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REVIEW ESSAY

Assessing Water Footprints Will Not Be Helpful in Improving Water Management or Ensuring Food Security

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The Water Footprint Assessment Manual: Setting the Global Standard
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The prices of food, energy, and other basic commodities have increased in the early months of 2011, due partly to unfavourable weather events and geopolitical uncertainties, and partly to increasing demand, as many countries emerge from the recent global recession. The demand for food and the agricultural input required to produce crop and livestock products are particularly strong, thus placing upward pressure on the prices of grains, dairy products, and sugar. The Food Price Index, maintained by the Food and Agriculture Organization of the United Nations, rose for the eighth consecutive month in February 2011, increasing by 2.2% from January (www.fao.org). The World Bank's Food Price Index increased by 15% between October 2010 and January 2011, and is presently just 3% below the peak observed in 2008 (World Bank, 2011).

Consumers in developed countries are adjusting their food purchases accordingly, while many residents of developing countries are falling further into poverty in the face of rising food prices. Households that are net food producers benefit from higher prices, but households that are net food purchasers are harmed (Wodon & Zaman, 2009; Dávila, 2010). Most residents of urban areas in developing countries are net food purchasers (Satterthwaite, McGranahan & Tacoli, 2010). Since June 2010, an estimated 68 million residents of low- and middle-income countries have slipped into poverty as a result of rising food prices, while an estimated 24 million net food producers have escaped extreme poverty (World Bank, 2011). Hence, the net increase in the number of persons living in poverty is 44 million. The increasing poverty has likely contributed to increasing malnutrition, as more people have become unable to afford necessary nutrients.

The current surge in food prices might be temporary or it might be part of a long-term trend, during which we will observe notable variation, over time. In any event, we can be assured that global food demand will continue increasing until 2050, due to increasing population and rising incomes (de Fraiture & Wichelns, 2010). Food prices will rise and fall with changes in seasonal output, as always, but if buffer stocks dwindle as demand

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increases or if countries engage in protective policies that reduce the movement of food in international markets, the spikes and declines might be sharper than in the past. In any view of the future, it is likely that the poor will remain particularly vulnerable to changes in supply and demand conditions in food markets, with potentially harmful impacts on millions of net food purchasers.

Given this outlook, it is essential that agricultural scientists, natural resource specialists, water resource engineers, and other scholars continue pressing forward to enhance the productive potential of agriculture in both developed and developing countries (Beddington, 2010; Flood, 2010). Improvements in agriculture are needed to ensure an adequate supply of food in the future and also to ensure sufficient effective demand, which involves the willingness and ability to pay for goods and services. Food insecurity, in terms of calories and nutrition, is often associated with inadequate income to pay for food, particularly when prices increase due to short-term deficits or long-term trends (Smith, Alderman & Aduayom, 2006). In many areas, inadequate effective demand is perhaps a greater cause of hunger and malnutrition among the poor than is inadequate supply. Improvements in agricultural productivity will lead to larger yields and greater supply, while also enabling farmers to earn higher incomes (Hanjra, Ferede & Gutta, 2009). Thus, such improvements enhance both the supply and demand components of efforts to ensure food security.

Water Plays an Important Role in Food Supply and Demand

Water is an essential component of both the supply and demand of local and international food markets. In addition to its role as a critical input in crop production, water is required for many activities at the household level (Smits, van Koppen, Moriarty & Butterworth, 2010; van Koppen & Smits, 2010). In developing countries, many smallholder households have inadequate access to high-quality water for crop production, drinking, cooking, and bathing (Zhou, Zhang, Abbaspour, Mosler & Yang, 2009; Namara *et al.*, 2010). When crop yields or personal health are constrained by inadequate access to water, households fall behind in their ability to pay for food and other essential goods and services (Tesfaye, Bogale, Namara & Bacha, 2008). In looking ahead to 2050, the efforts of researchers and public officials to enhance smallholder access to water will likely be just as important in ensuring global food security as efforts to improve crop yields through traditional agronomic and genetic research.

The challenges that lie ahead for water resource professionals, in agriculture and other disciplines, are substantial. We must continue to gain insight into how water is captured, allocated, and used in a variety of settings, while advancing our knowledge of the science and policy aspects of water resource management (Madramootoo & Fyles, 2010; Turral, Svendsen & Faures, 2010). Water is one of many inputs in a wide range of productive and consumptive activities, most of which enhance livelihoods while also causing pollution of water and other natural resources. The competing demands for water include those for consumptive use in agriculture and other sectors, and those for environmental enhancement.

