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Climate Change: Implications for Agriculture in the Near East

CONTENTS

I. INTRODUCTION

1. The Intergovernmental Panel on Climate Change (IPCC) was established to assess scientific, technical and socio-economic information relevant for understanding climate change, its potential impacts and options of adaptation and mitigation. In its Fourth Assessment Report, IPCC found the understanding of anthropogenic warming and cooling influences on climate has improved since the Third Assessment Report (TAR), "leading to very high confidence that the globally averaged net effect of human activities since 1750 has been one of warming". [1]

2. In addition, it found that "observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases".

3. Agriculture has multiple roles in any discussion of climate change. Not only is agriculture likely to be one of the victims of climate change, it is also a contributor through greenhouse gas emissions. Yet, at the same time, agriculture also has great potential to contribute substantially to climate change mitigation.

4. It is the purpose of this paper to provide overall information – mainly based on IPCC assessments and other recent reports – on potential climate change impacts, especially as it applies to the mandate of FAO in the Near East Region. In addition to this Introduction, the document includes: (II) a description of impacts in the Region, by sector; (III) a view of potential for adaptation and mitigation of impacts; and (III) conclusions.

II. IMPACTS

Regional impacts in the Near East Region

5. Annex I, an integral part of this document, provides country-by-country data on impacts, vulnerability and climate-related risks. Although some information is not listed for all countries, the missing information can usually be inferred from an ecologically similar country from the same area. The overall picture that emerges from the recent IPCC projections [2] is best analysed in terms of runoff – the difference between rainfall and evapotranspiration – which is related to crop water availability. The description that follows refers to the periods of 1980-99 and 2080-99, with the understanding that changes can be assumed to be gradual during the mentioned period.

6. More than 80 percent of the models agree that most of the region will have a decrease in water availability (expressed as runoff) of up to 40 mm per year, and that the decrease will be twice as high in the Anatolian Plateau. However, water availability could increase between 0 to 40 mm/year from southern Algeria to southern Egypt, most of Sudan and Somalia in Africa, the southern Arabian Peninsula and the south of western Asia – although there is less agreement on these areas among models than on areas with projected water availability decrease. Models agree on the increase (still about 40 mm/year) that could occur in the northeastern part of the Region (which includes parts of Kazakhstan). It is to be stressed that these predictions are a composite that takes into account both rainfall and temperature patterns, as well as the effect of increased temperatures on increased evapotranspiration.

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[1] IPCC, 2007. Climate Change 2007: *The Physical Science Basis, Summary for Policymakers*. Contribution of Working Group I to the Fourth Assessment Report of the *Intergovernmental Panel on Climate Change.*

2 IPCC, 2007. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Solomon, S., D., Qin, M., Manning, Z., Chen, M., Marquis, K.B., Averyt, M. Tignor & Miller, H.L., eds. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.*

7. Regardless of the expected rainfall and runoff patterns, the number of dry days is conjectured to increase everywhere in the region, with the exception of some central- Saharan areas. The number of frost days should decrease everywhere, while heat waves could increase in the Region's more continental areas. The length of growing seasons (LGSs) should decrease.[3] Apparent contradictions (such as decreasing LGS when runoff is predicted to increase) are an indicator of the uncertainties affecting the projections.

8. In all scenarios, the highest impacts are in Africa, the Middle East, India and Southeast Asia. Once temperatures increase by 3°C, 250 to 550 million additional people may be at risk worldwide – more than half in Africa and Western Asia – particularly where the declines in yield are greatest, dependence on agriculture highest and purchasing power most limited. Yields of the key crops across Africa and Western Asia may fall 15 to 35 percent or 5 to 20 percent, depending on whether there is weak or high carbon fertilization respectively, once temperatures increases reach 3 or 4°C.

9. An increase in surface temperature would cause shifts of biogeographic zones northward and to higher elevations in mountain areas, resulting in possible extinction of some species, thinning or disappearance of permafrost, mud-slides and perhaps silting of rivers and dams.

Land degradation

10. In a context where land availability, land degradation, price shocks and population growth are already a major concern for sustained agricultural productivity, changes in temperature, precipitation and climatic extremes will only add to the stress on agricultural resources. Arable land is already limited in the arid and semi-arid areas that cover most of the Near East Region, making agriculture potentially highly vulnerable to climate change.

