IDFC

IIR 2010

Infrastructure Development in a Low Carbon Economy

3iNetwork

India is the fourth largest emitter of CO2 in the world, according to the International Energy Agency. Although India has low per capita CO2 emission (1.18 tons against world average of 4.38 tons) and low CO2 emission intensity (0.33 kg per unit GDP in US$ PPP terms compared to world average of 0.47), its emissions are growing rapidly, driven by economic and demographic growth. Per capita emission is expected to remain below the average per capita emission of developed countries by 2030-31. Still, there is international pressure to accept binding commitments for emission reduction in the post-2012 phase. Though India has not conceded to such pressure, there is wider recognition now within, that India cannot afford inaction given its vulnerabilities to climate change. India's voluntary though non-binding decision to reduce emission intensity by 20-25% of the 2005 level by the year 2020, together with the pronouncement of National Action Plan on Climate Change (NAPCC) and Nationally Appropriate Mitigation Action Strategies, stand testimony to this growing recognition and commitment.

Treading a low carbon path will, however, not be easy. In particular, infrastructure development will pose a significant problem. After all, infrastructure development has traditionally been carbon intensive. The energy sector is responsible for 58% of the country's total green house gas (GHG) gross emissions of 1.9 billion tons of CO2eq. (electricity: 38%; transport: 8%; urban and rural residential energy consumption: 7%; and others such as petroleum refining: 5%). A low carbon growth agenda would therefore necessarily entail building infrastructure with less carbon footprint. But the development imperatives of high growth and poverty alleviation cannot be met without rapid infrastructure build-up. IDFC and the 3iNetwork decided to address this challenge. The theme of the India Infrastructure Report (IIR) 2010 was therefore appropriately set as *Infrastructure Development in a Low Carbon Economy.*

The challenges are immense. Technology and finance are central to the interventions that can steer infrastructure towards the low carbon trajectory. Government alone would not be able to provide the necessary finance, and thus considerable private sector investment would be required. An enabling legal, regulatory and institutional framework that facilitates effective innovation, development and deployment is critical. Sector specific needs and

problems only add to the complexities. The IIR 2010 addresses each of the above aspects.

It finds that the opportunities to move away from high-carbon infrastructure to clean technologies are many. Most of these have co-benefits: some would directly assist the efforts of poverty alleviation while others would improve cost competitiveness or productivity. This document provides a summary of the IIR 2010, indicating the many facets of low carbon infrastructure addressed by the Report.

Legal & Regulatory

A brief review by Videh Upadhyay of the extant laws, regulations and policies with environment implications indicates that there are some major gaps in the existing legal framework and challenges in implementation. The present Electricity Act 2003 addresses Renewable Energy (RE) issues marginally and does not deal with energy conservation and demand side management (also pointed out by Deo & Deshpande). Although there is an Energy Conservation Act (2001) providing for an institutional arrangement and a regulatory mechanism at the central and state levels for energy efficiency, but (as pointed out by Pandey) it focuses only on electricity and does not include for instance, the transport sector/automobile industry. Upadhyay further questions the efficacy of regulations, such as the Environmental Impact Assessment Notification (2006), and the institutional capability of agencies implementing such regulations.

A deeper problem is that all environmental legislation and regulations in India are underpinned only by the use or threat of criminal sanctions. Since criminal sanctions are too drastic, judicial and regulatory agencies are reluctant to prosecute environmental offenders. The paper, through illustrative reference of various court cases, draws attention to the fact that the Supreme Court has time and again upheld the 'Polluter Pays Principle' as part of the law of the land. There is thus a greater benefit of using civil penalties for breaches of environmental regulation, and restricting criminal prosecution for intentional non-compliance with the law.

It is also noteworthy that while there are environmental pollution prevention and forest conservation laws in India, compensatory afforestation is only for diversion of forest land for a project under the Forest Conservation Act not when revenue land is diverted for mega projects. The paper thus proposes reforms and amendments in existing legislation for more effective compliance and enforcement of environmental protection mechanisms, besides making the laws more inclusive.