During the past 30 years, physical and social scientists have learned a tremendous amount about water's role in agricultural production functions and industrial processes (Howell, 2001; Oweis & Hachum, 2009; Bossio, Geheb & Critchley, 2010; Molden *et al.*, 2010; Turral *et al.*, 2010). We have also learned much about the many services water provides in households and ecosystems (Mwakaje, 2009; Gordon, Finlayson & Falkenmark, 2010). We have made substantial progress in understanding point source and nonpoint source pollution, and we have proposed many policy options to motivate wiser use of water resources (Albiac, Playán & Martínez, 2007; O'Shea & Wade, 2009). Our knowledge and recommendations are not yet perfect, but we have come a long way, and we are on an exciting path of continued scientific discourse and policy relevance.

Why Then, Water Footprints?

Given our scientific and policy achievements to date, and the pressing demands for additional knowledge and insightful recommendations, we should perhaps be somewhat cautious of the suggestion by some researchers to replace or supplement our time-tested conceptual models and analytical methods with the estimation of water footprints. Defined as the volume of freshwater used to produce a good, while considering its full supply chain, the notion of a water footprint is inherently limited in scope. Water footprints consider only the volume of water consumed, without considering the use of other inputs or the opportunity costs of any inputs in a given production setting. Consumers, producers, and public officials require such information when evaluating opportunities to improve their use and management of scarce resources. Estimates of water footprints do not contain sufficient information to enhance understanding of water's role in any of its many functions, or to guide policy makers wishing to motivate improvements in water management.

Despite the statements of some promoters, water footprints are not multidimensional or comprehensive indicators of water allocation and use. Water volumes, alone, are not helpful in understanding the complex interactions that characterize water allocation and use in most settings. Those interactions involve physical, economic, and social dimensions that are not contained or reflected in estimates of water footprints.

The apparent goal in producing The Water Footprint Assessment Manual is to recommend a standard approach to estimating and evaluating the water footprints of consumers, firms, and countries. To that end, the authors of the Manual provide equations and definitions describing blue, green, and grey water footprints. They discuss also the importance of considering water use in production, processing, and transport, to account for the complete use of water along a production or value chain.

The authors suggest that a water footprint assessment should include four phases: setting goals and scope, water footprint accounting, sustainability assessment, and response formulation. In the chapter on goals and scope, the authors describe their perspective regarding blue, green, and grey water footprints. Blue pertains largely to surface water and groundwater, while green pertains to rainfall and soil moisture. The grey water footprint is an attempt to describe pollution in terms of water volume. The complete water footprint of a process or activity is estimated by summing the blue, green, and grey components.

Colour Schemes Are Not Always Helpful

The distinction between blue and green water footprints is imperfect, in part because the notions of blue water and green water, as presented in the literature (Rockström *et al.*, 2009) do not represent unique phenomena. Rainfall typically generates surface runoff and percolation. If the runoff is collected in a reservoir and delivered to farmers for irrigation, it is considered to be blue water. If the percolation becomes soil moisture and is used by plants *in situ*, it is considered to be green water. Rainfed crops generally are said to be produced with green water, rather than blue water. Yet the distinction between blue and green is not always clear.

Suppose a farmer in a rainfed area builds a small pond and collects rainfall to water his crops. Is the harvested rainwater blue or green? In acknowledging this conundrum, the authors recommend including harvested rainwater in the blue water footprint, because the rainfall would have otherwise become runoff (p. 26). Yet it seems just as likely that the rainfall would have become soil moisture or evaporated, particularly in arid and semiarid regions. In addition, shallow groundwater (green water) often moves in and out of streams (blue water). Evidently, water can change from green to blue, and back again, as it moves through a hydrological system. It is not clear what is gained by using the terms blue and green, given that terms such as rainfall, soil moisture, groundwater, and surface water are well established and generally well understood.

What Do We Learn from Grey Water Footprints?

