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AGRICULTURE IN A WATER SCARCE WORLD

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DESCRIPTION OF THE ISSUE

According to the McKinsey report (2009), the world is facing a water scarcity challenge where agriculture is its predominant consumer. It accounts for approximately 3100 billion m^3, or 71 percent of global water withdrawals today, and is expected to increase to 4500 billion m^3 by 2030. This increase is due to a number of factors: growing population and the ever growing necessity to cater for its food needs, economic growth, the variability of precipitation trends and increase in global temperatures. In addition to the increase in water scarcity, the agricultural sector faces an enormous challenge of producing almost 50% more food by 2030 and doubling production by 2050 (OECD, 2010). The main objective of this proposal is to discuss and shed light on different policies to sustainably manage our water resources in agriculture, which is the greatest consumer of this resource, as a reaction to the increasing stresses on this sector due to growing food demand in the presence of current and predicted climate changes and water management practices.

Most scientists agree that the water cycle is highly affected by climate change. The Intergovernmental Panel on Climate Change (IPCC) predicts that the average global surface temperature will increase by additional 2.0-11.5°F by the year 2100 (National Academies, 2008). The climate change will affect the amount, spatial distribution and the quality of global water which will highly affect the agricultural sector. First, with the increase in the temperature, the ice from the mountains melts faster. In irrigation systems that rely on high mountain glaciers for water, high runoff periods will advance earlier in the spring, when irrigation water demand is still low (UN-Water, 2010). The agricultural water consumption "evapotranspiration, soil evaporation and interception loss" increases and heat damage during the flowering stage occurs mainly for the tree crops such as citrus and fruit (Morrison et. al., 2009). Second, the change in the precipitation form from "snow to rain" will affect the seasonal flow in rivers. This change highly affects the agricultural sector—mainly the cultivation pattern since many farmers in the world depend on the snowmelt in the spring and summer time for crop irrigation. Third, precipitation intensity increases, or "the amount of precipitation per unit time", will increase the potential of the erosion of fertile soil, which is highly influenced by the quality and the quantity of agricultural products. Moreover, as intensity of precipitation increases, the higher the potential occurrence of dangerous floods and the lower the potential for groundwater recharge and soil water content. Hence, severe reductions in river runoff and aquifer recharge are expected in much of the world: the Mediterranean basin and in the semi-arid areas of the Americas, Australia and Southern Africa. This reduction affects the water availability and quality in these already water stressed regions (UN-Water, 2010). Fourth, the decrease in the precipitation frequency, "how often the precipitation occurs", will reduce the groundwater recharge, reduce the flows in the rivers and affect the water availability for the agricultural sector, mainly rain-fed crops such as fodder.

Many scientists expect alteration of the distribution of agriculture across the globe, shifting potential to high latitude areas, whereas in low latitudes where the majority of the developing countries lie, more frequent and severe droughts as well as floods will hurt subsistence agriculture in the semi-arid zones (UN-Water, 2010). With the dramatic changes in the climate and the population increase, the food production for domestic and livestock consumption depends on how the global water resources will be managed and used spatially and temporarily. Gerten (2010) summarizes that: there is a huge potential to produce "more crop per drop" in rain fed (and also irrigated) agriculture in many regions of the world. However, it appears that even under the management options considered here, freshwater resources on current agricultural land may not suffice to sustain a rising global food demand.

SUMMARY OF THE POLICY ACTIONS

Many different intergovernmental and non-governmental bodies have met over the past few decades to investigate, discuss, and plan for the future agricultural fresh water needs. Organizations such as the United Nations (under the auspice of UN-Water), the Intergovernmental Panel on Climate Change (IPCC), the Organization for Economic Cooperation and Development (OECD), along with many others, define and outline the policy goals for the international community to better their efforts at sustainable water resource management in agriculture. Conferences addressing the importance of water began almost three decades ago with the 1972 United Nations Education, Scientific and Cultural Organization's Conference on the Human Environment in Stockholm. This forum was followed by the 1977 United Nations Conference on Water, Mar del Plata. The United Nations Food and Agriculture Organization (FAO) cites that without policies in place to protect from water stress, increasing water scarcity throughout the globe affects entire regions and people that are dependent on irrigational farming (FAO, 2006).