Extreme geophysical factors

11. There is a growing understanding on the links between climate change and some extreme atmospheric factors. According to IPCC, it is "virtually certain" that fewer cold days and nights will occur over most land, as well as more frequent hot days and nights. Heavy precipitation events and an increase in the proportion of total rainfall that comes from heavy events are "very likely", and it is "likely" that more areas will be affected by droughts and tropical cyclones (Annex 1 includes major extreme factors).

Water availability

12. Water availability is expected to be highly sensitive to climate change. Agriculture accounts for 90 percent of the mobilized water resources, which is around 60 percent of the total renewable water resources in the region. Many of the Region's irrigation systems are under considerable environmental strain due to salinity, water logging or overexploitation of groundwater. Ground water, including non-renewable fossil water, is of primary importance in most countries.

13. A contrasted image is presented by IPCC. According to four models, groundwater recharge will decrease dramatically – by more than 70 percent – between now and 2050 along the southern rim of the Mediterranean. Regions that will have groundwater recharge increases of more than 30 percent by the 2050s include most of western Asia, while in the Arabian Peninsula and the extreme east of the area covered, models predict different patterns.

14. Shifts in precipitation patterns will affect crops, particularly rice, in many countries in the Near East Region. According to one study, temperature rises of 2°C will result in 1 to

[3] This applies to areas where water is the limiting factor. When frost is the limiting factor, LGS may increase.

4 billion people experiencing growing water shortages, predominantly in Africa, the Middle East, Southern Europe, and parts of South and Central America.

15. The Middle East and North Africa are particularly exposed to water shortages. An additional 155 to 600 million people may suffer an increase in water stress in North Africa with a 3°C rise in temperature. Yemen is particularly at risk given its existing low income levels, rapidly growing population and acute water shortage. Competition for water within the region and across its borders may grow, carrying the risk of conflict. Some parts of the Region, notably the Nile Delta and the Gulf coast of the Arabian Peninsula, are particularly vulnerable to flooding from rising sea levels.

Crop agriculture

16. Agricultural productivity in the Near East Region is likely to suffer losses because of high temperature, drought, floods and soil degradation, which, in turn, will put the food security of many countries under threat. Yield losses that may affect agricultural productivity in general and be detrimental to the supply of food may prove somewhat beneficial to growers as prices rise with greater demand for scarce products.[4] Economic losses may prove more manageable than environmental and human losses because economies adjust themselves from both the producers' and the consumers' sides.

17. Due to complex interaction of many factors, crop growing may become unsustainable in some areas. For example, maize yields in North Africa could fall by between 15 and 25 percent with a 3°C rise in temperature. Once temperature increases reach 3 or 4°C, the impacts will be strongest across Western Asia and the Middle East, where yields of the predominant regional crops may fall by 25 to 35 percent with weak carbon fertilization, or 15 to 20 percent with strong carbon fertilization. In West Asia, climate change is likely to cause severe water stress throughout the twenty-first century.

Economic losses due to changes in production and trade

18. Economies of developing countries in the Near East Region that traditionally offer only limited employment alternatives for workers dislocated by the changing profitability of farming and other climatically sensitive sectors may be relatively more vulnerable than those with more diverse economies. Those who are currently poor, malnourished and dependent on local production for food are the most vulnerable to climate change in terms of hunger and malnutrition. Existing vulnerabilities will be exacerbated further by a superimposition of climate change, reduced access to drinking water and reduced income, negatively affecting the health and overall well-being of the population and leading to the further stress of forced migration.

19. Many countries in the region have been major wheat and rice importers. Climate change impact may increase this dependence on imports.