In recent years, independent regulation and contract law have assumed greater importance with increasing private sector involvement in infrastructure. Upadhyay discusses the growing importance of Regulation by Contract and suggests how contracts could be strengthened so that appropriate environmental mitigation and enhancement measures are effectively incorporated. Some of the suggestions include linking contractor payments with environmental performance, inclusion of environmental best practices in contracts, lenders mandating adherence to best practices and norms on socially inclusive and environmentally sound practices as conditions precedent to financial closure.

The contribution by Pramod Deo and Vijay Deshpande discuss the role of the regulator and regulatory initiatives taken so far to mitigate the carbon footprint of the power sector and the scope for improvement in existing efforts. The electricity sector contributes around 38 per cent of India's total CO2 emissions, even when more than 400 million people having no access to electricity and 450 million have an income below Rs.60 per day. Deo & Deshpande explain how enormous opportunities exist to make the power sector less carbon intensive at every stage of the electricity cycle. These include improving conversion efficiency of fossil fuel and increasing renewable energy in power generation, reducing losses in transmission and distribution, and improving end-use efficiency in consumption.

Regulators in the power sector, both at the state and central level, have been influencing emission mitigation by prescribing efficiency norms and T&D loss reduction targets through the tariff setting process and promoting the development of renewable energy through Feed-in-Tariffs (FIT) and Renewable Purchase Obligations (RPO). But preferential tariffs and RPOs have limitations. For example, power distribution utilities have no incentive to continue purchasing costly RE power once their RPOs are met. To tide over this problem and create a market for RE, regulators have introduced Renewable Energy Certificates (REC), a tradable instrument with green attributes. In addition, they suggest initiatives that could be taken by regulators under the existing areas of intervention such as allowing distribution utilities to earn additional return on equity for undertaking demand side measures; load research; and database development of EE projects. New areas of intervention could include facilitating induction of smart grid technologies. Given that effective implementation and compliance are crucial for regulatory actions to yield desired results, they point out that regulators are working together to put in place mechanisms for monitoring and compliance of regulatory directives.

Anoop Singh's paper highlights the role of RECs in promoting renewable energy in an economically efficient manner and critically examines the CERC REC regulations and identifies areas for improvement. The paper discusses the implications of market

segmentation into solar and non-solar RECs, and proposes an alternative scheme that allows participation of all RE sources in a common REC market by using a multiplier factor for different sources. He demonstrates that the high level of floor and forbearance prices (much higher than the equivalent peak CER futures price in the European Exchange in July 2008) would translate into a windfall gain to the supplier and represents a higher implicit price of carbon, which needs to be reviewed.

Finance

In the context of the environmental threat posed by GHG emissions, there are several issues related to financing. From the public finance perspective, the issues are as to how and how much taxes should be imposed on GHG emissions and subsidies provided to more sustainable clean technologies and infrastructure. From the financial markets perspective, the issues are whether these technologies and infrastructure are viable on a risk-adjusted basis and if not, what will make them viable. Within the former perspective, the policy-makers have to evaluate the cost of any such adjustment and the incidence of such costs on individuals and entities from a welfare point of view. They also have to initiate institutions and frameworks whereby financial sector supports the technologies, which are sustainable and are potentially viable once initial risks are mitigated and scale possibilities are demonstrated.

The paper by Patricia Clarke Annez and Thomas Zuelgaray is from a public finance perspective. It estimates the impact of high energy prices on local government finances (municipalities) using data of municipalities from Spain and Maharashtra, India. The authors point out that the impact on local government finances would be severe due to high energy prices because while the taxes on energy are mostly collected at the federal level, as they ought to be given the fact the GHG emissions are a global externality; the expenditures of local governments are quite energy intensive. This makes the case for adequate compensation to local government by higher levels of the government to ensure adequate provisioning of services by the local government.

