A Study on Impacts on Global Warming on Sustainable Agriculture

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Abstract: Agriculture is a human activity that is intimately associated with climate. It is well known that the broad patterns of agricultural growth over long time scales can be explained by a combination of climatic, ecological and economics factors. Sustainable agriculture can be broken into three components: economic, environmental, and social. A major concern in the understanding of the impacts of climate change is the extent to which agriculture will be affected. Global climate change has become an important area of investigation in natural sciences and engineering, and irrigation has often been cited as an area in which climate change may be particularly important for decision- making. Although climate change is expected to have a significant impact on water availability and irrigation requirements, the extend and effect on the water resources planning and management process remains largely unknown. Climate change has many effects on the hydrological cycle and thus, on water resources systems. Global warming could result in changes in water availability and demand, as well as in the redistribution of water resources, in the structure and nature of water consumption, and exasperate conflicts among water users. Impact of global warming on crop water requirements plays a role of paramount importance in assessing irrigation needs. The planning and design process needs to be sufficiently flexible to incorporate consideration of and responses to many possible climate impacts. The main factors that will influence the worth of incorporating climate change into the process are the level of planning, the reliability of the forecasting.
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1. Introduction

Global climate change has become an important area of investigation in natural sciences and engineering, and irrigation has often been cited as an area in which climate change may be particularly important for decision- making. According to the Intergovernmental Panel on Climate Change, IPCC (1996), climate change would affect precipitation patterns, evapotranspiration rates, soil moisture and infiltration rates, the timing and magnitude of runoff and the frequency and intensity of storms. Subsequently, changes in evapotranspiration rates can substantially, alter rainfall-runoff processes, adding uncertainty to the understanding of important links between the hydrological cycle and ecosystems behavior. The level of atmospheric carbon dioxide (CO2) may, also, affect both water availability and demand, through its influence on vegetation.

Although climate change is expected to have a significant impact on water availability and irrigation requirements, the extend and effect on the water resources planning and management process remains largely unknown. Though a major effort has been devoted to analyzing the potential impacts of global climate change on water resource systems, by contrast relatively little has been done to review the adequacy of existing water planning and evaluation criteria in the light of these potential changes. In this context, the lack of consistent understanding and application of basic evaluation principles in the agricultural sector has, so far, hindered the prospects for devising an integrated assessment to account for the linkages between climate change and irrigation development. The challenge today is to identify short-term uncertainty. The question is not what is the best irrigation development over the next four or five decades, but rather, what is the best development for the next few years? Knowing that a prudent hedging strategy will allow time to learn and change course.

All these problems will become more pronounced in the years to come, as society enters an era of increasingly complex paths towards the global economy. In this context, European and global environments are closely linked by global processes such as climate patterns, hydrological conditions and socio-economic factors transcending regional boundaries. Consequently, achieving sustainable irrigation development in Europe will depend on the above factors and on the basic policies adopted by our society in the decades to come (Bakhtiari and Haghi 2003).

What is global warming?

• A rise in temperature over the earth's surface,
• Thought to cause extremes of weather e.g. drought, floods, hurricanes etc,
• Thought to be caused by human activity,
• Possibly caused by pollution. Chiefly the amount of carbon we add or leave in the atmosphere.
• It may increase temperature levels word wide (Ewings, 2008).

How dose global warming happen?

• Burning fossil fuels – coal, gas oil etc – releases harmful gases into the atmosphere,
• Carbon Dioxide (CO^2) is one of these gases – it is called a "greenhouse" gas because it stops heat escaping from the atmosphere,
• By continually producing CO^2 we are trapping even more heat in the atmosphere causing global warming,
• CO^2 has increased by 10% in the last 100 years (Ibid).

What are the consequences of global warming?

• Polar ice caps could melt – evidence suggests this is already happening – increasing sea/ocean levels,
• Causes flooding to low lying land – particular problems for countries like Netherlands and Bangladesh,
• Less water vapour in the atmosphere leading to more drought,
• Causes extremes of weather – hurricanes, flooding and droughts – which is very problematic for areas which do not normally have these types of weather conditions,
• Reduction in Ozone Layer which protects the world from ultra violet rays from the sun (Ibid).

