GLOBAL LAND OUTLOOK WORKING PAPER

CO-MANAGING LAND AND WATER FOR SUSTAINABLE DEVELOPMENT

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CONTENTS

EXECUTIVE SUMMARY

The inter-linked crises of land degradation, food security, ecosystem decline, water quality, and surface and groundwater depletion still stand in the way of poverty reduction and the achievement of the new Sustainable Development Goals (SDGs). While the "Green Revolution" of 50 years ago was successful in producing higher yields of food, it came with a steep price in terms of chemical water pollution, lost wetlands, decreased biological diversity and both surface and groundwater depletion. In these last decades of poor water governance, each sector grabbed the water it desired without much consideration for other users or ecosystem goods and services.

This situation has resulted in almost two-thirds of the world's people experiencing water scarcity at least one month a year according to new estimates. Without significant reforms and investments from both the North and South, the estimated $US 11 trillion annual loss of income from land degradation will grow, increased needs for food will not be met, social unrest will spiral out of control, and water scarcity will disrupt national economies and impact the global economy. Increased droughts, floods, and temperatures from climate change make the situation worse. Despite the gloomy outlook, the SDGs related to food security, water, and land (SDGs 2, 6, and 15) provide a new global political mandate for action to finally integrate agriculture and land use interests with those responsible for water management. The 3 SDGs are inter-related and meeting each of them is dependent on all interests working together on a landscape, basin, and aquifer scale to help balance competing uses of water resources. This co-management approach represents the answer to providing sufficient food for the future along with the sharing of water resources so all sectors can meet the SDGs.

This paper represents a contribution to the Global Land Outlook in terms of discussing the complex dimensions of land and water resources management. Per the Terms of Reference for its production, the paper explains complex interactions between land and water resources management. Hot spots of land degradation as well as hot spots of water scarcity are presented in a series of global maps that have been previously published. Good practices for combatting land degradation, deforestation, and desertification as well as good practices for saving water in agriculture--particularly irrigation—are covered.

A number of cases of integrated land and water resources management (IL&WRM) are presented to illustrate that measures, tactics, and policies have been successfully demonstrated and are ready to be scaled-up to meet the new imperative of SDGs in an integrated manner. A number of the cases included have been supported by the Global Environment Facility (GEF) as part of its special mandate to test, demonstrate, and facilitate new strategies and actions that address global concerns like land degradation and water resources. GEF has been well positioned to pilot interventions to address land degradation and transboundary water resources. Examples of progressively integrated programmatic approaches that have been supported by GEF since the 1990s are described. Those experiences demonstrate that individual projects often do not generate desired results. Instead, decadal-scale programmatic approaches of multiple projects can leverage not only on-the-ground improvements but also policy reforms necessary for sustainability and replication. The GEF represents a networked global source of grant funding with a series of UN organizations, NGOs, and development banks that can access the funding on behalf of governments and assist them according to their comparative advantages in partnerships with governments as needed.

With GEF being associated with several global climate adaptation funds, focus should continue on climate-smart agriculture, drought management planning, and building climate resilience in support of the SDGs.

Surface and groundwater management has been abysmal in both rich and poor countries. Serious governance failures, especially in sustaining good quality groundwater, are commonplace. More than 95% of usable freshwater on our planet is located underground. Meanwhile, water –using interests fight over the 5% represented by surface water. Agriculture people have only thought about food; energy people have only thought hydropower; and water people have only focused on drinking water or industrial supplies with little serious consideration of downstream, down-aquifer or ecosystem impacts. This is the root of the current problem facing mankind. Precious little surface water is left to fight over, aquifers are now over-used in areas of intensive irrigation, and contamination is widespread. Water management will never be successful until agriculture interests actively participate.

Agriculture consumes up to 70-80 % of water with its wasteful irrigation practices and represents the largest polluter of surface and ground water. A key failure has been that land management interests have not sufficiently cooperated with water resources management interests (and vice versa). Sector ministries have had a difficult time working together in an integrated manner in the same basin or aquifer recharge area. Water people coined the term integrated water resources management (IWRM) 20 years ago to address this but were not able to integrate agricultural and land use planning interests. Various cases presented herein have shown that national sector inter-ministry committees at the basin or aquifer scale are critical. Along with sufficient resources including incentives, technical assistance know-how, water users committees, and national political will, the desired co-management of land and water resources (IL&WR) is achievable in basins or aquifers. Land tenure reform, water rights, water allocation systems, and water pricing represent critical national reforms to support IL&WRM. The cases presented also show that climate smart agriculture and drought management planning are key tools for integrating land use planning with water planning. Likewise in rain-fed areas, including the savannahs of Africa, a new "green revolution", involving "green water" from precipitation and better capture, storage and use for crops, can increase yields as well as save water.

A discussion about global trade, markets, and subsidies is included to identify complementary policy measures to be pursued globally in concert with co-management for IL&WRM. For example global trade in "virtual water" (such as livestock feed) resulting from foreign "land grabs", prices for commodities in times of economic shock, distortions caused by agricultural subsidies in many countries of the North reducing farmer income in the South, gender issues related to land reform, girls education and reproductive health all require attention while co-management is being up-scaled. Meanwhile, the time for scaling-up of co-management is now. Adoption of the SDGs, availability of funding for climate-smart agriculture and drought management planning, and a new awareness of water scarcity on the part of the business community all provide driving forces for action. The time is now for co-management of land and water resources! There is no longer any alternative.

1. INTRODUCTION

Since the beginning of time, water has shaped the face of the earth, not only as a geologic agent but also as the major factor in the rise and fall of great civilizations and as a source of conflict and tension among nations. The first great civilizations rose on the banks of great rivers like the Nile in Egypt, Tigris and Euphrates of Mesopotamia, Indus in Pakistan, and the Hwang Ho in China. All these civilizations made the land productive by building large irrigation systems. Without the water there would have been small settlements, little food, subsistence populations. Yet the great civilizations collapsed when the water systems failed, were improperly managed, and yields were reduced by waterlogging or salinization—symptoms of land degradation.

Locations in the drylands have always been fragile for civilizations with their dry and variable climate, and stability has always been tenuous. Yet governments of both the North and of the South have not provided the level of attention drylands demand to maintain stability. The result the last three decades has been population growth outstripping water and food requirements, increased droughts and land degradation coupled with poor water management, tribal and religious rivalries, failing harvests, marginalized communities, armed conflicts, an unprecedented flight of refugees, failed states, and increased terrorism. The inability of national governments to secure water resources and land productivity combined with insufficient attention about these from the North has contributed to this instability, which is now impacting the North with social unrest and terror that make global economic down-turns and climate shifts even worse. Before social unrest got out of hand, Somalia, Syria, and Yemen suffered from drought conditions.

Today, the way we should be thinking about integrating water and land management to provide the essentials of life goes to the very heart of the increasing worldwide concern about human health, livelihoods, food security, the depleted natural resource base, and a new path to sustainable development. Unfortunately, inter-linked crises of land degradation, food security, ecosystem decline, water quality, as well as surface and groundwater depletion still stand in the way of poverty reduction and achieving the new SDGs; and new concerns about climatic extremes just make matters worse. Surface and groundwater management is abysmal in many rich and poor countries with serious governance failures. Agriculture people think about food; energy people think hydropower; and water people think drinking water or industrial supply. For 40 years there have been sector grabs for available water with little serious consideration of downstream or down-aquifer impacts; and very little priority has gone to the fourth use to sustain water ecosystems. This is the root of the current problem facing mankind with precious little surface water left to fight over and aquifers now over-used.

Water insecurity is the norm…from the United States to Africa; and the accompanying land degradation is a huge drain on the global economy with as much as $US 10.6 trillion in estimated damage every year---equivalent to a 17% reduction in global gross domestic product (ELD, 2015).

Agriculture uses up to 70-80 % of water, often with wasteful irrigation practices, in addition to being the largest polluter of surface and ground water. A key failure has been that land management interests have not sufficiently cooperated with water resources management interests (and vice versa), and sector ministries have a difficult time working together in an integrated manner in the same basin. Add continued energy demands for water and the situation is exceedingly complex. The inability to address the linked crises of food, energy, water, and environmental security threatens both domestic peace and world stability during this time of rapid global change and political unrest. This failure since the Green Revolution has contributed to migration of people to cities, civil war, refugees flocking to other countries, and now terror in the North as water constrains social stability.

This working paper serves as input to the Global Land Outlook (GLO) in exploring the relationship between land and water resources management as a prerequisite for sustainable food production as well as sustainable use of water ecosystems--ranging from wetlands and aquifers to rivers and the sea. Hotspots of unsustainable land management and desertification as well as water resources degradation and depletion are outlined with more emphasis on water with much of the upcoming GLO being focused on land. The need for integrated approaches is explained to address the hotspots of degradation along with practical examples of sound land management and water resources management practices in various sub-sectors that could be combined to yield sustainable uses of land and water resources. The Global Environment Facility has piloted a number of these successful cases that include policy, legal, and institutional reforms to sustain land and water resource bases. All of these approaches need to have expected climatic extremes factored in for resiliency if sustainability is to be achieved.

With the 2015 adoption of the Sustainable Development Goals (SDGs) by Heads of State, a new mandate exists to attain SDG 2, SDG 6, and SDG 15 in an integrated fashion. In support of these goals, global leadership is still needed to reform globalization policies with: trade reforms; agriculture subsidy reductions in rich countries; market distortions; and "land grabbing" as well as new support for multi-decadal partnership programs from development assistance organizations and the private sector to scale-up demonstration efforts toward improved sustainability.

The longer campaigns involving land and water rights, women's role in tenure, reproductive health, girls education, and food waste reduction/market access need redoubling to reduce future hunger for the poor. There is little hope for sustainable water resources management to balance all the competing uses of water including growing food unless land and water management authorities and stakeholders work together in an integrated fashion for both basins and aquifers that also incorporates resilience to extreme weather events.

With business as usual, catastrophic shortages of food and water coupled with seriously degraded ecosystems lie on the horizon. Estimates range from at least 60% more food is needed by 2050 to meet growing needs (FAO, 2014a) to WRI (2013) and IFPRI (2016) placing this figure at 70% when measured by calories. Needless to say, this challenge will be difficult given increased water use for industry, energy, people, and ecosystems let alone irrigation. Many on-site solutions are known, have been demonstrated in pilot situations and published in research reports. The inability of the world community to scale up successful case studies illustrates that serious policy reforms will be necessary to foster adoption of technical solutions. Integrated land and water management has been advocated for years as noted by both Falkenmark (1989) and Duda (2003) but integrated action has not been sufficient. It seems as if the North has not devoted needed funding to scale up integrated land and water resources management in developing countries as a response to adverse impacts of globalization until the South enacts needed reforms and stems corruption/ diversion of funding. This impasse has gone on for a while in the water areas and now threatens peace and stability in the world with insufficient investments in hot spots that have led to civil strife.

The paper examines symptoms of the lack of co-management of land and water resources. Hot spots of unsustainable land management and of water resources scarcity are identified to illustrate where action is needed to address water security concerns. Links between the two issues and SDG 2, 6, and 15 are identified along with arguments for integrated land and water resources management basin by basin and aquifer by aquifer. Examples of good practices in land and water resources management are covered that illustrate integrated approaches. Strategies and programs needed for the future to scale up these good practices that have been suggested elsewhere are summarized for application to meet SDGs. The paper concludes with ray of hope following adoption of the new SDGs by heads of states as well as a new driving force in terms of the business community realizing their profits are at high risk because of water issues, especially in their agriculture supply chains and especially during droughts.

2. UNSUSTAINABLE LAND MANAGEMENT – HOTSPOTS

Hotspots of land degradation and desertification are well known to specialists contributing to the GLO. A few examples are presented to set the stage for needing integrated approaches. While all continents except Antarctica experience these symptoms of unsustainable land management, the drylands constituting 40% of our planet's land mass, and their 2+ billion residents are particularly sensitive. With perhaps an estimated 20 % of drylands already degraded and hundreds of millions of people living in desertified areas, much more effort is warranted.