OECD states that many countries are addressing the combination of global climate change, rising populations, and agricultural water management techniques through policy regulations. "These regulations concern not only the use of water and management of water resources, but also strict regulations on the use of potentially polluting inputs such as pesticides, industrial fertilizers and manure (storage, management and field application) and land management measures to prevent the polluting agents from reaching surface waters and/or groundwater" (Vojtech, 2010). Policies that are future-focused entail regulating where the water used for irrigation purposes comes from: "Some countries (e.g. Australia, some states in the United States) manage a system of water abstraction rights and a system of tradable quotas and permits for water use" (Vojtech, 2010).

Two positive international examples of groups addressing water scarcity through transboundary water management cooperation and planning are International Commission on Irrigation and Drainage (ICID) and the Nile Basin Initiative. In existence since 1950, the ICID is "dedicated to enhancing the worldwide supply of food and fibre for all people by improving water and land management and the productivity of irrigated and drained lands through appropriate management of water, environment and application of irrigation, drainage and flood management techniques" (ICID). They are a non-governmental organization that is inclusive of most of the nation-states in the world working towards a common goal of increasing techniques as well as production. Due to historical insecurity surrounding the river, the Nile Basin Initiative, or NBI, set forth policy guidelines inclusive of sustainability as well as efficiency and equitability for participants regarding the Nile River water usage. The NBI "seeks to develop the river in a cooperative manner, share substantial socioeconomic benefits, and promote regional peace and security" (NBI). These two organizations shed light on how sovereign nation-states can and

do work together towards solving a problem that affects all of their citizens.

Other policies that currently exist are somewhat restricted to local, regional, or national levels. Examples can be found for specific regulations and they are inclusive of African, Arab, Canadian, Mexican, and the United States (International Water Law Project; World Water Council). The European Commission has a policy, entitled "EU Water Framework Directive," that is currently in place. Article 251 of the directive explicitly states, "Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such" (European Commission). Some nation-states are acknowledging the fact that mitigation techniques for global warming will not assist them in avoiding the on-coming water crisis. They are experiencing the lack of water resources immediately and must change some of their tactics now. Adaptation to the change in the hydrological cycle has encouraged (or forced) those people in the agricultural sector to look at different ways to grow their crops. In areas where there is extreme water scarcity, the "policy" can be to use wastewater—which, unfortunately, has not been treated properly. Communities that incorporate the use of this form of water may be currently facing droughts or a reduction in the water typically received from dams, rivers, etc.

While it is agreed upon by the international community that policies about water resource management (irrigation practices, etc.,) must recognize the necessity of a change in approach, there is no "one" policy that fits the entire globe or could be implemented by every country. Both OECD and the World Bank are pro-market-based in their approach to solving the water scarcity issue. The OECD states, "A mix of market-based, voluntary and regulatory approaches are addressing these issues. But there is widespread recognition of the need for greater use of market-based instruments, such as better pricing structures and tradable permits, accompanied by government regulations, as well as co-operative and local efforts among water providers and users." The World Bank, in reference to the increasing costs of water availability, denotes that the public alone cannot afford the predicted price escalations and that the private sector will become more involved in the shaping of water resource policies. A controversial issue for an international global policy is that water, although it is an international resource, is located within nation-states' boundaries. Attempting to "force" nation-states to "share" their water resources through an international policy might not be viewed as a reflection of their sovereign rights (Eckstein, 2009).

ECONOMIC IMPLICATIONS AND CONSTRAINTS

The need to optimize the agricultural process is a necessity. A controversial issue lies behind growing the same crops with varying amounts of water due to using dissimilar irrigation technologies. Different countries and areas in the world vary with respect to technological advancement and ability to afford and shift to newer more efficient practices.