The paper by Dhruba Purkayastha, Manisha Gulati and Sunder Subramanian is from a financial market perspective. They argue that if India has to move towards a low-carbon development path, the amount of financing required to support innovation and development of clean technologies and their commercial exploitation would be stupendous and would require consistent policy measures to address clearly identifiable gaps. To support the research, innovation and pre-commercial development phase of such technologies and infrastructure, which are risky, they suggest creation of a Technology Innovation Fund on the lines similar to the UK Carbon Trust. While the

Government of India in the recent past has mooted the idea of creation of a National Clean Energy Fund, the authors argue that its mandate should be clear and it should support low-carbon technologies in sectors other than the energy sector as well. They also identify gaps in the commercial development of low-carbon technologies and infrastructure and argue for measures such as creation of a dedicated Green Infrastructure Financial Institution by expanding the mandate of IREDA to provide debt to Clean Projects, and giving priority sector status to Clean Projects to encourage funding. They also advocate tighter environment norms with development of domestic carbon market under a cap and trade system.

For attracting private equity investments in clean technologies, Pinaki Bhattacharyya and Shishir Maheshwari argue that India has right enablers like high growth rate, high imports of conventional fuels, baseline energy shortage, cost efficient manufacturing and unexploited potential of clean energy. These can be the drivers for providing scale opportunities for private equity investments in clean technologies particularly in solar, wind and carbon mitigation services segments. Attracting further private equity investments in these segments, where they cite examples of existing activity, would require policies supporting clean energy, capacity building and measures to improve economics of the clean technology projects.

Ashok Singha, Papia Chakraborty, Suvra Majumdar and Vijay Mahajan highlight the role that can be played by micro-finance institutions (MFIs) in promoting the spread of clean technologies in agriculture and rural areas. They point out as to why Clean Development Mechanism (CDM) is not very effective in promoting clean technologies at grass-root level. High transaction costs related to CDM, including those associated with monitoring and verification, along with the lengthy processes makes the CDM relatively ineffective for grass-root adoption of low-carbon technologies due to lack of scale. Instead, they propose that MFIs can act as effective aggregator by using instruments proposed by them, namely, Aggregation of Micro-certified Emission Reduction (AMCERs) units or Aggregation of Verified Emission Reduction Transaction (AVERTs). They also cite examples of such initiatives at the grass-root level.

Energy Sector

Energy - both in the processes of production as well as consumption - is the largest contributor to CO2 in India. But there is a pressing need for accelerating development of energy producing capacity to fuel economic growth and alleviate poverty. India's per capita electricity consumption is about 700 kwh, a stark contrast to the per capita consumption of 12000-15000 Kwh in developed countries. The Integrated Energy Policy

projects that meeting India's growth ambitions would necessitate growth in India's power requirements by 5-6 times (3600 billion kwh or 800 GW) by 2031-32. Therefore, the need of the hour is to find a balanced approach that aims at enlarging the energy production and consumption base, while at the same time adopting technologies and processes which are least harmful to the environment. This will involve measures both on the demand side and supply side.

The first and most important measure that needs to be considered in this regard is energy efficiency (EE). There are a large number of areas offering tremendous scope for improving efficiency. These include manufacturing, lighting, household appliances, agricultural pumps, transportation and buildings. Lenora Suki points out that energy efficiency in buildings in urban areas can yield as much as 60% energy savings while efficient lighting can give 75% energy savings. What makes India's national low carbon growth strategies recognize EE as a key measure is not only the emission reduction potential from lower electricity consumption, but also because of the much needed 'additional' capacity it releases to meet the growing electricity demand. Not surprisingly, the Ministry of Power has put in place ambitions plans of adding 25000MW effective capacity through 23% efficiency improvement. The Energy Conservation Act 2001 mentions about 10000MW of avoided capacity through conservation and a 20 % increase in EE by 2016 through supply and demand rationalization. Deo & Deshpande point out that even if we are less ambitious, it is possible to have 112MT less CO2 emissions (or reduce about 15-16% of our total current emissions from the power sector). Yet, the EE opportunity is not being fully realized due to economic constraints, political barriers, technical challenges, and institutional shortcomings. These problems need to be expeditiously addressed through solutions such as innovative financing mechanisms involving energy saving insurance, tax-exempt municipal leasing, and green mortgages. At the same time, there is a need to implement utility-based approaches for financing demand side management (DSM). Global experience indicates that 2-3% of the utility revenue is put in energy efficiency and demand side management (DSM).