Various global assessments have provided estimates of land degradation/desertification and provide delineations of hotspots. Beginning with one of the first published in 1991, the Global Assessment of Human Induced Soil Degradation (Oldeman and others, 1991), called attention to the global nature of the problem with 15% of land surface suffering degradation. The FAO and others undertook a more recent global assessment (GLADA) that used remote sensing to identify areas where significant land cover change was occurring, both hot spots of land degradation as well as improvements (Bai and others, 2008). Over the two decade period of 1981 to 2003, the assessment found that land degradation hotpots cover about 29% of global land area and occur in all land cover types with about 2.7% of land area improving (see Figure 1). With its use of proxy indicators, the assessment identifies where biologically significant cover changes have occurred without understanding what caused the changes and without identifying older degraded areas. Hot spots of degrading areas appear in Africa south of the Equator, SE Asia and S China, N-Central Australia, the Pampas, and boreal forests of Siberian and N America (diseases, insects). Almost one fifth of degrading land was cropland - more than 20 percent of all cultivated areas; 23 percent was found to be broadleaved forest, 19 percent needle-leaved forests, and 20-25 percent rangeland.

A further refinement of GLADA and its remote sensing tools worked to filter out more confounding variables. As reported by Quang and others (2014) for the Economics in Land Degradation (ELD) project, human-induced biomass productivity decline from 1982-2005 found in 25% of cropland and vegetation-crop mosaics, 29% of mosaics of forests with shrub- and grasslands, 25% of shrub lands, and 33% of grasslands. While this updated study confirms land degradation to be a massive problem in croplands, it also identifies the serious extent of degradation in areas used for livestock grazing by pastoral communities. In total, there are about 3.2 billion people who reside in these degrading areas.

Figure 1: **Global Negative Trend in Surrogates of Land Degradation, 1981-2003 (Bai and others, 2008).**

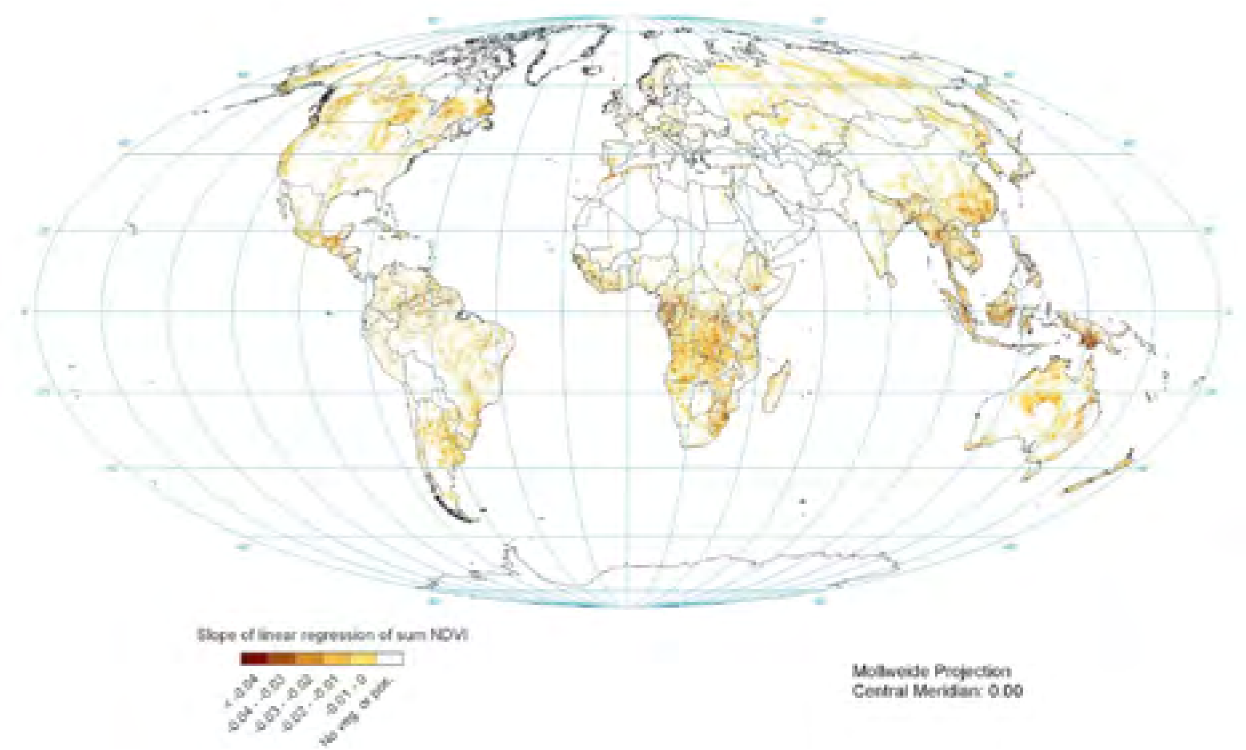
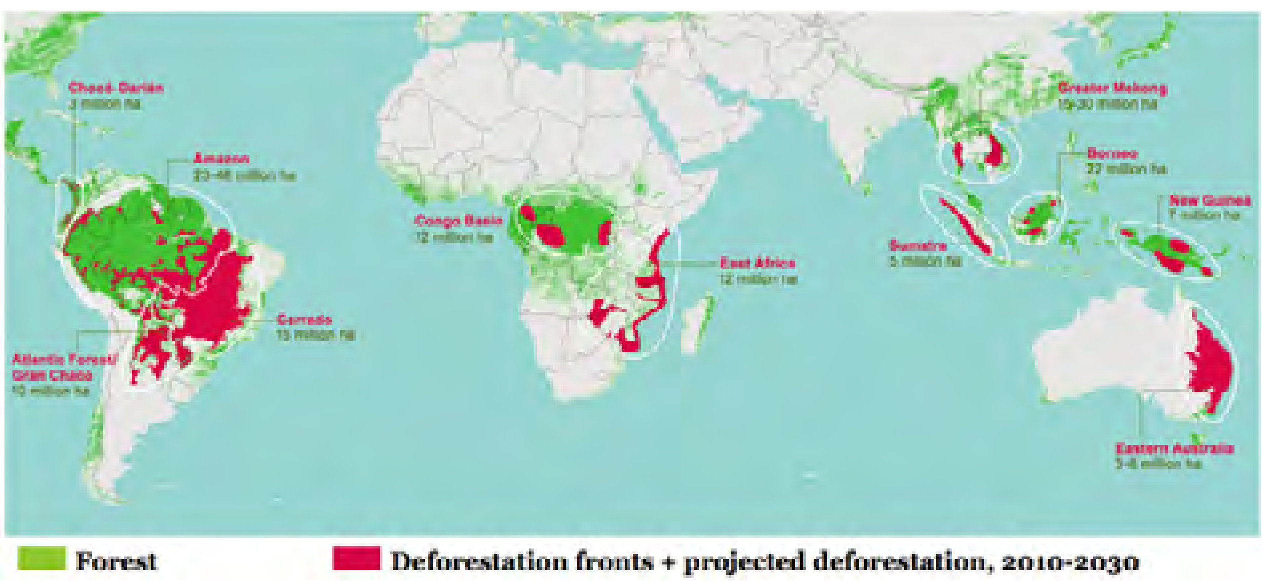


Figure 2: **High Priority Areas of Deforestation in Developing Countries (WWF, 2015).**



Several other sources of land degradation also contribute to the global picture. The rate of deforestation is still problematic and often leads to unsustainable land management practices. Serious hotspots for attention have been reported by WWF (2015) as noted in Figure 2 for developing countries. Wasteful irrigation practices with lack of sufficient drainage also degrade cropland and reduce crop yields. Too much water reduces yields, raises water tables, concentrates salts, and makes land unproductive through increases in salinity and alkalinity—sodic soils. Additionally, irrigation with salty groundwater increases soil salinity and decreases yields while irrigation over many decades such as in the Middle East can also result in salinization. Umali (1993) conducted a review for the World Bank that estimated 20% of irrigated land area suffered from irrigation-induced salinity crop yield reductions two decades ago. Pakistan and Uzbekistan are good example of the twin scourges of waterlogging and salinity with 24-26% of land impacted and even the US was impacted in the last decades at 28% of irrigated land. The well-known case of the Aral Sea in Central Asia is an extreme example of man-induced desertification where a relatively dry area loses its productivity. Umali also cited estimates of 2-3 million ha of irrigated land going out of production because of waterlogging and salinity annually that back then counter-balanced new land brought into production.

Up-to-date global assessments of waterlogging and salinity do not seem to be readily available. FAO's 2016 publication on Status of the World's Soil Resources and its accompanying Soils Portal (FAO, 2016) have sparse information on salt-affected soils. About 45 million ha of irrigated cropland were salt-affected as were 32 million ha in non-irrigated drylands. Other sources cited estimated that up to 50% of areas fully equipped for irrigation were affected by salinity in some countries from FAO's Aquastat database. In the 1990s, an estimated global annual income loss of $12 billion was determined from salinization of irrigated cropland. Urbanization and conversion to grasslands also contribute to loss of forests and in some cases land degradation when grazing is too intense.

3. COMPLEX RELATIONSHIPS BETWEEN LAND AND WATER RESOURCES MANAGEMENT

As the previous discussion regarding waterlogging in irrigation and loss of productivity from salinity/sodic soils shows, the relationship between water and land management can be complex. For example, while the first Green Revolution was successful in terms of food production, the way water was withdrawn from water ecosystems and utilized, wetlands converted and inputs such as pesticides and fertilizer applied, very serious water ecosystem damage occurred and has yet to be addressed. In fact, the Millennium Ecosystem Assessment found that of all ecosystem types, water ecosystems and aquatic biodiversity has been the most impacted globally—not tropical forests, not grasslands, but freshwater ecosystems and their production of fish for protein for the poor (WRI, 2005).

Likewise, crops, pasture, and livestock all need water for survival and productivity. Soil erosion from inappropriate practices not only results in sedimentation of waterways (with downstream flooding, fouling of drinking water treatment facilities, and degradation of aquatic biodiversity and fisheries needed for protein) but also has adverse onsite and down-river agriculture productivity impacts. Soil erosion reduces crop yields onsite as key surface layers of soil, organic matter and nutrients are removed along with their water holding capacity. Downstream, where sediment is deposited on floodplain agriculture pastures or cropland, yields are also reduced and deposits in waterways may cause flooding and elevated water tables of floodplains further decreasing yields.

Regarding desertification, it is not only the changing climate and rainfall variability with global warming that causes desertification but there is also man-induced desertification. The case of waterlogging and irrigation-induced salinity making cropland unproductive is one case. Overgrazing of drylands by poorly managed and excessive numbers of livestock can result in land degradation and loss of productivity as deserts encroach on the savannah. Even the wettest place on earth can become a "desert" through land degradation. Cherrapunji, India, is one of the wettest places located at an elevation of 1,484 meters on a plateau facing the plains of Bangladesh. It now faces an acute water shortage and the inhabitants often have to walk very long distances to obtain potable water. Irrigation is also hampered due to excessive rain washing away the topsoil as a result of cutting the forests, accelerated erosion, and land degradation. Soils on the plateau are poor owing to deforestation and soil erosion. With its winter droughts, the vegetation is even xerophytic in spite of Cherrapunji being an extremely wet place.

With regard to water resources mismanagement, wetlands are often converted to agriculture through drainage and building embankments and have lost much of their ecosystem goods and services in regulating and cleansing surface and subsurface waters. The conversion, often to irrigated agriculture and in deltas to important crops like rice, diminish biological diversity, inhibit groundwater recharge, contaminate downstream and subsurface drinking water supplies, and degrade the quality of coastal waters. Even cheaply constructed irrigation canals and ditches leak water that cause waterlogging of soils and productivity losses. Consumptive use from irrigation as well as dams and barrages for irrigation purposes divert precious water and ruin coastal habitats downriver, enrich estuaries with pollution, and change salinity levels that impair coastal communities and their fisheries. Dry riverbeds are the future and fisheries the poor depend on for protein are reduced or eliminated in favor of irrigated cropland. This occurs even in the US with a typical case being the Rio Grande where the state of Texas has brought suit against the state of New Mexico before the Supreme Court. Old agreements specify flows from one state to another and during increasing drought years no flow has entered Texas.

