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Low Carbon Pathways for Growth in India

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Chapter 11
Water, Ecosystem Services, and Food Security: Avoiding the Costs of Ignoring the Linkage

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Abstract This paper talks of the emerging paradigm of water management that acknowledges critical ecosystem services, and challenges the linear and positive relation between water availability and food security. The ways water used to be managed, globally, are changing rapidly. The existing engineering modes of water management entail constructing large structures intervening into the natural hydrological flows, and exploiting the water for human use. A large component of demand for water emerged from the need of the agricultural sector in various parts of the developing and developed world to ensure food security. Over time, the developed nations began realizing that such traditional engineering ways of water management entailing large constructions are not sustainable in the long run, and can have serious impacts on ecosystems. Since large parts of livelihoods are dependent on the ecosystem services, negative impacts on ecosystems affect livelihoods negatively, too. Hence, a new paradigm of water management recognizing the ecosystems livelihoods linkages is emerging. This new paradigm is known as Integrated Water Resource Management (IWRM) and, when applied at the level of a river basin, is referred to as Integrated River Basin Management (IRBM). This new paradigm delinks economic growth and food security from increasing water use, and provides for an ecosystemic definition of food security. However, this changing paradigm is yet to be recognized in policy documents of the developing world, especially India. For India to embark upon a low-carbon growth trajectory, it must embrace the new paradigm of water management.

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11.1 Introduction

The fact that ecosystem services and food security are inextricably linked is being increasingly recognized within academic circles, even though it rarely finds reference in the developing world's policy documents. In South Asia, this omission has led to adherence to the archaic notions of water management entirely based on the reductionist engineering paradigm looking at short-term economic benefits, and that ignores long-term social and ecosystem concerns. This paradigm is essentially an integral component of the colonial legacy as this was introduced and formalized under colonial capitalism in South Asia leading to a "metabolic rift" between human–nature relationship (Foster 2003; Gilmartin 1994, 1995). The most critical concern that the reductionist engineering paradigm misses addressing is that the livelihoods of the poor in the developing world are reliant on ecosystem services. Essentially, because of the importance that ecosystem services render to the livelihoods of the poor, such services are often classified as "GDP of the poor" (Martinez-Alier 2012). Unfortunately, India's policy documents and implementation plans rely on "arithmetic hydrology" rather than "eco-hydrology" and have ignored this linkage. They have also ignored the changing relation between water and food security, with the change being embedded in the new emerging paradigm of water management, also known as Integrated Water Resource Management (IWRM), which recognizes the critical role of ecosystems.

This paper therefore attempts to present the changing relation between water and food from the perspective of IWRM, where the ecosystem is considered an important component of water demand. The paper also highlights how water policy documents in India have ignored the notion of Integrated River Basin Management (IRBM).

This paper consists of seven sections. Section 11.2 of this paper relates the linkage between ecosystems and food security. It highlights the fact that food production is a provisioning service of the ecosystem, and therefore the ecosystem plays an important role in long-run food security. Section 11.3 talks of conflicts over water and land use arising from economic (agricultural) and ecosystemic use. It also talks of how dam construction (with irrigation as the major purpose) leads to conflicts over water use in India; it also brings in the debate over river interlinking. Sections 11.4 and 11.5 talk of the tenets of Integrated Water Resource Management (IWRM) and Integrated River Basin Management (IRBM), respectively. Section 11.5 also talks of how water policy documents in India have missed taking a river basin approach in the context of water resource management. Section 11.6 talks of the changing relation between water and food, and attempts to present an ecosystemic definition of food security. It is here that I explain how adherence to IWRM and IRBM provide pathways towards low-carbon growth. Section 11.7 consists of the concluding remarks.

11.2 Ecosystems and Food Security

Of the entire range of services provided by ecosystems (provisioning, regulating, supporting, and cultural) to human society (MA 2005), food provisioning, either naturally or through human intervention, is one of the most important. As pointed out by Richardson (2010), the role of ecosystem services in enabling food security needs to be looked at from three aspects, availability, access, and utilization of food. The structure of the ecosystems supports these utilities, through provision of critical ecosystem services facilitating production of food, creating opportunities to generate incomes, and creating a natural base for provision of energy for cooking (Richardson 2010).