The notion of a grey water footprint is even more troubling. The authors of the Manual define this as the "volume of freshwater required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards" (p. 30). They suggest that this approach reflects the recognition that "the size of water pollution can be expressed in terms of the volume of water required to dilute pollutants such that they become harmless". There are several problems with this perspective. First, it is not clear what is meant by the "size of water pollution". Generally, we speak of constituent loads and concentrations, and we evaluate the likely impacts of those measures on the environment. Some constituents cause harm due to high ambient concentrations, while others cause harm through bio-accumulation. For those that accumulate, the total load discharged into the environment can be a more important indicator of potential harm than the ambient concentration at any point in time.

Some regulatory agencies establish concentration standards to protect aquatic organisms from constituents that bio-accumulate. For example, the California Central Valley Regional Water Quality Control Board has established an ambient concentration criterion for selenium in the state's rivers (Quinn, 2009). While the concentration of selenium in receiving waters is not toxic, environmental harm occurs through bio-accumulation of selenium in the body tissues of aquatic wildlife (Frankenberger *et al.*, 2004; Wu, 2004). The ambient concentration criterion is designed to minimize the likelihood that bio-accumulation will cause harmful effects (Quinn, 2009).

Farmers in the Central Valley are required to reduce the loads of selenium discharged in agricultural drainage water, in conjunction with the ambient standard (Letey, Williams & Alemi, 2002; Quinn, 2009). The selenium is not rendered harmless by dilution. Each pound of selenium discharged is potentially harmful. Hence the goal of the programme is to reduce the total selenium load discharged into the environment. Estimating the volume of water required to reduce the selenium concentration in receiving waters (the grey water footprint) would not be a meaningful exercise.

More generally, the authors' procedure for calculating grey water footprints does not provide helpful information regarding the genesis, scope, or complexity of pollution issues. Many farmers in developed countries apply fertilizer, pesticides, and other chemicals in the course of crop production. Pollution issues may involve individual constituents, interactions between constituents, the characteristics of farm fields (slope, soil texture, depth to groundwater), and application technologies. Physical and social scientists have studied all of these components of pollution issues in substantial detail in many locations. The notion of a grey water footprint, by construction, contains no information that is useful in understanding a pollution problem or in designing a policy intervention to reduce pollution.

In Appendix II, the authors demonstrate an estimation of the grey water footprint for sugar beet production in Valladolid, Spain. They assume that 10% of the amount of nitrogen applied by farmers reaches free flowing water bodies. Using an ambient water quality standard of 10 mg per litre, measured as N, the authors calculate a grey water footprint of 22 cubic meters per ton of sugar beets (p. 142). The resulting number is expressed in the same units as the authors' estimates of blue and green water footprints, thus enabling them to sum the blue, green, and grey components. Yet the grey water footprint contains very little pertinent information. It is merely a calculation based on assumptions regarding the application and fate of a single constituent. We learn nothing of the fertilizer strategy or practices of any farmer. We gain no insight into farm-level polluting activities, actual ambient concentrations or loads, or any policies that might be helpful in reducing pollution.

Appropriate strategies and policies for reducing agricultural pollution will likely involve the use of non-water inputs, such as labour, management, capital, and farm chemicals. Each of these inputs is likely to interact with water in farm-level production functions. Farmers and public officials seeking to understand those interactions and to implement helpful strategies for reducing pollution will require much more information than is contained in estimates of grey water footprints.

Is All Water Use Unsustainable?

Much of the discussion in the Water Footprint Assessment Manual is normative and prescriptive. This tenor is established straightaway, in the opening sentence of the Introduction: "Human activities consume and pollute a lot of water." Key sections of the Manual address the issues of pollution and sustainability. While these topics certainly are pertinent, the authors seem to promote the view that water use is undesirable, and we should endeavour always to use less of it. We should also attempt to eliminate pollution if we wish to achieve sustainability.

The authors tell us that "most forms of water pollution are unnecessary and avoidable" (p. 90). Such a perspective is inconsistent with the more widely held view that many essential activities cause pollution of one sort or another. The pertinent policy challenge, most often, is to evaluate the incremental costs and benefits of polluting activities, determine the optimal levels of pollution, and craft policies that motivate firms and consumers to achieve those levels. Long ago, we left behind the notion of living and thriving in a pollution-free world. Such an idea is simply not achievable.

