share is cogeneration based on other agricultural residues. The remainder produce electricity via gasification that produce syngas using biomass.

Biofuels are another arena of bioenergy development in India, promoted by an ambitious blending mandate dating back to 2009, which projected a progressive increase to a 20 per cent share for bioethanol and biodiesel by 2017. However, the current share of bioethanol- mostly derived from sugarcane- remains well below 5 per cent, and progress with biodiesel has been even more constrained. The main concern over biofuels is the adequacy of supply: land for biofuel cultivation competes with other uses, as well as requires other resources such as water and fertilizer that may be limited and required in other sectors.

NUCLEAR

India has twenty one operating nuclear reactors at seven sites with an installed capacity of 6 GW. Another six nuclear plants are under construction.

The average load factor of the existing nuclear plants have been constrained by fuel shortages. This constraint was eased when India became a party to the Nuclear Suppliers' Group agreement in 2008, allowing access to technology, expertise, and uranium. The average plant load factor thus increased to 80 per cent in 2013 from a mere 40 per cent in 2008.

India has an ambitious plan to increase the role of nuclear in India's fuel mix by developing a new reactor: a fast breeder reactor that will run on thorium (India has the world's largest reserves of thorium). However, this has been talked about for many years and it is yet to be seen whether this is feasible in the timeline India has set itself.

The nuclear sector is also plagued with problems of financing due to the high capital cost of the technology. In early 2015 India and the US reached an understanding on nuclear liability issues that is expected to enhance US investment in nuclear projects in India.

HYDROPOWER

IEA notes that India's current installed hydroelectricity capacity of 45 GW (of which over 90 per cent is large hydro) represents a third of India's estimated hydel potential.

The government of India has taken a number of initiatives over the years to prioritize hydropower development and to attract investment. The National Electricity Policy of 2005 emphasized the need for full development of feasible hydropower potential, addressing issues of long-term financing and centre and state participation. The National Rehabilitation and Resettlement (R&R) Policy of 2007 emphasized the need for a more transparent and participative rehabilitation and resettlement process. The Mega Power Projects Policy in 2008 stated that mega hydro projects (>500 MW) are eligible for several benefits including a ten year tax holiday and no customs duty on the import of equipment. The Hydro Power Policy in 2008 emphasized the development of hydropower capacity and called for increasing the share of private sector participation. The Land Acquisition Act of 2014 replaced the archaic act of 1894 and provided greater clarity in land acquisition and R&R policies.

It is to be noted that the history of large dams in India have been extremely contentious. The number of large dams in India rose from 1947 to 4000 in the year 2000. More than half of these dams were built between 1971 and 1989 primarily for irrigation. However, starting in the 1980s, public investment in dams has been the focus of controversy based on the balance between the social, environmental, and economic costs of dams and their benefits. Two especially controversial projects were the Tehri dam that is built on the edge of the Central Himalayan Gap on a seismic fault line, and the Sardar Sarovar dam that has already displaced tens of thousands of people without providing them with adequate compensation.

Large hydro-projects fall under the purview of the Minister of Power. The Ministry of New and Renewable Energy is in charge of promoting small hydropower projects (SHP) (< 25 MW). Such projects do not cause massive environmental or social damage, and are thus very attractive. The potential of SHP in India is 15,000 MW by some estimates.

RENEWABLES

Renewables contribute less than 1 per cent to the energy mix as opposed to the global average of 7 per cent. However, this percentage is set to increase. India plans on reaching 175 GW of renewables (excluding large hydro power plants) to its energy mix by the year 2022, up from the current 37 GW. To do this, India aims to have 100 GW of solar energy by the eyar 2022, double wind capacity to 60 GW by 2022, and raise nuclear capacity from 6 GW today to 63 GW in the year 2032.

SOLAR AND WIND ENERGY

On June 30, 2008, the then Prime Minister of India, Dr. Manmohan Singh launched India's National Action Plan on Climate Change (NAPCC). A key goal of NAPCC is: ensuring that India's economic growth be energy efficient, and shifting from fossil fuels to renewable energy sources.

Wind energy currently accounts for the largest share of non-hydro renewable energy. India is the fifth largest producer of wind with 23 GW of capacity installed in 2014. Solar energy has played only a limited role thus far. In order to harness the power of solar energy, the Jawaharlal Nehru National Solar Mission (JNNSM) was launched on 11th January, 2010. On the 17th of June, 2015, the Union Cabinet increased the power capacity target under JNNSM five times; from 20GW by 2022, to 100 GW by 2022. This will make India one of the largest producers of solar energy in the world, surpassing Germany and the US. Only China has set a similar goal: 100 GW of solar panels by the year 2020.

India currently has 3.8GW of solar PV installed. This goal implies that India will have to install 96 GW of solar panels in 7.5 years at about the rate of 13 GW/year. Given that, the total new power generation in India in 2014 from all sources of energy was 18 GW, with coal accounting for 70 per cent of new generation; such a target is very ambitious.

This new target thus calls for a gigantic undertaking to raise funds, and execute projects. The total investment in setting up 100 GW will be around Rs. 6,00,000 crore. The press release issued by MNRE states that: "In the first phase, the Government of India will provide Rs. 15,050 crore as capital subsidy to promote solar capacity addition in the country. This will be provided for Rooftop Solar projects in various cities and towns, for Viability Gap Funding (VGF) based projects to be developed through the Solar Energy Corporation of India (SECI) and for decentralized generation through small solar projects. Apart from these, solar power projects with investment of about Rs. 90,000 crore would be developed using Bundling Mechanism with thermal power. Further investment will come from large scale Public Sector Undertakings (PSUs) and Independent Power Producers (IPPs)."

However, there are barriers related to funding. State distribution companies that are currently running at losses, have to buy the renewable energy, which is currently more expensive than traditional energy. Extensive power reforms are required to save these distribution companies. To lighten the load on these distribution companies, the Ministry of Power has proposed abolishing inter-state transmission charges for renewable energy.

There has also been a dollar tariff proposal that would allow the bidding of solar projects in dollars to make lending from outside India attractive. However, this will take time to implement. The Reserve Bank of India has also added loans for renewable energy (capped at a maximum of US $2.5 million) under priority lending which would make financing easier. This will have the potential to boost rooftop solar energy production.
How will the solar target be met physically?

According to latest announcements by the Ministry of New and Renewable Energy (MNRE), the 100 GW will comprise of:

1. 40 GW of utility-scale solar (between central and state governments).
2. 40 GW of rooftop solar.
3. 20 GW under the 'entrepreneur' scheme (20,000 projects of 1 MW).

India's Renewable Purchase Obligation (RPO), which requires that thermal energy producers generate a certain percentage (0.25 per cent in 2012 extending to 3 per cent in 2022) of their energy from renewables, or purchase renewable energy certificates (RECs) to make up for shortfalls, has the potential to realise 40 GW of utility solar. However, for this to work out, a stricter enforcement of the RPOs is required. One of the ways this can be achieved is to make state distribution licenses contingent on RPOs being met.

Note that the Ministry of Power has further confirmed the instituting of Renewable Generation Obligations (RGO) for power producers in the near future. It is reported that the central government will allocate 15 GW of this target by 2019. There is however, worry that RGOs will add further strain to electricity generators that are already suffering losses.

The government plans to install 25 mega solar parks of around 100 MW each (2.5 GW in total); of these, 17 have been finalized. India's armed forces and national companies, including the Indian Railways, have also been asked to set up large-scale plants on surplus land.

In 2012, PM Modi incentivised building solar installations over irrigation ditches and canals in rural areas to decrease evaporation. The advantage of this scheme is that it does not involve disputes over land. It is expected that a 100 MW solar power capacity will be achieved in this manner. The total cost of this program is around $160 million, of which, the central government will provide $38 million as financial assistance. All of the projects are required to be commissioned in a span of 3 years.

In addition, the state-run Solar Energy Corporation of India (SECI) is inviting firms to bid for contracts to build 2 GW of solar power capacity. This 2 GW will comprise of projects in the range of 250 MW (time period 24 months) to 500 MW (time period 30 months).

difficult. This is especially so, because rooftop subsidies have been cut by half to 15 per cent from 30 per cent, which MNRE claimed offset the recent lowering in price of panel components. However, it is reported that the net metering policy that the central government has been pushing is due to be brought in, and can incentivise an increase in installation. The Tata Power Delhi Distribution Limited (TPDDL) plans to generate 400 MW of rooftop solar energy in Delhi by the year 2022, thus setting a precedent for commercial and industrial rooftop deployment.

The scheme to encourage entrepreneurs is yet to be finalized. In an earlier announcement, Power Minister Piyush Goyal is reported to have said that the scheme would focus on encouraging unemployed youth and farmers to set up 1 MW solar installations. The government said that it would provide 50 per cent of the equity upfront to get started. However, Bridge to India has pointed out that it is "not clear" how MNRE will fund the $741 million needed for the entrepreneur scheme.

Note that India also has to worry about obtaining the volume of solar panels to reach this goal. There are only about a dozen solar companies in India capable of installing up to 100 MW of solar a year. PM Modi's visit to

China has resulted in the signing of three MoUs with Chinese solar companies. In addition, 'Make in India' program is pushing for the development of a solar manufacturing ecosystem in India. It is unclear though whether such an ecosystem can be developed within the timeline proposed.

Another impediment to the physical installation of the panels is that of land security. A quick calculation indicates that in order to meet the 100 GW by 2022 target, 1,000 sq km of land is required for projects. The government hopes that the proposed Land Bill aims to make tenure of land more secure. Note that this Bill is currently mired in controversy. Therefore, it remains to be seen if the government can meet its 2022 target.

INDIA'S INDC

India's population is still on the rise. By the year 2040, another 315 million people will be living in Indian cities. This transition is expected to have wide ranging effects on India's energy mix, as urbanization is expected to drive energy use from biomass towards electricity and oil. It is project that India will account for one quarter of the total rise in global energy demand- far ahead of any other country.

At the same time India has pledged in its INDC to:

- "Reduce the emissions intensity of GDP by 33 to 35 per cent by the year 2030 from 2005 level". This means that India will ensure that it will reduce emissions emitted per unit of GDP produced.
- "Achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by the year 2030 with the help of transfer of technology, and low cost international finance including from Green Climate Fund (GCF)"

As mentioned previously, India has already set ambitious renewable energy targets. This INDC, however, takes India's level of ambition further. It is unclear whether this is a conditional target. The clarification of the above by the Indian government could act as a signal to the world to show India's commitment to its renewables agenda. Further, the INDC defines non-fossil fuel based electricity as inclusive of nuclear power and clean coal. It is not clear what the relative proportions are, and what 'clean' coal means.

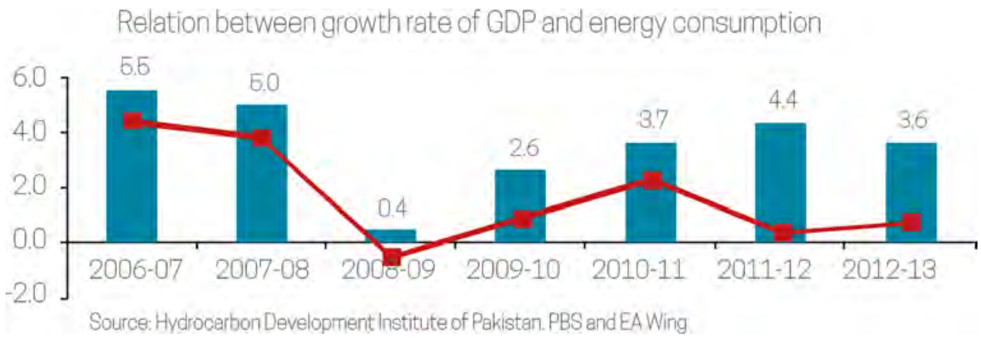
Thus the future of India's energy sector although exciting, presents several challenges.

ENERGY SECTOR IN PAKISTAN

Pakistan is the sixth most populous country of the world comprising 2.56 percent of the total global population. However, it ranks 37th in energy consumption at 0.37 percent of the world total. The per capita energy consumption in Pakistan is only 43 W, one seventh of the world average.

Pakistan has an energy crisis. It faces energy deficits of 4500 to 5000 MW (in recent years this shortfall has sometimes reached 8500 MW ~ 40 percent of national demand). Urban areas regularly experience several hours of daily outages, while in some rural regions residents are lucky to receive electricity for only a few hours everyday.

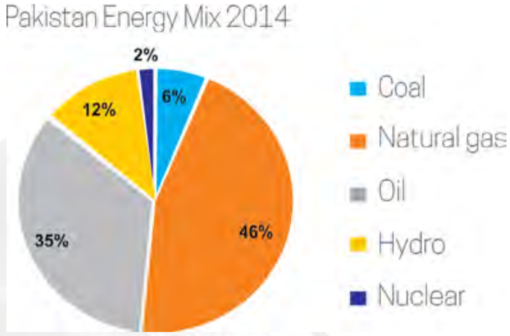
As can be seen from the figure below, there is a high correlation between the growth rate of GDP and that of energy consumption. In recent years, power outages have cost Pakistan up to 4 percent of GDP. Hundreds of factories have been forced to close down.



Pakistan's energy crisis is more a result of inadequate governance, rather than just a supply shortage. The energy sector suffers from widespread inefficiencies, including transmission and distribution losses that exceed 20 percent, as well as from several billion dollars of debt. The debt which is termed as 'circular' is a consequence of flawed pricing of energy, with a few customers paying their energy bills (bill collection rate is 87 percent) and theft of energy which leads to further cash flow problems for energy generators, distributors, and transmitters who already lack funds.

Pakistan's energy crisis has sparked angry protests within the country. On top of that, militants have exploited Pakistan's energy insecurity by targeting existing energy infrastructure causing even more widespread deficits.

Pakistan's energy mix consists almost exclusively of oil and natural gas. For both, consumption levels are so high that Pakistan's national oil and gas company: Oil and Gas Development Company Limited (OGDCL) projects that indigenous oil reserves will be exhausted by the year 2025, and that Pakistan will run out of natural gas by the year 2030.



OIL

In 2014, Pakistan produced 98,000 barrels of oil/day. There are thirteen companies involved in crude oil production. Of these thirteen companies, OGDCL has the highest share of almost 57 percent. Oil consumption on the other hand was 437,000 barrels per day in the year 2013. Imports are thus used to bridge the massive gap between supply and demand. The annual oil import bill of Pakistan is at a staggering US $15 billion. High Sulphur Furnace Oil, High Speed Diesel, and Motor Spirit have the highest share in the import bill, at 48 per cent, 32 percent, and 16 percent respectively.

The refining capacity of Pakistan is 14 MT. There are seven refineries in the country (although the Dhodak refinery remained shut down during 2012 due to depletion of the oil wells). The main users of petroleum products are the transport and power sectors, which jointly account for almost 90 percent of the total consumption. From 2001-02 to 2012-13, there has been a declining trend of consumption of petroleum products due to a shift to other energy sources driven by volatile oil prices.

Table 14.1: Supply and Consumption of Oil/Petroleum Products

Oil/Petroleum Products											
Fiscal Year	Supplies (Growth Rates)				Consumption						
	Oil		Petroleum Product		Oil / Petroleum Products						
					Total	Share in Total Consumption (%)					
	Crude Oil Imports	Local Crude Extraction	Imports	Producttion	Consumption Growth Rate	Household	Industry	Agriculture	Transport	Power	Other Govt
	%				%						
2001-02	-1.00	10.01	-10.03	8.29	-3.90	2.0	9.5	1.33	47.28	37.18	2.73
2002-03	1.02	1.13	-6.49	0.62	-3.00	1.7	9.8	1.20	49.13	36.59	1.62
2003-04	9.88	-3.55	-38.72	7.22	-18.42	1.7	11.1	1.37	63.07	20.41	2.30
2004-05	6.00	6.60	9.79	7.54	9.31	1.3	10.5	0.97	61.51	23.53	2.16
5005-06	3.90	-0.76	5.87	0.23	-0.30	0.9	11.6	0.56	66.77	28.84	2.45
2006-07	-4.49	2.84	38.63	-1.75	15.18	0.6	9.5	0.58	47.38	40.01	1.39
2007-08	6.95	4.01	8.34	4.27	7.32	0.7	5.9	0.60	61.90	39.18	1.72
2008-09	-4.34	-6.13	10.52	-8.61	-0.94	0.5	5.4	0.39	49.34	42.27	2.05
2009-10	-14.54	-1.36	12.07	-8.47	6.81	0.5	5.1	0.30	46.32	46.07	1.69
2010-11	-3.34	1.41	10.67	-0.94	-1.28	0.5	7.2	0.21	47.08	43.09	1.98
2011-12	-8.19	2.21	6.98	-5.79	-1.10	0.4	7.6	0.12	49.61	40.66	1.58
Jul-Mar											
2011-12	NA	NA	NA	NA	NA	0.4	8.2	0.16	49.23	40.41	1.54
2012-13	NA	NA	NA	NA	-10.04	0.5	7.5	0.14	49.57	40.82	1.53

Source: Hydrocarbon Development Institute of Pakistan
NA: Not Available:

NATURAL GAS

Natural gas is considered a cheaper substitute for oil in the generation of power- especially when a country mainly relies on oil imports. Despite this, due to the misallocation of natural gas at the expense of the power sector and a low growth in supplies, Pakistan has seen an increase in expensive oil imports to compensate for the reduction in gas. Note that this is in contrast with India, where gas forms only a small part of the energy mixes in the power sector.