As a response to increased droughts over the years, surface water has been less available and wells dug to utilize groundwater. The result has been depleted aquifers and sometimes more saline water as salty water enters formerly fresh lenses. Agricultural chemicals have also contaminated aquifers globally. Health concerns from pesticides and from excessive amounts of nitrates have resulted. Even livestock manure can enter groundwater supplies to contaminate drinking water with deaths having been recorded in Europe and North America. Even irrigation return flow can be highly contaminated and salty to the point it can disrupt fisheries the poor depend on for food security. All these water-related issues illustrate agriculture as being the largest source of surface water and groundwater pollution—even down to estuaries where livestock waste and fertilizers create "dead zones" reducing home values, creating health hazards from toxic algae, and causing fish kills/degradation from nutrient over-enrichment. Agriculture remains the number one source of impairment globally of rivers and groundwater (and of freshwater biological diversity), with pollution as well as depletion of water flows and aquifer levels. Interrelation-ships among land management, agriculture, and water ecosystems need to be addressed together in an integrated fashion. What makes the task so difficult is that other sectors also demand water, so institutions must be created to balance conflicting water uses with stakeholder participation in river and aquifer basins.

4. UNSUSTAINABLE WATER RESOURCES MANAGEMENT – HOTSPOTS

While there have been a few global analyses of land degradation, there have been many global assessments related to mostly surface water resources from many different perspectives, among them drinking water, wetlands loss, energy and water, agriculture and water, water ecosystem aspects, and water scarcity as a whole. Information is much less available for groundwater with remote sensing technology recently providing initial assessments of groundwater status. The complexity of such analyses is a problem with hydro-met stations falling into disrepair on some continents and quality assurance being problematic elsewhere. Surrogate indicators can be utilized as with global land degradation assessments. Attribution to sources of depletion and degradation is clear in areas of intensive irrigation but difficult to unravel where energy, agriculture, and urban water all contribute. The fundamental challenge facing agriculture is to produce more food while also balancing competing sectoral uses for surface and groundwater in specific basins. This paper presents a number of progressively more sophisticated global assessments available to highlight hot spots of water scarcity, water shortages, and water problems globally.

Some early assessments were expressed on a country basis rather than river basin (Rosegrant and others, 2002), including projections made for the World Water Forum in 2000 (Cosgrove and Rijsberman, 2000). The World Resources Institute (WRI) has produced global water-related assessments basin by basin for 20 years with progressive sophistication for identifying hotspots. An initial global analysis published in the journal Science by Johnson and others (2001) covered water for people and nature. It estimated that 2.3 billion people lived in river basins under water stress in the mid-1990s with 1.7 billion living in highly stressed basins where chronic water shortages threatened food production and economic development. Their projection for 2025 was that almost 50% of people on earth (3.5 billion) will live in stressed basins by 2025. More sophistication was shown in 2004 through the Comprehensive Assessment of Water in Agriculture as WRI teamed up with IWMI to identify smaller basins with environmental water stress compared to human water use stress, with an estimated 1.4 billion people coping with environmental water stress some 20 years ago (Smatkhtin and others, 2004) as shown in Figure 3 based on a slight UNEP modification into a water scarcity index showing hotspot basins where the 1.4 billion people coping with environmental water stress reside.

Figure 3: **Hot spots of water scarcity adapted by UNEP (2008) based on WRI (Smatkhin and others, 2004).**

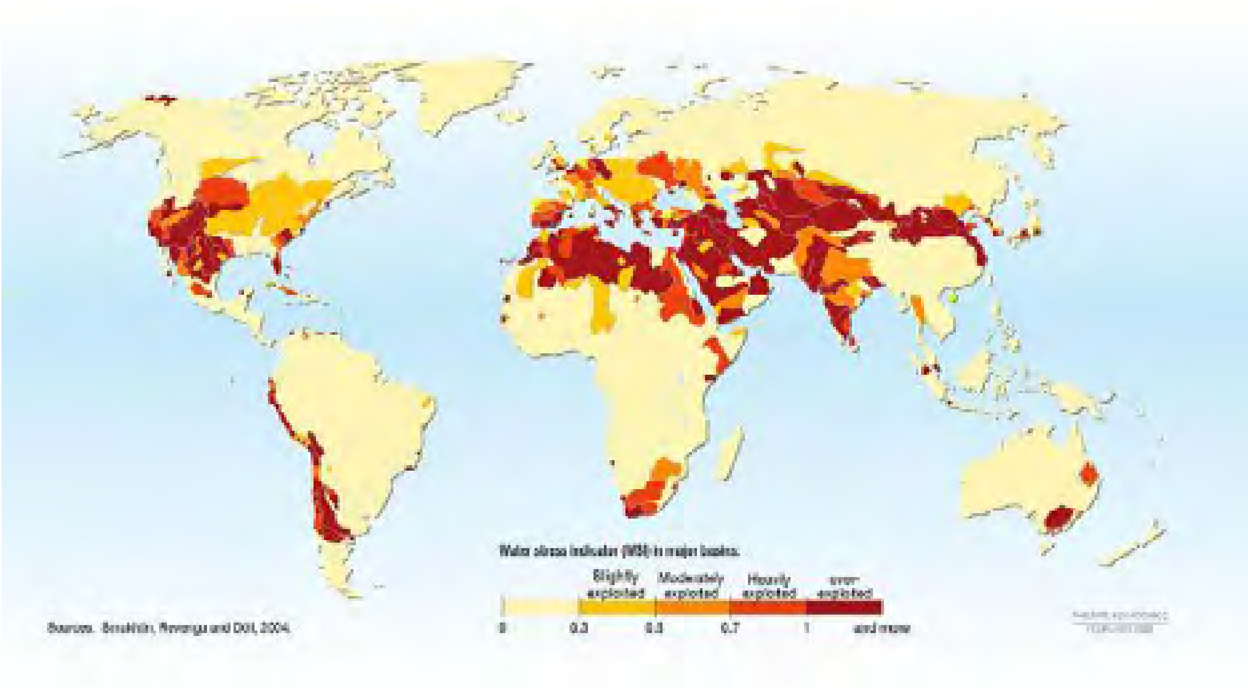
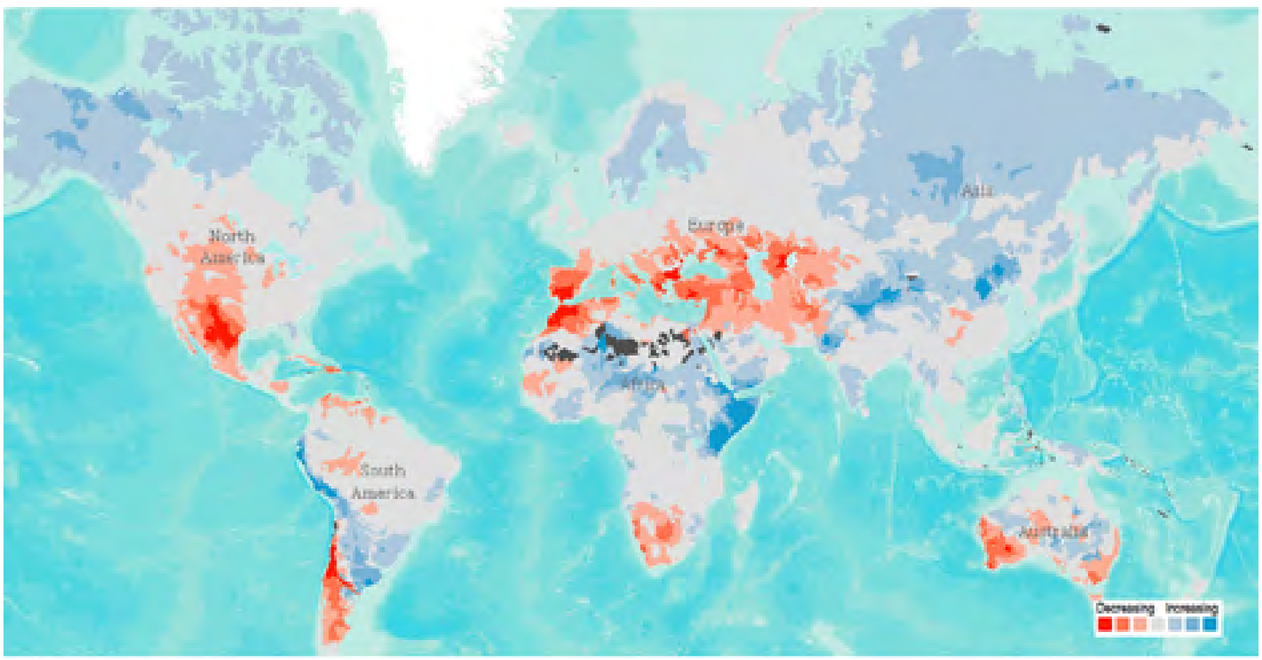
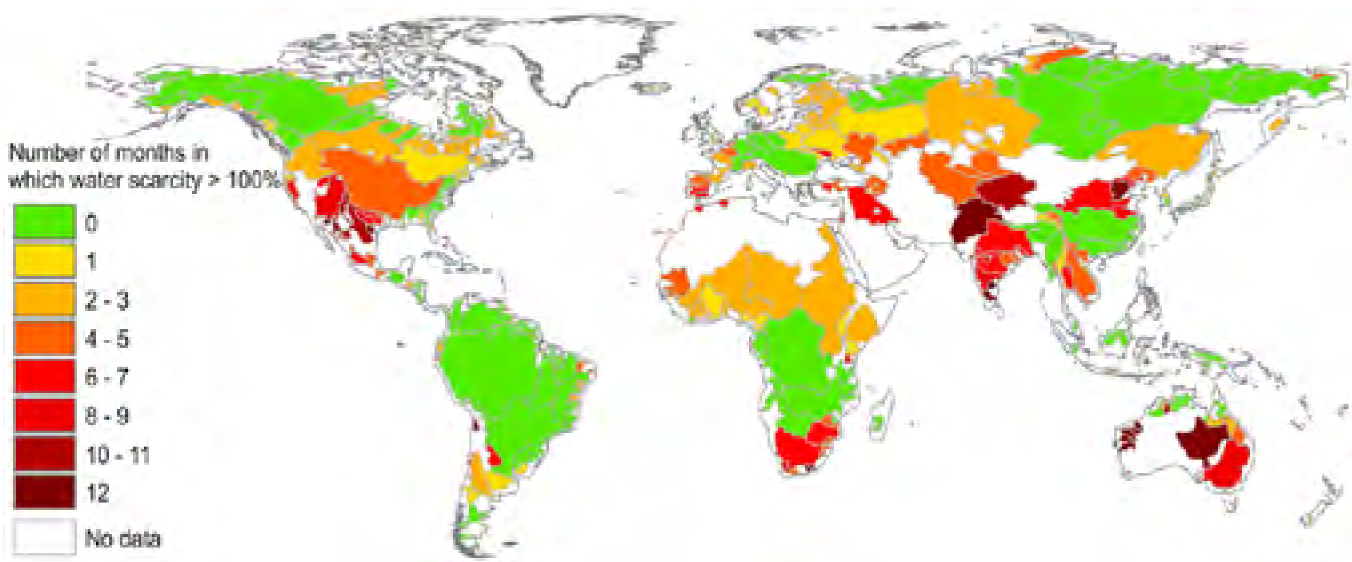


Figure 4: **Projections for changes in water supply from 2010 t0 2040 with a business as usual climate scenario based on WRI's AQUEDUCT modeling system from WRI website (Gassert and others, 2015).**



WRI has over time transformed its analysis capability into a global water risk mapping tool known as AQUEDUCT. Figure 4 is taken from an AQUEDUCT report (Gassert and others, 2015) building on Figure 3. Figure 4 presents additional hotspots of projections for changes in water supply from 2010 to 2040 in basins assuming not much global policy change on climate. Areas facing worse water scarcity are shown in shades of red while improved situations are shown in blue. Despite this sophistication, Hoekstra and others (2012) developed global basin assessment techniques based on consumptive use, not water withdrawals, and on a monthly basis. They argued that this was a more accurate estimation of water scarcity that would not underestimate stress as do other assessments. Figure 5 illustrates this analysis that found for the period 1996-2005 2.6 billion people lived at least one month with severe water scarcity. Recently, Mekonnen and Hoekstra (2016) utilized updated techniques and found that 4 billion people, two-thirds of the planet, experience severe water scarcity at least one month a year.