Water productivity, defined as the output per unit of water volume consumed, varies from place to place. This process is not just a matter of available technology or available human, social and institutional capital. Water productivity is also related to climate. From a climate and soil perspective, an example of the Nile River's water could be more productive for the crops in the highlands of Ethiopia than for making the same downstream in the desert of Egypt. In this case, the actual water productivity in Egypt reaches close to its potential, while in Ethiopia, the actual productivity is far below its potential, so that Egypt's actual water productivity is still higher. The fact that different countries have different water productivities creates a comparative advantage for those countries that have relatively high water productivity in producing water-intensive crops (Hoekstra, 2010).

The issue further goes beyond the complexity of allocating water type resources and areas of higher water productivity to actually making use of this knowledge through trade. Not only agricultural products are meant by trade, but also the trade of the water embedded in growing those products, known as virtual water. An obvious effect of international trade in water intensive commodities is that it generates water savings in the countries that import those commodities. This effect has been discussed since the mid 1990s (Allan, 2001; Hoekstra, 2003). In the period 1997-2001, Japan (the largest net importer of water intensive goods in the world) annually saved 94 billion m^3 by not using its domestic water resources. This volume of water would have been required, in addition to its current water use, if Japan domestically produced products instead of importing them. Similarly, Mexico annually saved 65 billion m^3, Italy 59 billion m^3, China 56 billion m^3, and Algeria 45 billion m^3 (Chapagain et al., 2006). Water should be viewed and recognized as a global resource, and the actual amounts of water saved by the countries previously listed should be viewed as a reduction to a global water bill. The whole world's responsibility is to bring this bill down. A major example of virtual water import is Jordan. Jordan imports close to 90% of its food (Forbes, 2008). Importing five to seven billion m^3 of water in virtual form per year is in sharp contrast with the 1 billion m^3 of water Jordan withdraws annually from its domestic water sources (Haddadin, 2003; Hoekstra and Chapagain, 2007, 2008). Taking an extreme side of this issue, if trade of food products did not exist, Jordan would be forced to extensively use its domestic water resource which is mainly blue water (surface or ground water), thus depleting it and rapidly causing hunger threats. Yet by externalizing its water footprint, Jordan is in a weak spot of water dependency which could be costly on the political and social levels.

Hoekstra (2010) mentioned that according to international trade theory that goes back to Ricardo ([1817] 2006), nations can gain from trade if they specialize in the production of goods and services for which they have a comparative advantage, while importing goods and services for which they have a comparative disadvantage. This is elaborated by Wichelns (2004), as he explains the economic efficiency of trade in a water-intensive commodity is attractive if the opportunity cost of producing the commodity is comparatively low. This is the case when there is a relatively high production potential for the water intensive commodity due to, for example, relative abundance of water and/or a relatively high water productivity (yield per unit of water input) in the country. Import of a water-intensive commodity (instead of producing it domestically) is economically attractive if the opportunity cost of producing the commodity is comparatively high because water is relatively scarce and/or water productivity in the country is low.

SYNTHESIS OF THE ISSUE

Even though shifting to more efficient and less water consuming irrigation techniques would seem like a major contributor to reduce our water use, the "type" of water used for growing the crops is a significant dimension that should be put into perspective. When calculating the water "footprint" of growing a certain crop, consideration should be made to the source of this consumed water. Irrigation of crops could be done through the use of "green" and "blue" water. "Green" water is the precipitation on land that does not runoff or it recharges the ground water but is stored in the soil or temporarily stays on top of the soil or vegetation. Eventually, this part of precipitation evaporates and transpires through plants. "Blue" water is the fresh surface or ground water coming from fresh water lakes, rivers and aquifers (Water Footprint Network 2010). Though growing wheat, for example, would consume the same total amount of water when grown in two different places in the world, the fractions of blue and green water needed are major in determining the sustainability of the process. Green water generally has a lower opportunity cost than blue water. The more blue water intensive the agricultural process is the

more the water withdrawal and stress on the aquifers and water tables. Putting this concept in mind, the choice of what and where to grow should be defined after spatially allocating the presence and types of waters in different areas around the globe in order to get higher water productivities while keeping practices and uses sustainable.