The Electricity Act 2003 provides state regulatory commissions (SERCs) with the authority to issue directives that promote EE and DSM. However, most states have yet to issue such directives. If the SERCs make these mandatory, the retail electricity tariffs would need to increase by 10-15 paise per unit (if the subsidized agriculture and below poverty line (BPL) categories are excluded). With the cap-and-trade regime evolving in India, EE initiatives can yield a win-win opportunity for India moving along a low carbon path. However, EE would not address the challenge of providing 78 million households (predominantly rural) access to electricity.

Chandrashekar Iyer, Rajneesh Sharma, Ronnie Khanna, and Akil V. Laxman point out that while grid extension does offer benefits of continuous supply from a relatively cheaper source of electricity, it is unlikely to be cost effective or environmentally friendly, given the current fuel mix of electricity generation. Quick computations indicate that electrification of these 78 million households through the grid would entail CO2 emissions to the tune of about 50MT/year (assuming 0.82kgs CO2/kwh from CEA, 26% T&D losses, and average annual consumption of 630Kwh for rural households). Therefore, Decentralized Distributed Generation or DDG using local feedstock and renewable sources could play a big role here. Renewable Energy (RE) based DDG has emission mitigation potential of 45-50 MT or about 6% of the emissions from the power sector. Despite these known benefits, DDG has not penetrated to the extent it should have. Limitations of finding site-specific options and financing of such small initiatives involving individuals or communities with low creditworthiness has been a key barrier. Involvement of multiple agencies with little intra- or inter-agency coordination and poorly drafted schemes that often land up targeting the same people is another.

More broadly, RE has a big role to play both at the grid and off-grid level. Ashish Garg, Manisha Gulati, and Nachiketa Tiwari highlight that, besides meeting the electricity requirements in rural and remote areas in a clean manner, RE creates job opportunities for the local people. They focus on wind, solar and waste-to-energy technologies and discuss the potential of these technologies for India. But the large scale deployment of some of these technologies, as of the other RE sources, has been affected due to barriers such as absence of a comprehensive overall policy for RE, weak state level regulatory frameworks, non-availability of evacuation infrastructure, and availability of finance for small projects. Commercial viability of technologies such as solar for large scale electricity generation and storage still demand more R&D. Addressing these problems, creating a supply chain, developing equipment standards, carrying out detailed assessments of resource potential even for established RE technologies, and improving awareness levels on RE among the people are critical for mainstreaming RE in India's low carbon energy development strategy.

Abhijeet Deshpande and Rohit Chadha explore the use of captive solar to meet the power requirements of big residential and commercial establishments that currently use diesel-based captive power. Using the case of a large business park in Gurgaon, Haryana, they assess the economic viability of captive solar power for such establishments and conclude that solar power is competitive against diesel and can mitigate the risks associated with volatile diesel-prices and changing load conditions.

Given the low efficiency and high costs of many RE technologies, coal is likely to remain the mainstay of the country's electricity needs. Over time, though, domestic coal reserves would not be able to meet India's requirement, a problem already evidenced from the growing coal import. Another problem is that Indian coal contains high ash content and lower calorific value, although low on sulfur, compared to coal available in other countries. Thus, development and deployment of clean coal technologies (CCT) is essential. Dr. Malti Goel describes the various clean technologies available for coal beneficiation, combustion, conversion, and post-combustion stages, the early initiatives made in these technologies; and the bottlenecks and current status of clean coal technology in India. The more advanced technologies involve carbon capture after combustion and storage of that carbon in safe custody. Coal gasification and coal liquefaction are less pollution emitting technologies, but their implementation on industrial scale involves a number of tradeoffs between financial and technological considerations. Outlining a clean coal technology roadmap, she concludes that although clean coal technology has not made much headway due to financial, infrastructure and regulatory barriers, it is looking more promising as a result of global warming concerns. Prospects exist for technology transfer under International protocols. Not surprisingly, this is one of the main areas that Nationally Appropriate Mitigation Action Strategy of GoI is looking into.