Efficient allocation of domestic gas supplies is thus of extreme importance. The government has formulated a Gas Allocation and Management Policy, 2005 which highlights a merit order in a low gas supply scenario. However, the actual allocation of gas has been blatantly violated by gas companies since 2005.

Unaccounted for Gas (UFG) comprising of physical losses, measurement errors and theft is another major problem in Pakistan. In 2013, UFG was 13 percent of the total gas produced contributing to the deficit. Remedial actions such as maintenance of the low pressure distribution system, as well as instituting of high penalties for theft need to be taken.

Experts believe that natural gas will have a major role to play in alleviating Pakistan's energy crisis in the short and medium term. Demand side interventions should be given equal importance to supply side actions. The gas that Pakistan currently has must be efficiently used. Cogeneration should be made mandatory; efficient machinery should also be promoted.

On the supply side: Pakistan is believed to have a lot of unexplored conventional and non-conventional gas reserves: tight gas, shale, and coal bed methane. Unfortunately, international and domestic companies alike have shown minimal interest in petroleum licensing activities in the country. Gas fields in Pakistan tend to be modest in size- estimated to be between just 10 to 50 billion cubic feet, and are thus less attractive to international companies.

This is compounded by other exploratory risks such as lawlessness in areas with high potential for gas. Benefits of indigenous gas production have not accrued to citizens in the past, and therefore local communities view the development of gas with mistrust. In addition, a modern telecommunication system does not exist in high potential regions such as Baluchistan, and remote areas of Khyber- Pakhtunkhwa etc.

Poor petroleum policies are also responsible for keeping potential companies away. Analysts contend that low natural gas prices are the biggest disincentive for exploration in the country. Gas produced from the current 44 fields is priced in accordance with 33 unique pricing formulae that all track crude oil- but are capped as crude oil prices rise. Now is the time for Pakistan to move towards more sustainable gas pricing. Experts have proposed that fertilizer prices should be stabilized by giving direct subsidies to farmers. Pakistan should hike gas prices such that the industry bears a larger brunt than the commercial sector. Currently, counter intuitively, given the socioeconomic context of Pakistan- industry and large customers are charged lower tariffs than households.

Other than pricing, taxes, the treatment of imported goods, currency conversions and technical issues also contribute to difficulties in attracting investment. The sector is also over-regulated. Multiple bodies: the Ministry of Petroleum and Natural Resources, the Oil and Gas Regulatory Authority and other executive level government commissions and committees operate in the sector. The recent passage of the 18th constitutional amendment giving the federal and provincial governments 'equal rights' has further made the distribution of power between the bodies unclear.

Finally, the current glut of gas in regions which are easy to access and low-risk have further dampened the enthusiasm of international companies to brave the above mentioned risks and develop Pakistan's untapped natural gas reserves.

Pakistan should also look at other alternatives to natural gas such as biogas. Experts believe that the biogas potential of Pakistan is as much as the current annual production of natural gas. Biogas can be upgraded to pipeline-quality gas and thus merits the serious consideration of the gas sector. The other alternative is the more expensive LNG, and gas sourced from Iran via a pipeline.

Some element of competition and consumer choice should be integrated into the gas sector. It has been proposed that gas producers should be allowed to sell gas directly to large consumers at a mutually agreed-on price. Instead of controversial, politically untenable privatization, efforts should be made to pare down distribution companies to the divisional level in order to increase accountability.

In Pakistan, CNG is being sold at 50% of the price of petrol and diesel. This steep price differential has resulted in arbitrage, with long queues at gas stations and resource husbanding. Experts note that there is a strong case for banning the use of gas in vehicles with large engines in order that gas might be saved and diverted to the power sector.

COAL

Pakistan has untapped good quality lignite reserves estimated at over 186 billion tons including 175 billion tons identified in the Thar region. The major users of coal are the cement sector (58 percent) and brick kilns (41 percent). Currently, almost 4 million tons of coal is imported to cater to domestic demand. In order to tackle its energy crisis, Pakistan needs to move towards achieving a more affordable fuel mix. An audit carried out in 2013 revealed that the average cost of production of energy in Pakistan was about nine cents/kWh. Theft, and transmission and distribution losses, contribute to pushing electricity prices to between 14.6 and 14.7 cents/kWh. This is in comparison to the 7 cents/kWh in India. In order to reduce losses and protect the end customer, Pakistan needs to move away from expensive hydrocarbon imports to more affordable coal.

In the short term, Pakistan must import coal and convert furnace oil powered plants to coal powered ones. Furnace oil tariffs in 2015 ranged between 19 to 22 cents /kWh, while coal based tariffs are only an estimated 10 cents/kWh. Pakistan must simultaneously redouble efforts to develop new coal-fired power plants.

In the longer term, Pakistan must aim on developing its domestic coal resources in the Thar region- along with the construction of transport infrastructure to transport the coal from this region to the rest of the country. Many experts believe that this is the only sustainable way for Pakistan to close the energy supply-demand gap, and enable Pakistan to achieve energy security.

Pakistan needs to find a way to develop these fields. Conventional independent power producers (IPPs) have a long gestation period; meanwhile conventional generation companies owned by the government (GENCOs) have failed in the past in providing energy efficiently. The government needs to find a model of implementation to exploit indigenous reserves. It is important to note, that the development of the Thar coal fields will be challenging - Pakistan does not have the technical know-how or financing to undertake such a vast endeavour. In fact, in late 2014, China withdrew its support for building several coal plants in Baluchistan citing insufficient infrastructure.

The Pakistani government's initiative of providing sovereign guarantees to secure funding for a coal mining project of Sindh Engro Coal Mining Company (SECMC), as well as the National Electric Power Regulatory Authority's (NEPRA) announcement of an attractive electricity tariff for IPP's is seen by experts to be a step in the right direction. Pakistani government officials admit that they are aware of the environmental concerns associated with coal, but also say that coal based generation is a tiny fraction in Pakistan as compared to ~70 percent in India, and the 40 percent world average. They say that coal production is necessary for Pakistan to develop itself to the same level as its regional peers.

RENEWABLES

The energy situation that Pakistan faces today is almost identical to the one it faced in the 1990s. In 1994, in order to spur private investment in the energy sector, a new power policy was adopted based on a cost-plus model. Investors were offered attractive upfront tariffs, a guaranteed return on investment of 15 to 18 percent, and various tax exemptions after justifying costs to the regulator, irrespective of the performance of their plants.

While the policy attracted a record level of investment (> US $5 billion) and the addition of 4500 MW of energy to the grid in record time, it provided no incentive to investors to adopt efficient technologies, as investors received an identical return on investment regardless of whether investments were made in costly technologies that produced electricity at lower tariffs, or less expensive technologies that produced electricity at higher tariffs.

Power policies thus favoured low-cost facilities that could be brought online quickly. Most developers chose to build inexpensive plants that ran on oil. Excess capacity made it hard for the government to fulfil its obligations under the power purchase agreement. Demand soon caught up with supply, however, when the price of oil increased, and the cost of generation skyrocketed and the government was unable to make payments.

Rather than accepting responsibility for its flawed policy, successive governments have vilified the IPPs, maintaining the status quo while supporting large unsustainable subsidies that according to studies mainly benefit the middle class. However, in recent years NEPRA has worked on establishing an up-front tariff irrespective of the cost of the project (that can be reduced if costs are less than an upper ceiling). As per Pakistan's Medium Term Development Framework (MTDF) it aims on increasing renewable energy production to a minimum of 9700 MW.

In 2006, NEPRA approved an upfront tariff of US $0.16109/kWh for wind. At the time, under the then renewable energy policy, developers could choose to avail themselves of either the cost plus model or the up-front tariff. However, later the second option was phased out. Adding to the confusion in 2012, NEPRA released a new upfront tariff of US $0.146628/kWh. This change in policy undermined the commitment of the Pakistani government to renewables.

An upfront tariff is usually determined based on an evaluation of project costs, and an expected return on investment, balanced against the government's long-term cost of buying power. However, because of the past backlash against IPPs, NEPRA's upfront tariff is designed to limit the upside potential of the investment by project owners.

In its draft 2013 up-front tariff for wind, NEPRA proposed a tariff for a plant producing at a load factor of 31 percent. Any energy produced at capacity factors above this amount is paid for at a lower tariff. This discourages developers from aiming at higher efficiency equipment as the returns on more efficient turbines are lower. It was hoped that NEPRA would not repeat this mistake with the solar energy sector, and encourage developers to use the most efficient technology. However, this has not been the case. Pakistan needs to move towards a more efficient pricing strategy of renewables in order to encourage their development.

HYDROPOWER

Hydroelectric power is also being investigated seriously by the Pakistani government. The total hydroelectric potential of the country has been conservatively estimated to be at 45,000 MW. Only a fraction of this has been realised. A highly politicised debate has raged for thirty years over the construction of the Kalabagh dam which has deflected attention away from other dam projects. As a result, the percentage of hydropower in Pakistan's energy mix has plummeted. In 2004, Musharraf announced his plan to begin building the dam - but nothing happened. Following this, in the year 2012, the Supreme Court of Pakistan ruled that construction begin, however no action has been taken on this ruling to date.

Recently, the Pakistani government finally decided to proceed with the construction of the Diamer Bhasha dam which is expected to take eight years to construct. The cost of this dam is twice that of the proposed Kalabagh dam, and unlike the latter does not have the capability of diverting water for the purpose of irrigation.

PAKISTAN'S INDC

Pakistan submitted a 350 word INDC with no commitments to do anything to tackle climate change. This was particularly disappointing as Prime Minister Nawaz Sharif declared he would prioritize climate change at the UN General Assembly in September 2015.

The INDC submitted was vastly different from the draft INDC prepared by the Ministry of Climate Change that unconditionally committed to a five percent reduction in greenhouse gas emissions, ~54 tons of carbon by the year 2030.

CONCLUSION

This analysis was aimed at shedding light on the energy sector in India and Pakistan and contrast what was happening in each country with what is going on in the world. It was seen that both countries have a long way to go in closing the supply-demand gap of energy. India has a further burden of shifting to cleaner energy sources. Pakistan on the other hand is facing an energy crisis and is focused entirely on increasing its energy supply and making its energy mix affordable. It also has plans for integrating renewables in the current energy sector, but this goal is secondary.

INDIA & PAKISTAN: JOINED BY AGRICULTURE

MOHAN GURUSWAMY

Historically, India evolved as nation state located mostly in the northwestern part of the sub-continent. For a large part, it was a contiguous agro-climatic zone fed by the glacier melt of the Indus and largely monsoon fed Ganges river basins. Almost 800 million people now live in these two river basins. The two river basins were host to one of the world's most resilient and ancient civilizations. The Indus River once hosted the Indus Valley Civilization along its banks, one of the first major human settlements in the subcontinent, and discovered in 1921-22, dating back to the year 3500 BCE. It is here that the modern Indian nation evolved and subsequently moved eastwards into the Gangetic basin and the Deccan.

The name Hindustan itself derives from the river Sindhu or Indus, as it is known now. The Indus river basin one of the largest river basins in the world, and comprises of the main Indus and its tributaries. It is shared by India and Pakistan; out of about 200 million people are nurtured by it. 72 percent of Pakistanis and 23 percent of Indians live in the Indus basin.

The transboundary Indus river basin has a total area of 1.12 million km^2 distributed between Pakistan (47 percent), India (39 percent), China (8 percent), and Afghanistan (6 percent) (Table 1). The Indus river basin stretches from the Himalayan mountains in the north to the dry alluvial plains of the Sindh province in Pakistan in the south, and finally flows out into the Arabian Sea. In Pakistan, the Indus river basin covers around 520m the Himalayan morcent of the territory, comprising the whole of the provinces of Punjab and Khyber Pakhtunkhwa, and most of the territory of the province of Sindh and the eastern part of Balochistan. The drainage area lying in India is approximately 440morcent of thrly 14 percent of the total area of the country. From its source in the Tibetan plateau, the Indus River initially flows northwest before bending south to flow southwest through Pakistan into the Arabian Sea. Snow and glacier melt water is the main water input for this river system as rainfall is low in this region, and is generally concentrated to the monsoon season of July to September.[10]

The lower reaches are very braided and the river ends in a delta, which includes numerous mangroves. These mangroves are an important resource not only for the wildlife but also for the millions of people who depend on them including fishermen.

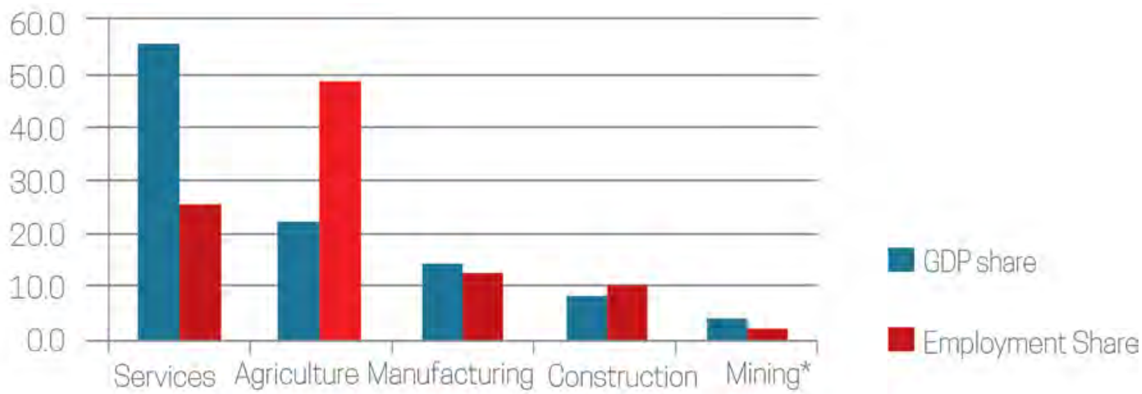
As the system relies strongly on melt water, it is highly vulnerable to change particularly increased temperatures, that alter the pace at which the glaciers melt, consequently impacting the river-flow in the Indus in the long run.

The Ganges basin is a part of the Ganges-Brahmaputra-Meghna basin draining 1,086,000 square kilometers in Tibet, Nepal, India, and Bangladesh. To the north, the Himalaya or lower parallel ranges beyond form the Ganges-Brahmaputra divide. On the west the Ganges Basin borders the Indus basin, and the Aravalli ridge. Southern limits are the Vindhyas and Chota Nagpur Plateau. On the east the Ganges merges with the Brahmaputra through a complex system of common distributaries into the Bay of Bengal. Its catchment lies in the states of Uttar Pradesh, Madhya Pradesh, Bihar, Rajasthan, West Bengal, Haryana, Himachal Pradesh, and Delhi, and the whole of Bangladesh, Nepal, and Bhutan.