As such, agricultural systems fundamentally depend on ecological processes, which clearly explain the production aspect. What is less understood is the role of ecosystem services in ensuring access to food. Sen (1981) postulated that food security cannot only be a function of availability, but also must be a function of access. Household-level access to food is facilitated and supported by ecosystem functions, directly or indirectly. These include provisioning services that allow for the transport and processing of food as well as for the production of agricultural goods and raw materials that can be sold to generate income. One of the most critical examples in this regard is the creation of nonfarm employment opportunities that help generate incomes for households (Richardson 2010). Households in the rural areas of the developing world engage in harvesting and use of wood and non-timber forest products (NTFPs) which often emerge as another source of their livelihoods, enhance their purchasing power, and increase their access to food, and nearly one-third of the world's forests are primarily used as a source for such products. Given the seasonal nature of agriculture, the production and sale of charcoal, food, and other NTFPs is important in sustaining many rural households during the off-season (Osemeobo and Njovu 2004; Richardson 2010).

The utilization dimension of food security is concerned with how households utilize the food accessible to them. Therefore, while access is a necessary condition of food security, it cannot really be the sufficient condition till the utilization criterion is satisfied. Utilization is generally a function of safe and sanitary cooking practices and the quality of nutrition (Webb et al. 2006). Ecosystem services contribute to the utilization of food by households and smallholders in various ways. These might occur through the supply and availability of safe drinking water and food preparation; the fuels and energy for hygienic heating, cooking, and storage of food; the materials for sanitation and health care; and the micronutrients necessary for an adequate diet (Richardson 2010). Safe and healthy cooking of food is a crucial component of food utilization: this helps in improving the nutritional value of food, preventing disease, and enhancing the taste. Biomass sources are used in various parts of the developing and underdeveloped world for energy needs of cooking. A large part of this is fuelwood, lops and tops, and NTFPs (Richardson 2010). Nature further provides add-on spices that enhance taste, and add to the nutritional quality of food (Richardson 2010).

11.3 The Conflictual Outcomes

Agricultural expansion during the last century has caused widespread changes in land cover, watercourses, and aquifers, thereby degrading ecosystems, and restricting their ability to support some services including food provisioning (Falkenmark et al. 2007). Agricultural expansion in most of what are perceived to be the "water-scarce" economies were essentially results of intervention in hydrological flows through constructions of large dams and storage and diversion mechanisms (Ghosh 2009). No doubt, making more water available for irrigation allowed water-intensive crops to be grown and enabled land-use change but the latter has threatened the ecological foundation of the world food system. Quite unfortunately, the management policy of many agro-ecosystems has essentially been based on the premise that they are delinked from the broader landscape (Falkenmark et al. 2007). There has been scant recognition of the ecological components and the processes that support the sustainability of such agro-ecosystems. As a result, the carrying capacity of the ecosystem has been defied by traditional agricultural and water management regimes. Some ecosystems, therefore, were made to cross the ecological thresholds, leading to a regime change in the ecosystem and their concomitant services (Falkenmark et al. 2007). The resultant reduction in the ecosystem's resilience also restricts the sustainability of its food provisioning service. Unfortunately, beyond a point, even the water supply augmentation plans (through dam constructions), and land-use change (entailing bringing more land under agriculture by cutting down forests or filling wetlands), do not work and can have a negative impact on food security, with the impacts intensified by climate change, as argued by Chaturvedi (2015) in this volume.