The large and growing base of fossil fuel driven captive generation also merits attention. Tirthankar Nag points out that there is more than 20GW of installed captive above 1MW and of almost matching total capacity below 1MW. Most of these are widely dispersed and operate inefficiently, making monitoring and compliance difficult. But unless the inefficiency of these plants is addressed, the low carbon energy trajectory of the country could hit a barrier. He advocates progressive policies that encourage larger plant sizes through group captives, a model captive power policy for encouraging sale of surplus power to the grid, and reduction of cross-subsidy charges for ameliorating the emission intensity of fossil fuel-based captive capacity addition.

Finally, the twin challenges of low carbon growth and energy security necessitate focus on Nuclear Power. There has been a resurgence of nuclear power globally for these very reasons. Many countries that had called off their nuclear program have once again restarted their programs. In the meantime, there has been a shift from open cycle (involving one time use of nuclear fuel) to closed cycle (involving enrichment and reprocessing for reuse) technologies. However, this has been accompanied by heightened concerns of safety as well as diversion and misuse of enriched fuel for defense purposes. Dr. Manpreet Sethi explores the advantages of investing in nuclear expansion, which is today possible with the conclusion of the Indo-US civilian nuclear cooperation

agreement that has opened India's participation in international nuclear commerce. India's nuclear program aims to utilize its 360,000 tons of high quality thorium reserves (amounting to about 32 per cent of the world's reserves). The dependency on limited and poor quality of domestic uranium reserves which can at best add some 10000 MW would be eliminated once India graduates to the thorium cycle.

Clearing misperceptions about the energy insecurity arising from uranium imports and the resulting price volatility of retail electricity, Dr. Sethi points out that nuclear technology in India has reached a state of self reliance. India can now even export technology. However, a great deal of further research and development is needed in the third stage of the nuclear programme that will enable the utilisation of indigenous thorium and obviate uranium dependency. Concerns of safety and security will need to be addressed and greater public awareness generated on the merits of nuclear energy in India's energy mix.

Transport Sector

Transport is a growing contributor of GHG emissions. Most current initiatives in addressing climate change and other sustainability concerns in the sector focus on meeting transport demand efficiently and hence are based on technological improvements in fuels or automobiles, or on shifting demand from personal vehicles to less carbon intensive modes such as mass transit and non motorized transport. Increasingly, however, it is being recognized that it is important to account for mobility needs in urban development, and it may be possible to decouple transportation demand from growth and development through integrated land use and transport planning.

The paper contributed by Sanjiv S. Sahai and Simon Bishop in this report focuses on issues and challenges in achieving low-carbon intensity of travel demand using an integrated multimodal urban transport system. Using Delhi as an example and citing studies from elsewhere, they point out that there is a need to introduce private vehicle restraint measures such as higher parking charges, road pricing etc. besides improving public transport supply and quality. Delhi's focus on metro has not been able to release pressure on the roads from private motorized transport since bus share has fallen. Some of the past initiatives, such as flyovers and road development, have in fact created difficulties for non-motorized transport users such as pedestrians and cyclists. The level of integration across cleaner modes remains low; while metro has been given a thrust, integration with, and the development of the bus system and NMT has not received equal attention. Land use planning is also not integrated with transport system planning and development. These aspects would need to be addressed if Indian cities were to acquire the characteristic of a low-carbon transport system.