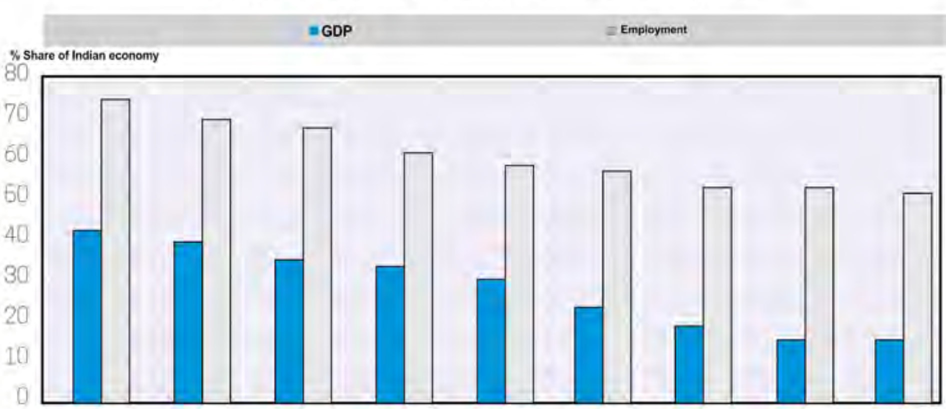
Several tributaries rise inside Tibet before flowing south through Nepal. The basin has a population of more than 500 million, making it the most populated river basin in the world. The annual surface water potential of the basin has been assessed as 525 km³ in India, out of which 250 km³ is utilizable water. There is about 580,000 km² of arable land, or 29.5 percent of cultivable land in India. [11]

INDIA

Agriculture plays a vital role in India's economy. Over 58 per cent of the rural households depend on agriculture as their principal means of livelihood. Agriculture, along with fisheries and forestry, is one of the largest contributors to the Gross Domestic Product (GDP). The shares of Agriculture to the GDP and Employment are shown below. It highlights India's dependence on Agriculture, as it is the biggest employer by far. According to the census of 2011, there are 118.9 million cultivators across the country, or 24.6 percent of the total workforce of over 481 million. In addition there are 144 million persons employed as agricultural labour. The number of cultivators and agricultural laborers combined would be around 263 million or 22 percent of the population (1.2 billion).



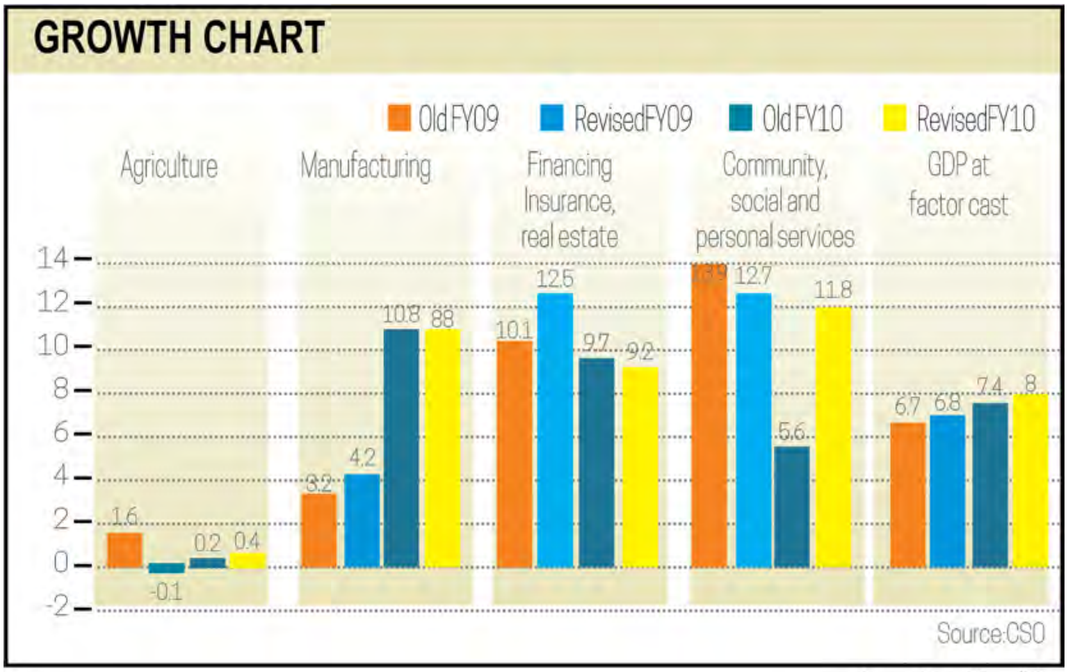
Agriculture's share of national employment remains large in India



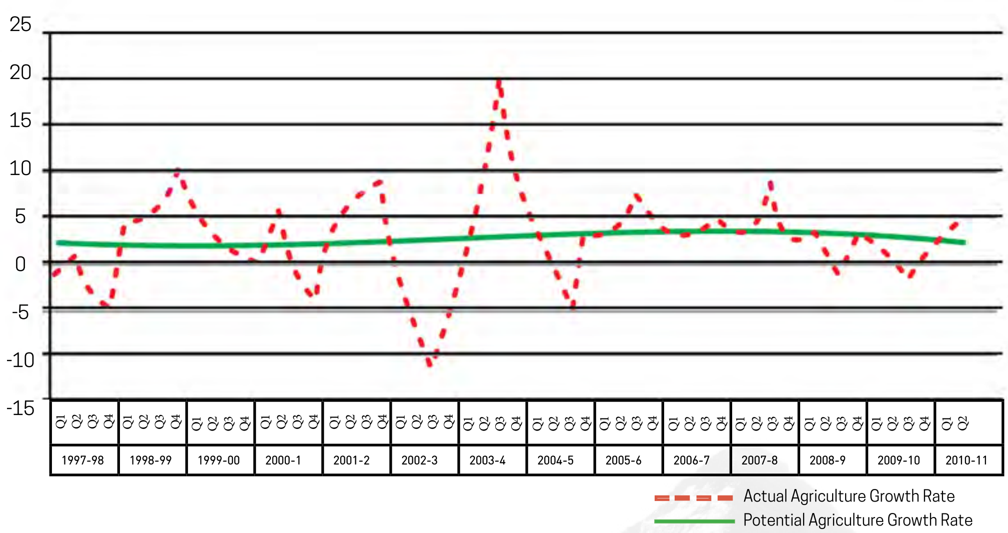
Sources: Employment share from 1977-78 to 1999-00 from papola,TS. (2006). Employment Trends India, Institute for Studies in Industrial Development, New Delhi, India: Employment share for 2004-05;2009-10 from World Bank (2014a), World Development Indicators (database). GDP share data from Government of India (2013a). Economic Survey 2012-13, Government of India, New Delhi.

StatLink http//dx.doi.org/10.1787/888933099029

As per estimates shared by the Central Statistics Office (CSO), the share of agriculture and allied sectors (including agriculture, livestock, forestry, and fishery) was 16.1 percent of the Gross Value Added (GVA) during 2014–15 at 2011–12 prices. During Q1 FY2016, agriculture and allied sectors grew 1.9 percent year-on-year and contributed 14.2 percent of GVA.



Ahmed Raza Khan /Mint

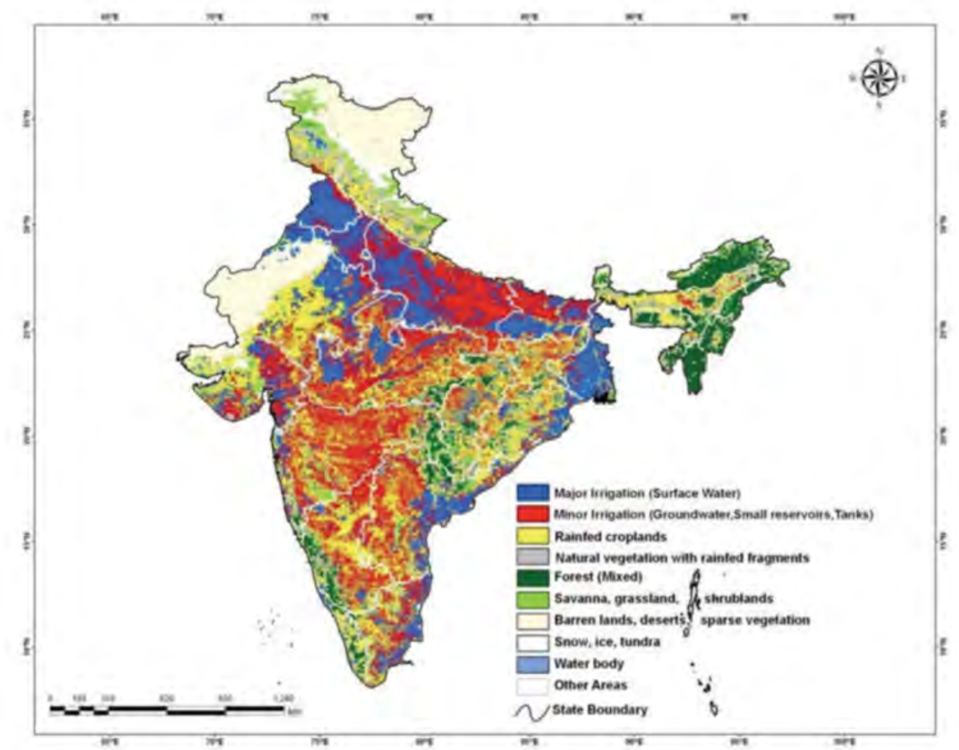


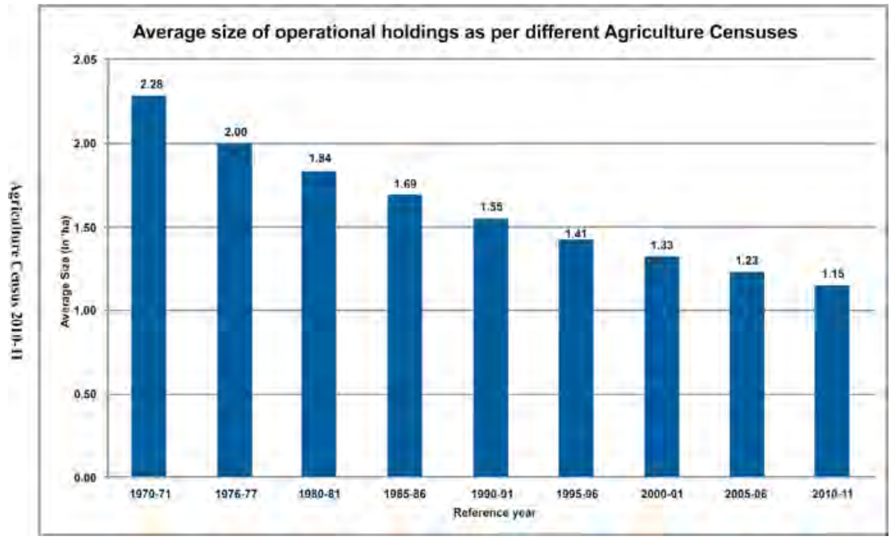
Source: Constructed based on data from CSO

LAND USE

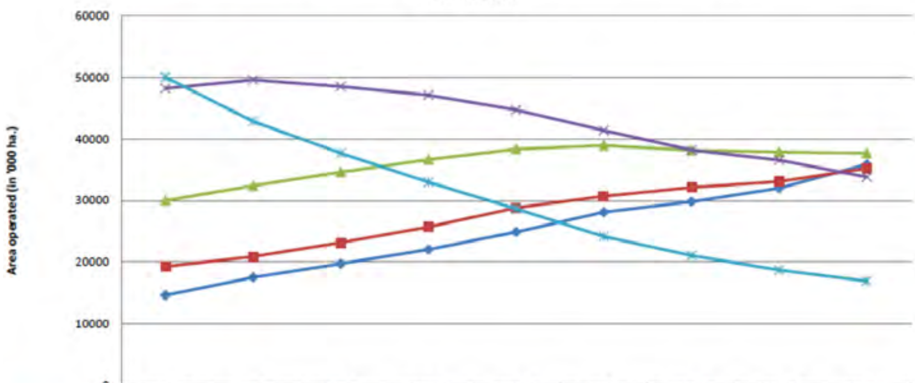
With 157.35 million hectares, India holds the world's second largest agricultural land area, but the average size of operational holdings has almost halved since 1970 to 1.05 ha. Over two thirds of Indian agriculturists are small and marginal farmers. About 51.09 percent of the land is under cultivation, 21.81 percent under forest, and 3.92 percent under pasture. Built up areas and uncultivated lands occupy about 12.34 percent of the land, while about 5.17 percent of the total land is uncultivated waste that can be converted into agricultural land. The remaining 4.67 percent of the land is comprised of other types.

Landholding size	Propartion of Household (%)	Propartion of Area Owaned (%)
Marginal	69.38	16.93
Small	21.75	33.97
Semi-Medium	5.06	17.63
Medium	2.84	17.64
Large	0.95	13.83
Source: 48 NSS round (1997-92)		

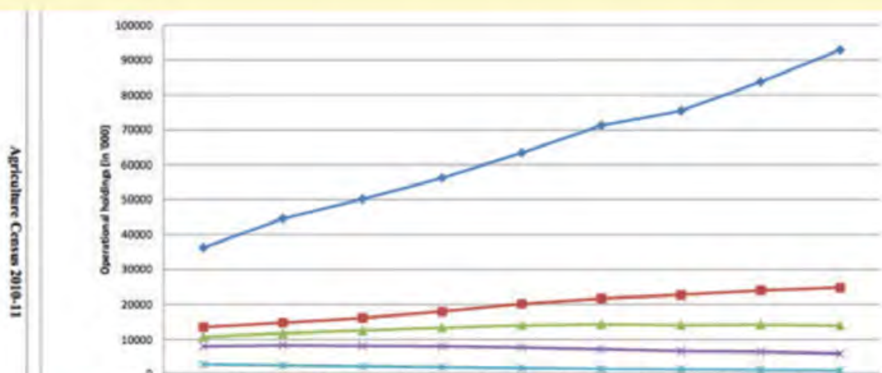




Area operated by operational holdings as per different Agriculture Censuses



	1970-71	1976-77	1980-81	1985-86	1990-91	1995-96	2000-01	2005-06	2010-11
Marginal	14599	17509	19735	22042	24894	28121	29814	32026	35908
Small	19282	20905	23169	25708	28827	30722	32139	33101	35244
Semi-Medium	29999	32428	34645	36666	38375	38953	38193	37898	37705
Medium	48234	49628	48543	47144	44752	41398	38217	36583	33828
Large	50064	42873	37705	33002	28659	24160	21072	18715	16907



	1970-71	1976-77	1980-81	1985-86	1990-91	1995-96	2000-01	2005-06	2010-11
Marginal	36200	44523	50122	56147	63389	71179	75408	83694	92826
Small	13432	14728	16072	17922	20092	21643	22695	23930	24779
Semi-Medium	10681	11666	12455	13252	13923	14261	14021	14127	13896
Medium	7932	8212	8068	7916	7580	7092	6577	6375	5875
Large	2766	2440	2166	1918	1654	1404	1230	1096	973

AGRICULTURAL PRODUCTION AND GROWTH

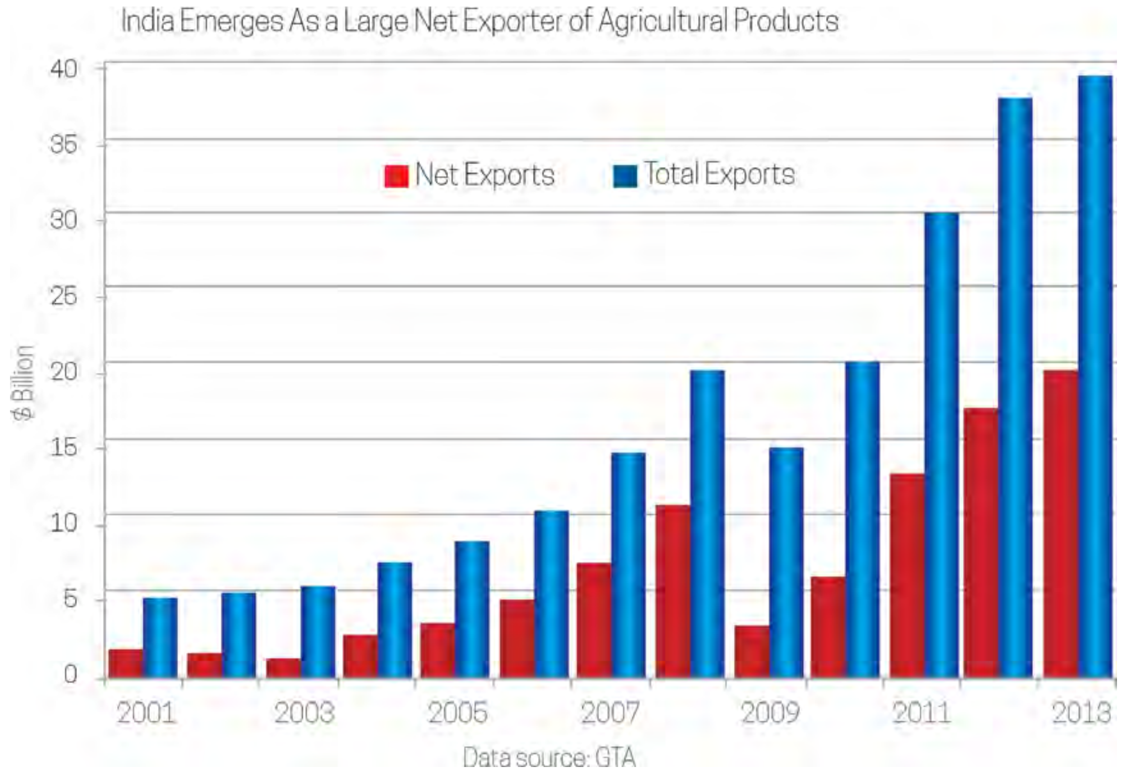
Total food grains production in India reached an all-time high of 251.12 million tonnes (MT) in FY15 (as per 3rd Advance Estimates). Rice and wheat production in the country stood at 102.54 MT and 90.78 MT, respectively. This sets India among the top 15 leading exporters of agricultural products in the world.