In subsequent sentences, the authors suggest that "nearly all processes that result in a grey water footprint [their measure of pollution] are unsustainable" (p. 90). In addition, "many processes with a blue water footprint [those using surface water or groundwater] are unsustainable". It is difficult to understand the rationale for suggesting that nearly all activities that generate pollution and many of those that utilize surface water or groundwater are inherently unsustainable.

Perhaps some of the difficulty in understanding the authors' statements can be traced to their definition of sustainability. The authors consider two criteria (p. 73):

- the water footprint of a process is unsustainable when the process is situated in a certain period of the year in a certain catchment or river basin in which the overall water footprint is unsustainable; and
- the water footprint of a process is unsustainable in itself—independent of the geographic context—when either the green, blue or grey water footprint of the process can be reduced or avoided altogether (at acceptable societal cost).

While the reasoning is not completely clear, it appears that a process is considered unsustainable if it is possible to achieve the same outcome while using less water or generating less pollution, provided the social cost of adjustment is acceptable. The authors do not offer a perspective regarding which costs might be acceptable and which might be prohibitive. In any event, this definition of sustainability is not helpful in guiding policy analysis. Public officials must examine the incremental costs and benefits of activities that generate negative externalities, such as pollution or the wasteful use of resources held in the public trust. Policy analysis requires thoughtful study of many variables and interactions. Considering an activity or process to be unsustainable simply because an estimate of its water footprint can be reduced is not particularly helpful in policy discussions.

The time dimension of the authors' definition of sustainability also is problematic. They suggest that a process, such as irrigation, is unsustainable if water consumption exceeds water availability (adjusted for environmental flow requirements) at any time of the year. Two issues arise in such a perspective:

(1) it is not clear who will establish the environmental flow requirements, and how those might optimally reflect competing demands on water resources; and
(2) it might be socially optimal to violate environmental flow requirements in some months, in return for social benefits the authors do not consider.

It might also be socially optimal to overdraft a renewable aquifer during dry years, while allowing the aquifer to recover in wet years. Such a programme can generate greater social net benefits over time than adhering strictly to a criterion that requires withdrawals or consumption to be less than recharge in every year. One might also consider that, in some cases, depletion of a nonrenewable resource will be socially optimal. A general prescription that all nonrenewable resources should be sustained indefinitely is not necessarily appropriate.

When considering the water footprints of consumers, the authors offer the following perspective on sustainability (p. 75):

> The sustainability of the water footprint of a consumer also depends on whether the consumer's water footprint is smaller or larger than an individual's fair share, given the limitations to the water footprint of humanity.

While the notion of fairness has a place in philosophical discussions of societal preferences regarding resource allocation and consumption, it is not clear how such a perspective is helpful in understanding or improving water use and management. The notion of humanity's water footprint is yet another construct that has no conceptual or scientific basis. While humans everywhere rely on water, individual consumption of water varies widely with differences in regional water endowments, climate, weather patterns, income levels, historic water rights, and other social and institutional considerations.

Linking the idea of sustainability to some notion of a fair share of the planet's water resources might seem appealing to some observers, but such a perspective fails to consider any of the reasons why water consumption levels vary substantially worldwide. It also seems to suggest that by reducing water consumption in one country, a consumer can contribute to increasing the water consumption of consumers in another country. Yet the links between resource endowments, water policies, economic development goals, and social programmes are quite complex, even within a single country. It is not clear, for example, how consumer decisions regarding water use in Paris will enhance the availability of water—and, hence, water consumption—in urban households in the Middle East.

The authors extend their notion of fairness to the discussion of national water footprints and the global allocation of water between the production of food and other goods. They consider items with large water footprints to be products of concern, or "luxury products" that impose a cost on the environment or food production (p. 98). Examples include meat, agriculture-based cosmetic products, and first-generation biodiesel or bio-ethanol. The authors propose limiting or reducing the amount of water allocated to these items, which occupy the "top-layer of humanity's water footprint". Their goal is to preserve sufficient water for the environment and basic human needs.

While the authors' intent is well placed, the descriptions and mechanisms they propose are not helpful. For example, there are important social and economic issues involved in government decisions, in some countries, to subsidize the production of bio-fuels. Those issues, which might or might not include the volume of water used in production, should be examined within the broader context of social net benefits, economic development, and natural resource management. It is important to also consider that existing policies have created markets in which many producers earn their current livelihoods. Changes in policies that will impact those livelihoods need to be evaluated carefully, with due consideration of many issues in addition to water consumption.