Threats to the ecological foundations of agriculture arise from resources that are becoming scarce over time, because of increasing competing uses that are getting diversified in nature, and increases in the human demand for food and other uses due to population growth and changes in human preferences, thereby validating the Malthusian creed. The drivers of this process are: competition for land and water, traditional resource-consuming agricultural practices, deforestation, and unsustainable pesticide use (that reduces the long-term soil productivity, and also contaminates groundwater), and climate change. This accentuates conflict over water and land. Poor people in the developing world, who rely on ecosystem services for their livelihoods, are extremely vulnerable to ecosystem changes. Therefore, there is no doubt that the failure to tackle ecosystem degradation and loss can severely undermine the attempts towards achieving the Millennium Development Goals (to be replaced by Sustainable Development Goals or SDGs after 2015) of poverty reduction, food security, and environmental sustainability.

Water conflicts, more often than not, have been results of a constructionist paradigm. The western world, led by USA, was the harbinger of development through this constructionist regime. From the 1920s to 1960s, huge dams were constructed, more so for irrigation needs. But, over time, serious ecological impacts resulted over the Colorado River basin in the western US, for example, the construction of the Hoover Dam, the Tennessee Valley Project, and the Central Arizona Project have led to ecological problems, whose long-term costs are higher than the short-term benefits. Environmentalists have been vocal about the livelihoods problems that have been an outcome of the ecosystem damage through the losses in ecosystem services. This has led to a trend in the western world to decommission dams. As noted by Gleick (2000), around 500 dams have been decommissioned in the US and Europe in the 1990s, noting the extensive ecosystem damages and potential for conflicts. Rehabilitation and livelihoods losses even during the construction phases have been sources of social conflict (Homer-Dixon 1994), the costs of which are often not taken into consideration while carrying out impact assessment (Ghosh 2008).

Hence, the outcome is not merely a conflict between communities and government agencies but it is a conflict over sectoral use of water as well, with the ecosystem emerging as a critical source of water demand from the sustainability perspective. This is increasingly being recognized by the emerging paradigm of Integrated Water Resources Management (IWRM).

11.3.1 Supply-Side Interventions and Water Conflicts in India

Ghosh and Bandyopadhyay (2009) postulate that one of the major reasons for water conflicts in India have been water supply augmentations plans. This was shown by them in the context of the Cauvery River basin, where they find evidence of how attempts to reduce the "scarcity value" of water by plans to augment supply for paddy cultivation intensify conflicts between the riparian states of Karnataka and Tamil Nadu. It is further argued that one of most important reasons for the conflict is that irrigation water is highly subsidized and is therefore treated as a "zero-value" resource. A free resource is prone to be wasted, and that is exactly what prevailed in the Cauvery basin, leading to conflicts. Ghosh (2015) further goes on to argue that the environmental security concerns over the transboundary water relations between India and Bangladesh have arisen more due to the reliance on the reductionist engineering paradigm brought into South Asia by British engineers, who hardly had much idea about waters flowing down the Himalayan terrain. The application of "one for all" technology in water resource planning and management has been the prime cause of concern.

11.3.1.1 Proposal for Interlinking of Rivers in India

The proposed River Link Project (RLP) in India is based on traditional engineering perspectives, and one of the latest glaring examples of the reductionist "arithmetic hydrological" paradigm based approach to water management in South Asia

(Ghosh 2012). It is a very large project for storage and long-distance transfer of water, mainly from the Ganges-Brahmaputra-Meghna (GBM) basin to river basins in drier areas in western and southern India (Fig. 10.1). The project includes the construction of nine large and 24 small dams and digging of 12,500 km. of canals. This project has drawn serious criticism from the perspective of sustainability and equity (Bandyopadhyay 2009: 147–183) and from that of economics (Alagh et al. 2006). Bandyopadhyay and Perveen (2008) have expressed their apprehensions on the interlinking of rivers project and feel that the project may further aggravate interstate water disputes, as well as aggravate the international hydro-political situation in South Asia (Ghosh 2012). They identify avenues through which new interstate conflicts may emerge. It is a fact that the federal states in India have always enjoyed rights over water for apportionment and allocation. However, under the centralized scheme of allocation under the ILR, the existing modes of riparian rights of the states get disturbed, leading to conflicts; already a few states have expressed their dissent. Unfortunately, these views, critical of the scientific credibility of such a large project, have not had any impact on the official policy. Hence, the question remains whether the official approach will continue to follow the reductionist engineering perspective or be willing to accept the emerging holistic perspective of ecological engineering (Ghosh 2012).