With about 20 agro-climatic regions, India experiences all 15 major climates in the world. Consequently, it is a large producer of a wide variety of foods. India is the largest producer of spices, pulses, milk, tea, cashew, and jute; and the second largest producer of wheat, rice, fruits and vegetables, sugarcane, cotton, and oilseeds. Furthermore, India ranks 2nd in the global production of fruits and vegetables, and is the largest producer of mango and banana. It also has the highest productivity of grapes in the world.

Agriculture in India, largest crops by economic value

		Economic value	Unit price	Average yield, India (2010)	World's most productive farms (2010)	
Rank	Produce	(2009 prices, US$)	(US$ / kilogram)	(tons per hectare)	(tons per hectare)	Country
1	Rice	$35.74 billion	0.27	3.3	10.8	Australia
2	Buffalo milk	$25.07 billion	0.4	1.7	1.9	Pakistan
3	Cow milk	$14.09 billion	0.31	1.2	10.3	Israel
4	Wheat	$12.13 billion	0.15	2.8	8.9	Netherlands
5	Sugar cane	$8.61 billion	0.03	66	125	Peru
6	Mangoes	$8.12 billion	0.6	6.3	40.6	Cape Verde
7	Bananas	$7.60 billion	0.28	37.8	59.3	Indonesia
8	Cotton	$5.81 billion	1.43	1.6	4.6	Israel
9	Potatoes	$5.31 billion	0.15	19.9	44.3	USA
10	Fresh Vegetables	$5.28 billion	0.19	13.4	76.8	USA
11	Tomatoes	$4.12 billion	0.37	19.3	524.9	Belgium
12	Buffalo meat	$3.84 billion	2.69	0.138	0.424	Thailand
13	Onions	$2.92 billion	0.21	16.6	67.3	Ireland
14	Okra	$2.90 billion	0.64	10.6	20.2	Cyprus
15	Chick peas	$2.83 billion	0.4	0.9	2.8	China
16	Fresh fruits	$2.79 billion	0.35	7.6	23.9	Israel
17	Eggs	$2.65 billion	0.83	13.8	24.7	Jordan
18	Soybean	$2.61 billion	0.26	1.1	3.7	Turkey
19	Cattle meat	$2.39 billion	2.7	0.1	0.42	Japan
20	Groundnuts	$2.33 billion	0.42	1.1	5.5	Nicaragua

India is the largest producer, consumer, and exporter of spices and spice products. It ranks third in farm and agriculture outputs. Agricultural exports constitute 10 per cent of the country's exports and are its the fourth-largest exported principal commodity.



Over the recent past, multiple factors have worked together to facilitate growth in the agriculture sector in India. These include growth in household income and consumption, expansion in the food processing sector and increase in agricultural exports. Rising private participation in Indian agriculture, growing organic farming, and use of information technology are some of the key trends in the agriculture industry.

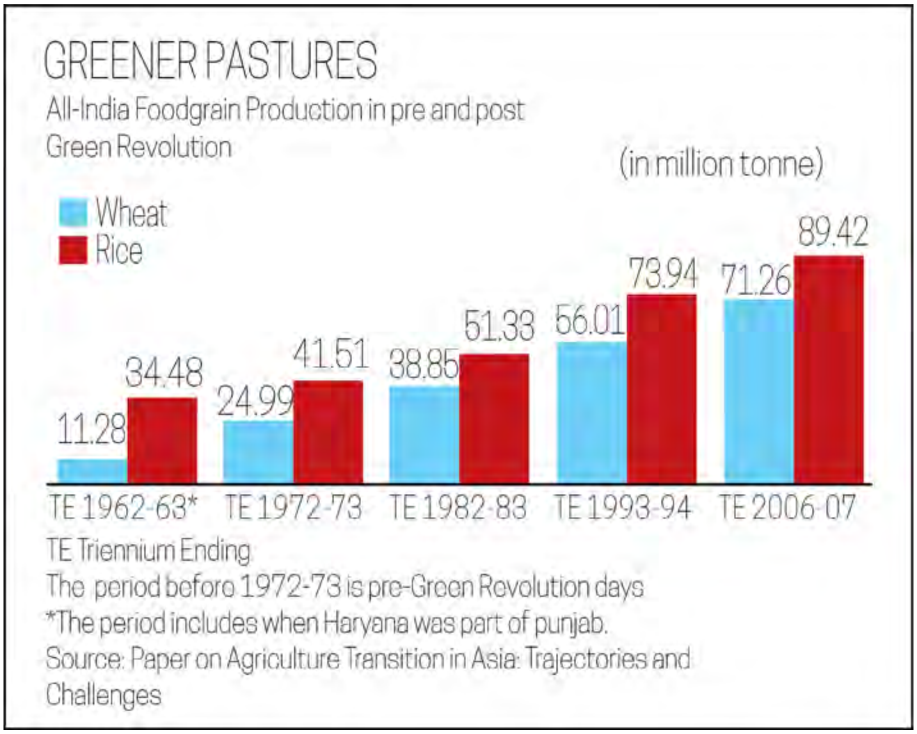
With an annual output of 138 MT, India is the largest producer of milk. It also has the largest bovine population. India is the largest importer of pulses at 19.0 MT and 3.4 MT, respectively. It is also the second-largest producer of sugar, accounting for 14 percent of the global output. The sixth-largest exporter of sugar, it accounts for 2.76 percent of the commodity's global exports.

Spice exports from India are expected to reach US$ 3 billion by 2016–17 due to its creative marketing strategies, innovative packaging, strength in quality, and strong distribution networks. The spices market in India is valued at Rs 40,000 crore (US$ 6.16 billion) annually, of which the branded segment accounts for about 15 percent.

It was around the mid-1960s when the Paddock brothers, the 'prophets of doom', predicted that in another decade, recurring famines and an acute shortage of food grains would push India towards disaster. Stanford University Professor Paul R. Ehrlich in his 1968 best selling book The Population Bomb warned of the mass starvation of humans in the 1970s and 1980s in countries like India due to over population.

Their prophecies were based on a rising shortage of food because of droughts, which forced India to import 10 million tonnes of grains between 1965-66 and a similar amount a year prior. Little did they know that thanks to quick adoption of a new technology by Indian farmers, the country would more than double its annual wheat production from 11.28 million tonnes in 1962-63 to more than twice than that within ten years, to 24.99 million tonnes. In 2007, production of grains was at 71.26 million tonnes. Similarly, rice production also grew spectacularly from 34.48 million tonnes to almost 90 million tonnes in the year 2007.

In the four decades that followed, starting from 1965-66, wheat production in Punjab and Haryana has risen nine-fold, while rice production increased by more than 30 times. The twin states and parts of Uttar Pradesh now not only produce enough to feed the country, but enough to leave a significant surplus for exports.



The technology and the subsequent state support is perhaps the single vital event that changed the face of Indian agriculture. At a time when the country is to mark the golden jubilee of that momentous event, it is also time to look back at the gains and losses from that revolution.

Alongside, a well-oiled mechanism of price assurance to producers through a system of Minimum Support Prices, implemented through obligatory procurement, inter-year and intra-year price stability through open market operations and distribution of subsidized food grains through a network of ration shops was put in place.

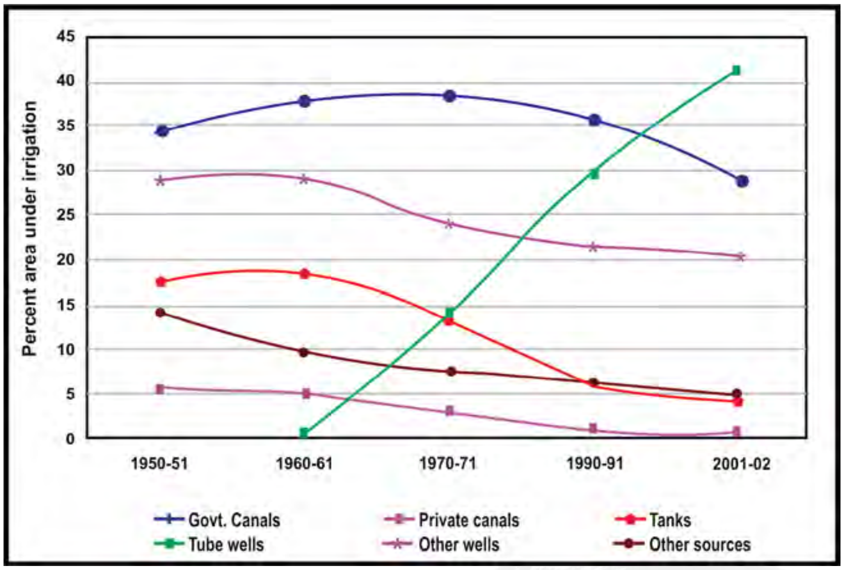
All these changed India from a grain-deficit state to one of the world's biggest producers of wheat and rice. The entire north-western region of Punjab, Haryana, and western UP were early adopters of the technology, as land in these areas was suitable for adoption of new varieties, and an abundant water supply coupled with farmers who were willing to alter their cultivation patters.[13]

IRRIGATION AND WATER USE

In 1951, India's irrigation covered crop area was at about 22.6 million, having increased to a potential of 90 mha by the end of 1995, inclusive of canals and groundwater wells. However, the potential of irrigation is dependent on a reliable supply of electricity for water pumps and maintenance, and the net irrigated land has been considerably short. According to the 2001/2002 Agriculture census, only 58.1 million hectares of land was actually irrigated in India. The total arable land in India is 160 million hectares (395 million acres). According to the World Bank, only about 35 percent of total agricultural land in India was reliably irrigated in 2010. India possesses nearly 30 percent of the global annualized irrigated areas, and is the leading irrigated-area country in the world.

The total area available for irrigation (TAAI) for India at the end of 2010 was between 101 Mha and 113 Mha; 41 percent was from major irrigation (major and medium irrigation schemes), while 59 percent was from minor irrigation (groundwater, small reservoirs, and tanks). Of this, 38 percent was from surface water and 62 percent was from groundwater. The increasing reliance on groundwater is now very clear.

YEARS	CANALS		TANKS	TUBE-WELLS AND WELLS	OTHER SOURCES
	GOVT	PRIVATE			
1980-81	37.32	2.17	8.22	45.70	6.59
1985-86	37.54	1.11	6.60	48.77	5.98
1990-91	35.34	1.00	6.13	51.42	6.11
1995-96	31.01	1.05	5.84	55.61	6.49
1999-00	30.66	0.78	4.73	58.76	5.08
SOURCE: MINISTRY OF AGRICULTURE					



The GIAM estimates about 67 percent of India's cropland as irrigated and the remaining 33 percent as rain-fed.

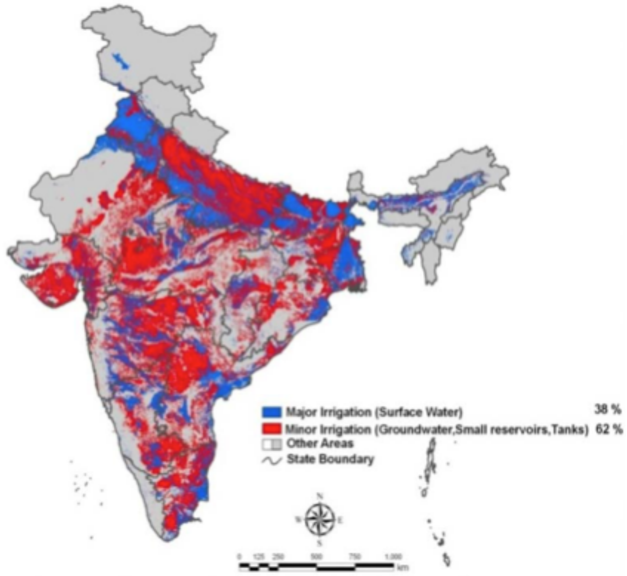


FIGURE 1
Basin wise distribution of exploitable surface water resources
Total 690 km³ Year on average

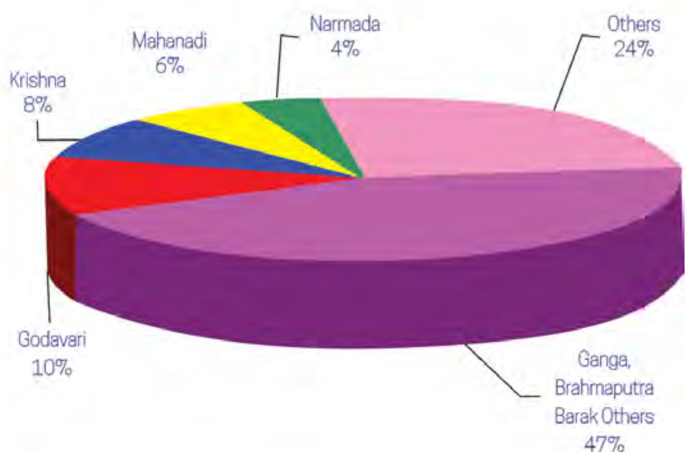
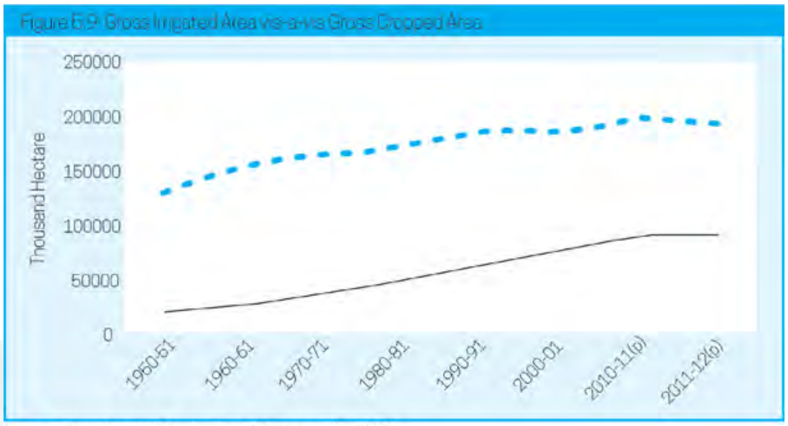


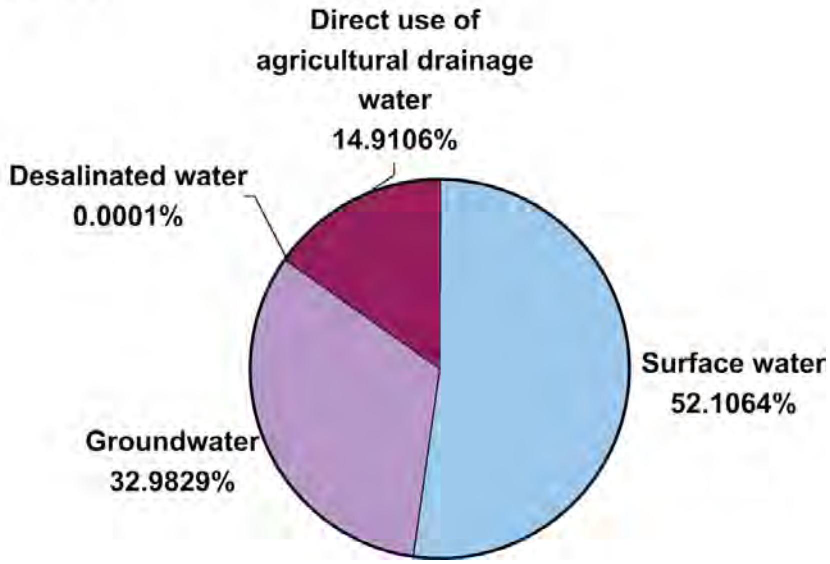
Figure 5.9: Gross Irrigated Area vis-a-vis Gross Cropped Area



Source: Department of Agriculture & Cooperation (DAC).