Water Is Global, but Scarcity Is Local

By virtue of the hydrologic cycle, water is a global resource. Yet water scarcity might be viewed better as a local and regional phenomenon, rather than a global one. Most water scarcity problems pertain to distinct watersheds or basins. Administrative boundaries also are pertinent. A consumer in New York cannot solve a water scarcity problem in Capetown or Cairo. Local or national policies are needed in each setting to allocate scarce water resources and encourage wise use. It is not helpful to suggest that residents of water-scarce countries might find solutions to their problems in faraway lands. International co-operation is often required to achieve optimal management in situations involving transboundary water resources. Such cases generally involve hydrologic linkages between consumers and producers in separate administrative jurisdictions.

The message put forth in the Manual is quite different. As suggested by the title, the authors promote developing a global standard for water footprint assessment. In their view:

> when two products have the same water footprint, they make a similar claim on the globe's limited water resources, even though when made in two different places, the local environmental impact may be different. (p. 94)

This statement expresses inconsistent perspectives. Indeed, while the volumetric water footprint might be the same for a given product, the local impacts of water use can vary substantially with location. Hence, it makes little sense to suggest that the products make the same claim on the globe's limited water resources. The impact of using an additional cubic metre of water in an arid region can be quite different from the impact in a humid region. A global water standard or global benchmarks for producing goods and services, defined in terms of water footprints (p. 91), would not be helpful. Water allocation and use must be evaluated within local and regional settings.

Too Many Criteria for Such a Limited Perspective

The authors endeavor to embellish their discussion of sustainable water footprints by describing environmental, social, and economic dimensions (p. 77). They mention the need to maintain environmental flows to protect ecosystems and the livelihoods of people dependent on those systems. That perspective is certainly appropriate, but the information contained in water footprints will not be helpful in such analysis.

Regarding social sustainability, the authors suggest that basic human needs must be guaranteed and that:

> a minimum allocation of water to food production is to be secured at [the] global level, since river basin communities are not necessarily self-sufficient in food, provided that food security is ensured through food imports. (p. 77)

The notion of allocating water to food production at the global level neglects the local and regional nature of agriculture, and the importance of allocating water appropriately within river basins and countries. There is no point in assigning a global water master to determine planetary water allocations. Water scarcity and water quality are local and regional issues, and are best addressed at those levels.

The authors attempt to link their notion of sustainability to economic efficiency, but the effort falls short. In particular, the authors suggest that:

> the benefits of a (green, blue, or grey) water footprint that results from using water for a certain purpose should outweigh the full cost associated with this water footprint, including externalities, opportunity costs, and a scarcity rent. (p. 77)

If not, then the footprint is unsustainable. While it is helpful to mention externalities, opportunity costs, and rents, economic efficiency requires that incremental benefits equal incremental costs. Comparing the sums of costs and benefits is not the correct criterion.

Throughout their discussion of sustainability assessment, the authors describe several criteria, some of which are competitive, rather than complementary. For example, the authors require that sustainable footprints must meet the social, environmental, and economic criteria described in Box 4.2 (p. 77). Yet, often economically efficient outcomes are not socially equitable. And the goal of ensuring global food security in 2050 and beyond will not be achieved without some impacts on natural resources and the environment.

Good policy analysis acknowledges the complementary roles of science and politics. Scientists can describe the likely incremental impacts of policies that influence the allocation and use of water resources, and they can suggest helpful policy measures. Yet, public officials determine the relative weights placed on the many criteria the authors describe in their discussion of sustainability. It is not likely that all the criteria will be satisfied by any one policy programme or any stylized assignment of water footprints in a river basin or across a continent.

Estimating Costs and Benefits Is Not Quite So Simple

The authors suggest that the water footprint of a process is unsustainable if better technology is available at a lower cost (p. 90). For example, the water footprint of a furrow-irrigated field is not sustainable if the farmer could use drip irrigation at a reasonable cost, or if drip irrigation would generate social benefits. From society's perspective:

> when internalizing economic and environmental externalities posed by overexploitation and pollution of water resources, water footprint reduction will generally result in a societal benefit or, at most, a reasonable social cost.