In a paper on the issues and concerns related to development of low-carbon urban transport, Dinesh Mohan points out certain interesting facts challenging the conventional wisdom that provisioning of public transport would help in alleviating the problem. He points out that worldwide most cities in Europe developed after 1950s do not have a core Central Business District (CBD), which is empirically associated with high use of public and non-motorized transport. Once car ownership became more common, it did not make sense to use public transport unless the roads were congested and the commute was to a single CBD from all directions. For developing countries, availability of cheap and less-noisy air-conditioned cars with music system and the economics of fuel-efficient motorcycles have made the shift to public transport even more difficult. He goes on to argue that besides provisioning of public transport, there is need to improve road safety, reduce crime and threat-perception on the road if we want to encourage use of public and non-motorized transport as these factors are a major deterrent to use of low-carbon modes of transport. Given the absence of a single CBD, cities should have low-income population spread all over the city to increase their proximity to their places of work.

In another paper on Urban Transport, Akshima T. Ghate and Sanjivi Sundar estimate the vehicular carbon emission in 23 out of 35 (in 2001) million-plus Indian cities from passenger transport activities. They estimate it to be of the order of 18.9 MMT in 2001 accounting for one-fourth to one-third of the entire country's on-road passenger transport emissions. Given the increasing importance of urban transport in carbon emissions, they advocate the use of well-known "avoid-shift-improve" framework by instituting measures such as using IT for reducing transport need, improving public transport, demand side management through road pricing, parking etc., and improving the technology of vehicles.

Using the "avoid-shift-improve" framework, Kaushik Ranjan Bandopadhyay analyses the challenges facing India in moving towards low-carbon transport. He highlights the increasing personalized transport usage, penetration of motorized transport in the rural areas with road improvement projects, increase in freight movement due to economic growth and distorted transport planning supporting personalized transport as major challenges in avoiding and optimizing carbon intensity of transport in India. Falling public transport and rail share are the challenges in Indian context from the point of modal shift. Relatively poor emission standards, declining non-motorized transport share and insulation of domestic consumers from international energy prices are some of the challenges in reducing energy intensity of transport. The absence of cleaner fuel and dependence of transport sector on oil are challenges from the point of reduction of carbon factor in the fuels used. In addition, he argues that there are institutional and governance

related challenges posed by para-transit modes. He goes on to suggest measures required to face these challenges.

In a paper discussing the approaches followed elsewhere to improve fuel economy of vehicles, Rita Pandey discusses the form policy interventions should take to promote fuel efficiency of vehicles in India. Besides fuel tax, taxes or subsidies based on the fuel efficiency level of cars and regulatory norms on manufacturers have been tried. She argues that given the results of studies and other constraints, there is a case in India for introduction of purchase tax on new vehicles based on their fuel economy as consumer myopia tends to value fuel economy less than what it is truly worth. She also points out that the emission standards should be specified in grams per liter and not in terms of grams per kilometer, as they are currently in India.

Operating procedures and optimal fuel utilization is another area for improving carbon intensity of transport sector. Y Komalirani and Gauravkumar Joshi estimate the emission from domestic flights on Delhi-Mumbai corridor. They argue that the extent of wastage of fuel due to hovering around, congestion and current operational procedures can be brought down by improving air traffic management and new approaches such as Continuous Descent Approach (CDA), and Performance Based Navigation System. They also provide an estimate of likely savings in terms of emission reduction.

Urban Sector

India is still at a nascent stage of urbanization, which provides it a unique opportunity to achieve low carbon growth. The scale of urban expansion in India is, and will continue to be enormous, which means a tremendous pressure on the environment.

While urbanization impacts climate change, Sridhar also points to the impact of climate change on urbanization through loss of assets and income, loss of health or ability to work, and reduced resilience to future shocks Cities will have to adapt to deal with the multidimensional impacts that climate change will bring in its wake such as extreme weather conditions, drought and water scarcity.

Conversely the current pattern of urban development will have a profound impact on climate change. Although existing cities are very dense with high pedestrian and non motorized traffic, there is a clear trend towards suburbanization, which leads to unsustainable urban sprawl. Nallathiga draws our attention to faulty urban planning policy and land use and development control regulations in the large cities that, under the guise of decongestion for better provision of public services, encourage sprawl. He suggests using the planning framework for spatial planning of towns and cities integrated with

energy, transport, infrastructure and other sector policies. Byahut advocates climate change action plans and mainstream comprehensive planning should be integrated. Specific instances presented by Sridhar where an integrated approach or partially integrated approach has been successfully implemented are the Vienna City Council's Eco-Business Plan, Indore's water availability tracking systems, and Ahmedabad's bus rapid transport system coupled with its efforts to use waste for energy production.