FIGURE 3

Water withdrawal by source
Total 761 km³ in 2010



In a 1991 United Nations FAO report, the ultimate sustainable irrigation potential of India was estimated to be at 139.5 million hectares, comprising 58.5 mha from major and medium river-fed irrigation canal schemes, 15 mha from minor irrigation canal schemes, and 66 mha from groundwater-well fed irrigation systems.

PERIOD	NET IRRIGATED AREA					GIA
	CANALS	TANKS	WELLS	OTHERS	NIA	
1952-53	8613 (41.80)	3468 (16.51)	6339 (30.17)	2588 (12.32)	21008 (100.0)	23016
1962-63	10568 (42.15)	4651 (18.55)	7430 (29.64)	2420 (9.65)	25070 (100.0)	28631
1972-73	12983 (41.22)	3822 (12.13)	12377 (39.30)	2313 (7.34)	31494 (100.0)	38560
1982-83	15808 (39.55)	3165 (7.92)	18593 (46.52)	2406 (6.02)	39971 (100.0)	51006
1992-93	17247 (34.92)	2817 (5.70)	25884 (52.40)	3114 (6.30)	49395 (100.0)	65215

India's irrigation now is mostly groundwater-well based. At 39 million hectares (67 percent of its total irrigation), India houses the world's largest groundwater well equipped irrigation system (China with 19 mha is second, USA with 17 mha is third). Compared with the UN estimated water potential, it is clear that India has some way to go.

THE FLIPSIDE OF THE GREAT INDIAN AGRICULTURE STORY

The Indian subcontinent houses nearly half the world's hungry people. Half of all children under five years of age in South Asia are malnourished, which makes conditions in the region even worse than those in sub-Saharan Africa.

The rural economy in South Asia is predominantly land based, absorbing nearly 70 percent of the total population. However, tough growing conditions for crops and continuous fragmentation of holdings in these areas make them extremely vulnerable to climatic fluctuations and low yield. In the so-called "poverty square" of South Asia, more than half of the farmland consists of marginal and small farms, less than one hectare in size. Moreover, because of rapid population growth, the average farm size in this region has decreased by half every 15 years since the year 1960.

In India, approximately 92 million households or 490 million people are dependent on marginal or small farm holdings as per the 2001 census. This translates into 60 percent of the rural population or 42 percent of the total population.

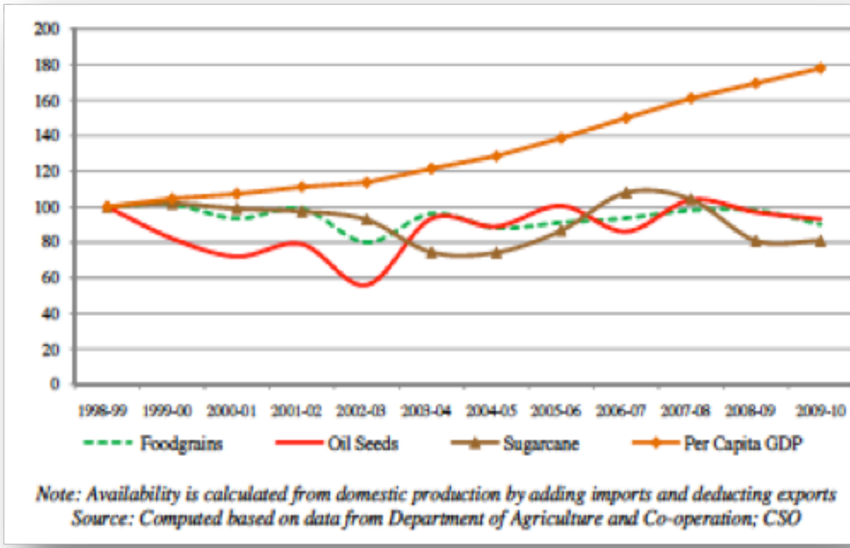
Year	GSAfg*	Production of food grains according to time trend	Production of food grains if the growth of irrigation is 50 % more per year.
2010	128.25	235.98	271.89
2025	125.06	268.88	322.65
2050	112.72	271.65	334.79

About 70 percent of the Indian population lives in rural areas, while all-weather roads do not connect about 40 percent of rural habitations. Due to a lack of proper transport facilities and inadequate post harvesting methods, food processing, and transportation of foodstuffs, an annual wastage of $12 billion (Rs. 50,000 crores) out of an out of about $83 billion or Rs.370, 000 crores results.

There is a pronounced bias in the government's procurement policy, with Punjab, Haryana, coastal AP, and western UP accounting for the bulk (83.51 percent) of the procurement.

The food subsidy bill has increased from Rs. 24.5 bn in 1990-91 to Rs. 175 bn in 2001-02 to Rs. 562 bn in 2009-10, or about 1 percent of the GDP. Instead of being the last resort-buyer, FCI has become the preferred buyer for farmers. The government policy has resulted in mountains of food-grains coinciding with starvation deaths.

The subsidy provided to agricultural consumers has quadrupled from Rs. 73.35 bn in 1992-93, to Rs. 304.62 bn in 2001-02. Free or highly subsidized power has meant that farmers have slid to the bottom of the State Electricity Board's priority list. While the subsidy was launched to reach the lower rung farmers, it has mostly benefited the well-off farmers.



The rate of production growth has slumped from 3.19 percent in the 1980s to a mere 1.73 percent in the 1990s. In the year 2000, it was at 1.6 percent. The growth in yield has halved from 2.56 percent in the 1980s to 1.02 percent in the 1990s. Clearly, India's yield rates are lagging way behind other agricultural countries, while its per capita availability of cereals and pulses remains largely unchanged since 1980, at about 420 and 36 grams respectively. [14]

COUNTRY	AGRICULTURAL PRODUCTIVITY (Kgs/hectare)
India	2318
Brazil	3095
China	4904
Egypt	7269
Kenya	1662
Malaysia	3172
Mexico	2817
Poland	3087
Turkey	1949
USA	5886
Source: Dun & Bradstreet	

Public investment in agriculture in real terms, had witnessed a steady decline from the Sixth Five-Year Plan onwards. With the exception of the Tenth Plan, public investment has consistently declined in real terms (at 1999-2000 prices) from $ 14.20 bn (Rs.64, 012 crores) during the Sixth Plan (1980-85) to $11.60 billion (Rs 52,107 crore) during the Seventh Plan (1985-90), $10 bn (Rs 45,565 crore) during the Eighth Plan (1992-97), and about $9.5 bn (Rs 42,226 crore) during Ninth Plan (1997-2002).

The share of agriculture in total GCF at 93-94 prices has halved from 15.44 percent to 7.08 percent between 2000-01. In the period between 2001-12 almost half of the amount allocated to irrigation was spent on power generation. While it makes more economic sense to focus on minor irrigation schemes, major and medium irrigation projects have accounted for more than three fourths of the planned funds.

THE CHALLENGE AHEAD

By the year 2050, India's population is expected to reach 1.7 billion, which will then be equivalent to nearly that of China and the US combined.

A fundamental question then arises; can India feed 1.7 billion people properly? If the food availability is bad now, what is likely to be the situation in 2050 when India will have an additional 430 million mouths to feed?

Farm outputs in India in recent years have been setting new records, having gone up from 208 million tonnes (mt) in 2005-06 to an estimated 263 mt in 2013-14. Even accounting for population growth during this period, the country would need probably around 225 to 230 mt to feed its people.

Thus, food production is not the real challenge facing India's hunger problem; India is producing enough food to feed its people. The actual challenge is to put enough money in their hands to buy more food.

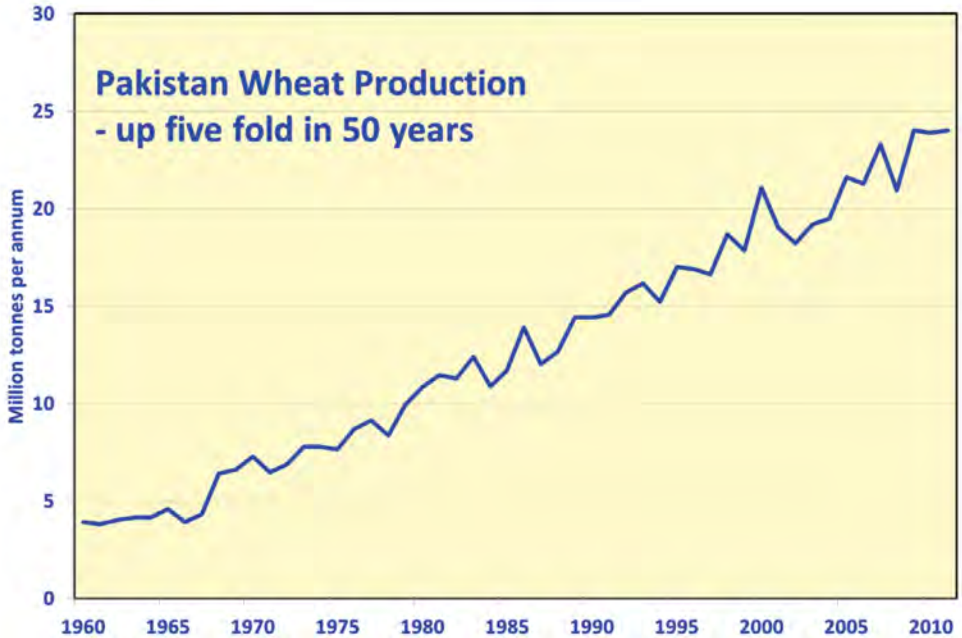
PAKISTAN

Agriculture is the backbone of Pakistan's economy. It provides food to consumers and fiber for domestic industry; it also provides livelihood and employment to the majority of the country's population and is the major source, directly and indirectly, of the country's export earnings. Agriculture constitutes, on average, one-fourth of the total Gross Domestic Product (GDP), and employs about 45 percent of the labour force. More importantly, 66 percent of the country's population living in the rural areas is directly or indirectly dependent on agriculture for its livelihood. Almost 68 percent of the country's exports are agro-based. [15]

Pakistan's principal natural resources are arable land and water. Pakistan's agriculture accounts for about 21 percent of GDP and employs about 43 percent of the labor force. Punjab is the most agriculturally rich province of the country, where wheat and cotton are grown in abundance. Mango orchards are mostly found in the provinces of Sindh and Punjab, making Pakistan the world's 4th largest producer of mangoes.

Pakistan has a rich and vast natural resource base, covering various ecological and climatic zones. This by nature allows it to benefit from the great potential for producing a range of agricultural crops. A wide and diversified variety of crops, fruits, vegetables, and condiments are grown. In the crops sector, four major crops dominate – wheat, rice, cotton, and sugarcane – and, on average, contribute about 32 percent to the value added in overall agriculture. Minor crops account for 12.3 percent of the value added in overall agricultural production of Pakistan.

Wheat is of vital importance to Pakistan, as it is the staple food of its people. The focus of Pakistan's agriculture and food policies since independence has been on the attainment of self-sufficiency in wheat production, aided by a continued reliance on imports in most years to meet domestic demand. Exports have either been non-existent or minimal, notably those in the years 2001, 2002, and 2003, with wheat exports accounting for its highest share of global exports at just over 0.8 percent, in the year 2003.



Pakistan lies within diverse ecological and climatic zones, thereby engaging in the production of a wide variety of crops in different regions of the country. The major crops – which include cotton, rice, wheat, and sugarcane – account for about 32 percent of agricultural value added. However, minor crops, although only constituting 12.3 percent of national agricultural value added, are also very important to the country's overall production, as a sizeable part of the population depends on these at the regional level. Recent studies have highlighted the importance of minor crops like gram, chili, banana and tobacco, and have suggested keeping these crops in focus. Livestock is another increasingly important sub-sector of Pakistan's national agriculture, with around 30-35 million people of the country's rural population engaged in rearing livestock. This sub-sector now contributes 50 percent to agricultural value added, higher than the crop sector (47.4 percent), and equal to about 10.3 percent of the overall national GDP.

During the fiscal year 2014-15, the overall performance of the agriculture sector recorded a growth of 2.9 percent compared to the growth of 2.7 percent during last year due to positive growth in all related agricultural sub sectors. In this year, growth rates observed in the industry were: Crops 1.0 percent, Livestock 4.1 percent, Forestry 3.2 percent, and Fishing 5.8 percent. The agricultural industry's crop sub-sector component, which includes important crops, other crops, and cotton ginning, showed a growth rate of 0.3 percent, 1.1 percent, and 7.4 percent, respectively. At a contribution of 25.6 percent in agricultural value added, important crops are of equal importance, despite experiencing a meager growth of 0.3 percent in the fiscal year 2014-15 against a growth rate of 8.0 percent during the same period of last year on account of revised production estimates of the wheat crop.[16]

In 2015, Pakistan has seen another good year of the wheat harvest (its main staple) with an estimated national production of 25.6 million tons (MT), a little short of the target set at 26 MT by the government, however it is slightly higher than last year's production of 25.3 MT. Similarly, production of rice has been the highest ever recorded for the country with 7.0 MT - showing a growth of 3.0 percent over last year's production that was 6.8 MT.

The important crops performance remained weak as only cotton and rice production recorded a positive growth of 9.5 percent and 3.0 percent respectively, while sugarcane, maize, and wheat production recorded a negative growth of 7.1 percent, 5.0 percent, and 1.9 percent respectively, with respect to last year's estimates. Other crops contributed 11.1 percent to the value addition of agriculture, with a recorded increase of 1.1 percent during 2014-15 against a negative growth of 5.4 percent during the same period last year. This was attributed to the increase in production of pulses, vegetables, and fruits which recorded a positive growth of 13.0 percent, 2.5 percent, and 0.9 percent respectively against the negative growth of pulses and vegetables by 35.9 percent and 8.8 percent respectively, on account of better water availability, more fertilizer off-take, and relief in the prices of agriculture inputs coupled with an enhanced availability of agriculture credit.[17]

The livestock sector, which accounts for 56.3 percent of the country's agricultural out-put recorded a positive growth of 4.1 percent in 2014-15 against 2.8 percent growth during the same period last year. The Fishing sector contributed 2.1 percent in agriculture value addition, recording a growth of 5.8 percent as compared to last year's growth of 1.0 percent. The forestry sector recorded a growth of 3.2 percent this year as compared to the negative growth of 6.7 percent last year.

Pakistan has two crop seasons, "Kharif" and "Rabi". "Kharif" is the first sowing season that begins from April through June, and is harvested during October-December. Rice, sugarcane, cotton, maize, moong, mash, bajra, and jowar are "Kharif" crops. "Rabi", the second sowing season, begins in October through December, and is harvested in April through May. Wheat, gram, lentil (masoor), tobacco, rapeseed, barley, and mustard are "Rabi" crops.

LAND USE AND IRRIGATION

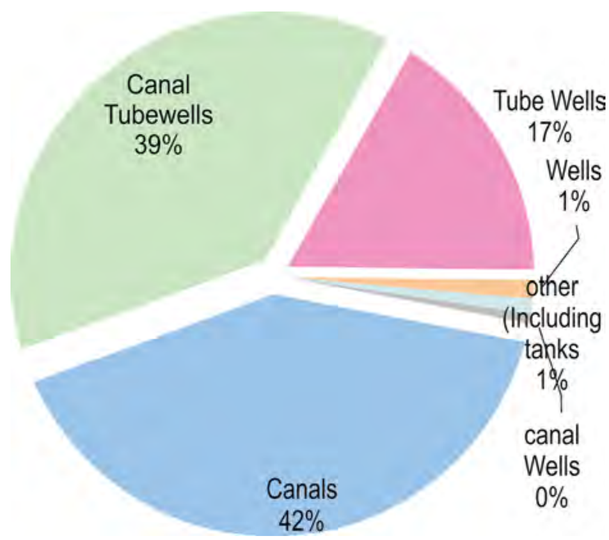
Agriculture constitutes the backbone of Pakistan's economy, contributing 21.4 percent to the national gross domestic product. Out of 22 million hectares, 74 percent of cultivated area is irrigated (14.6 million hectares). The per capita water availability in Pakistan is continuously on decline, standing at 1000 cubic meter per person per year in 2012-13, against 5600 cubic meters per person per year at the time of partition. Agricultural water availability is dwindling with each passing year, particularly due to the decrease in the country's water storage capacity, increasing population growth, and climate change.