Figure 5: Number of months a year in which "blue water" footprint exceeds "blue water" availability or severe water stress - for major river basins for period 1996-2005 (Hoekstra and others, 2012).

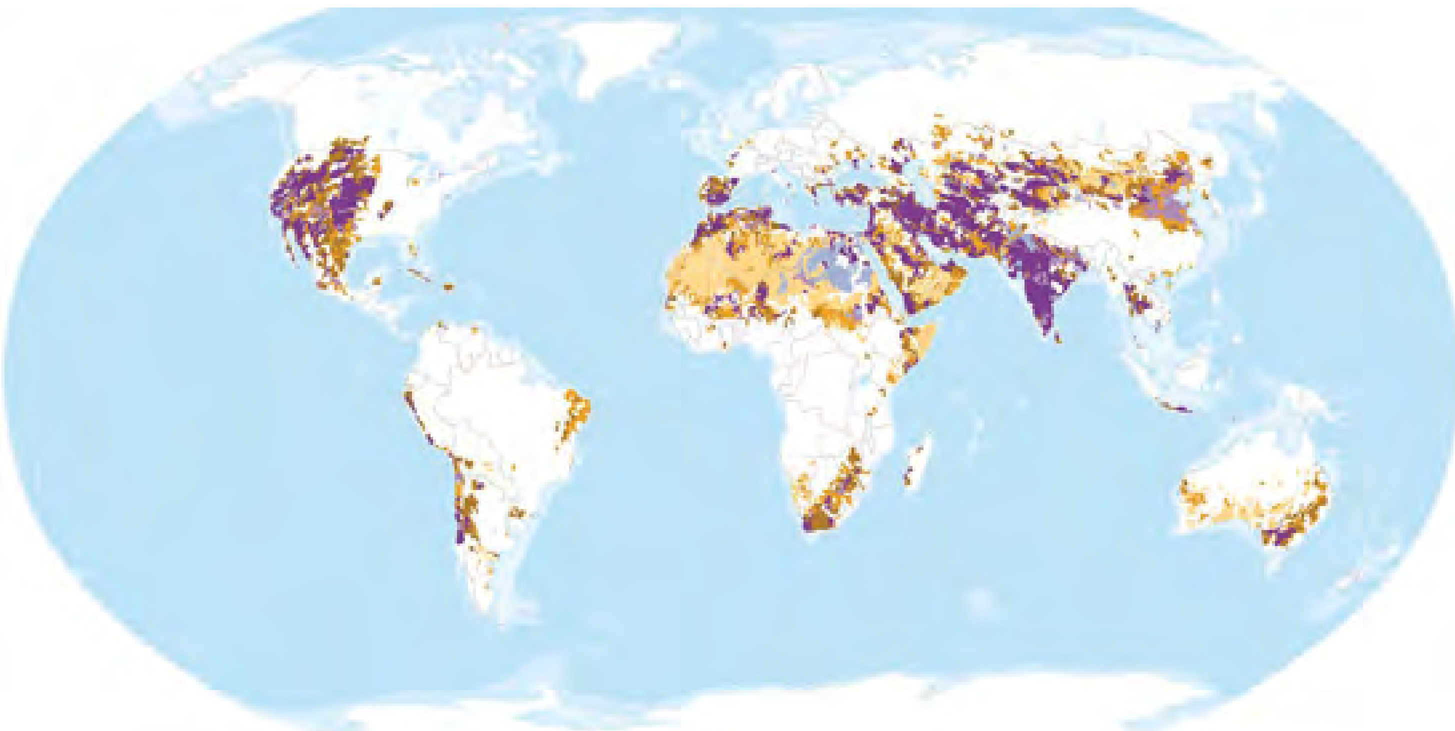


Hoekstra's Figure 5 analysis brings important water jargon into the discussion of land and water co-management. The term "blue water" refers to water in rivers, lakes, and groundwater that is commonly used for irrigation of crops through construction of infrastructure. Complementary to this is "green water", the water that falls as rain, enters the soil root zone, and returns to the atmosphere as vapor from evaporation or transpiration by plants. After irrigation with "blue water", the consumptive portion used by a crop returns to the atmosphere as the "green water" portion of the hydrological cycle. As droughts from climate change worsen, green water becomes more important, and drought management planning needs to be an integrated part of land/water co-management.

The key point is that in areas of high water stress or scarcity, the best future strategy would be to more effectively use rainwater to grow additional food rather than more groundwater depletion or dams to divert depleted rivers. This strategy for the future has been made abundantly clear by one additional recent global assessment presented by The Nature Conservancy--TNC (Richter, 2016). Figure 6 from the TNC publication illustrates that most of the worse water scarcity hotspots identified in previous global basin analysis have irrigation as the dominant source of the water depletion, which would be expected with irrigators tending to maximize yields in the absence of good water governance.

Figure 6 identifies the hotspot basins of irrigation and livestock/ pastoralism where less water use is needed, not more, to balance competing water uses in major river basins. This would be an enormous undertaking for co-management of land and water resources, so better use of "green water" and supplementary irrigation are needed. When adding similar areas of groundwater depletion, the area expands. Figure A1 in the Annex from UNESCO (Walton, 2015) presents recent estimates of groundwater depletion based on remote sensing satellite techniques. As the Aral Sea basin and other rivers that have been depleted from Chad to Texas show, unsustainable irrigation practices and poor water management combine to create concerns for food and water security as well as stability of resident communities. These "closed" river basins with unsustainable use of water resources demand more intensive co-management of land and water resources in the future.

Figure 6: Water stress categories primarily responsible for depletion in river basins.
Dark purple (chronic stress) and dark brown (episodic stress) have irrigation as the dominant cause while light brown denotes pasture/livestock as the dominant cause **(Richter, 2016).**



These global assessments and others not presented here illustrate the serious situation that almost 4 billion people have to live with water scarcity. As noted by Richter (2016), at least one-third of the rivers, lakes and aquifers on our planet are being heavily tapped for their water resources. More than 90 percent of water consumption in water-scarce regions goes to irrigated agriculture. Globally, irrigation consumes 10 times more water than all other uses combined. There are few places in the world where water scarcity can be alleviated without substantially reducing the volume of water being consumptively used in agriculture. In addition, none of these analyses address the fact that 50% of wetlands have been lost, primarily to drainage or embankments for agriculture and are in need of restoration to return the goods and services communities used to get for free. These assessments also ignore the scarcity of usable water because of agriculture water pollution and the far-field degradation resulting downstream in coastal estuaries degraded by agriculture nutrient over-enrichment like the Gulf of Mexico, Chesapeake Bay, the Black Sea, or coastal waters of Asia.

5. OVERVIEW OF SOUND LAND MANAGEMENT AND WATER RESOURCES MANAGEMENT PRACTICES – EXAMPLES

This section on "good practice examples" is divided into two sub-sections covering sustainable land management practices for different agricultural situations and then a third sub-section on integrated water resources management examples. The situation is complex because it is not just a simple matter of applying new techniques in agriculture or new measures in water management. For example, to make SLM a reality to meet food security and poverty reduction SDGs, a complex and integrated array of policy shifts and incentives are needed that are hard for some governments to adopt. Longstanding concerns about land tenure reform and women's rights related to those reforms have been obstacles in some cultures. In others, government finds it more lucrative to maintain rights to land and sell off what it desires for profit. Then there is the problem of population increases in some places like Sub Saharan Africa (SSA) where perhaps 50% of the increase in planet's population by 2050 is expected to occur. Targeting measures to SSA in the area of girl's education, reducing fertility rates, and reproductive health are also essential to close projected food gaps (WRI, 2013). And then, 30% of food never makes it to market or is spoiled, so improved roads, storage, access to finance are all part of the long-term puzzle to address all the SDGs, not just newer, water saving and agronomic practices.

At the core are proven, water-saving SLM practices in two categories with examples provided in subsequent sections. In areas like SSA that may be semi-arid /arid but still have rain-fed agriculture, improved management of green water (perhaps with supplemental groundwater irrigation) is important along with common sense agronomic practices to save scarce "blue" water for other downstream uses, including water ecosystems critical to community sustainability to adapt to changing and often drier climate extremes. Second, very different measures are covered for areas with intensive irrigation, many of which need to release water to restore downstream water ecosystems communities need for survival as climate shifts to more extremes rather than expand wasteful irrigation practices). For both areas of land degradation and water scarcity, integrated approaches with decadal campaigns for policy changes needed to be addressed together because of interdependencies and between food security and climate change there should be a driving force for both developing country and rich country action. Flood recession agriculture represents a special need to protect or re-establish downstream of dams with artificial low releases.

5.1 Sustainable Land Management Practices

For areas needing more intensive green water management, all the normal agricultural sources of research and demonstration are sources of information on good practices—from the CG system and its International Water Management Institute (IWMI) to IFPRI, FAO, WRI and the International Institute for Sustainable Development (IISD). Complementing these sources are key reports issued by the UNCCD Secretariat and the GEF Secretariat with its GEF agencies illustrating measures successfully proven on the ground.

The WRI (2013) progress report on its landmark study entitled "Creating a Sustainable Food Future" documents many good practices. In fact, they note examples from Zimbabwe, Burkina Faso, and Zambia where some practices can increase income up to 140%. Some combinations can produce 4-7 fold increases in yields, and a combination of simple several water savings measures can double productivity. When combined with micro-dosing of small amounts of fertilizers to address Sub-Saharan Africa's notorious lack of soil fertility, large increases in yields were recorded in Zambia as reported by WRI (2013). The IFPRI (2016) Global Food Policy Report also highlights measures to improve productivity while saving water such as improved rice varieties doubling water use efficiency with yield increases of 50 %. The IFPRI report notes that a whole farm approach is critical for improving productivity and addressing land degradation with examples of legumes improving soil fertility and productivity in Malawi and crop diversification in Tanzania improving incomes 70%. Even aquaculture in wetlands can add to farm income.

The UNCCD (2014) in its publication "Desertification: The Invisible Front Line" provides a number of examples of inexpensive measures that can make a difference. Even more information is included in the recent publication on achieving SDGs and how LD figures in (UNCCD, 2016). The GEF in its review of the land degradation focal area summarized experiences with SLM and integrated watershed management (GEF, 2014). In fact, GEF assistance to countries to reverse land degradation also includes several separate climate adaptation funds that GEF operates and that can be joined-up with the GEF Trust Fund to fund projects and programs---such as the new Great Green Wall effort as described in a GEF report (Bakarr and others, 2011). This review and programs such as the Great Green Wall will be further discussed in a following section.

In the 14 years that LD has been a GEF focal area through July 2016, GEF has allocated almost $US 1 billion in grants for SLM projects in that area with hundreds of millions more provided by associated projects in the Biodiversity and International Waters focal areas, so many experiences have been generated by many countries.

The water savings measures have been proven but need upscaling. Rain water harvesting, agroforestry, mulching, bunding, planting pits with green vegetation in the bottom providing organic matter and nutrients, small ponds for livestock and supplemental irrigation, terraces, drip kits and treadle pumps, contour plowing and other soil conservation measures (such as conservation tillage), all contribute to water savings, yield increases, farm incomes, and reduction of land degradation. Numerous guides exist, for example from FAO (2012) and IWMI (Bunsen and Rathod, 2016) on water harvesting as a key way to recharge soils with water and improve green water management. IWMI (2015) reports great success in Ethiopia with soil bunds and infiltration ditches. Climate-smart agriculture is becoming more commonplace as shown by ICRAF (Bayala and others, 2016) including use of mobile phones for farmers and user associations sharing texts on weather forecasts for proper planting times in countries of the Niger basin. In Senegal, as of August 2015, 915 village chiefs and many radio stations signed up for the service covering up to half the country's population. Droughts and floods will get worse, so access to insurance products and financial institutions will also be critical. IISD has reported on Centenary Bank of Uganda's role in providing climate smart financial service products for climate resilient agricultural value chains in Uganda, including weather index insurance (Daze and Dekens, 2016).