The authors offer no conceptual or empirical support for such a broad-ranging statement. It is easy to consider situations in which reducing water footprints will reduce social benefits or result in unacceptable social costs.

Consider, for example, the case of sovereign wealth investments in agriculture in foreign countries. A country with funds to invest might suggest they will produce crops using only drip irrigation, to minimize evaporation, thus generating low estimates of water footprints. The estimates might be substantially lower than the water footprints of smallholder households currently producing crops using furrow or flood irrigation methods on the same land the investors wish to utilize. Displacing the smallholder families in favour of the sovereign wealth investors will certainly reduce the water footprint of crop production. Yet the social cost of displacing the families and disrupting their livelihood activities could be substantial. And if water is not scarce, or the smallholder families have developed a sustainable form of crop production over time, why should water footprint analysis even matter in such a setting?

This example highlights the potential harm of focusing on such a narrow measure of water consumption. Public officials must consider a broader, more complex set of information when evaluating resource allocation policies. Water resource specialists should be the first to advise public officials that a myopic view of water use and consideration of simplistic measures, such as water footprints, will likely lead to inappropriate decisions. We must ensure that our analysis is sufficiently broad and comprehensive in order to provide helpful guidance to public officials, as policy decisions can have substantial impacts on livelihoods and communities.

Response Options Must Be Realistic and Appropriate

Much of the discussion on response options in Chapter 5 of the Manual reflects an inadequate understanding of the role of water resources in agricultural production and the demands that will be placed on agriculture in the 21st century. For example, the authors suggest that "in agriculture, the grey water footprint can be reduced to zero by preventing the applications of chemicals to the field" (p. 100). This can be achieved, we are told, through organic farming, although "it will be quite a challenge and require substantial time before all conventional farming can be replaced by organic farming" (p. 100). Furthermore:

> over a time span of a few decades, the total blue water footprint in the world can be reduced by half, to be achieved partly by increasing blue water productivities in irrigated agriculture (through the application of water-saving irrigation techniques and by 'deficit' instead of 'full' irrigation) and partly by increasing the fraction of production that is based on green instead of blue water. (p. 100)

As the global population increases from about 7 billion to 9 billion or more in 2050, the world's farmers will need to produce around 30% more food. Given that the relationship between water consumption and crop yield is essentially linear (Perry, Steduto, Allen & Burt, 2010), it will not be possible to feed the world in 2050 without transpiring substantially more water than is transpired in agriculture today. Improvements in water management certainly are needed in some regions, and will contribute to achieving higher crop yields. However, it is quite unhelpful to suggest that drip irrigation systems or deficit irrigation methods should be adopted, with the goal of reducing the world's blue water footprint by half during the next few decades. It is even less helpful to suggest that organic farming will be sufficient to feed the world at any point in time.

Also in Chapter 5, the authors reiterate their perspective that all water issues are global, and not local. They cite their own writing in Section 4.3 as evidence that:

> water footprints need to be reduced also in water-abundant areas whenever reasonably possible, not to solve local water problems in these areas, but to contribute to a more sustainable, fair and efficient water use globally. (p. 102)

The authors suggest that reducing water footprints in water-abundant areas will reduce pressure on water resources in water-poor areas. Hence, "the solution for the problems in water-scarce areas greatly lies in the water-abundant areas" (p. 102). From the authors' perspective:

> reducing the water footprint by 1 m^3 in one catchment is equivalent to reducing the water footprint by the same amount in another catchment, even if one catchment shows a much higher water scarcity or water pollution level than the other one. (p. 102)

The authors support this perspective by reminding us that the volume of freshwater available worldwide is limited.

The line of reasoning made evident by the quoted statements in the previous paragraphs is misplaced. The incremental costs and benefits of improving water management will vary across catchments, regions, and countries. Each situation must be evaluated on its own merits. Improvements in water management in one catchment or country will not reduce the pressure on scarce water resources elsewhere. In addition, given the outlook for increasing food demands and rising food prices, farmers in many regions will have sufficient incentive to improve water management and increase productivity, provided that institutional signals (such as water prices and allocations) reflect scarcity conditions. Attempting to place local water issues in a global context, as the authors have proposed, can only dissuade farmers, resource managers, and public officials from attending to the complex issues they must address in their local river basins and within their administrative boundaries.