Smart growth strategies as in compact city development have been proposed by Nallathiga and Byahut as a means of linking spatial planning to a low carbon trajectory. Examples of cities where compact city or smart growth strategies have been implemented are Curitiba (Brazil), Singapore, Hong Kong (PRC), Freiburg (Germany) and Portland (US). The approach includes mixed land use, creating walkable neighborhoods, developing a strong sense of place and attractive communities, providing a variety of transportation choices, and preserving green spaces. However, it is important to address issues of displacing lower income residents, housing unaffordability, increased congestion, air pollution, transportation costs, and reduction of open spaces due to densification measures and lack of political will for implementation.

Singhal, Berry and McGreal hypothesize that progressive cities with an integrated approach to regeneration/renewal towards a low carbon economy promote their economic competitiveness. A support for the hypothesis comes from the city competitiveness index 2010 in the UK which shows that more competitive regions are associated with low carbon dioxide emissions per capita, though there are outliers. Cities such as Bristol, Manchester and Leeds have identified carbon savings options and have developed actions plans to implement them. Further, they point out that mature cities have workable case study exemplars and solutions while emerging cities are still in formative stages in terms of their progression towards a low carbon economy.

There are, though, opportunities for knowledge-sharing among cities. Byahut highlights the networking role of local governments under the ICLEI-Local Governments for Sustainability initiative in rejuvenating Indian cities and emphasizes the role of coalition building by municipal governments as a key strategy for garnering support, both political and technical, for urban climate change action plans.

Rural Sector

Rural India has dismal infrastructure with huge potential for large investments in both hard and soft infrastructure: roads and communication, drinking water and sanitation, education, health, and agriculture. Investments in wasteland management; rainwater

management, crop residue management, storage and distribution of agricultural produce, energy efficiency in household and farm sectors, afforestation and reforestation will not only have long term positive impacts on poverty reduction and livelihoods but also reduce India's carbon footprint. Some of these proposals will address mitigation and carbon sequestration, besides helping the sector adapt to climate change. But this will require adoption of technology, ushering in requisite institutional frameworks and enabling policies. Against this backdrop, the IIR covers low-carbon options for the development of infrastructural for rural India.

Dixit et al examine the challenges and opportunities for carbon neutral infrastructure development in agriculture. They identify conservation farming, wasteland management, watershed development, agri-horti and horti-pastoral systems; vermi-composting, and energy production by scientifically processing from cattle dung, crop residue and agro industrial wastes as the core investment areas for carbon saving and carbon capture options. They suggest changes in farming practices such as moving to organic farming and altering the process of cultivation for water intensive crops, especially rice, that not only reduces water consumption but also increases yield. They emphasize the creation of decentralized infrastructure for storage and distribution of agricultural produce to contain food miles. Finally, they highlight how energy efficiency in the farm sector can save electricity, thereby reducing GHG emissions. For instance, use of energy efficient pump sets can help save 28 billion units of electricity per annum, thereby reducing 17 mtCO2e/year.

Sinha et al reinforce the mitigation and sequestration potential of rural India by pointing out the role of forests in offsetting the carbon load by sequestering carbon. The total carbon stock estimated in India's forests as of 2007 is 7290 million tons. They provide an overview of government initiatives in this direction, particularly under the National Action Plan on Climate Change and highlight how afforestation and reforestation can be potential revenue generators by earning credits under the Kyoto Protocol's Clean Development Mechanism. They point out that agro-forestry or agro-horticulture has carbon sequestering capabilities that are higher than that of agriculture because under tree cover, the carbon sequestering capacity of soil is higher, soil fertility is maintained and soil exhaustion controlled. Given the carbon sequestration potential of trees, they recommend compensatory afforestation for urban areas as well because these areas have dust sequestration and pollution mitigation potential