11.4 The Paradigm Debate Over Water and Emergence of Integrated Water Resource Management[1]

Traditionally, water has been looked at as a resource occurring in "abundance" in nature, and hence, increasing demand was never seen as posing any potent threat. Hence, the impression that became predominant, emanated from the idea that water scarcity is spatial, and more water can be diverted to the water-scarce zones from water-rich zones, through appropriate supply augmentation plans. In order for "water to be distributed equitably", the colonial engineering thought process led the idea of supply expansion plans through interventions in the natural hydrological flows (e.g., Rao 1975). As a result, water resource planning generally relied on linear projections of future populations, per capita demand, agricultural production and levels of economic productivity (Gleick 2000).

Towards the middle of the last century, serious concerns were expressed on the long-term wisdom of following such a strategy that is focused exclusively on increasing interventions into the hydrological cycle. Despite its impressive short-term successes in providing larger supplies, it is increasingly being realized that addressing the new and emerging challenges is no more possible in the long term, unless some fundamental changes take place in the way humans have looked

[1]This section draws largely from Ghosh (2008), (2012), and (2015), where I have previously talked of the paradigm debate earlier.

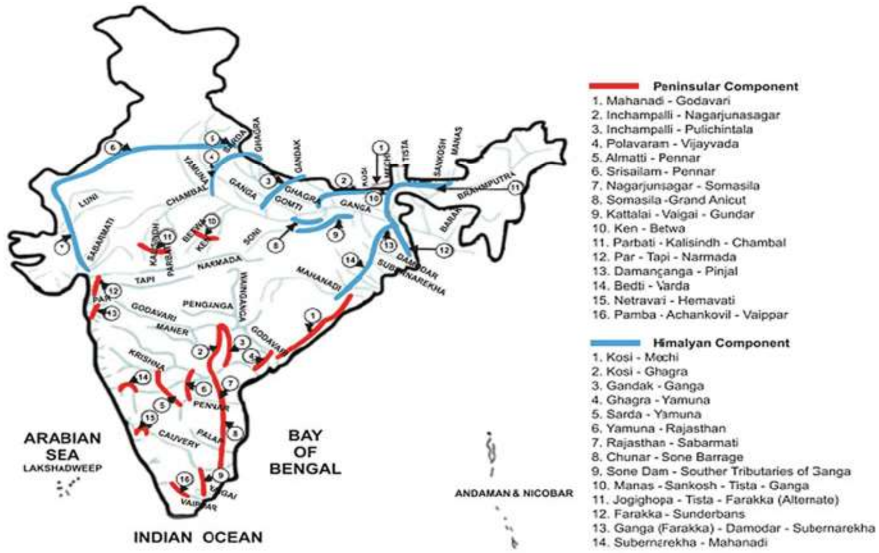

Fig. 1 Map of ILR: Peninsular and Himalayan components. *Source* Amarasinghe (2012)

at water resources so far. The "business-as-usual" thinking has started to be feared as counterproductive. There emerged the need for a fundamental change in terms of a new interdisciplinary paradigm that has been constantly gaining ground over the years. The new ways of managing water on the basis of a holistic knowledge base have increasingly been identified as Integrated Water Resource Management (IWRM).