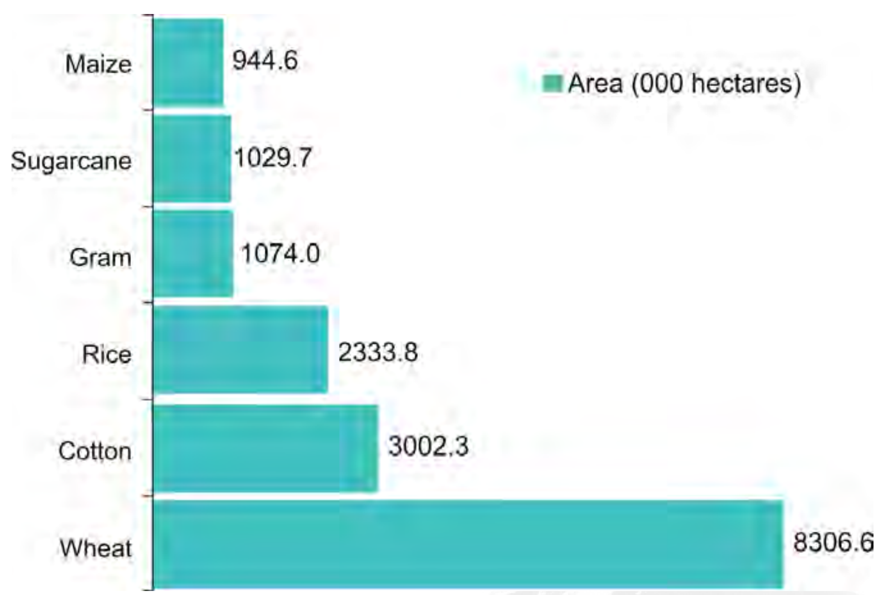
Pakistan boasts the world's largest irrigation system, with the total length of canals in the country at 56073 km, while the total length of watercourses is 1.6 million km. About 106 million acre feet of water is diverted to canals, of which about 15 percent is lost in main and branch canals. 8 percent of the water is lost in distributor minors, while 30 percent is lost in water courses, and 30 percent lost in the field, thus marking the efficiency of the irrigation systems at just over 41 percent.[18]

LAND USE IN PAKISTAN		
CATEGORY	**AREA**	
	(MH)	**(MA)**
1. Geographical Area (total area)	79.3	196.0
2. Area suitable for agriculture	31.2	77.1
3. Irrigated + Barani	22.1	54.5
4. Irrigated area by all sources	18.0	44.5
5. Additional area that can be bought under irrigated agriculture	9.2	22.6

Pakistan's agricultural output is closely linked with the supply of irrigation water. During 2014-15, the availability of water for Kharif in 2014 stood at 69.3 (MAF), showing an increase of 5.8 percent since the Kharif crop of 2013, and 3.3 percent more than the normal supplies of 67.1 MAF. Water availability during the Rabi crop season 2014-15 is estimated at 33.1 MAF, which is 1.8 per cent higher than the Rabi crop of 2013-14, but 9.1 percent less than the normal availability of 36.4 MAF.

By the year 2025, the demand for water in Pakistan is projected to reach 274 MAF, while supply is unlikely to be much more than 191 MAF. Unless this demand and wastage is curtailed, the severity of the water crisis will intensify.[19]





According to the Pakistan-based NGO, Society For Conservation and Protection of The Environment (SCOPE), about one-half (50.8 percent) of rural households in Pakistan are landless, while 5 percent of the country's population owns almost two-thirds (64 percent) of its farmland. The World Bank, under the agricultural census of 2000, found that 63.3 percent of rural households were landless. Of the remaining 37 percent of rural households, 61 percent of these owned less than 5 acres, totalling 15 percent of the total land. 2 percent of households owned 50 acres or more, accounting for 30 percent of the total land area. Concentration of ownership is also thought to be less productive than owner-farmed land. According to the World Bank, "most empirical evidence indicates that land productivity on large farms in Pakistan is lower than that of small farms, holding other factors constant. Small farmers have "higher net returns per hectare" than large farms, as per the farm household income data.

Ownership holdings by size of area owned, according to the agriculture census of 2000, show that 61 per cent of the total private holdings of Pakistan are under five acres and ownership of 50 acres and above are only two per cent. Majority of the landholdings at 94 percent, lie in the category of less than 25 acres while only 6 percent of holdings lie in the category of 25 acres and above.

There are wide provincial variations such as in Punjab and NWFP, where dominant ownership holdings fall in the category of under five acres at 61.34 percent and 79 percent respectively, while in Sindh and Balochistan, the majority of the land ownership lies in the size class of five acres to under 25, 46, and 52 percent respectively. In Sindh and Balochistan, shares of landholdings of 25 acres and above are the highest among all four provinces at 12 and 18.6 percent respectively.

Since the majority of land holdings are of less than five acres, the income patterns of the owning households become highly vulnerable to the vagaries of weather and economic shocks — any exogenous shock, unfavorable weather conditions, a bad crop, or an adverse economic policy, proves their undoing and they slip below the poverty line. A vicious cycle of poverty ensures — starting with lower or rather zero initial assets' base — that the small farmers are unable to bridge the economic gap on their own unless official economic policies are positively biased towards them.

Agricultural income for majority of the rural poor accrues from the food crops, mainly rice and wheat. Wheat dominates the total cropped area occupying 40 percent of the total area, followed by cotton and rice at 14 and 12 percent respectively, while the share of sugarcane lies at only 4 percent of the total cropped area (agricultural census 2000). These two food crops serve as the staples for majority of the households.

CHALLENGES AHEAD

The Government of Pakistan has postulated its 5 top objectives for achieving food security are to:[20]

- Protect the most food-insecure segments of the population through effective relief measures, including long-term arrangements, and adaptation mechanisms.
- Create a modern, efficient, and diversified agricultural sector – aligned with associated water and energy infrastructure – that can ensure a stable and adequate provision of basic food supplies for the country's population, and provide high quality products to its industries and for export.
- Optimize production and supply mix in line with current and projected needs by leveraging our unique strengths.
- Ensure that the entire supply-chain related to food security is geared towards provision of stable and affordable access to adequate, nutritious, and safe food for a healthy life.

- Use the resource base in an efficient and sustainable manner – with outcome based benchmarks agreed in line with regional and global standards.

Pakistan's population is expected to exceed 300 million by the year 2050. Pakistan's current population stands at 188 million.

By 2050, it will need to produce at least 50 percent more food to feed a population on track to reach about 300 million. Currently, with a population of around 200 million, thousands go to bed hungry, and millions suffer from malnutrition, with trends suggesting that things will further deteriorate.

The current food and agriculture systems are depleting with regards to both sustainability and hunger prevention. Farming alone devours the lion's share of available water; rivers and aquifers are being over abused; the land being used for food production has been lost to human settlement.

A situation that could easily become unmanageable is the shortage of food due to either land or water shortages, or both. Pakistan faces a difficult challenge in trying to feed their future population.

Note: This is a background paper meant for discussion and is an aggregation of data, notes and comments from a variety of sources. The writer has tried to attribute them as far as possible. Any exclusion is inadvertent.

CLIMATE CHANGE AND ITS IMPACTS ON GLACIERS IN HIMALAYAS

SHAKIL A. ROMSHOO

CLIMATE CHANGE SCENARIO

Climate change and its impacts on the fluctuation of glaciers is a natural phenomenon that has been occurring throughout the five billion-year history of mother Earth. However, during the past few decades, global climate change has had a significant impact on the high mountain environment including snow, glaciers, and permafrost that are particularly sensitive to the changes in the atmospheric conditions. Therefore, the recent glacier recession observations have been used for understanding climate change impacts.[21] Instrumental records show a systematic increase in the global mean temperature[22] found to be increasing at a rate of 0.07°C decade^{-1} over the last century.[23] In addition, the 1990s, 2000s, and 2010s were the warmest decades recorded, with 2014 the warmest year since the start of the global mean temperature record in 1856.[24] This warming however, has not been globally uniform. High northern latitudes have been particularly affected, with reconstructions of mean surface temperature over the past two millennia suggesting that the late twentieth century warmth is unprecedented,[25] and have been attributed to the anthropogenic forcing of climate.[26] There are suggestions that the Himalaya region is showing a different response to global warming[27] with an increased Diurnal Temperature Range (DTR), and more cooling of mean temperature in some seasons, possibly as a result of local forcing factors. In the dry spring months preceding the Indian summer monsoon, much of the water in the Himalayan Rivers comes from melting snow and ice.[28] Concern has been raised that global warming may reduce the glaciers and their capacity to store water, as well as the amount of seasonal snow available for melting. With melting of the Himalayan glaciers, climate related risks are likely to increase in the near future. In the long term, there can be no replacement for water provided by glaciers that could further result in water shortages on an unparalleled scale in the region.[29]

On the impact of climate change on the Himalayas, based on an assessment of given temperature changes in line with global climate change projections,[30] expectations of significant decreases in river flows in the rivers originating from the Himalayas have arisen.[31] Reports of significant retreat and depletion of glacier volume across the Hindu Kush Himalayan region[32] have supported these concerns. There still remain significant gaps in knowledge about the effects and impacts of climate change on Himalayan glaciers and other water resources.

As per the IPCC (2014) report, the spatial variation in the observed and projected climate change has been predicted to be larger in mountain ranges and their downstream areas compared to plains and coastal areas. It has been reported that temperatures will increase more in high mountains than at low altitudes[33], as the rate of warming in the lower troposphere increases with altitude. Besides, mountain areas exhibit a large spatial variation in climate zones due to large differences in altitude over small horizontal distances making them more vulnerable to climate change.[34]

A comparative analysis between temperature data in the Karakoram and HKH mountains of the Upper Indus Basin (UIB) for seasonal and annual trends over the period 1961–2000 was conducted, and the results compared with the neighbouring mountainous regions and the Indian subcontinent.[35] Strong contrasts were found between the behaviour of winter and summer temperatures, and between maximum and minimum temperatures. It was concluded that mean and minimum summer temperatures provide a consistent trend of cooling in UIB beginning in the year 1961.[36] Another study showed similar temperature falls in both the monsoon and pre-monsoon period for the high mountain region in the Central Himalayas.[37] However, a third study reported significant changes in temperature during all the seasons but did not find any significant changes in the precipitation patterns over Kashmir Himalaya.[38] It was duly noted though, that the form of precipitation has changed over the region with less snowfall observed during the winters. Scanty snowfall, and an increase in the corresponding proportion of rains particularly due to increasing temperatures during the winter and spring seasons were also observed. There is evidence that the historic climatic trends in the UIB are not in line with the global trends in the seasonal temperatures,[39] or precipitation trends.[40] An assessment of the changes in climatic variables over the entire area of Pakistan shows significant departures from the global pattern. Additionally, an analysis of the time series of the available temperature data since 19th century in the Indian Himalayas shows a significant increasing trend in the annual temperature for all three stations examined in the North-western Himalayan region.[41]

In light of the scenario discussed above, the indicators of climate change are quite clear and loud in the Indus Basin.[42] The effects of climate change in the region are already hitting many sectors, and have adversely affected the cryosphere, hydrology, land system practices, forestry, and the livelihood of the communities inhabiting the catchment areas of the rivers originating from the Himalayas. Higher atmospheric temperatures and the change of precipitation into liquid form at higher altitudes in the Himalayas will lead to a retreat of glaciers and reduced stream flows.[43] The impacts of the changing climate on glaciers and hydrology are discussed below.

CLIMATE CHANGE IMPACTS ON GLACIERS

The perennial snow and ice cover of the entire Himalayas is about 40,000 km^2 with the greatest share lying in the Karakoram Himalayas[44] that has an extensive formation of glaciers due to high altitudes. Nearly 11.5 percent of the total area of the UIB is covered by perennial glacial ice including most of the largest valley glaciers. While most of the world's mountain glaciers have been shrinking for at least the last 50 years[45], including those in the neighbouring Greater Himalayas,[46] there is a disagreement among scientists whether all glaciers of the Himalaya–Karakoram–Hindu Kush region are retreating. Another researcher, Goudie opined that the historical records of glacier fluctuations in the Himalayas and the Karakoram ranges indicate that, in the late 19th and early 20th centuries, the glaciers were generally advancing, followed by a period of predominant retreat from 1910–1960.[47] Karakoram glaciers have declined by 5 per cent or more since the early 20th century, mainly between the 1920s and 1960s. From the later part of the 1990s, some findings about the glaciers stabilizing and, in the high Karakoram, even glacier advance have been reported.[48] This is contrary to most of the glaciers in the world reported to be shrinking for the last several decades, including the neighbouring Greater Himalayas analysed by Berthier.[49] This contrast in glacier evolution shows a climate change pattern in the Karakoram Range that differs from that in the Greater Himalayas.

The IPCC reports that glaciers in the Himalayas are receding faster than in any other part of the world, and this receding and thinning of the Himalayan glaciers can be attributed primarily to the global warming occurring due to anthropogenic factors such as aerosols with black carbon and dust, deforestation, forest fires, human-induced pollution, and the emission of greenhouse gases[50]. ICIMOD reports that glaciers in the Hindu Kush-Himalayan Region are retreating at rates of 10 m to 60 m per year and many small glaciers (<0.2 sq.km) have already disappeared.[51] The UNEP (2010) listed works of different researchers based on satellite observations,[52] concluding that the majority of the glaciers in the world's mountainous regions are losing mass in response to climate change. Glaciers in much of High Asia appear to be declining, some at higher rates compared to the global averages.[53] According to climatologists, alpine glaciers such as those in the UIB of the Himalayas are particularly sensitive indicators of climate change and the receding trend of these glaciers is expected to continue.[54]

In an analysis conducted by Dyurgerov and Meier, of the mass balance changes of over 200 mountain glaciers globally, results concluded that the reduction in global glacier area ranged from 6,000 km^2 to 8,000 km^2 between 1961 and 1990.[55] Furthermore, forecasts suggest that up to a quarter of the global mountain glacier mass could disappear by the year 2050 and up to half could be lost by the year 2100.[56] As reported by UNEP, it is very likely that glaciers will largely disappear by the end of this century in some regions,[57] whereas in other regions, glacial cover will persist but in a reduced form for many centuries ahead.[58] There is however, inadequate data available on the cryosphere, climatology, hydro-meteorology, and other related earth system processes that could help us conclude the fate of the Himalayan cryosphere with a fair amount of confidence. The Third Pole is grossly under-monitored relative to the Arctic and Antarctic. Only a handful of stations are conducting in-situ observations in high mountain regions. The socio-economic impacts of melting glaciers have not been studied in detail. The repository of paleo climate data at high-altitude in the form of tree rings, pollen, ice-cores, paleosols, and historical satellite images may help researchers to better understand the characteristics of the cryosphere in the area.

The average mass-balance of Siachen glacier in the Nubra Valley, eastern Karakoram range, India was found to be negative,[59] at its lowest in 1990-91 (-1.08 m). A positive mass balance was calculated for 1988- 89 (+ 0.35 m) that was attributed to comparatively heavy winter snowfall amounts and low temperatures during the ablation season. The Baltoro glacier located on the southern part of the Karakoram Range, and one of the largest in the Range and the world (approx. 1500 sq.km in area and more than 60 km in length), has apparently retreated only about 200 m over the past 50 years.[60] Under another study, direct measurements of melt in the ablation zone of a Karakoram glacier were made, and subsequently reported that the debris cover considerably reduces the rate of ice melt.[61] A mass balance of - 0.7 to - 0.85 m per year of water equivalent over a total glacier area of 915 sq. km in the Himachal Pradesh region of northwest India, which are comparable to the global average, were also reported.[62] Three GCMs (global circulation models) were applied across the greater Himalayan region, with warming effects based on a high emissions scenario, over a 30-year period of 2001–30, and were found to indicate a spatially averaged glacier thickness reduction of approximately 2 m for the period 2001–30, however only for those areas located below an elevation of 4000 m.[63] It was reported that the Bada Shigri, Chhota Shigri, Miyar, Hamtah, NagpoTokpo, Triloknath, and Sonapani Glaciers in the Chenab River Basin India retreated at a rate of 6.8 to 29.8m per year . A study conducted in the Upper Indus Basin of the Western Karakoram indicated the average thickness change over glaciers during 2004-08 in the Hunza Valley to be approximately + 0.10 m/year in the ablation zone, and approximately + 0.64 m/year in the accumulation zone, implying a recent mass balance regime that is positive.[65] A separate study reported terminus changes for more than 250 glaciers across the Himalayan range and noted that the debris-free glaciers in regions of low relief have been mainly retreating, while debris-covered glaciers in high-relief areas (Karakoram glaciers) were mostly stagnating and in-situ down wasting, but not always retreating.[66]

The retreat of glaciers gives a very clear indication of a global climate that has been warming since the Little Ice Age (LIA), that occurred from approximately 1650 to 1850.[67] The evidence from the glacier moraines in the Himalayas provides an idea of the last maximum extent of these glaciers during the LIA and validates the fact that the glaciers have been retreating globally since this period in response to a warmer climate.[68] However, glacier systems at the highest elevations have not responded to recent climate warming in the same way as glaciers that extend to lower elevations, simply because glaciers at higher elevations remain below freezing during much of the year, even in the presence of a warmer climate.