Irrigation with sewage effluent remains a key solution for the future as noted by IWMI (2010) near towns, for example in 33 areas of Egypt where sewage effluent has supported tree plantations and agroforestry. As Duda and others (2012a) reported, even composted sewage from inexpensive village compost toilets around Lake Victoria in Uganda can be utilized for agroforestry with benefits not only to soil nutrients but also to a cleaner Lake Victoria as a result of the work of the Entebbe Woman Association. By the way, the GEF International Waters (IW) focal area has supported many of these "green water" measures for improving productivity, arresting land degradation, and saving water in many of its integrated land and water projects. Good examples with real farmer focus include the Lake Victoria Basin projects in 3 riparian countries (World Bank, 2005) and the Bermejo River Basin projects in semi-arid areas of Bolivia and Argentina (UNEP, 2011). Both cases show increased water holding capacity from increased organic matter and soil conservation measures. As noted in the integrated management section below, the GEF IW projects provide platforms for the water sector and land/agriculture sectors to work together more effectively and in a participatory manner with farmers on a hydrologic unit basis as well as bring in other water users to help balance needs in river basins and aquifer systems.

Additionally, conservation agriculture is particularly important by minimizing soil disturbance, maintenance of cover crops and crop residues, and crop rotations. Benefits for carbon sequestration, enhanced resilience to climate change, and increased agricultural productivity. Increased soil organic matter with conservation tillage helps to store more soil moisture and increase productivity. Likewise, minimum tillage and integrated pest management (in lieu of toxic chemicals) helps conserve soil biodiversity to maintain and increase soil porosity, which improves infiltration and water retention. All these measures need to be used now while countries work through the difficult processes of sorting thru land tenure reform and the associated issues of women, food waste, and credit/insurance/market access.

5.2 SLM for Intensively Irrigated Areas

Beyond the fragile drylands where improved green water management is critical, areas with unsustainably intensive irrigation water withdrawals, infrastructure, practices, and institutions and have damaged downstream water ecosystems and impacted multiple uses of water for businesses and communities. While improved green water management can help even this situation, there are other proven irrigation-related measures for upscaling. The trouble seems to be that past water efficiency gains have gone back into expanded irrigated areas rather than helping to balance waterbody use. The global extent of dry lakes, inland seas, rivers, and aquifers downstream of intensely irrigated areas documents a lack of sustainable land management in agriculture and lack of ability to balance competing uses of water. Without enormous public outcry and national subsidized action, there has been little political will or success for IWRM in these basins and aquifers.

There are no shortages of best practices, guides, and success stories for techniques to reduce water use in irrigation with a century of literature on methods and strategies. All sorts of surface gravity techniques exist from flood to furrow, border, and surge irrigation. Pressurized sprinklers save more water than gravity and vary from center pivot to linear, side rolling, and solid set. The most efficient types are referred to as micro-irrigation, surface, sub-surface, and micro-sprinklers. Saving water in irrigation is full of practical challenges with opportunities for savings from storage, conveyance, and distribution systems to application technology and use of crop residues. Everything from lining canals to conservation tillage and land leveling can save water.

Various strategies such as alternative cropping, irrigation scheduling, deficit irrigation (apply less than needed), and others like water pricing, water markets, and use of reclaimed wastewater make saving water a complex undertaking for most farmers. Among the guides discussing these measures are good ones from Australia (Fairweather and others, 2011), Texas (Texas Water Conservation Board, 2013), Oregon (Shock and others, 2013), California (Cooley and others, 2014), and FAO (Cornish and others, 2004 and Hodgson, 2004). Even a form of water harvesting known as managed aquifer recharge (MAR) can be critical in saving water. Simple structures can be built to collect runoff to recharge aquifers –see guide from UNESCO (2005). Storing water underground with minimal evaporation is a much smarter option than building a dam for storage that wastes water through evaporation.

Plant breeding to develop drought, flood, and salinity resistant varieties of crops also contributes. For example, the CG's IRRI (2015) reports that millions of hectares of these climate and salt smart varieties of rice have been planted across Asia. For irrigated areas that have lost productivity from waterlogging and salinity, recovery also has a range of practices. Installation of drainage or pumping of tube wells to lower water tables is one measure. Applying more irrigation water to leach salts out is another with the example of the Nile River being used to flush salt from irrigated land in Egypt out to the sea. Other measures include: eliminating use of irrigation water with too much salt, only irrigating with what crops need for evapotranspiration, planting salt tolerant crops or grasses and trees, cultural practices such as deep tillage or land leveling, and application of chemical amendments ranging from gypsum to acids or organic matter. Crop productivity can be restored on some of these degraded lands.

Wasteful irrigation is an impediment. The problems for basin-wide application of water savings measures include variability of conditions, types of technologies, access to capital, and human resistance to change. For example, IWMI reviewed this problem for the Ganges and Indus Basins finding some areas with high water productivity but many areas with low productivity and much difficulty in getting more efficient practices implemented (Cai, 2010). Even in Europe, Portugal in particular, improving water efficient irrigation with innovative practices does not meet with favor from farmers who deem they already use adequate efficiency measures (Levidow and others, 2014). In the US, wasteful flood or furrow irrigation still is practiced in places. In the Middle East and North Africa, most countries could not meet current water demands back 7 or 8 years ago according to the World Bank (2009).

The Bank analysis pointed out progress in water use efficiency in Morocco with its leaders and the King being champions for water reforms. However, in many other countries, water is still allocated for low value uses despite shortages and like in the US reforms have proven to be politically untouchable.

IWMI identified another problem in attempting to save water in basins. Their research into Pakistan's rice-wheat systems found that some water savings technologies will be adopted at the field scale but that expansion of irrigated areas then may negate any saving that may be available downstream (Ahmad and others, 2005). The same can be true in the US west under its special "prior appropriation" water rights system. There is little incentive for large irrigators with "senior" water rights to install water savings measures when under the law, water not used can then become available for use by those with "junior" water rights. Continued operation under an archaic 1902 water law in the western US hinders balancing competing uses of water in basins. Like the MENA region, groups receiving subsidies related to water are politically stronger than those pushing for reforms. No national groundwater law also has accelerated aquifer depletion in the US in places such as the very important Ogallala Aquifer of the US Midwest.

Despite the challenges, when the surface and groundwater depletion raises water security concerns, there are a few places where action has begun to balance competing uses of water and restore important water ecosystems. While Australia provides the best example, action is beginning in portions of California and in several basins of China for balancing land and water resources management where intensive areas of irrigation exist. The Murray-Darling basin of Australia, the San Joaquin-Sacramento River Basin with its delta and San Francisco Bay in California, and the Tarim River/Taitema Lake basin along with the Hai River Basin in China provide two other examples. The first two will be discussed here and the two China examples in the next section on IL&WRM.

The Murray-Darling River Basin in Australia is one of the best examples of a semi-arid basin with conflicts among intensive irrigation, urban water, and maintenance of water ecosystems, both quality and quantity. The first agreements on water among the states were signed one hundred years ago to address repeated droughts. Thirty years ago the conflicts and economic losses were well recognized, and work began on a series of reforms agreed 20 years ago that included: water rights, water markets, tradeable water allocations, consumption-based pricing, full cost recovery, removal of cross-subsidies, legally recognized shares of water to sustain ecosystems, stakeholder engagement, modernized basin institutions, new national water law, and other reforms.

Much progress was made in irrigation water productivity, urban water savings, and ecosystem restoration, yet it took a drought of millennial proportions from the late 1990s through 2010 for serious implementation, of which a new integrated land and water management plan is only on its third year of implementation after adoption in 2012. A recent summary of the case study underscoring the mainstreaming of drought management planning was presented by the Australian Water Partnership (2016). The reforms made in this basin provide a great model for other basins to follow globally and targets that were set proved to be important drivers to maintain momentum over time.

The Western US represents a special case. The Sacramento and San Joaquin Rivers cover much of California draining to a large delta and San Francisco Bay. Diversion of water to the Central Valley irrigation projects with half of California's agriculture, urban water supply diversions for 2/3 of California's population, and reduced flows to the delta along with excessive pollution loading have created competing economic, ecological, urban, and agricultural conflicts and a degraded San Francisco Bay. Faced with extinction of species and economic losses with repeated droughts, an agreement was signed 20 years ago to begin actions to coordinate national and state actions. An agreement resulted that is fondly referred to as "CalFed" with up to 25 national, state, and local agencies working with special authorities and funding to find water savings and pollution reduction in irrigation and urban water to restore the degraded river, delta, and bay ecosystems. Like the Murray-Darling case, a nationally supported program is needed for long periods of time—20 to 30 years in rich countries. The discussions about creating the program are available in CalFed Bay-Delta Program (2000). Three pieces of national legislation were passed in 1992, 2004, and 2009 to authorize the special water efficiency, pollution reduction, and restoration programs (USGAO, 2015), and while some progress has been made, the irrigation-water ecosystem conflict remains and is politically polarized with special interests clinging to the old 1902 western water reclamation law in the US.

Progress seems much slower with CalFed than in the Murray-Darling Basin, but there is progress on integrated land and water management for both quality and quantity interventions aimed at sustainability. Very few other success stories of a widespread nature seem to exist. If it takes 30 or 40 years to make progress in the North, just think of the challenge of doing the same in intensively irrigated areas of the South in order to meet multiple SDGs. National legislation, national commitments, multiple government ministry coordination and cooperation, policy, legal and institutional reforms, cost sharing for installation of modern technology, proper pricing of water for larger irrigation users, and massive, long-term programs with partnerships between the North and the South are needed along with coordinated help from development banks and UN organizations if food needs are to be met and integrated Land and water management achieved in balancing competing water uses in river and aquifer basins.

In essence, these examples illustrate the importance of participatory land use planning coupled with water management on a watershed or basin scale that needs scaling up, especially for drought management planning related to climate change. Irrigation or farmer user organizations and basin water-related committees and organizations become critical tools along with agricultural extension personnel and water officials who understand the area rather than just working in the capitals. Incentives help as well as noted later in this paper for GEF projects aimed at agriculture nutrient reduction in the Danube Basin—34% cost share from farmers, 33% from the government, and 33% from the GEF. Land use planning from the EU represents one good way of integrating water issues into agriculture (European Environmental Agency, 2006) for the North and FAO (2014) for East Africa or German cooperation guidelines (GIZ, 2014) for the South. The integrated land and water examples listed below also demonstrate basin and sub-basin integrated approaches. Globally, SDG 6 on water mandates implementation of IWRM. Before 2015, the WSSD Johannesburg targets mandated producing national IWRM plans. The next step is to move to basin scale planning with basin, sub-basin, and aquifer-recharge area water planning in conjunction with land use planning and technical assistance on agriculture in the same areas to meet SDGs 2, 6, and 15.

5.3 Integrated Land and Water Resources Management Examples

The Tennessee Valley Authority (TVA) was created through legislation passed by the US Congress in 1933 to help promote the unified use, conservation and development of the highly eroded, disease-ridden, and poverty-struck 7 states of the Tennessee River Basin in the southeastern US. The organization was like a mini-US government that achieved a coordinated land and water approach to natural resources management and economic development because national government ministries were not able to work together in this part of Appalachia to address the poverty, disease, droughts, floods, declining crop productivity, and soil erosion plaguing the basin. Think of how land degradation and poverty looks in Bolivia, the hills of Vietnam, and Sub-Saharan Africa; that was the situation in the Tennessee Valley in the 1930s. With a focus on restoring soil productivity for agriculture, constructing multi-purpose dams for power, stabilizing gullies, drought management, urban water, recreation, flood management, navigation and regional economic and industrial development, the TVA worked with and built capacity of state agency personnel to address the situations---even rampant yellow fever and malaria in an integrated fashion---always considering land and water and then balancing multiple uses of the river for development.