11.4.1 The Emerging Paradigm of Integrated Water Resources Management

The professional and scientific views of water resource management are changing rapidly, based on scientific analyses of past mistakes and availability of new information. This "changing water paradigm" (Gleick 1998; Bandyopadhyay 2004) represents a real shift in the way humans think about water. The realization of a need for holistic modes of water management has been reflected in some of the policy actions of the developed world, primarily with the dawning of the ecological concerns (Gleick 2000). The new paradigm recognizes human society as a subsystem of the biosphere in which water is a key element (Falkenmark 1997; Falkenmark 2003). Based on the various contending thoughts and ideas, the notion of IWRM has been conceptualized in the form of the following points:

(a) *Water is viewed as an integral part of the global hydrological cycle, and not as a stock of material resource to be used for the satisfaction of human requirements*: With the continued emphasis on the economic benefits of water, its ecological functions in sustaining ecosystem health, and thence human health, have been largely ignored. In the emerging holistic and interdisciplinary paradigm, water is viewed in the context of the broader global hydrological cycle. Neglecting to recognize the ecological cost of diverting water is actually internally subsidizing the use of water for economic purposes at will (Flessa 2004).
(b) *Supply of ever-increasing volumes of water is not a prerequisite for continued economic growth.* The availability of water has traditionally been seen as an essential precondition for continuing economic growth (Bandyopadhyay 2004). The new paradigm, however, suggests the opposite, in that, economic growth has been delinked from water supply augmentation plans. This helps shift the focus to demand-side management of water, an approach long overdue. It also helps create a pathway for low-carbon growth (Gleick 2000; Falkenmark et al. 2004).
(c) *Clear and strict prioritization of various types of needs and demands for water, including those by ecosystems, is needed.* The new and interdisciplinary paradigm prioritizes the various competing uses of water; one is between the needs of the ecosystem and the needs of human society. The other is among the needs of human societies themselves (Bandyopadhyay 2004). An important component of current water resource management is setting the right priorities by understanding the involved trade-offs.
(d) *There is a need for comprehensive assessment of water development projects within the framework of the full hydrological cycle.* A crucial element of the new and holistic paradigm is the creation of an interdisciplinary knowledge base able to offer nonpartisan and comprehensive assessments of the justifications and impacts of water resource development projects (Bandyopadhyay 2004; Barbier and Thompson 1998).
(e) *A transparent and interdisciplinary knowledge base for understanding the social, ecological and economic roles played by water resources is required*. The complexities of managing water-related problems include a real understanding of the nature of water resources and their complex links and interrelations with other systems. This means that single-disciplinary approaches will no longer work and new, innovative strategies will have to be developed for coping with water problems, involving multidisciplinary approaches (Falkenmark et al. 2004; Bandyopadhyay 2004).
(f) *Droughts and floods are to be visualized in the wider context of the ecological processes associated with them.*
(g) *Appropriate new social and economic instruments for promoting careful and efficient uses of water resources or for the reduction of damage to their quality from pollution should be developed.* The new paradigm emphasizes the need for a new economic perspective evaluation of water. The question of pricing of water, the desirability, or otherwise, of the growing trend towards privatization

of water resources as the final solution, the ecological economic valuation of the ecosystem services provided by water systems, are all part of a rapidly emerging knowledge base of water economics.

(h) *There is a need to accept restructuring the institutional frameworks for water resource development at local, state, river basin and national levels for making it equitable, sustainable, and participatory*.

These elements should be seen as indicative and not exhaustive. They are subject to further refinement as the process of the shaping of a new paradigm progresses. Such a list, for the time being, can offer the fundamental guidelines for putting the new paradigm into force. Given the above, the new emerging paradigm recognizes that irrigation development has often come with a high environmental price tag (Molden and Fraiture 2004). The costs range from degradation of aquatic ecosystems, fragmentation, and desiccation of rivers, and drying up of wetlands. Barbier and Thompson (1998) and Acreman (2000) show that in many cases the monetary values generated by irrigation proved to be less than the monetary values generated by the ecosystems they replaced. Falkenmark (2003) stresses that by benefitting from the shared dependence of humans and ecosystems on water, IWRM can integrate land, water, and ecosystems and promote the three E's—two human-dependent ones (social equity and economic efficiency), and one related to the ecosystem (environmental sustainability). As an unbiased catalyst for reconciling these concerns, and prioritizing the competing ends, valuation of the economic vis-à-vis environmental uses of water becomes critical.