20. By 2100, under a baseline climate change scenario, the average cost of climate change in parts of the Near East Region, especially the Middle East, is predicted to be equivalent to around a 2.5 percent and 1.9 percent loss in GDP respectively, compared with what could have been achieved in a world without climate change. Under a high climate change scenario, the average cost of climate change is predicted to be 3.5 percent of GDP in Africa and the

[4] This may not apply to subsistence farmers. Fischer et al. 2002 identify an overall decrease of GDP of agriculture in developing countries (-1% (Standard deviation < 1)) and Asia (-2.3% (SD < 2)). Fischer, G., Nachtergaele, F., Shah, M. & van Velthuizen, H. 2002. Global agro-ecological assessment for agriculture in the 21st century: Methodology and results. Laxenburg, Austria/Rome, Italy, International Institute for Applied Systems Analysis/FAO

Middle East due to loss of agricultural land and/or threats to coastal cities. Others are vulnerable to increased desertification (Stern, 2006).

21. According to the Stern 2006 review[5], there are reasons to assume that some of the worst projections might materialize, due to the accumulation of extremes. The poorest people would be hit the hardest by climate change and the cumulative effects of extreme weather could be worse than anticipated. If emissions continue unabated, temperatures could rise to much higher levels in the next century, committing the region to far greater impacts. This would include the risks associated with mass migration and conflict. At the 95th percentile, and under the baseline climate change scenario, the projections rise to a 7 percent GDP loss in Africa and the Middle East by 2100. Under the high climate change scenario, the costs of climate change rise significantly to losses of 10 percent GDP at the 95th percentile.

Livestock and rangelands

22. Climate change in arid lands of the region will result in less available soil moisture, exacerbating the current situation of the already degraded land. Rangelands are the dominant land types in the Near East and, because of their extent, small changes in vegetation cover can significantly affect the organic carbon dynamics and storage in the ecosystem.

23. The livestock nomadic system spreads over a wide area with low and erratic rainfall, extending from the dry and low rainfall rangelands in the Middle East and the Arabian Peninsula to the high rainfall areas (above 1200 mm) in southwest and southern Sudan. It is in this area that further decline in available moisture is expected, resulting in an overall decline in productivity.

24. In temperate areas, temperature increases may lead to an increase in pasture production in mid-latitudes, with corresponding increases in livestock production. In general, unhoused livestock are expected to benefit from warmer winters, particularly in the higher latitudes in the eastern Near East Region and at higher elevations, with minor improvements in feed quality in temperate high-rainfall zones possible. However, greater summer heat stress is likely to occur with negative affects on animals.

25. Livestock pest and disease distribution and their transmission patterns will be altered, with epidemics almost certain.

Forests

26. In the Near East, the majority of forest products are used for subsistence and in support of small-scale, household-based enterprises that provide income and employment for rural people, especially women. Despite their importance for local economies and livelihoods, forest products in the Near East remain largely neglected in the policy and decision-making processes of natural resource management.

27. A depletion of soil moisture may cause the productivity of major species to decline, increase fire risk and change the patterns of the Region's main pests and diseases. Modification in the habitat will subsequently induce changes in the wildlife population.

Freshwater and ocean fisheries

28. The Near East Region has a vast coastal area and several rivers with good potential for fishing. The Near East Region has become a net exporter in the fisheries sector, but its global

[5] Stern, N., S., Peters, V., Bakhshi, V., Bowen, A., Cameron C., Catovsky, S., Crane, D., Cruickshank, S., Dietz, S., Edmonson, N., Garbett, S-L, Hamid, L., Hoffman, G., Ingram, D., Jones, B., Patmore, N., Radcliffe, H., Sathiyarajah, R., Stock, M., Taylor, C., Vernon, T., Wanjie, H. & Zenghelis D. 2006. Stern Review: *The Economics of Climate Change*. HM Treasury, London. 575 pp.

share of trade is marginal, accounting for only about US$135 million in 1999. According to IPCC, many basins already suffer from a lack of water. These basins are located, among others, in Africa, the Mediterranean region and the Near East.

29. It is extremely difficult to predict how climate change may affect fish stocks and the fishing industry, particularly in the context of the present stresses on fish stocks. While higher ocean temperatures may increase growth rates of some fish, the reduced nutrient supplies that result from warming may limit growth. Ocean acidification is likely to be particularly damaging.

30. According to IPCC, effects on macrophyte communities and spread of warmer water species due to increased temperatures already have been observed in the Mediterranean, as have changes in populations, recruitment success, trophic interactions and migratory patterns of fish populations.