After reviewing the literature it is clear that the issue of achieving food security through agriculture in our water scarce world is multidimensional covering social, economic, and political issues as well as concepts of climate and resource variability, technological advancement (and availability) and global trade. No one plan or policy is sufficient to cover all aspects of concern and could come up with a magic solution that would be attractive and applicable by all parties and systems. It is vital that the problem should be identified and broken down at a global scale after regarding water as a global resource. After reaching the level of different smaller interconnected components of the problem, solutions could be applied and achieved at local or regional levels. A possible approach to solving this issue would start by identifying the present and projected amounts and kinds of foods our growing global population demands.

RESEARCH PROPOSAL

As stated earlier, the main concern is finding an innovative way to properly and sustainably manage our agricultural sector in the presence of different constraints and changes discussed in order to feed our "hungry" world. We are aware of the absence of an exhaustive global policy regarding that issue as all initiatives until this point fall in the circle of discussions and recommendations on the global level, where implementations have only been successful on a regional level.

Currently arising are different questions that might limit or constrain achieving a solution:

- Are the agricultural products globally distributed spatially to fulfill the global food needs based on the lowest opportunity cost possible?
- Are the practices in the agricultural sectors set towards adopting optimized practices that would improve on the quality and quantity of the products with the same amounts of water? (i.e., is the concept of "more crop per drop" effectively used?)
- Do we have an exhaustive study which identifies optimal places for growing different crops that could be updated regularly with changing resources and limitations?

A major impediment causing this issue is the absence of cohesive global policies that organize and guarantee the rights of all concerned parties, especially developing countries who are least capable of accommodating to changes and are the most at risk from a political and socioeconomic standpoint. They are the first to be affected by major global events such as food spikes. This vulnerability demonstrates a need for a global non-governmental body to make sure that resources are properly allocated and food would be within the reach of all populations while emphasizing the use of sustainable and efficient practices but setting aside all other factors. Hunger is a global issue, but it is a fact that solving the issue could only be feasible at a local scale. For that reason, this body would consist basically of agricultural ministries of all countries, as well as UN agencies and Programs, UN regional commissions, non-UN Partners.

An extensive study is proposed to be done by this body in order to identify the areas which are expected to have increase in precipitation due to climate change, along with areas of fertile soil and adequate conditions of water abundance and technologic advancement in which applying agricultural practice would be optimum and most efficient. Specific crops could be assigned to particular areas to be grown in order to achieve efficiency. This means that a major shift would have to happen in the allocation of agricultural practices in order to optimize the system. This is

major and would not happen immediately, but policies need to be working in this direction. In this sense, assigned lands all over the globe will be responsible for acting as a "food basket" feeding the entire global population attempting to achieve food security, reducing world hunger and optimizing the use of our resources.

This proposed non-governmental body should be given the power to enforce a global policy in which agricultural practices are improved for food availability for the earth's population. By being a part of the NGO, each nation-state would relinquish some of their sovereignty over their agricultural sector in order to work together for the common global goal of supplying ample food. This policy would be economically incentivized because groups such as the World Bank would encourage the implementation of the policy (realizing that an increase in agricultural products equates to more profit as well as reducing the amount of time/money/labor spent on ineffective irrigation techniques would be economically intelligent).

It is definite that the creation of such a body won't happen overnight. The need for spreading awareness of the concept of feeding the global population especially in countries which are agriculturally sufficient is essential at this stage. Such countries should be educated that the luxury of growing food and having it readily available today might not be the case in the next fifty years, where the need of adopting such a policy would be more essential yet harder to implement. In the case of global agreement to move forward with such a proposal, a lot of communities suffering from hunger would be able to get the proper nutrition sufficient for their diets. Moreover, it will prevent countries on the verge of hunger to go through dealing with this issue. So, if successful, the proposed global NGO would cause in an increase in the amount of food produced

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