11.5 The River Basin as the Planning Unit: Evolution of Integrated River Basin Management

While Integrated Water Resources Management (IWRM) became the key mantra, it was thought that the river basin should be considered the spatial unit of riverine management. This led to the development of the notion of Integrated River Basin Management (IRBM), leading to a paradigm shift from the earlier reductionist notion of project-based approach to river basin management. The primary tenet of IRBM is that naturally functioning river basin ecosystems, including any wetlands and groundwater, are an integral part of the water system. Hence, while the entire river basin is treated as an ecosystem, management of the river basin has to include maintenance of ecosystem functions and services so as not to cause destructive impacts on the ecosystem services (Boelee 2011; Mattas et al. 2014). This "ecosystem approach" is the key ideas far as the Convention on Biological Diversity (CBD 1992) is concerned.

Interestingly, over time, many policy documents began acknowledging ecosystem concerns without really understanding how to interpret them. The National Water Policy of India also acknowledges this notion but shows little application of it. For example, the 2007 Award by the Cauvery Water Tribunal, certain quantities of water are stated as being "unavoidable escapages to the sea" (sic.). In many cases, there is a clear misinterpretation of the notion of environmental flows without much understanding of the eco-hydrological processes associated with it. Environmental flows describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems; through the implementation of environmental flows, water managers strive to achieve a flow regime, or pattern, that provides for human uses and maintains the essential processes required to support river ecosystems at an agreed sub-pristine level. However, most policy documents in South Asia place an ad hoc quantity or percentage as "flows" that have very little ecosystemic and scientific basis. This becomes clear in the National Water Policy 2012, Govt. of India, which states, "…A portion of river flows should be kept aside to meet ecological needs ensuring that the low and high flow releases are proportional to the natural flow regime, including base flow contribution in the low flow season through regulated ground water use" (MoWR 2012: 4).

A systems approach to river basin management can be considered as an improved alternative,—often referred to as "Pareto Improvement" in economics. River basins are sensitive over space and time; any single intervention has implications for the system as a whole. Activity taking place in a part of the basin (e.g., disposal of wastewater, deforestation) will have impacts downstream. A vivid example of this was the cyanide spill in the River Tisza (a tributary of the Danube) from a mine in Romania in January 2000. The highly toxic chemical swept downstream through Hungary, devastating aquatic life along the course of the river and contaminating the drinking water of hundreds of thousands of people (WWF 2002). The other example is the construction of the Farakka barrage in 1975 on the lower Ganges in India. The idea of constructing this barrage was to divert water to resuscitate Kolkata port. However, over time excessive sedimentation in the barrage led to stream-flow depletion further downstream along the natural course of the Ganges, especially in the estuarine zones (Rudra 2004; Bandyopadhyay 2012a; Danda et al. 2011). There have been ecosystem losses in the form of mangrove depletion and other species loss, as also to livelihoods (Bandyopadhyay and Ghosh 2009; Bandyopadhyay 2012b; Mukherjee 2011).

While today's best practices in water resources planning entail integration of water quantity and quality management for both groundwater and surface water, there remains a need for a comprehensive understanding of how the natural environment and the resident population of a basin are impacted by various levels of interventions in the rivers or by adoption of new policies, land use as well as land and vegetation management. This is best done in a highly participative way, involving all the major stakeholder groups, and in a way that achieves a balance between the level of economic development and the consequent impact on the natural resource base of a river basin as agreed to by the stakeholders. This participatory and comprehensive approach is what is generally referred to as good integrated river basin management (IRBM).

11.6 Knowledge Gaps in Relation Between Water Resource Use and Food Production: IWRM, IRBM, and Low-Carbon Growth Pathways

Food production has traditionally been thought of as an increasing function of land and water. Therefore, the necessary condition for achieving food security is perceived in the form of supply-side interventions by bringing in more land under agriculture, and water resource development projects. Both these entail exploitation of nature, and interventions in the eco-hydrological cycles. While land-use change has critically affected livelihoods, the other critical knowledge gap between the developed and the developing nation is the divergence in the understanding of perceived relation between water and food. The delinking of water from growth, as is perceived in the understanding of IWRM, conforms to the principles and pathways to low-carbon growth, as will be discussed in Sect. 11.6.1.