III. ADAPTATION AND MITIGATION OF IMPACTS

Vulnerability and adaptive capacity in the Near East Region

31. Vulnerability is directly related to a country's ability, or inability, to adapt. Annex I shows some indicators describing current vulnerability patterns as well as conjectured impacts as derived from some recent studies. In Central Asia (30N-50N; 40E-75E), IPPC studies indicate with "high confidence" that crops are highly vulnerable and livestock may suffer due to deterioration of rangeland; water resources are "likely" to become more vulnerable because of reductions in runoff and groundwater recharge, higher transmission losses in irrigation systems and more evapotranspiration from crops; and water stress may increase. In North Africa's current marginal areas, agricultural losses are "likely" and even "very likely", and crop yield and rangeland production will decrease due to the impact of increased temperature and decreased precipitation. The number of people under water stress will increase, for the same reasons as explained for Central Asia.

32. Based on relatively old data on actual arable land in use and irrigated areas from the mid-1990s (refer to Annex I), a rather diverse picture emerges for different countries. For instance, while Algeria and Iraq probably still have potential to expand agricultural areas (Algeria has 61 percent of potentially arable land actually in use; Iraq has 75 percent), others such as Yemen and Saudi Arabia reach high percentages of 317 and 237, respectively because they have expanded into marginal lands.

33. Most countries have no or very limited rainfed cropping potential (Kuwait, Oman, Qatar, Saudi Arabia, UEA and Yemen all have less than 5 000 ha). Irrigation is used extensively but may cause problems in terms of groundwater recharge. Many countries seem to use their full rainfed and irrigation potential already. Some have gone even beyond, indicating expansion in marginal lands.

34. According to the FAO projections, developing countries account for 75 percent of global irrigated land and are likely to expand their irrigated area until 2030 by 0.6 percent/yr, while the cropping intensity of irrigated land will increase from 1.27 to 1.41 crops/ha/yr, and irrigation water-use efficiency will increase slightly. These estimates do not take into account climate change. Most of this expansion is projected to occur in already water-stressed areas, such as southern Asia, the Near East and North Africa.

New Opportunities

35. Even though countries in the Near East may participate in the Clean Development Mechanism which accepts afforestation and reforestation as eligible activities, many areas in the Region cannot grow forests. However, there are also large expanses of degraded land that

could be reforested if grazing is controlled. Planted forests may help to counteract negative effects of climate change on natural forests and improve local water cycles. Some countries in the Region such as Kuwait, Oman, United Arab Emirates and Egypt are building solid experience in afforestation and reclamation of desert areas, using sewage water for irrigation.

36. In addition to the forestry sector, other opportunities will most probably materialize in the following areas:

- improved fertilizer use – N_2O released into the atmosphere is a loss and an indication of inefficient farming;
- improvements to crop water management and productivity – development of water harvesting, conservation techniques, etc., aids adaptation to rainfall variability;
- improved rice farming – higher yields are accompanied by reduced methane emissions;
- increased use of conservation agriculture – improves soil carbon storage (sink) and soil structure, and increases water holding capacity;
- improved low-impact harvesting in forests and better soil protection;
- increased large-scale plantings of perennial crops – although limited in the region due to insufficient water availability (except in areas where irrigation is possible) there are several pine species, tamarind, citrus, almonds and several acacias that sequester carbon and protect soil and sloping lands, thereby offering an economic buffer against soil degradation and mitigating impacts;
- substitution of bioenergy and fossil fuel – although a possible option, FAO stresses that adverse effects on food security and the environment should be carefully assessed before embarking on any large-scale developments in this area.

IV. CONCLUSIONS

37. Climate change scenarios mostly agree about the future of the Near East Region.

- In the western and central parts, the current trend of reduced precipitation is likely to continue.
- In the south and particularly in the easternmost parts of the Region, most models agree that rainfall could increase.
- Throughout the region, agricultural impacts and groundwater availability would follow the same overall geographic pattern.

38. Although IPCC recognizes there are many variables that can affect future impacts such as local soil and physiographic conditions, it still perceives climate change as an imminent threat that needs to be addressed as soon as possible, particularly in areas threatened by aridification. In the FAO context, efforts to mitigate climate change and to enhance the resilience of rural populations and their livelihoods to climate variability and climate change impacts can be considered in line with efforts to achieve higher levels of sustainability.