What is meant by sustainable agriculture

The classic definition of sustainability gleaned from the Brundtland report rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. In relation to environmental considerations the basic issue is whether agricultural activities can produce food efficiently and at low cost (and therefore benefit consumers) and profitably (benefiting farmers) without degrading natural resources. Advances in productivity, linked to pesticide use, mechanization, livestock intensification etc., have invariably been associated with environmental damage as noted above. In Northern Ireland for example the use of animal wastes and artificial fertilisers have contributed to the eutrophication of many rivers and lakes while fish kills are regularly reported due to release of farm effluent into freshwaters. However, the concept of sustainable agriculture is a complex one that incorporates a number of other, arguably, equally important factors.

Legg points out that while the basic premise of sustainable agriculture, outlined above, is easily understood there are important characteristics of sustainable development applicable to agriculture that should be noted:

"First, it is a dynamic process, which focuses on the ability of the economy to meet demand in cost-efficient ways through developing, combining and substituting resources in the production process — provided that there are appropriate signals to producers and consumers on which they can make their decisions.

• Second, it is a global concept, which recognises that allowing flows of resources between sectors and economies through international trade can maximise production while reducing pressure on fragile resources.

• Third, it is a multidimensional phenomenon, encompassing economic, environmental, and social dimensions. The concept of sustainable development goes beyond the economic growth that is conventionally measured in Gross Domestic Product, and takes into account the state of resources and environmental performance of the economy, as well as current and future social and distributional aspects (Northern Ireland Assembly, 2001).

Objectives for sustainable agriculture

Sustainable agriculture must:

Produce safe, healthy food and non-food products in response to market demands, now and in the future

Enable viable livelihoods to be made from sustainable land management, taking account of payments for public benefits provided

Operate within biophysical constraints and conform to other environmental imperatives

Provide environmental improvements and other benefits that the public wants - such as re-creation of habitats and access to land

Achieve the highest standards of animal health and welfare compatible with society's right of access to food at a fair price

Support the vitality of rural economies and the diversity of rural culture

Sustain the resource available for growing food and supplying other public benefits over time, except where alternative land uses are essential in order to meet other needs of society (Sustainable Development Commission, 1999).

The Components of Sustainable Agriculture

Sustainable agriculture can be broken into three components: economic, environmental, and social. While discussed separately here, it should be noted that the goals overlap, impacting and influencing each other. For example, economic decisions will also impact the environmental and the social components.

Economic sustainability

To be truly sustainable, a farm must be economically profitable. The environmental and social benefits of sustainable production methods do not always translate into economic gains. Some farms that operate sustainable may be more profitable than their conventional farming counterparts; however, the reverse can also be true. Many factors aside from crop production methods can affect the bottom line. These can include, among other things, the grower's management strengths/weaknesses, decision making abilities, and marketing skills. That said, sustainable agriculture practices can have a positive economic impact on a farm. For example, diversifying the farm with several crops and markets helps to reduce financial risk.

ENVIEONMENTAL SUSTAINABILITY

Environmental concerns are central to sustainable agriculture. Sustainable agriculture is frequently described as: ecologically sound practices that have little to no adverse effect on natural ecosystems.

However, more than that, sustainable agriculture also seeks to have a positive impact on natural resources and wildlife. This can often mean taking measures to reverse the damage (e.g. soil erosion or draining of wetlands) that have already occurred through harmful agricultural practices. Renewable natural resources are protected, recycled, and even replaced in sustainable systems. Also inherent to sustainable agriculture environmental concerns is the stewardship of non-renewable resources, such as fossil fuels.

Achieving a healthy, balanced ecosystem takes time. Making the transition to sustainable farming is a process that generally requires moving forward step-by-step. While there are common goals that are critical to sustainable agriculture, there is no single approach that will guarantee sustainable success on every farm. The methods for accomplishing those goals must be tailored to the individual farm.

A key to successful sustainable production is healthy soil. Depending on the condition of the soil, it can take several years to build up organic matter and improve soil quality. Sustainable methods of enhancing soil fertility and improving soil structure can include: using nitrogen fixing legumes, green manure, and animal manure; minimizing or eliminating tillage; and maintaining year round soil cover. Fertilizer decisions are based upon soil test results. While synthetic fertilizers can be used to supplement natural inputs, they are applied on an as-needed basis. Synthetic chemicals known to harm soil organisms and soil structure must be avoided in sustainable agriculture.