Traditional food policies perceive food security as a positive function of water availability. Recent literature, however, refutes such a relation (e.g. Förare 2008; Ghosh and Khan 2012). Developed nations have been lately emphasizing demand management of water, and development of institutions such as markets to achieve efficient allocation. Considering their huge and harmful impact on ecosystems and consequently on livelihoods, large dams are being decommissioned in many parts of the developed world. It is being recognized that merely satisfying short-run agricultural needs without thinking of the sustainability of ecosystem services might be counterproductive for long-run food security, considering their linkages with the provisioning services of ecosystems. Various resource-saving practices, such as the System of Rice Intensification and newer irrigation techniques, are also being innovated. Various experiments have refuted the direct proportionality between water and food availability and this knowledge is increasingly being recognized in the policy frameworks of the US, EU, and many other parts of the developed world. Bandyopadhyay and Ghosh (2009) have highlighted the deficit of this knowledge in South Asia, and have emphasized on the need for creating the knowledge base on the water–food nexus.

While Falkenmark et al. (2007) infer that by 2050, food demand will roughly double; the demand for water allocations for agriculture will rise, as also demand for land. Though plausible options lie in increase in water use and expansion of agricultural lands, supply-side interventions such as water augmentation plans by building large dams, and bringing in more land under agriculture by cutting down forests, as also unsustainable use of fertilizers and pesticides, will have deleterious impacts on the ecosystem, threatening the very ecological foundation of food provisioning services in the long run. Therefore, there is no doubt that the trade-off between the short-term economic needs and the ecosystem sustainability (with its implications on long-term food security) exists.

Options therefore need to be sought in demand-management practices, and institutional reforms. From a very regional food security perspective, trade in "virtual water" (or agricultural imports) can indeed play a crucial role. Each option has its own implication for the nonagricultural ecosystem and the services they generate. However, for serving the longer term economic needs of food security, a more holistic perspective is needed. This will entail an integrated approach for managing land and water resources and ecosystems that acknowledges the multi-functionality of agro-ecosystems in supporting long-term food production.

Undoubtedly, long-term planning is subject to uncertainty. Most of the tools developed so far for dealing with trade-offs (spatial or temporal) involving ecosystem services work best when ecosystem behavior and responses to external stimuli are known and understood. However, ecosystems are hardly subject to such certainty. Outcomes are therefore unpredictable and difficult to control (Falkenmark et al. 2007). However, ad hoc decisions might prove counterproductive. Decisions related to tradeoffs under uncertain conditions should be based on a set of alternative scientifically informed arguments, considering the entire eco-hydrological cycle, and the trade-offs that may exist with the interventions into this cycle. As such, even institutional mechanisms like Payment for Ecosystem Services (PES) may be thought of. PES can work in agriculture, where ecosystem services are threatened and the opportunity costs for alternatives are not very high (Ottaviani 2011).

11.6.1 Low-Carbon Growth Pathways

While IWRM talks about an ecosystems approach to managing water and in the process talks of river basin as the planning unit, there is no doubt that this creates the right pathway for low-carbon growth. Various publications recognize this characteristic. In a recent publication, UNESCAP (2013) recognizes that adopting IWRM and treating river basin as the planning unit through IRBM creates opportunities for converting water resource constraints and threats on environmental security in various hydro-political relations into opportunities. More importantly, IWRM talks of keeping water in-stream thereby helping the ecosystem services many of which are provisioning and regulatory in nature. More interestingly, the food provisioning service, which has been discussed in this paper, helps in food production through natural processes rather than the energy consuming technology. Keeping water in-stream and non-conversion of forestland to agricultural lands augments regulating services such as climate regulation, carbon storage, and sequestration.