CLIMATE CHANGE IMPACTS ON THE STREAM FLOWS

The consequences of climate change for Himalayan glaciers have become a great concern. Upstream snow and ice reserves of the Himalayan river basins, crucial to sustaining seasonal water availability over the entire South Asian region, are likely to be affected substantially by climate change, but to what extent are yet unclear.[69] As the mountains are the source of the region's rivers, the impact of climate change on hydrology is likely to have significant repercussions, not only in the mountains, but also in populated, lowland regions that depend on mountain water resources for domestic, agricultural, and industrial purposes as well as hydropower generation.[70] Concerns about the potential impacts of climate change on streamflow in the Indus, given the temperature changes, have given rise to expectations of dramatic decreases in the magnitude of streamflow.[71] However, some reports suggest that such threats might be exaggerated.[72]

Snow- and glacial-melt form the major hydrologic processes in mountainous Himalayan regions, where the changes in temperature and precipitation form are expected to seriously affect the melt characteristics.[73] Rivers that are fed heavily by glacial melt water will respond differently to temperature rises than rivers which are mostly fed by rainwater during the monsoon.[74] In the Indus basin, the Karakoram, Himalaya, and Hindu Kush Mountains form the major sources of the flow in the River Indus feeding the river by a combination of melt water from seasonal and permanent snow fields and glaciers, and direct runoff from rainfall. About 40 per cent of the melt water originates from glaciers in the Indus Basin.[75] However, the glacial or snow-melt component shall vary with time and space and thus varying reports of the glacier- and snow-melt contributions to the stream flow in Himalayan rivers. The melt water component is extremely important and the primary source for irrigation of the entire Indus basin. Several authors have reported that 80 per cent of the flow of the Upper Indus River is contributed by less than 20 per cent of its area, essentially from the zones of heavy snowfall and glaciered basins above 3500 m in elevation.[76] It was also reported that some 90 per cent of the lowland flow of the Indus River System originates from the Hindukush, Karakoram, and western Himalayan mountain areas.[77] Though primarily snow- and glacial-melt feed the runoff from the upper Indus basin,[78] the southern slopes of the Himalayas receive direct runoff from summer monsoon precipitation . If all the Himalayan glaciers were to disappear, there would be a much greater impact on the water resources emanating from the western Himalaya than the east, with a reduction in annual mean flow of about 33 per cent in the west, but only about 4–18 per cent in the east, compared to the 1990 levels, because of the glacial extent and the climatic differences between the drier western and monsoonal eastern ends of the region.[80]

In a study of the Sutlej River basin, it was found that climate change is going to impact seasonal water supplies more than annual water supplies.[81] The impact of observed seasonal temperature trends on runoff revealed a decrease of 20 per cent in the summer runoff in the rivers of Hunza and Shyok, attributed mainly to the observed 1°C fall in mean summer temperature since 1961.[82] Together, the Shyok and Hunza catchments contribute more than 25 per cent of the inflow to Tarbela Dam, which is the main controlling structure for the Indus Basin Irrigation System, one of the world's largest integrated irrigation net-works. Another study showed statistically significant decline in the stream flows from most of the major tributaries of the Jhelum in the UIB despite less demands for irrigation of the water demanding paddy culture that is on the decline in the basin.[83] These reductions in the streamflows are attributed to the reduced glacial mass, scanty snowfall, and increasing water demands for burgeoning populations in the basin.[84]

Monthly trends of stream flows in the UIB were assessed and found predominantly increasing trends in winter and decreasing trends in the summer runoff.[85] Three hypothetical glacial depletion scenarios were considered under another study: total disappearance of glaciers, 50 per cent disappearance, and no disappearance from 2071–2100 in the UIB, and found that both temperature and precipitation tend to increase towards the end of the 21st century leading to the increase in discharge with both a 100 per cent and a 50 per cent reduction in glaciers, whereas with 0 per cent reduction in glaciers, less water was available.[86] For the upper Indus basin, the removal of all glaciers, with an accompanying increase in the winter and summer temperatures of 4.8°C and 4.5°C respectively, and precipitation increases of 19.7 per cent and 15.7 per cent (climate model scenario for 2071-2100) indicated a reduction in summer maximum flow of approximately 30 per cent.[87] Additionally, a reduction in the percentage of total precipitation fell as snow from 60 per cent to 48 per cent. Patterns of earlier snow melt could actually be beneficial for agriculture in some regions, as this pattern would provide more water for local irrigation and increased input to reservoirs when they are most empty at the beginning of the growing season. While working on spatiotemporal trends in snow cover in the upper Indus basin from 1999 to 2008, researchers observed a significant negative trend for winter snow cover.[88] They concluded that there were indications of climate change affecting the hydrology of the upper Indus basin due to accelerated glacial melt. This conclusion was primarily based on the observation that the average annual precipitation over a five-year period was less than the observed stream flow.

The effects of climate change were investigated on both low and high flows of the lower Brahmaputra for the period 1961–2100[89]. The analysis showed that extreme low flow conditions are likely to occur less frequently in the future. However, a very strong increase in peak flows was projected, which may, in combination with projected sea level change, have devastating effects for Bangladesh. A different study based on precipitation and stream flow models on a large-scale basin, the Niyang River basin in south east Qinghai (Tibetan Plateau, China) indicated significant increasing trends in stream flow, both annual and wet season, without any significant difference in precipitation.[90]

GLACIAL LAKE OUTBURST FLOODING

There is evidence for increasing incidence of glacial lakes and outburst floods in the Himalayas associated with glacial retreat.[91] Such evidence is lacking amongst the larger glaciers of the Karakoram where some are still advancing or surging.[92] Most of the glacial lake outbursts in the Karakoram have resulted from the surging advance of glaciers across major headwater streams, blocking the river flow in an ice-free valley.[93] Several events of much larger magnitude arising from both GLOFS and dam breaks have occurred over the past century on both the Hunza and Gilgit rivers. An assessment of the potential damage to the hydropower infrastructure due to the potential damming of the water in the form of Glacier Lake at the snout of the Panjtarni glacier stated that, in case of a glacial lake outburst near Panjtarni glacier, it will last for about 5 hrs and will have a peak discharge of about 293685 cusecs, at about 4.21 hrs after the beginning of the outburst event. The computed discharge at the proposed Powerhouse site is about 69, 250 Cusecs that is almost 7-8 times the recorded peak discharge of the Sindh River in the UIB.[94]

NEED FOR COOPERATION

The glacier cover in the entire Himalayas is about 40, 000 km^2. Nearly 11.5 per cent of the total area of the Upper Indus Basin (UIB) is covered by perennial glacial ice including most of the largest valley glaciers, the largest area outside the polar and Greenland regions. Of the concerns about the impact of climate change on the Himalayan Cryosphere, based on an assessment of given temperature changes in line with global climate change projections, expectations of significant decreases in river flows in the rivers originating from the Himalaya have arisen. Reports of significant retreat and depletion of glacier volume across the Hindu Kush Himalayan region further support these concerns. It is pertinent to mention here that the two countries share the waters emanating from the Himalayas under a cooperative mechanism outlined in the Indus Water Treaty (IWT). There are however, significant gaps in knowledge about the effects and impacts of climate change on the Himalayan glaciers and other water resources that have in turn led to several myths and misunderstandings. The effects of climate change are quite visible in the region and have adversely affected the cryosphere, hydrology, land system practices, forestry, and even the livelihood of the communities inhabiting the catchment areas of the rivers originating from Himalayas. It is therefore necessary that the two countries work on developing a mechanism for cooperation on understanding the impacts of changing climate on various sectors that are dependent on the Himalayan Crxyosphere.

RECOMMENDATIONS

Lack of credible data and research is a major limitation in correctly assessing the impacts of climate change on the cryosphere and various dependent sectors. The two countries need to cooperate to bridge the gaps in knowledge about the status and health of the cryosphere under changing climate in the region.

- There is evidence for an increasing incidence of glacial lakes and outburst floods in the Himalayas associated with glacial retreat. The emerging glacial lakes have the potential to damage infrastructure and human life, in the event of a lake outburst. There is ample merit for the two countries to cooperate on the monitoring and assessment of the development of glacial lakes in the higher reaches of the Himalayas.

- The increasing frequency of flooding in the region is a common cause of concern in both the countries. Both sides have witnessed virulent flooding in recent years that resulted in huge losses to the physical infrastructure and human life. The flooding phenomenon can be better understood through the quantification of the hydrological and climate processes that operate at the basin scale and beyond. There is need for scientific and administrative collaboration between the two countries for the development of a basin wide hydrological model with real time forecasting and early warning interface with the involvement of the relevant people from both the countries.

- There is, as yet, a very limited network of observation stations in the mountainous Himalayan region for characterizing and understanding the land surface and atmospheric processes. The two countries need to join efforts to strengthen this network of observatories.

- The two countries should facilitate the exchange of academics for establishing a long-term cooperation in studying the issues of common concern in the region including the cryosphere dynamics, and the impacts of its shrinkage on water availability. The two countries are sharing waters in the Indus under the IWT and it is important that a credible knowledge base about the impacts of climate change on waters emanating from the glaciers is generated.

- The generation of information and knowledge on climate change and water concerns under a collaborative and joint ownership will help the two governments to deal effectively and appropriately with policy issues governing the sharing of waters between the two countries.

The proposed recommendations envisage the exchange and sharing of information and expertise, close coordination, and frequent interactions among the various stakeholders from the two countries. These proposed initiatives for cooperation on climate change and water management issues has potential for generating goodwill and trust for addressing other bilateral issues between the two countries.

INDIA, PAKISTAN, THE SNOW LEOPARD, AND CLIMATE CHANGE

JAVED IQBAL

INTRODUCTION

Wildlife is an important indicator for assessing ecological health, and significant for developing responses to challenges pose by climate change. However, the current state of global wildlife is disturbing due to the fact that the world's animal population is showing the worst ever decline. As a result, the population of animals in the wild is declining, while several species are already extinct. According to a World Wildlife Fund (WWF) study, Living Planet Report, the number of wild animals on earth has halved in the past 40 years. The report states that habitat loss, habitat degradation, and exploitation through hunting are the main reasons for the declining population of wildlife.[95] This change in wildlife means change in ecosystem and hence, extreme vulnerability to climate change.

The story in South Asia, especially in the Indian sub-continent, is no different. The wildlife populations in India and Pakistan face a variety of challenges; many of them are endangered and on the red list of threatened species by the International Union for Conservation of Nature (IUCN). Habitat loss and habitat degradation are the major threats to wildlife in the region. As per the Inter-governmental Panel on Climate Change (IPCC), India and Pakistan are suffering the severe impacts of climate change like rising temperatures, melting glaciers, and rising sea levels with the worst effects felt on the economy, nature, and human settlements.[96] This situation can be attributed to a degrading ecosystem that is a resultant of the increasing wildlife depletion in the region. This paper argues that the impacts of climate change can be mitigated by the conservation of wildlife and its habitat.

WILDLIFE ALONG LINE OF CONTROL (LOC)

The area referred to as the line of control (LoC) is home to indigenous people with their rich cultural heritage and possession of the richest diversity of flora. The high-altitude areas of Jammu and Kashmir along the Line of Control (LoC) support a unique wildlife diversity of global conservation importance. This includes a highly endangered population of species such as the snow leopard (Uncia uncia), bears (Ursus arctos isabellinus), markhor (Capra falconeri), wolf (Canis lupus), Tibetan gazelle (Procapra picticaudata), Tibetan argali (Ovis ammon), Asiatic ibex (Capra ibex), Ladakh urial (Ovis vignei), musk deer (Moschus spp.), marmots, pikas, and hares.[97] Unfortunately, the region is suffering the effects of negative interventions of human activity at an alarming rate. The cold war-like situation on the LoC poses major threats for further habitat degradation, reduction of natural prey, and poaching of wildlife in the region. This in turn has led to human-wildlife conflict, with the movement of animals to the human settlement areas in search of shelter and food. The human-wildlife conflict has been a serious concern responsible for the extinction of many endangered species.

INDIA PAKISTAN HOSTILITY AND THE WILDLIFE

The India Pakistan conflict has impacted not only the lives of the people due to militarization and cross-border shelling but also the flora and fauna of the region. Animals found in the vicinity of the disputed India-Pakistan border in Jammu and Kashmir are on the verge of extinction. The main impacts of armed conflict on wildlife occur through habitat destruction and poaching.

During border tensions, the LoC and its peripheral regions experience heavy shelling from both the sides of border, and subsequently animals living in and around the LoC are always prone to be killed or injured in the resultant shelling and cross-firing. The fencing along the border has also resulted in creating permanent barriers and restricted the movement of wild animals. Many wildlife populations like Markhor (Capra falconeri) seem to have been divided permanently by the fencing. A study on the subject states that the barbed fencing and planting of landmines in the rugged territories of LoC has led to the fragmentation of habitat of many wild animals in the region, many times also proving fatal for them when they accidently trip the landmines. Quoting local wildlife department officials, the author adds, the fencing has blocked the corridor of animals in the areas and restricted their free movement to and fro. The animals that have been most affected are bears, leopards, and musk deer. As per the author, many animals that crossed to the Pakistan side of the territory while the fence was being erected could not come back and therefore have lost their Indian homes permanently. Another threat to animals in the area is that of land-mines. In the past, many animals have been killed or maimed in blasts, and such cases are reported to be fairly in large number.[98]

In addition, the presence of a large number of security forces deployed in the region, and the movement of their supplies that results in the destruction of the mountainous landscape on the Indo-Pak border are potential sources of disturbance to wildlife and its habitat. The huge deployment of Indian and Pakistani armies along the line of control, resulted in large scale poaching of rare species like the Ibex, Blue Sheep, Urian, the big horned sheep, Antelope, and Snow Leopard.[99] As a consequence, some rare species like the Snow leopard and Long Tailed Himalayan Marmot have been pushed to the verge of extinction.

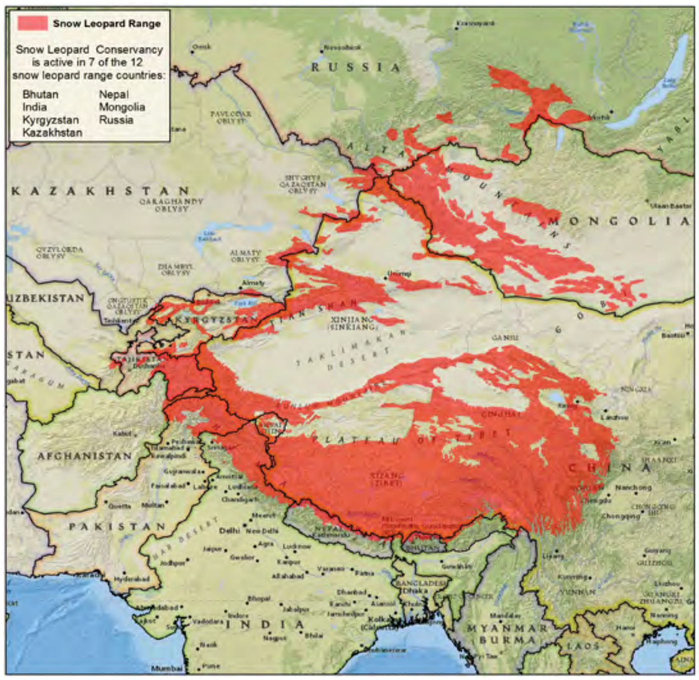
In a study that measures the impact of armed conflict on wildlife, Shambaugh argues that habitat destruction and the accompanying loss of wildlife are among the most common and far-reaching impacts of conflict in Jammu and Kashmir. He adds, habitats are sometimes directly affected during armed conflict; vegetation may be cut, burned, or defoliated to improve mobility or visibility for troops. With habitat destruction, certain animal species may become locally threatened, or even extinct.[100]

The enmity has had a particularly dangerous impact upon the existence of the Snow leopard especially by escalating man-animal conflict. According to Asihwarya Maheshwari of the World Wildlife Fund (WWF), “It is here in Kargil that one of world’s most elusive creatures, the snow leopard, roams wild and free. During my research I have learnt about the tremendous decline in wildlife sightings since the 1999 Kargil war, so much so that even the common resident birds had disappeared,”.[101]

THE SNOW LEOPARD-MAN CONFLICT

Considered the world’s most elusive feline, the presence of Snow leopards is an indicator of a healthy high-mountain ecosystems. Healthy mountain ecosystems in South Asia provide essential ecosystem services including the storage and release of water that supports about one-third of the world’s human population. Over 330 million people depend daily on the water flowing down from the snow leopard habitat. Therefore, it is important to note that the continued degradation of, and possible extinction of the snow leopard’s mountain ecosystem would harm people everywhere.[102]

The snow leopard lives in the mountains at elevations of 3,000 to over 5000 m (10,000-17,000 feet). It prefers the steep, rugged terrain of the mountains with cliffs, ridges, gullies, and slopes interspersed with rocky outcrops.[103] The total number of the endangered species left in the world is estimated at between 4,500-7,500 in 12 countries of Central Asia — Afghanistan, Bhutan, China, India, Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Pakistan, Russia, Tajikistan, and Uzbekistan.[104] Snow Leopards are protected in most countries under national and international laws. The species has been listed in Schedule I of the Wildlife Protection Act (1972) of India and is listed as endangered in the 2008 International Union for Conservation of Nature (IUCN) Red List of Threatened Species as globally “Endangered”. They are listed in Appendix 1 of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1977) to check export and import of their body parts.