39. Several areas for action constitute opportunities for the countries in the Near East Region in the context of international negotiations. The following can be highlighted:

- promotion of agriculture as a key player in the reduction of atmospheric greenhouse gases, including building the capacity of agricultural personnel and decision-makers;
- identification, development and promotion of practices that reduce greenhouse gas emissions or sequester carbon, while contributing to sustainable development;
- identification of activities with the potential to mitigate emissions of greenhouse gases, increase the resilience of production systems against vagaries of the current

climate and the threats of climate change, and improve adaptation capacities through conservation agriculture, afforestation, sustainable management and monitoring of forests and rangelands, soil storage of carbon, improved fertilizer use and ruminant digestion as well as with non-structural measures such as crop insurance and the careful promotion of bioenergy as a substitute for fossil fuels in climatically suitable areas;

- collection, adaptation, exchange and dissemination of geo-referenced and tabular climate-change data and statistics for agriculture, including the gathering of information and development of databases and networks to monitor soil carbon, and overall carbon accounting;
- improved use of tools to assess the impact of atmospheric conditions on crops (forecasting), the use of weather and climate forecasts in farm-level decision-making, and the development of techniques, which optimise the use of climate resources.
- developing policies, legislation and activities in natural resource management that can lead to sustainable livelihood, mitigation and adaptations to climate change.

Annex I: Climate change impacts and vulnerability of the countries of the Near East Region

Country	Vulnerable sectors and possible impacts of climate change	Common climate-related disasters[1]	% of total population under desertification risk[2] 1997	Total actual renewable water resources per capita (m^3/inhab/yr)[3] 2005	% of potential arable land actually in use[4] 1997	Projected % change in agricultural production capacity for 2070-99 with respect to 1961-90 baseline[5]
Afghanistan	Access to safe drinking water may worsen.[6]	Landslides (2006), floods	98	2608	265	-13
Algeria	Vulnerable to natural hazards such as floods and drought.[7]	Floods (1969)	53	443	63	-26
Azerbaijan	Decrease in water resources. Projected rise of the Caspian Sea level. Winter pastures may be negatively affected.[8]	Floods (1995)	59	3584	51	
Bahrain	Low-lying areas of the country's islands vulnerable to sea level rise[9]	None		157		
Cyprus	Sea level rise vulnerability index[10]=6 Damage on marine environment. More frequent, intense and longer droughts and heat waves. Water stress.[11]	windstorms (1969), extreme temperatures	93	965	33	
Djibouti	Sea level rise vulnerability index=0.37 Ground water recharge may be affected. Increased risk of floods and other extreme events.[12]	Floods (1989), drought	0	421	0	
Egypt	Reduced productivity of crops and increased water requirements. Heavily populated Nile Delta vulnerable to sea level rise.[13] Sea level rise vulnerability index=0.15	Floods (1994), windstorms	0	794	2893	28

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Iran	Change in length of growth period and number of freezing days.[14] Damage from intense cyclones originating in Arabian Sea.[15]	Drought (1999), floods	95	1970	385	-18
Iraq	Possible impacts on Tigris-Euphrates stream flow.[16] Increasing irrigation demand.[17]	Drought (1969), floods	95	2917	131	-32
Jordan	Increasing irrigation demand.[18] Possible rainfall decrease adds additional stress to already scarce water resources.[19]	Drought (1999), floods, windstorms, high temperatures	100	157	72	
Kazakhstan	Spring wheat decreases, winter wheat increases, with overall net decrease projected. Rangelands changes project decrease in wool production.[20] Glacier decreasing in northern Tien Shan.[21]	Extreme temperatures (1997), floods, wildfires	96	7116	478	28
Kuwait	Low coastal areas vulnerable to sea level rise. Storm surges affect coastal oil production.[22]	Floods (1997)	0	8	500	
Kyrgyz	Decreased cropland for cereals.[23] Glacier decreasing in northern Tien Shan.[24]	Landslides (1994), windstorms, floods	100	3952	164	