The authors remind us, also in Chapter 5, that a consumer's water footprint is not sustainable unless it is smaller than the consumer's fair share of water in the world (p. 103). In addition, no component of the consumer's water footprint may be located in a hotspot (defined by the authors as a place where water consumption exceeds the available supply or water pollution exceeds assimilative capacity), and no component of the water footprint could be reduced or avoided altogether at reasonable societal cost. These criteria for sustainability are likely to establish a threshold that cannot be achieved by most consumers. Yet this might be the good news, as the criteria could mislead consumers into making choices that do not truly enhance water resource management or the livelihoods of individuals who rely on tenuous access to water and other natural resources, particularly in poor countries.

The authors suggest that consumers can reduce their water footprints by choosing products that have low water footprints or products generated in regions in which water is not scarce. The second option seems in conflict with the authors' suggestion that all water footprints matter, even in water-abundant areas; but more importantly, water footprints do not convey information regarding livelihoods or environmental impacts. Estimates of water volume, alone, are remarkably insufficient to help consumers make wise choices.

Summing Up

In their chapter on Future Challenges, the authors suggest that water footprint analysis can inform the study of water resources management in two ways: estimates of water footprints can be helpful in examining the sustainable, equitable, and efficient use of freshwater; and water footprint accounts can be helpful in examining the environmental, social, and economic impacts at catchment level. Yet water footprints are essentially estimates of the water volume consumed in production, processing, and transport. They do not contain information describing environmental, social, or economic impacts.

Some observers might suggest that water footprints, despite their inherently limited scope, are helpful as a starting point in examining important resource issues. That might be true if we did not already have sufficient frameworks and terminology for conducting such research, and if water footprint analysis actually enhanced the understanding of water resource management. Established perspectives regarding water withdrawals, consumption, return flows, and reuse are much more informative and helpful than estimates of water footprints. Reducing complex interactions that involve many inputs to a simplified presentation of a visually compelling indicator of water volume will not enhance understanding or improve the quality of decisions regarding water management. Much more information is needed to truly understand sustainability, efficiency, and the impacts of water use on livelihoods and the environment.

While the interest in calculating water footprints appears to be strong and increasing, the number of supporters and practitioners is not a sufficient statistic for evaluating scientific credibility or policy relevance. Water footprints contain too little information to inform public officials about issues that involve many variables and have important physical, social, and economic dimensions. If the ultimate goal of improving water management is to improve the quality of life, while ensuring sustainable use of limited resources, then water resource analysts will need to examine much more than simple estimates of water consumption. Such estimates are not adequate, even as a starting point for meaningful analysis, given that they contain such limited information.

We must also speak clearly about the locus of responsibility for enacting correct policies and motivating wise use of resources. It is not helpful to suggest that producers or consumers in faraway lands are causing water scarcity or degrading water quality in the back yards of others. Public officials in each river basin, province, and country must take responsibility for managing water resources wisely, while not being distracted by the notion that the water footprints of consumers and producers elsewhere are to blame. Citizens of distant countries certainly can choose to modify their consumption practices if they wish to influence producer choices regarding natural resources and livelihoods. In such cases, citizens will require more helpful information than is contained in estimates of water footprints. For example, suppose consumers in a wealthy country wish to improve livelihoods in a developing country by influencing private companies using water to irrigate large areas of cropland. The consumers might wish to know how those farming operations impact non-water resources, and how they contribute currently to the livelihoods of poor residents in nearby towns and villages. None of that information is contained in any estimate of a company's water footprint.

If we wish to ensure food security in 2050, while lifting millions of farm households and urban residents from poverty, we must continue to conduct research that examines the role of water resources in agriculture and other livelihood activities. We must determine where policy interventions will be helpful in improving access to limited water resources for the poor, and then recommend appropriate interventions. We must continue to enhance our understanding of agricultural productivity in rainfed and irrigated settings, with a goal toward increasing global food supplies and improving the incomes of smallholder farm families.

The study of water resources, in all of its challenging complexity, will remain essential in these efforts. Public officials and natural resource managers will continue to utilize recommendations arising from scientific investigation of key relationships involving agricultural inputs and productivity, environmental impacts, and livelihoods. By contrast, the assessment of blue, green, and grey water footprints will not enhance understanding of water resource issues or contribute in meaningful ways to the improvements in water management that are needed to alleviate poverty and ensure food security.

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