It succeeded to bring the economic status up to the national average over its first 50 years. As a result of downsizing from conservative governments, TVA settled into a more limited power generation and river basin management role while national ministries and state organizations shoulder the burden in the 21st century. More information can be found at USAID Water Team (undated) and TVA (1989).

Many people called the TVA approach IWRM, but it was really integrated land and water resources management (IL&WRM). IWRM was popularized in the Dublin Water Conference of 1992 that pre-dated the Earth Summit. IWRM has continually been identified as the preferred water management approach starting with Agenda 21, then the 2002 Johannesburg targets, and was adopted by Heads of States in SDG 6. SDG 6.5 directs nations to "implement integrated water resources management (IWRM) at all levels, including through transboundary cooperation as appropriate". It acknowledges the importance of managing water resources for sustainable development with the need for the water-related sectors to collaborate beyond the existing 'silo' approach to the desired integrated approach to water resources management. Full integration has a far-reaching challenge in that water goal SDG 6 will only be achieved if other goals are successful, and other SDGs will only be achieved if SDG 6 is successful. Yet "land" is not mentioned in SDG 6, so land and agriculture have a key role to play if any success is to be achieved.

A library full of IWRM literature is available, ranging from: guidebooks (Global Water Partnership--GWP, 2000), website tool kits from GWP (www.gwp.org), and case studies (Mitchell, 1990) to criticism (Jeffrey and Geary, 2006) and practical approaches (Butterworth and others, 2010). Some success stories at smaller scales exist, especially for simple water sector conflicts such as the Tarim River basin described below. The Johannesburg target related to producing national IWRM plans and many countries did so (UNEP, 2012)--but perhaps without serious commitment to place-based, basin-by-basin or aquifer-by-aquifer application and less than serious involvement of agriculture and energy ministries. It has been viewed as a much too complex, water only approach which remained within water circles because ministries many times have a hard time working together. Even in the North, for example the US, rivalries had existed among sector ministries that impeded cooperation on non-point source pollution. Nonpoint source pollution reduction funding went to EPA alone for many years until the agriculture community relented and included minor funding in the annual "Farm Bill" legislation as part of its conservation provisions. However, total funding has been miniscule given agriculture being identified as the major source of water pollution in the US.

While IWRM just has not met its promise, it is not the fault of the concept. From theory to application assumed knowledge about the water system, human capacity to do the work, and ability to understand complexity. When funding was made available, some water ministries kept the money for themselves rather than share with other ministries, and environmental ministries avoided engaging the more powerful agriculture-related ministries about their contribution. Same with energy issues such as hydropower which often experiences conflicts with irrigation and ecosystems. Plus, engaging stakeholders in the basins can be a daunting challenge for ministry officials. Multi-stakeholder dialogues up and down basins would be critical for implementation.

From IWRM to Nexus Dialogues. With disappointments in IWRM, a related concept called "water, food, energy nexus" was promoted at the Bonn Water Conference in 2012. Copious literature exists on what the unproven nexus concept should be, for example FAO (2014b). Nexus dialogues were conducted in some areas as pilots to test the concept and results were reported by IUCN (Bellfield, 2015). However, environment has sometimes been ignored in nexus discussions and the disappointments in IWRM may not warrant abandonment just because agriculture and energy ministries were left out by water interests. Furthermore, SDG 6 does include the Heads of State agreed mandate to implement real IWRM and does not include "nexus" language. That is why SDG 6 is now so critical for land interests and provides an opportunity, and a new imperative, for proper IL&WRM to be implemented.

Key cases of water savings in irrigation from China. In terms of large scale IL&WRM beyond the Murray-Darling Basin and TVA in balancing competing water uses for quality, quantity, and timing of flows, two examples in China come to mind. The first relates to the Tarim River Basin in the desert of western China where excessive diversions of water for irrigation dried up the river and an important lake -just like Lake Chad or the Aral Sea. The Government of China sought help from the World Bank with two lending operations and technical assistance from Australia over a decade from the late 1990s into the late 2000s. Just as in the cases of Australia and the Central Valley of California and CalFed, the concept of consumptive use and evapotranspiration (ET) was introduced. The concept was used to reduce irrigation withdrawals and application with a new water rights/allocation system based on consumptive use (ET management) in a pilot prefecture, introduce cropping diversification, line canals, incorporate revegetation with trees (30% increase) and grasslands (15% increase) and introduce IPM and laser-guided land grading.

Associated with this were repeated artificial releases of water from upstream dams to restore 300 km of the green river corridor (reversing desertification) and some 200 square kilometers of the lake. Ecosystem benefits returned rapidly with satisfaction among all in the basin with the higher crop yields. Crop production increased 18% while farmer water use decreased 17%.

This successful effort is summarized in an available review of the implementation completion report of the World Bank (2005). In this case, the artificial "environmental flows" from upstream dams were an important component in the IL&WR approach along with testing the new approach of water allocations and increased water prices based on volumetric water use.

An even more significant case of IL&WRM is one supported by the GEF and the World Bank in the water scarce North China Plain where intensive irrigation, and irrigation pumping, have severely reduced flow in the Hai River Basin, from Beijing to Tianjin, seriously depleting aquifers. The International Waters (IW) Focal Area of the GEF builds countries' capacity with regard to IL&WRM in transboundary water systems. This also includes single country river basins and aquifers that drain to coastal areas by virtue of connection to coastal oceans. The Hai basin is one of these latter cases. GEF has developed and tested processes for building trust and confidence as well as capacity for participative IL&WRM. The GEF strategy involves work at various levels of government---from multi-country to national sector as well as sub-national and local levels to analyze the land and water issues, set priorities, and develop reforms, while working on-the-ground with local demonstrations of good practices and measures. Box 1 outlines these processes that can catalyze national and sub-national commitments to reforms for IL&WRM.

Box 1: GEF International Waters (IW) Focal Area Processes for Projects that Help Achieve IL&WRM

The GEF IW focal area provides grants to countries to address different water-related sectoral conflicts in basins and aquifers. In the last 2 decades, the focal area has provided about $US 1 billion to help countries secure their water supplies for multiple uses, including ecosystem sustainability through actions in virtually every economic sector as noted by Duda et al.(2012a). The GEF Council focused IW on elements of Agenda 21 and then the Johannesburg targets, which included IWRM, with practical processes for addressing multiple stresses on water resources basin-by-basin and aquifer-by-aquifer.

GEF's practical experiences resulted in 3 recommended processes leading to IWRM---(1) formation of national inter-ministry committees; (2) production of an analysis for the basin of concern on status of the river or aquifer basin, different sector water uses, conflicts, and future projections (known as a Transboundary Diagnostic for multi-country water systems or a diagnostic analysis for single country systems), and (3) development of a strategic action program of policy, legal and institutional reforms and investments that address the priorities in the analysis through a multi-stakeholder, participative processes across sectors to balance the competing uses, make tradeoffs and form partnerships for action. If ministries in a country or multiple countries for transboundary systems agree to implement the action program, then GEF may follow up with multiple projects containing grant funding to help implement the solutions to the priority concerns identified by the analysis and included in the action program. Establishment of the functioning national inter-ministry committee is an indicator to be reported in project monitoring and evaluation.

Such an analysis and resulting program of action provides tools for engaging stakeholders in the process and can help simplify complex situations in order to understand them and to divide the needed actions into simpler management sector pieces for sector action that would be planned for implementation in budgets over time yet be consistent with ultimate water balancing.

GEF has supported many examples of the use of these 3 elements to address land and water-related issues as well as engage government officials from many ministries in the GEF transboundary water projects, with many of the cases being described in GEF reports (Duda and others, 2012a; 2012b).

The GEF/World Bank Hai River Basin IWRM project involved many facets of water and land reforms for improved quality in the river and aquifer as well as reduced water use in irrigation so more will be available for environmental flows to the river and to reduce overdraft of the aquifers. The 7 year project, with $74 million from the Government of China, $41 million from the World Bank, and $17 million in grants from the GEF IW focal area, pioneered water and land management reforms in an integrated manner with very positive results, and along with the experiences in Australia for the Murray-Darling basin, the Hai Basin example illustrates paths forward for basins with intensive irrigation to meet the SGDs.

The Hai Basin project demonstrated the utility of increased charges for irrigation water, a new water rights/allocation system under Chinese Law based on consumptive use (estimates of evapo-transpiration or ET) and not standard withdrawal amounts, satellite technology for integrated land-water planning to support issuing and then enforcing the water allocations under law, and other water saving irrigation technologies to begin the process of rebalancing food security and water and environmental uses in the basin and its depleted aquifer system. A truly innovative approach to IL&WRM based on the previous Tarim River experience, the project also included water quality improvement measures, capacity building for the basin water resources commission under Chinese law, and use of ATM cards for individual farmers with only enough allocations for their pumping to meet the reduced allocations needed for the real water savings.

Satellite data on estimated ET at a 30 meter by 30 meter scale was utilized with simulation models to provide reduced allocations to farmer-led water user associations. In turn the associations distributed the quotas to over 100,000 farmer households through the ATM cards for pumps that they pay for—once the allocation was gone, no more water could be pumped. Extension services assisted with recommending practices for green water savings, best management practices (mulching, plastic, cropping patterns, drip technology), and alternative crops for increased farmer income. The result of the 7 years project was per capita income being increased by 193%, water productivity increased by 82%, and consumptive use decreased 27% -with the real water savings available to stabilize the aquifer draw-down and leaving more water in the river for ecosystem use. Description of the project and results are available in World Bank (2011) and Duda and others (2012a).

The key point is that the pragmatic success of this GEF project moved the government of China to utilize under its water law the new ET remote sensing/water rights/ water allocation system based on consumptive use for all new water allocations (well permits, water rights, irrigation scheduling). The project also catalyzed application of the ET-based allocation system to the entire Tarim Lake basin in a new project entitled "Xinjiang Turpan Water Conservation Project" and led to a follow-on GEF/ World Bank/China funded GEF IW project to scale up the results to the entire Hai Basin. Formal agreement among ministries that never worked together (the national inter-ministry committee) makes coordination and cooperation work not only in the capital but also down in the field in counties. Various analyses were produced in the first project that led to a knowledge management system being established for use basin-wide with the revitalized basin commission. There is an IWRM plan for the basin now being implemented with more provisions to improve water quality and restore river flows and aquifer levels. The setting of targets to be achieved consistent with GEF policy proved to be important so progress could be measured.

Imagine, if this Hai Basin approach can work in the water scarce, intensely irrigated North China Plain, the reforms and practices will be able to help balance competing water uses and implement IL&WRM in other global water scarcity hotspots illustrated by the maps in earlier sections of the paper. Places like Peru, Egypt, Pakistan, India, Iraq, Iran, Central Asia, Western US, Mexico, Chile, Jordan, Lebanon, Morocco, Algeria, and Tunisia could all benefit from the reforms and measures related to land and water. But it is politically hard to change from a "use it or lose it" approach to irrigation or archaic 100 year old water laws to use of modern satellite technology, reformed water rights and water allocation systems, increased charges for use of irrigation water in larger systems (where political resistance often lies), functioning inter-ministry committees, updated water laws, river or aquifer basin commissions with authority, and national commitments to provide needed funding to co-finance installation of water saving technology and run the management institutions to provide stewardship of the scarce water resources.

As the World Bank reference to progress on water reforms in Morocco noted earlier, it takes leadership and political courage of a President, Prime Minister or King to overcome influence from elites and special interests to do what is best for the rest of the people in a country when it comes to water scarcity and land degradation. Like co-management of land and water resources to balance competing uses in a stressed basin, the "haves must give up a little to allow the have-nots to have some". As land use planning for agricultural landscapes interacts with participatory water management planning as part of IL&WRM in basins or aquifers, water use must be balanced among other sectors and ecosystem services as well.

Cities especially have many tools once there is political will to reduce water waste. A great example is Windhoek in dry Namibia. Repeated droughts have produced a rich history of integrated water demand management from raising tariffs to reduce use to water conservation devices in new buildings since the 1990s and reuse of reclaimed wastewater (Lahnsteiner and Glempert, 2007). Reclaimed wastewater is even used for irrigating pastures in this arid setting. California represents another example of urban areas saving water in droughts---up to 23% savings. Drought management planning is a key tool for introducing and facilitating IL&WRM in basins and aquifers to identify alternatives for balancing competing water uses given recent devastating droughts and adaptation funding available for developing countries.