The mitigation potential of agriculture and sequestration potential of forests can be leveraged as a source of financing for infrastructure development. Gujral et al explore the

potential of agricultural offsets, that is, compensating for carbon emissions in other activities by engaging in low cost mitigation and/or sequestering activities in agriculture, as a policy instrument for emission reduction. Given that agriculture accounted for about 18% of the total GHG emissions of the country in 2007, they believe that agricultural offsets have immense potential for GHG abatement. They opine that the co-benefits from agricultural offsets (such as reversal of non sustainable farm production systems and supplementary income stream to the farm sector) at a time when agricultural productivity is stagnating, offsets are an attractive policy alternative. They suggest the establishment of an 'offset authority' to approve agricultural abatement practices that would be eligible for off sets for the purpose of trading to large emitters; determine the carbon abatement value to be assigned to those off sets and possibly establish a market exchange between emitters and providers of agricultural off sets. Transaction costs associated with these offsets can be reduced by aggregating individual offsets into a portfolio that offer economies of size. They recognize the concerns about implementation, and the risks and uncertainties involved but suggest that these concerns should not prevent the government from taking policy approaches such as the establishment of voluntary carbon off set markets to introduce a carbon price to the agriculture sector.

Integration of a low carbon growth strategy at the rural level will involve setting policy priorities at local level, institutional capability to implement and monitor policies, and improved knowledge and understanding of climate change issues. Dilip Ghosh's insightful case-study of the workings of the panchayats and the government machinery in rural West Bengal draws our attention to the lack of governance, awareness and understanding of environment and climate related concerns at the local panchayat level, and poor implementation capacity for low carbon initiatives at the level of local rural institutions.

Conclusion

India is at early stages of infrastructure development, and so the opportunities for carving out a low carbon development path are many. This IIR (2010) looks at 'how' to build infrastructure in a carbon smart way, the challenges ahead and ways to overcome them.

There are three key interventions through which we can achieve a low carbon economy: carbon reduction, switching and capture. Carbon capture is mainly prevalent in forestry and can be encouraged in other sectors through technological advancements. On the other hand, reduction and switching can be more easily achieved by applying the "avoid, shift, improve" framework across all major infrastructure sectors to reduce demand for infrastructure services, to shift towards lower carbon forms of service provision, and to

increase the efficiency of energy/infrastructure use. Of course, this requires appropriate price signals and provision of viable alternatives.

A key problem in that there is no price on carbon in India. Far from that, the ground reality is that carbon intensive fuels are in fact priced lower. Eliminating economic distortions is an imperative for moving towards a competitive low carbon economy. A priority is therefore to let prices reflect costs to avoid wastage. Gradually, environmental externalities should be incorporated in pricing and valuation of resources.

Initiatives for valuing carbon savings and price discovery through market mechanisms are being taken by introducing Energy (Electricity) Saving Certificates under the Perform Achieve and Trade Scheme of the National Mission on Enhanced Energy Efficiency and Renewable Energy Certificates. However, these are limited in scope. Several other instruments such as agricultural offsets can be explored.

While developing a carbon market is a good incentive for promoting low carbon initiatives and achieving at least overall target emission reductions, it requires a sophisticated eco-system of institutions (to validate/certify/audit, monitor, and aggregate). Further, carbon markets take time to mature and serve their intended purpose. Therefore, until such a market develops, there will have to be greater reliance on tax and subsidy instruments – such as direct and indirect carbon taxes and feed-in-tariffs.

At the same time, performance norms would have to be established across all sectors such as industries, buildings, appliances, vehicles and so on. Institutional strengthening, capacity building and greater monitoring for compliance with performance standards and their enforcement will be critical.

The future of India, given its resource endowments, would depend on technological advancement, fully exploiting indigenous resources in a low carbon manner. Clearly, this would require substantial funds. Government support can complement private investment, especially in research and development where the risks for private capital are very high.