The critical aspect here is with the acknowledgement that water also has a supporting service. In its floodplain, water supports forest and biodiversity, as also providing important provision services. The forest biodiversity, in its turn, plays important provisioning, regulating, cultural and supporting services. Natural water recharge, water purification, etc. are a few of such services. Further, the role of water in the carbon sequestration process of the forests is a common public knowledge.

Ghosh (2009) lists the various ecosystem services provided by water, and talks of the importance of valuation of economic and ecosystem services to understand the trade-off arising out of prioritization of water use between the various sectors. Definitely, there is a critical trade-off for approaching water management through IWRM, and for approaching water management through the mechanism of the traditional supply intervention plans which cannot be the pathway for low-carbon growth.

In this context, let me reiterate what I have already argued in this paper as an important mechanism for adopting IWRM, i.e., use of economic instruments, which entails scarcity value-based pricing of water. This has also been argued by Ghosh and Rachuri (2011). The biggest problem in the developing world, and more so in India, is that irrigation water is subsidized to the extent of being almost zero. It is hardly recognized that this subsidy is a veiled tax on the ecosystem demand for water, which hampers the long-term food security. Subsidized electricity essentially adds fuel to this fire, and in many parts of India (e.g., the Punjab-Haryana belt with the prevalence of the rice-wheat cycle; the Cauvery River basin where from the 70s onwards, cultivation of a less water consuming *Ragi* was replaced by paddy), this led to depletion of groundwater. Hence, proper pricing of water should be thought of clearly to prevent the reprehensible wastage of water in agriculture. As argued by Ghosh and Rachuri (2011), for embracing the low-carbon growth path, there is a need for water prices to reflect the scarcity value of ecosystem services.

11.7 Concluding Remarks

Food security is an important policy concern in India. However, production mechanisms followed so far have been resource-intensive, and more so from the perspective of water resources. Policy documents have failed to embrace an integrated agricultural and water policy, as they fall under two different ministries. But the fact remains that agriculture consumes more than 85% of the total accessible water, and more so because of the process of subsidization. As argued in this paper, in its attempt to promote low-carbon growth, therefore, there is a need to promote less water-intensive agricultural practices in India. But, a micro-level attempt is not sufficient. There has to be a broader macro-policy mechanism that needs to be put in place. In this context, this paper attempted to highlight a few things.

Therefore, the following set of messages becomes important in the context of the sustainability of the ecosystem, water, and food nexus that needs to be embedded in IWRM. First, ecosystems are crucial for providing long-term food needs of the human society, and this needs to find explicit recognition in policy documents. Food security is not a linear function of water use, and there needs to be more emphasis on demand management of water rather than supply augmentation. Second, an integrated management approach is needed for land, water, and the ecosystems at the basin level to enhance the multiple benefits, and minimize the detrimental effects on the ecosystem services. Third, there is an urgent need to develop institutional and economic measures to prevent ecosystem degradation, and encourage changes in the practices of business-as-usual. Pricing of agricultural water is an important element here. Fourth, there is a need to develop less resource-intensive practices (e.g., System of Rice Intensification) for producing crops that have traditionally been high-resource-consuming. Fifth, policy documents need to explicitly recognize that the relation between water and food is not necessarily linear. Rather, irrigation development projects (like large dams) might even have detrimental impacts on food availability and livelihoods in the long run. Sixth, solutions to the problems of food security need not be sought in water supply-side management alone, but more emphasis needs to be placed on distributional and the demand-side aspects as well. This can help in a more integrated approach to water management, while considering the release of pressure on the ecosystems. Seventh, this also goes well with the emerging literature on environmental flows that ask the question of how much water the river needs. A river basin approach is needed to promote the needs of the ecosystem keeping in view the ecosystem livelihoods linkage. Eighth, IRBM needs to be taken up as the doctrine governing the management of water, and adequate institutional arrangements should be put in place to promote the paradigm in practice. These few messages become critical for water systems management in order to create a pathway for low-carbon growth.

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