6. CONCERNS FOR TRADE POLICY, AGRICULTURAL SUBSIDIES, AND MARKETS

With globalization has come a whole host of issues related to trade policy, global markets, land grabs by foreign nations, prices for commodities in times of shock, and the distortion cause by agricultural subsidies in many countries of the North. Agricultural subsidies in the North, for example, reduce world prices for food produced in developing countries so that their farmers find it hard to compete with those in rich countries. During the recent Doha round of talks on subsidies, the World Bank (2008) estimated global agriculture subsidies to exceed $US 245 billion annually. Other damaging subsidies can be subsidized electricity to run irrigation pumps (half of India's irrigated land comes from pumping groundwater) that discourage spending on water savings measures (World Bank, 2008) or fertilizer subsidies that divert money for conservation or water savings to farmers' pockets—especially elite ones.

Trade policy talks have been underway for 16 years now with another key meeting of countries scheduled through the World Trade Organization for 2017. While scaling up of IL&WRM needs to be undertaken today, institutions interested in achieving the SDGs do need to be vigilant and ensure countries work toward a decision to remove damaging and distorting subsidies as soon as possible. The subsidies distort market prices and reduce farmer income that could be used to invest in newer water saving technology or to pay higher prices for water aimed at cost recovery and/or maintaining management of their river or aquifer system for their use.

Increasing "Land-grabs". While commodity prices can be determined by trade, transport, land use, and finance, shocks occur like the spike in food prices in 2007-8, or prices can be lowered when harvests are greater than expected. The 2008 high prices fostered a flurry of "land grabs" by foreign investors and a wave of criticism for global institutions seen to have fostered the land transactions. In the past decade, about 81 million acres of land worldwide—an area the size of Portugal—was estimated to have been sold off to foreign investors. Some of these land grabs occur without transparency in a climate of weak government land tenure arrangements. Without the prior and informed consent of communities, the result can be farmers being forced from their homes if no formal tenure exists. Families can be left homeless and hungry as elites with connections pocket the money.

These large land deals are supposed to be aimed at growing food, but the crops grown on the land rarely feed local people. Instead, the land is used to grow profitable commodities like sugarcane, palm oil, and soy—often for export. In some cases the land is used to grow rice, feed for livestock or corn to export agricultural products to substitute for not being able to grow them because of water scarcity. Land tenure reform and land rights issues are volatile enough in some countries that adding a third party that forces displacement of farmers can lead to socio-political instability. These foreign investors acquiring land raise three issues: (1) displacement of farmers, (2) further degradation of land through intensive cropping and abuse of water resources with creation of new downstream or aquifer conflicts, when weak institutions allow the investors to do what they may, and (3) positive value of export of agricultural products as "virtual water" in global trade that can reduce pressure on stressed waters back home.

In addressing the first issue, the nonprofit organization GRAIN (2016) recently released an important update of their analysis from 8 years ago on land grabbing. They report global investors having spent more than $US 90 Billion the last decade buying agricultural lands adding up to the size of Finland in 491 deals in 78 countries. Many of the largest investments were in Africa with money from the Gulf States and Asian countries. They suggest these purchases and the disenfranchisement of poor farmers is not a fad but a trend. One Hedge Fund was reported to set up a fund of $1US Billion for the purchases. Sovereign wealth funds were also major contributors. However, pension funds were the largest source of finance for this practice, even ones from the US. The companies purchasing the land most often were registered in tax haven countries, so offshore structures and illicit financing play a role.

Most disturbing is that a number of Asian countries include in their national plans explicit support for national corporations to purchase cropland; these corporations register in the tax shelter counties and acquire the lands along with securing the trade routes back to the countries to ensure delivery. Such global actions can be damaging not only to land and the farmers displaced but to adjoining communities.

GRAIN (2016) reports that during the 2015-2016 El Nino droughts, many communities next to these corporate irrigation operations lost their water supplies as extensive irrigation depleted the water sources.

Also troubling is that a land use decision is a water use decision and land grabbing is also about water grabbling. The GRAIN report also included reviews of some of the contracts for cropland purchase and they unfortunately included legal guarantees for use of water. IFPRI (von Braun and Meinzen-Dick, 2009) has reviewed the land grab situation identifying threats and offering suggestions. The World Bank (2015) issued a report with assistance of IISD on the situation and measures that should be utilized in investment contracts to protect both communities and the investor. In fact, IISD (Smaller and others, 2014) published a guide to negotiating foreign investment contracts for farmland and water; however they reported very few countries have the domestic legal framework in place to successfully enter into these contracts. It seems as if this trend of foreign purchases is here to stay. But the issue of a land grab being a water grab is worthy of more investigation with regard to transfer of virtual water in exports to water-short countries.

The water used to grow a crop or make a product can be referred to as "virtual water". For a decade, international trade in agricultural products has been advocated as one solution for water short countries. This strategy can help if the crops are grown in water rich countries. But if they are grown in water scarce areas or like land grabs in Africa produce direct adverse impacts on poor communities as well as indirect impacts eventually with land degradation and more water stress, they are not appropriate. IWMI covers the subject well regarding trade of virtual water in cereals (Fraiture and others, 2004). They found that trade in virtual water products can save water and may gain in importance over time. However, it is unlikely that water scarcity will shape global trade flows and many importing countries just have no option but to import food because their water situation is so serious.

Land grabs in developed countries too. Land/water grabs occur not only in developing countries but also in the North, for example, Australia. Moreover, with the archaic water system in the western US based on a 1902 national water law, foreign investors may purchase land with water rights or the water rights allocation itself and then export the crops grown as virtual water. This has created outrage in the western US especially when drought occurs. One notable case is in the desert of Arizona where companies from the Middle East are pumping limited groundwater supplies and exporting it in the form of alfalfa hay for livestock feed, with alfalfa being one of the most water-wasting crops.

There is an angry reaction of local residents as they see their wells running dry from foreign corporate farms growing alfalfa despite a law on groundwater. A video entitled "Camels Don't Fly, Deserts Don't Bloom" documents the conflict from students at Arizona State University (Bhandani and others, 2016). Foreign companies purchased about 4000 hectares of land with 50 wells and are pumping year-round to maximize yields for export to where aquifers have already been depleted—legal despite a state groundwater law.

In California, multi-year droughts are common because it is desert. Over abstraction of surface and ground-water continues even in drought to support unreasonable ad unsustainable expectations for agriculture. More than 20 % of water used in California is used to grow alfalfa for livestock feed, the most intensive water using crop that has a very low value---a waste of water. Much of it is exported to China, Korea, Japan, and the Middle East because prices are so high (Culp and Glennon, 2012). The current 5-year drought in California has met with legislated mandatory price increases and conservation measures for urban water causing hardships for some. At the same time, water is wasted in the Imperial Valley growing alfalfa under no restrictions in the irrigation district under the 1902 national water reclamation law with its "use it or lose it policy"—50% more than other crops due to conditions of heat, salinity, cheap, subsidized water(Culp and Glennon, 2012). Estimates are that virtual water equivalent to that for supplying 1 million California residences each year is being exported in alfalfa for livestock feed for the benefit of a very few people while urban water users face mandatory conservation measures. Situations as these create the equivalent of social instability and backlash against ineffective governments during drought conditions.

This discussion about global trade, markets, and subsidies is meant to put into perspective the technical challenge of co-managing land and water in basins to balance not only their uses but those of other interests. While improved IL&WRM measures and associated polices need to be up-scaled as soon as possible, there is an associated set of interventions and campaigns needing to be waged on the longer term, difficult, and politically sensitive policy issues that MUST be addressed. Land tenure reform, gender issues involving land rights, water rights and allocation systems, pricing policies, trade policies, reduction of agricultural subsidies, land grabs, and market mechanisms all need intensive attention if the SDGs are to are achieved and additional security concerns avoided.

7. DECADAL SCALE PROGRAMS NOT PROJECTS NEEDED WITH COHERENT PARTNERSHIPS INCLUDING BUSINESS

Established in 1991, the Global Environment Facility (GEF) has been the largest funder of projects to protect the global environment. More importantly, it is at the center of a network of many development assistance organizations that can all pull together in a joined up fashion through GEF's participatory strategy and through its grant funding that provides coherent coordination and complementarity to assist recipient countries in the enormous challenge they face on the road to sustainability. The original GEF focal areas were Biological Diversity, Climate Change, and International Waters. It took about 10 years for the North to agree to have Land Degradation as a full-fledged focal area. This is a symptom of the perception the world community had that land degradation was a local problem. This paper has underscored that water resources management has failed and will continue to fail globally unless land and agriculture interests become involved with water interests in IWRM. Excessive expectations for irrigation represent the number one driver for global river, lake, and aquifer depletion; and agriculture represents the number one source of water pollution for rivers, lakes, estuaries, and groundwater.

IL&WRM was advocated by the GEF staff back in the 1990s (Duda and El-Ashry, 2000) and practiced in the GEF because the GEF Strategy (GEF, 1995) approved by the North and South at the GEF Council included land degradation as it could be integrated with the 3 main GEF focal areas. Project experiences in GEF's first decade illustrated the reality that single projects do not normally make great strides in reforms and that integrated approaches among GEF focal areas was necessary. Politically, supporters of each focal area, especially the Rio Conventions, still wanted their own projects, but leadership of GEF during the Fifth Replenishment fostered the testing of integrated approaches that have continued into the current Sixth Replenishment.

GEF's role has been to test, experiment, demonstrate, and catalyze action by recipient countries assisted by others. The GEF Council relented in the early 2000s to support programs of projects, and the GEF IW focal area was one of the first with Council approval in 2001 of the Black Sea Danube Nutrient Reduction Investment Fund through the World Bank for a series of projects over a decadal time span aimed at integrated land and water resources management in the Danube basin to reduce nitrogen and phosphorus pollution in the Black Sea that created a "Dead Zone" of polluted water. More than half of the projects noted in the GEF publication entitled "From Ridge to Reef: Water, Environment, and Community Security" for the Danube Basin nutrient reduction program involved cropland and livestock nutrient pollution reduction plus construction of wetlands and restoration of formerly drained wetlands as a cost effective solution for trapping nutrients in the river (Duda and others, 2010). The success of the $70 million dollar GEF (plus $240 mil co-financing) programmatic approach, one example of IL&WRM, has spawned many more programmatic approaches catalyzed by the GEF.

Regarding land degradation itself, a progression of a series of projects in Africa bundled together under the name "Desert Margins" in the early 2000s was a first attempt to utilize GEF funding with partners in the CG system to gain experience in addressing land degradation and desertification in a somewhat programmatic fashion (UNEP, 2011). With lessons learned about the need to have involvement of national ministry leadership and development banks, a program termed TerrAfrica was developed with NEPAD and multiple GEF agencies once Land Degradation became an official GEF focal area. Experiences under TerrAfrica- SIP have been recently outlined elsewhere (FAO, 2016). $US150 million in GEF financing was combined with co-financing to generate almost $US 1 billion in SLM interventions, including integrated land and water and also utilizing GEF IW funding, in 32 projects covering 26 countries. Five GEF agencies implemented the projects according to their comparative advantages. Among them were the African Development Bank, FAO, the International Fund for Agricultural Development (IFAD), the United Nations Development Programme (UNDP), the United Nations Environment Program (UNEP) and the World Bank, all working in close coordination with the governments, NEPAD and regional economic commissions. Partnerships among agencies and governments are critical because the task is so large and multifaceted.

Among key issues were that land-related ministries drove the planning and implementation in some projects with water ministries only marginally involved. Also, original design and GEF expectations were for substantial progress to be made on land tenure reform---but that was not realized. While land tenure is a politically sensitive issue, progress needs to be made in reforms, not avoided, not only for the sake of meeting the SDGs in poor communities but also to stem the land grabbing concern that can only get worse as water scarcity increases in middle income countries. One example in the GEF IW focal area for reforms relates to the Danube Basin. As part of the programmatic approach for Danube nutrient pollution reduction, GEF specified that the individual projects must include related policy reforms and not just expenditures of the GEF grants in the field. Future GEF funding should also come with the requirement for land tenure reform or else it may fail the test for sustainability.