Insects, diseases, and weeds are managed, rather than controlled, in sustainable systems. The goal is not necessarily the complete elimination of a pest, but rather to manage pests and diseases to keep crop damage within acceptable economic levels. Sustainable pest management practices emphasize prevention through good production and cultural methods. Some strategies include:

Using crop rotations that will disrupt the pest life cycle, improving soil quality, practicing good sanitation, using optimum planting densities, timing planting and transplanting operations to avoid high pest populations, employing biological control, and growing resistant varieties. Monitoring pests through frequent crop inspections and accurate identification are essential to keeping ahead of potential problems. Many Integrated Pest Management techniques can be incorporated into a sustainable program.

Social sustainability

Social sustainability relates to the quality of life for those who work and live on the farm, as well as those in the local community. Fair treatment of workers, positive farm family relationships, personal interactions with consumers, and choosing to purchase supplies locally (rather than from a more distant market) are just some of the aspects considered in social sustainability.

Community supported agriculture (CSA), farmers markets, U-pick, cooperatives, and on-farm events are just some of the ways a sustainable farm can have a positive impact on the local community. In essence, the farm supports the community and the community supports the farm (Kluson, 2001).

Constraints in Achieving Sustainable Agriculture

Climate change could cause irreversible damage to land and water ecosystems and loss of production potential in agriculture. It would affect the agro-ecological suitability of crops, which may lead to increased pest and disease infestations. Climate change will have a disproportionate impact on poor people in rural areas where livelihoods of the majority depend on agriculture. Depletion of soil fertility and degradation of forest resources, water resources, pastures, and fisheries is already aggravating poverty in the country (Manzanilla, 2007).

Environmental impacts of agriculture

Soil quality the soil itself should be protected from further erosion, salination, loss of organic matter and accumulation of Heavy metals. Loss of organic matter from soils means increased greenhouse gas emissions as carbon is released. The National Soil Inventory has shown that the organic content of soils is decreasing.viii Soil quality is of course vital to the long-term productivity of farming.

Landscape Farming shapes much of our landscape – over 70 per cent of UK land is farmed.

Water quality and quantity Use of water for irrigation has increased dramatically over the past 20 years. Over-abstraction of water is already causing damage to ecosystems, while use of irrigation can cause soil salivation over time. Surface and ground water must be protected from pollution by animal waste, cryptosporidium, pesticides, nitrates and phosphates. In 1999 agriculture was the source of 14 per cent of water pollution incidents in England and Wales. In addition to pollution incidents, agriculture also delivers low level pollutants to watercourses, such as pesticide and fertilizer run off from fields. Agriculture is also the main source of nitrogen in watercourses, which causes eutrophication.

Air quality Farming creates dust and smells, and contributes to acid deposition. Agriculture's contribution to acidification has become proportionally more important as other sectors have reduced emissions.

Climate Agriculture directly emits around 8 per cent of UK greenhouse gases. These emissions are projected to decline in the future, due to reduced and more targeted use of fertilizer, and a decrease in livestock numbers resulting from market and policy constraints. I Agriculture's contribution is predominantly through emissions of methane and nitrous oxide.

Biodiversity Protecting the genetic resource base, in terms of species used for food and also other life on and around farms is essential. We must protect the current diversity of plants and animals used for food – this will ensure that food production systems are robust in the face of disease and changing environmental conditions.

Wildlife and semi-natural habitats there is a need to protect the diversity of animal and plant life associated with farming. Wildlife is important as part of the genetic resource base, and also because of its value to people (Sustainable Development Commission, 1999).

AGRICULTURE AND ENVIRONMENT

A. Agriculture and land use

The term "land use" is more comprehensive than the term "soil use". Land, commonly, stands for a section of the earth's surface, with all the physical, chemical and biological features that influence the use of the resource. It refers to soil, spatial variability of landscape, climate, hydrology, vegetation and fauna, and also includes improvements in land management, such as drainage schemes, terraces and other agrobiological and mechanical measures. The term "land use" encompasses not only land use for agricultural and forestry purposes, but also land use for settlements, industrial sites, roads and so on [1].

B. Land degradation and desertification

Because of the current climate patterns and intensification of human activities Mediterranean countries are already faced with a real threat of land degradation and desertification and there is no doubt that the present enhanced greenhouse effect will only exacerbate this threat in the short term.

The main causes of these processes can be summarized as follows:

change of agricultural systems towards specialized – mechanized hill farming;

modification of morpho – structural and infrastructural features of the cultural landscape concerned;

abandoned, previously cultivated fields and/or farms and their man-made structural and infrastructural elements;

increase in forest and pasture fires.