Map of Snow Leopard Range

THREATS	INDIA	PAKISTAN	CHINA
Habitat Degradation	10	11	06
Prey Reduction	08	15	11
Poaching	10	12	08
War and Related Military Activities	09	09	08
Human Wildlife Conflict	10	15	12
Lack of Effective Enforcement	12	13	12

Table: Threats to snow leopard, wild prey, and their ecosystems

Key to scores: Low threat=1-5; Medium threat=6-10; High threat=11-15
(Source: Global Snow leopard& Ecosystem Protection Program)

The threats to the snow leopard include the reduction of natural prey, military activity, poaching, and degradation of habitat. However, the major threat to Snow leopard comes from the human-wildlife conflict in revenge for livestock attacks by the animal.[105]

The Line of Control cuts right through the habitat of the Snow Leopard. The area is fenced and full of military activities including military movement, border fencing, artillery firings, and shelling. These activities disturb the ecological balance in the animal range area. According to experts, "Animals have a cruising range. In case of a leopard, it is between 25 and 40 square kilometers. When you limit the range, it moves out of its ecological niche. The result will be that the animal will either fall in conflict with humans or die of stress".[106] The animal is forced to move to the inhabited lowlands in search of shelter and food. In its struggle for survival, it damages food crops and attacks livestock, causing huge economic losses to the affected rural families. A study on human-wildlife conflict, conducted by WWF during April-May 2009 in 12 villages of LoC regions of Kargil and Drass, 73 cases of livestock depredation by snow leopards were reported, and a livestock loss was estimated at around 10,000 USD. According to the study, domestic livestock comprised nearly half (45.5 per cent) of the diet of the Snow leopard,[107] which indicates the high proportion of livestock depredation and the extent of carnivore-human conflicts in Kargil and Drass.

For Kargil and Drass, the Snow leopard is a symbol of the survival of life forms in a region with a harsh climate. Ironically, the population that should be protecting such a symbol sees it as a threat to its own survival, making it even more vulnerable to extinction.

PEACE PARK: A WAY FORWARD

The depleting wildlife and the resultant vulnerability to climate change offer an opportunity for both India and Pakistan to work together in the conservation of wildlife where their habitats fall on either side of the border. India and Pakistan can work together in the conservation of trans-border wildlife particularly the snow leopard, with its habitat on either side of Line of Control (LoC). With the Snow leopard on top of the food chain in its habitat, its conservation will result in the conservation of many other wildlife species that are also on the verge of extinction, and thus result in the development of a wild ecosystem to slow down the effects of climate change. This over all protection of the snow leopard, its natural prey, and habitat can be achieved by converting the LoC into a peace park. Peace parks are protected areas spanning the boundaries of neighboring states. Through the establishment of peace parks, the two neighboring countries enjoy equal opportunity to jointly manage the common protected areas and hence can foster more peaceful relations with each other. The IUCN has advocated the creation of peace parks, while the organization believes that "protected areas along national frontiers can not only conserve biodiversity but can also be powerful symbols and agents of cooperation, especially in areas of territorial conflict.[108]

The two neighboring countries could therefore learn from various precedents such as the Åland Islands, Morokulien Peace Park, the Euro city of Haparanda - Tornio, and the Oulanka - Paanajärvi trans-boundary national park. Peru and Ecuador resolved a long-running territorial dispute by setting up two national peace parks near the most contested stretch of land on their border. Until then, the countries had fought three wars along their border. These examples provide valuable lessons for cross-border cooperation as their experiences of the softening of borders through practical approaches, all of which could be utilized in areas along the LoC, the most visible site of confrontation and hostility between India and Pakistan. In particular, it provides useful ideas to create a peace park on areas across the LoC itself, which is a haven for wildlife harbouring endangered species. This is what Dr Nelson Mandela has to say about the idea: "I know of no political movement, no philosophy, and no ideology that does not agree with the peace parks concept as we see it going into fruition today. It is a concept that can be embraced by all".

Doing so could also be a milestone in joint cooperation between the countries that could help them in the path towards sustainable peace.

RECOMMENDATIONS

Conservation of wildlife and their natural habitats are vital to addressing challenges posed by climate change in the sub-continent. India and Pakistan should consider setting up trans-border peace parks across the LoC to protect the habitat of the snow leopard and other wild animals. This initiative can become a model for bilateral cooperation while achieving real gains in the protection of the wildlife and their habitat.

India and Pakistan should consider setting up of a wildlife conservation consortium involving wildlife experts, activists, government, and non-governmental organisations working in the field.

The two governments must also help build a network of concerned scientists and conservationists through regular seminars and conferences to facilitate open dialogue and cross-border cooperation on the subject.

Both countries should also make a serious commitment for their armies to comply to in times of peace and war, with international standards designed to safeguard natural resources.

India and Pakistan should encourage international organisations to facilitate the protection of the snow leopard and other wild animals in the trans-boundary habitat.

The two countries should initiate grant programmes to support education, research, or conservation projects on snow leopards, their habitat, and wildlife in general.

TASK FORCE MEMBERS

PROFILES

AMB. SHAFQAT KAKAKHEL

Ambassador Shafqat Kakakhel is a senior retired Pakistani diplomat who served as the UN Assistant Secretary General and Deputy Executive Director of the UN Environment Programme (UNEP) from 1998 to 2008. He joined the Foreign Service of Pakistan in 1969 and was posted in Beirut, Cairo, Bonn and Jeddah in various capacities. Mr. Kakakhel has also served as the Deputy High Commissioner in New Delhi and High Commissioner in Nairobi. During his tenure in Nairobi, he represented Pakistan as Permanent Representative to the UN Environment Programme and the UN Centre for Human Settlements (HABITAT) from September 1994 to August 1998. He was elected President of the UNEP Governing Council in May 1995 and was also selected as the Chief Negotiator for the G-7 in the preparatory meetings of the second World Summit on 'Human Settlements' in 1995-6. He was a senior member of the Task Force on Climate Change established by the Government of Pakistan in 2008 to comprehensively examine the impact of climate change and how it can be mitigated. Amb.Kakakhel has written extensively on Pakistan's water situation and trans-boundary issues between Pakistan and India.

Mr. Kakakhel holds a B.A. degree in Economics and Political Science, and a M.A. in Political Science. He designed and taught a course on Global 'Environmental Issues and Governance' for M.Phil programme at the 'Environmental Economics Center' of the Pakistan Institute of Development Economics in 2009. Shafqat Kakakhel was elected member of the Executive Board of the UNFCCC 'Clean Development Mechanisms' for 2009-10 and again for the years 2011-12, representing the Non Annex parties of Asia Pacific. He is a member of the Board of Governors for the Sustainable Development Policy Institute (SDPI) in Islamabad since 2009 and has served as its Chairperson since 2013.

Email: shafqatkakakhel@gmail.com

MR AHMAD RAFAY ALAM

Ahmad Rafay Alam is a Pakistani environment lawyer and activist. After over decade of practice, in 2013 Rafay merged his experience in civil, corporate, and constitutional law with his passion for public interest environment litigation and co-founded Saleem, Alam & Co., a law firm that specializes in energy, water, natural resources, and urban infrastructure. Rafay is a regular op-ed columnist on environment, local government and urban issues and has contributed to The News, The Express Tribune, The Friday Times and has been published in Dawn, The Nation, The Daily Times, Tehlka, Vogue India and Libas International. Rafay's Partition story – which he shares with Martand Khosla - A House Partitioned, has been included in This Side, That Side, a graphically illustrated anthology of Partition literature and his essay, The Last Mughal of Shalimar, described by Tehlka as "superb piece of writing", was included in The Life's Too Short Literary Review (2009).

Rafay has lectured property and environment law at the Lahore University of Management Sciences, urban development at the University of Punjab and climate change and environment economics at the Lahore School of Economics; and is a frequent Review Panelist at the National Management College, Lahore and a regular lecturer in higher education institutions throughout Pakistan. His research and policy papers on law, climate change, transboundary water, sustainability, environmental economics and regulation have been published in The Pakistan Law Journal, Pakistan Law Digest, The Pakistan Development Review and by Chatham House, The Population Association of Pakistan and by LEAD Pakistan. Rafay serves as a Director on the Boards of the Lahore Waste Management Company, the Urban Unit and the Punjab Saaf Paani (Clean Water) Company. He served as Chairman of the Lahore Electric Supply Company from 2011 to 2013. He is a Member of the Punjab Environment Protection Council, the Parks and Horticulture Authority of Lahore and the Lahore Canal Heritage Park Advisory Committee. Rafay is also is a Member of the Board of Directors of the Citizens Archive of Pakistan, Vice-President (Punjab) of the Pakistan Environmental Law Association, General Secretary of the Public Interest Law Association of Pakistan and Secretary of the Lahore Biennale Foundation. He frequently appears as amicus curiae before the Lahore High Court and is the Secretary of the River Ravi and Fire Safety Commissions.

Email: rafay@saleemalam.com

DR MOHAN GURUSWAMY

Mohan Guruswamy obtained his undergraduate education in Mathematics, Physics, and Chemistry at Nizam College, Hyderabad, India. He holds post-graduate qualifications in Public Policy, International Affairs, and Management, and is an alumnus of the John F. Kennedy School of Government, Harvard University, and the Graduate School of Business, Stanford University. With an interesting career path that included teaching, senior management, journalism and government service as the Advisor to the Finance Minister with the rank of Secretary to the Government of India, he now heads the Centre for Policy Alternatives, New Delhi. Mohan Guruswamy has widely travelled in India and abroad, and has authored several books on policy issues, some recent ones that include The Looming Crisis in India's Agriculture; India: Issues in Development; India's World: Essays in Foreign Policy and Security Issues; India China Relations: The Border Issue and Beyond; and his latest, Chasing the Dragon: Will India Catch-up with China? He is a frequent commentator on national and international TV and Radio on matters of current interest and pens a widely read and disseminated newspaper and magazine column. His papers on Redefining Poverty, Income Inequality, Backwardness of Bihar, Economic Development in West Bengal, FDI in Retail have been published in well regarded journals like the Economic and Political Weekly, Seminar and the Journal of Public Policy, UK.

Email: mohanguru@gmail.com

PROF SHAKIL A. ROMSHOO

Professor Romshoo has a multidisciplinary academic and research background having obtained a Doctorate degree in Civil Engineering (water resources) from the University of Tokyo, Japan and a Master's Degree in Remote Sensing and GIS from the Asian Institute of Technology, Bangkok, Thailand. Currently, Dr. Shakil A Romshoo is Professor and Head of the Department of Earth Sciences at the University of Kashmir, India. He has previously worked as a Scientist at the Japan Aerospace Exploration Agency (JAXA), Tokyo and Senior Fellow at the Energy and Research Institute (TERI), New Delhi, India. Prof. Romshoo has published more than 120 publications in peer reviewed international journals and book chapters. Besides academics, administration, and consultancy, Prof. Romshoo is currently engaged in collaborative and sponsored research on Hydrology, glaciology and climate change impact studies in the North Western Himalayan region. He is a member of many policy and decision-making committees and working groups related to environment, water, climate change, and disaster management at the national and international level. He has won several national and international awards for his academic achievements, amongst which some notable awards include the Kasumigaura International Prize from Government of japan in 2009, the National Geoscience Award from government of India conferred by the President of India in 2013 and the President Appreciation Medal for the promotion of Geomatics in India in 2015.

Email: shakilrom@yahoo.com

DR JAVED MOHAMMAD IQBAL

Javed Mohammad Iqbal, a native of border district of Kargil in the state of Jammu and Kashmir, works as an Assistant Professor in Srinagar. Dr. Javed holds a B.Sc. in General Science and Master's degree in Zoology from University of Kashmir, Srinagar. He is also a M.Phil/Ph.D graduate of Jawaharlal Nehru University, New Delhi. Javed's doctoral research at Jawaharlal Nehru University examined the global health governance of emerging infectious diseases. His research interests include international health, international politics, conflict resolution, peace building, governance, human rights and human security.

Javed is the initiator of Peace Schans-Snow Leopards, a children and youth led initiative to convey the message of peace through the conservation of snow leopards and other wildlife species at great threat of extinction due to prolong conflict in the region. He volunteers as the Chief Coordinator of the Peace Gong Bureau Kashmir, a global children newspaper to promote diversity and encourage dialogues among children from different cultures and communities through media literacy, where his contribution as the Chief has won him the United Nations Award for Volunteerism. He is the former co-facilitator and founding member of the Asia Pacific Youth Network, formed by young people and rights organizations from 20 countries in the Asia Pacific region.

In 2014, Dr. Javed was selected for Swedish Institute's Young Connectors of the Future, an intercultural leadership programme that aims to lay a foundation for dialogue and knowledge sharing among young leaders from South Asia.

Email: javednaqi@gmail.com

PEER REVIEWERS

PROFILES

DR. ADIL NAJAM

Dr. Adil Najam is the inaugural Dean of the Pardee School of Global Affairs at Boston University, where he also serves as a Professor of International Development and of Earth and Environment. He is the former Vice Chancellor of the Lahore University of Management Sciences (Pakistan).

Dr. Najam was a lead author for the Third and Fourth Assessments of the Intergovernmental Panel on Climate Change (IPCC), work for which the ICC was awarded the 2006 Nobel prize. In 2008 he was invited by the United Nations Secretary General to serve on the UN Committee on Development (CDP). In 2010 he was awarded the Sitara-i-Imtiaz (Star of Excellence), one of Pakistan's highest civil awards by the President of Pakistan.

He is the author of over 100 schoalrly papers and over a dozen books, including Global Environmental Governance: A Reform Agenda: <http://www.amazon.com/gp/product/189553691X?ie=UTF8&-camp=1789&creativeASIN=189553691X&linkCode=xm2&tag=allthingspaki-20> (2006).

A winner of MIT's Goodwin Medal for Effective Teaching and the Flecther School Paddock Teaching Award, Dr. Najam serves on the International Board of WWF and is the Board Chair of the South Asia Network of Development and Environmental Economics (SANDEE).

Email: adil.najam@gmail.com

ROHAN D'SOUZA

Rohan D'Souza is Associate Professor at the Graduate School of Asian and African Area Studies (Kyoto University). He is the author of Drowned and Dammed: Colonial Capitalism and Flood control in Eastern India (1803-1946), Oxford University Press, 2006. He has co-edited with Deepak Kumar and Vinita Damodaran, The British Empire and the Natural World: Environmental Encounters in South Asia, Oxford University Press, 2011 and has also edited Environment, Technology and Development: critical and subversive essays, Orient BlackSwan, 2012.

His research interests and publications cover themes in environmental history, ecological politics, sustainable development, and modern technology. He has held postdoctoral fellowships at Yale University and the University of California (Berkeley). He has also held visiting fellowships at University of Sussex, Australian National University, University of Tokyo, and the University of Pennsylvania. His most recent project is to study how contemporary climate change discourses are shaping the writing of environmental histories on South Asia.

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