A truly integrated land and water resources programmatic approach related to desertification has subsequently been spearheaded by African Heads of States with help of GEF and its agencies to combat desertification in 9 countries bordering the Sahel and Sahara from Senegal to Djibouti. Known as the Great Green Wall programmatic approach (Bakarr and others, 2011), it focuses on appropriate native plantings that can survive in arid regions as well as green water management measures to stem land degradation in this hotspot region. The programmatic approach has set targets for governments to achieve and has had the support of Heads of States. Governments have shown commitments by working with the World Bank on the program and assembling over $US 1.8 billion to go along with $US 100 million from the GEF Trust Fund and two of the climate change adaptation programs GEF operates. If this program can achieve land tenure and other reforms and GEF can stretch the assistance into a decadal period of support, progress should be made toward the SDGs.

Watersheds and aquifers (along with their recharge areas) provide services to the agricultural community. Payment for those services has been lacking with people thinking water should be free. The reality is that watersheds and aquifers continue to be degraded with many unable to provide expected water to multiple users downstream. Along with land tenure reform, water pricing (charges from irrigation, mining, and urban water users) is desperately needed to maintain those basin water services. As noted many years ago by Duda and El-Ashry (2000), water use charges are still a critical tool as shown in the Hai Basin example, the Murray-Darling, and in urban water pricing increases during the recent California drought that saved almost 25% of water.

Past experiences point the way toward strategies for future scaling up of IL&WRM as a first step toward balancing competing uses of water basin by basin or aquifer by aquifer, and that approach is a prerequisite to meeting multiple SDGs. This paper supports priority being placed on:

- involving Heads to State to ensure reforms will be enacted;
- working through programs rather than one-off projects;
- developing decadal programs with clear targets for measuring progress and coherent and complementary support from the development assistance community—each organization working according to its comparative advantage through meaningful partnerships;
- employing climate smart measures at landscape scale and drought management planning at basin and aquifer scales (not forgetting that recharge areas are critical and land management in those areas can degrade or protect valuable groundwater supplies);
- requiring inter-ministry committees (with memoranda of understanding among them) for projects and programs to ensure horizontal and vertical government integrated approaches;
- requiring land tenure reform accompanying public grants and development assistance along with enacting water rights/allocation systems relying on consumptive use rather than "use it or lose it" withdrawals;
- adopting water charges/pricing for larger irrigation, mining, and urban uses—which often need legislative reforms to enact—with the funding staying in the basin or aquifer to achieve sustainable management arrangements; and
- significant increases in development assistance support to enact the needed reforms and operationalize IL&WRM on the landscape, basin, or aquifer.

Awakening of the private sector. With Heads of State adopting the SDGs, availability of successful strategies for achieving IL&WRM, and with high level support for recent programmatic approaches to scale up previous successes, there is cause for optimism that finally land sector interests and water sector interests will work together toward SDGs. The 2015-16 strong El Nino created a number of disaster situations illustrating that the world community can no longer wait – one other driving force for action is that the water using private sector now realizes that its operations are at risk because of the silos that have prevented IL&WRM, beginning with the formation in 2008 of the 2030 Water Resources Group of private sector leaders that issued its landmark call to action entitled "Charting our Water Future" (McKinsey and others, 2009). Nascent attempts at water savings by Coca Cola in its operations, and more recently Heineken, have sparked a flurry of activity in the business community on saving water the last 8 years. Coupled with formation of the CEO Water Mandate, a new UN High Level Panel on Water, and new warnings from the World Economic Forum that water represents the number 1 risk in terms of risk to the global economy (WEF, 2015), corporate water stewardship has become an important element with many companies adopting measures to reduce water use at facilities.

Coca Cola has become the first Fortune 500 Company to fully replenish all the water used at its bottling operations. The company set a target of doing so a decade ago and met that target of giving back water to nature and communities during 2015--through 248 community water partnership projects in 71 countries that focused on safe water access, watershed protection and water for productive use (see Rozza and others, 2013). While Coca Cola and other companies have worked some through their agriculture supply chains to find savings, much more remains for business to accomplish. Multi-nationals need to take the lead in going beyond just their facilities and provide resources, assistance, and incentives to its suppliers to save water and apply proper SLM as part of IL&WRM. NGOs and governments of the North can catalyze the partnerships necessary with businesses and governments in the South toward reforms.

If multi-national corporations walk the talk with their agricultural supply chains and influence high-level government officials with whom they interact, a good deal of progress can be made through IL&WRM to reach multiple SDGs. Scaling up of co-management of land and water resources will be the key.

8. CONCLUSION – CO-MANAGEMENT IS A REALISTIC STRATEGY FOR ACTION

In the 30-40 years since the green revolution of intensive irrigation and other inputs reached its objective of growing more food, the reality has set in that such single sector action has devastated biological diversity and depleted and degraded precious surface and groundwater supplies. Careless use of agriculture land and deforestation have increased land degradation and reduced crop productivity when up to 70% more food is needed when measured by caloric value. The concept of IWRM was developed by water people and not sufficiently integrated with the agricultural and land use community. Lack of sound surface and groundwater governance has made the situation worse when coupled with increases in droughts and floods as climate changes. Water resources will continue to decline until agriculture and land use interests work together in a participatory fashion on a hydrologic unit basis—integrated land and water resources management or IL&WRM. Aquifers have no hope of sustainability until growers, producers, and pastoralists become active members of the water community to protect sensitive recharge areas. Co-management will become more of a reality because there is no other option with the decline in water resources. Studies presented in this paper identify up to 40% of people on the planet living with at least some water scarcity and prospects for feeding the hungry are dim without real change.

Over the last several decades, many policies and best practices have been identified to reverse land degradation, save water irrigation, combat deforestation and desertification, and integrate land into water resources management. The examples presented herein illustrate great potential for scaling up. It is a new day with the business community now understanding its profits will be limited unless sound IL&WRM is implemented in its supply chains. World leaders have come together to adopt the SDGs and provide new political will for action to achieve poverty reduction, sustainable land management, and sustainable water management. Serious perturbations of climate with increased droughts and floods have devastated countries and economies providing another driving force for action---climate change adaptation. Development assistance organizations like the GEF have shown that scaling up would be difficult single project by single project. Programs of multiple integrated land and water projects over a decadal time scale are necessary—not just for on-the-ground measures but also for policy, legal, and institutional reforms to sustain and internalize within governments IL&WRM. With money from the North comes the responsibility for reforms from the South. Without resources from the North and leadership from the business community, the reforms will not be forthcoming for IL&WRM. The longer the North waits, the more poverty, poor governance, social unrest, and refugee influx will become intractable problems.

In the US, there is a television commercial with the slogan "pay me now or pay me later". It refers to changing oil frequently in your vehicle and using a good oil filter…or the owner will pay more with expensive engine repairs at a later date. The time for "pay me now" is here! Scaling up of IL&WRM policies and practices needs political will and resources now. There is no better time with the opportunities that are now present with corporate awareness that profits are at risk, climate change adaptation, and the new SDGs being adopted by Heads of States. The measures are proven, the reforms have been enacted on a limited scale, and the modalities of assistance through partnerships have been tested. Implementing "green water management" in rain-fed basins will be more straight-forward.

Implementing water savings in areas of depleted surface and groundwater from intensive irrigation will be more difficult, but savings of 20% of consumptive use are not out of the question if the Hai Basin GEF case is any indication. But experience tells us these IL&WRM measures will not be enough. While improved IL&WRM measures and associated polices need to be up-scaled as soon as possible, there is an associated set of interventions and global campaigns needing to be waged on the longer term, difficult, and politically sensitive policy issues. Land tenure reform, gender issues involving land rights, girls education and reproductive health, water rights and allocation systems, pricing policies, global trade policies, reduction of agricultural subsidies, land grabs, and market mechanisms all need intensive attention if the SDGs are to are achieved and additional security concerns avoided.

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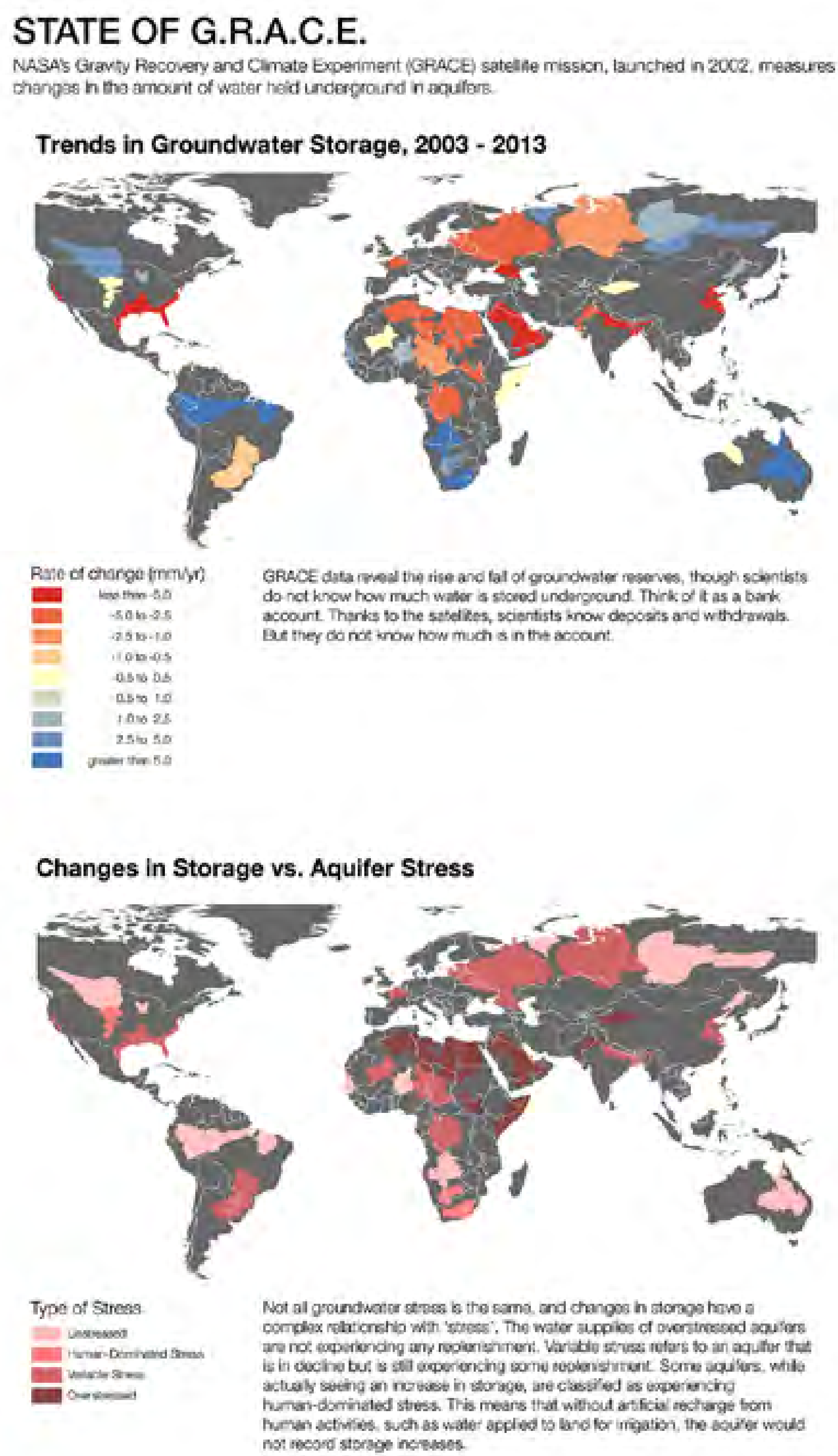
Figure Annex 1A: **Groundwater Hotspots of Depletion (Walton, 2015).**



GLOBAL LAND OUTLOOK WORKING PAPER

United Nations
Convention to Combat Desertification