In the eighties and early nineties, global warming and the impact of the agricultural systems introduced in the sloping lands of the Mediterranean environment in the previous decades were identified as the main culprits of soil erosion and land degradation. Accelerated runoff and erosion, previously unreported, began to be observed in cultivated sloping areas. The unprecedented pressure to increase crop productivity at lower costs, made possible by the technological revolution in agricultural management, had led to soil erosion in the agricultural ecosystem, due to hydrological impact, resulting in severe deterioration in soil fertility and degradation of the landscape.

After having thoroughly examined the problem, the scientific community concluded that a more detailed evaluation of the situation in the different Mediterranean environments was needed.

Furthermore, it was recognized that research activities were too fragmentary to be able to cope with the demand for sound soil conservation measures. Another recommendation that emerged was the use of pilot areas for a quantitative assessment of accelerated erosion and of the effects of new conservation measures in the water erosion prone areas of the Mediterranean. It was also suggested that projects be allowed more flexibility, so that programs could be modified during implementation, to benefit from experience gained and lessons learned (De Wrachien, 2004).

C. Agricultural and water use

In the Mediterranean region nearly 70% of the available water resources are allocated to agriculture. In the arid and semi-arid countries of the region agricultural water use accounts for as much as 80% of the water consumed, decreasing to 50% of the total available resources in the Northern countries.

Conclusion

Agriculture is a human activity that is intimately associated with climate. It is well known that the broad patterns of agricultural growth over long time scales can be explained by a combination of climatic, ecological and economics factors. Modern agriculture has progressed by weakling the downside risk of these factors through irrigation, the use of pesticides and fertilizers, the substitution 44 of human labour with energy intensive devise, and the manipulation of genetic resources. A major concern in the understanding of the impacts of climate change is the extent to which agriculture will be affected. The issue is particularly important for the Mediterranean countries, where water availability and sustainable irrigation development pose a growing problem under today's climatic Conditions and entropic pressure. Thus, in the medium and long terms, climate change is an additional challenge that agriculture has to face in meeting national food requirements.

Climate change has many effects on the hydrological cycle and thus, on water resources systems. Global warming could result in changes in water availability and demand, as well as in the redistribution of water resources, in the structure and nature of water consumption, and exasperate conflicts among water users. Scenarios based on GCMs forecasts do not provide sufficiently reliable information for the assessment of the hydrological consequence of climate change at the scale of the Mediterranean region. Nevertheless, it is reasonable to assume that the largest changes in the hydrological cycle are expected for the snow dominated basins of the Alpine Europe, while annual stream flow is likely to decrease over the river basins in the southern part of the region.

Impact of global warming on crop water requirements plays a role of paramount importance in assessing irrigation needs. In the last decade, global vegetation models have been developed that include parameterization of physiological processes such as photosynthesis, respiration, transpiration and soil water intake. These tools have been coupled with GCMs and applied to explore future scenarios at both regional and world-wide levels. In the context of the Mediterranean environment the models outcomes show that irrigation requirements are likely to increase in most irrigated areas in the north of the basin, while in the south the patter becomes complex.

Concerning irrigated agriculture, most of the current 16 million ha of irrigated land, in the Mediterranean, were developed on a step by step basis over the centuries, and were designed for a long life (50 years or more), on the assumption that the climatic conditions would not change. This will not be so in the future, due to global warming and the greenhouse effect. Therefore, engineers and decision-makes need to systematically review planning principles, design criteria, operating rules contingency plans and water management policies.

Uncertainties as to how the climate will change and how irrigation systems will have to adapt to these changes is issues that water authorities are compelled to address. The challenge is to identify short-term strategies to cope with long-term uncertainties. The question is not what the best course for a project is over the next fifty years or more, but rather, what is the best direction for the next few years, knowing that a prudent hedging strategy will allow time to learn and change course.

The planning and design process needs to be sufficiently flexible to incorporate consideration of and responses to many possible climate impacts. The main factors that will influence the worth of incorporating climate change into the process are the level of planning, the reliability of the forecasting.

The development of a comprehensive approach that integrates all these factors into irrigation project selection, requires further research on the processes governing climate changes, the impacts of increased atmospheric carbon dioxide on vegetation and runoff, the effect of climate variables on crop water requirements and the impacts of climate on infrastructure performance.

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