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Lebanon	Increased stresses on water resources. Shift of arable area to more arid climate zone. Negative impacts on citrus, olive, apple and sugar beet production.[25]	Windstorms (1992), floods	49	1189	114	
Libya	Recurring droughts and dependence on rainfed agriculture. Possible desertification of Jifara Plain in northwest.[26]	None	97	106	88	
Malta	Shorter rainy season will decrease crop production.[27] Sea level rise vulnerability index=507	None	0	128	33	
Mauritania	Decreased water resources. Dependence on water originating outside border. Degradation of arable land. Degradation of pasture and loss of livestock.[28]	Drought (1980), floods	98	3826	15	
Morocco	Ouergha watershed will likely see changes in runoff.[29] Sea level rise vulnerability index=0.24	Drought (1999), floods	80	934	76	-30
Oman	Seawater intrusion into freshwater aquifers[30] Storm surges affect coastal oil production.[31] Decreasing groundwater level.	Windstorms (2007)	0	336	6300	

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Pakistan	Changes in growing season length affect wheat production. Decreased wheat yield projection is possible.[32] Glacier extent affects Indus River basin.[33] Glaciers in Himalayas will recede.[34]	Floods (1992), drought, windstorms	99	1415	392	-20
Qatar	Increasing water stress. Storm surges affect coastal oil production.[35]	N.A.	0	86	800	
Saudi Arabia	Water stress will increase due to warmer temperature.[36]	Floods (2003), windstorms	0	96	380000	-10
Somalia	Food shortage may worsen under warmer temperature and extreme weather events.	Floods (1997), drought, ocean surges	96	1377	43	
Sudan	Decreased precipitation and increased temperature and evaporation will lead to reduced groundwater recharge. Water stress will increase. Dependence on water originating outside border. Projected decrease of millet and sorghum.[37]	Drought (1991), floods	86 Desertification of arable areas, arable zone shifts southward.	1879	15	-50
Syria	Possible impacts on Tigris-Euphrates stream flow.[38] Increasing irrigation demand.[39]	Drought (1999), floods, windstorms, land slides	79	1441	98	-16

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Tajikistan	Hydropower generation could be affected.[40] Decrease of glaciers and ice cover. Changing temperature and rainfall pattern could negatively affect agriculture.[41]	Floods (2004)	90	2537	45	
Tunisia	Mediterranean coastline vulnerable to sea level rise. Increased water stress. [42]	Floods (1979), drought	38	459	150	
Turkey	Decreasing stream flow continues in western basins.[43] Possible impacts on Tigris-Euphrates stream flow.[44]	Flood (1998)	70	2953	110	-4
Turkmenistan	Increase water requirement for cotton and wheat. Reducing glacier threatens river water availability.[45]	Flood (1993)	77	5004	195	
UAE	Seawater intrusion into freshwater aquifers[46] Storm surges affect coastal oil production.[47]	None	0	49	3900	
Uzbekistan	High temperatures and water deficit may have negative impact on crops and pasture vegetation productivity, and livestock.[48] Rainfall increase may lead to occurrence of flash floods. Reduction in snow and ice reserves reduces water availability.[49]	Floods (2005), Landslides	88	1904	104	1

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Yemen	Risk of desertification. Increasing irrigation demand.[50]	Floods (1982), drought	100	198	30900	-17

[1] Based on CRED database http://www.em-dat.net/disasters. The disasters are listed according the number of people affected. For the most recent disaster, the year of occurrence is also given. Only the most important 10 recent disasters are taken into account.
[2] Land resource potential and constraints statistics (TERRASTAT: http://www.fao.org/ag/agl/agll/terrastat/). All the countries with 0% (except Malta) lie largely or entirely in the hyperarid zone. Malta does not have land categorized as desert or drylands, thus is under no risk of desertification.
[3] AQUASTAT: http://www.fao.org/nr/water/aquastat/main/index.stm
[4] TERRASTAT: Irrigation cultivation is not considered in estimating potential arable land, thus in many countries actual cultivation exceeds potential. Those countries are under greater risk due to heavy reliance on irrigated water and uncertainty of water availability under climate change scenarios.
[5] Cline, W.R. 2007. *Global warming and agriculture: impact estimates by country.* Center for Global Development. Preferred estimates based on World Bank Ricardian model and a crop model.
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