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MINISTERIAL CONFERENCE ON WATER FOR AGRICULTURE AND ENERGY IN AFRICA: THE CHALLENGES OF CLIMATE CHANGE

Sirte, Libyan Arab Jamahiriya,
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IRRIGATION PROJECTIONS FOR 2030-2050

I. THE BASELINE

1. This paper presents the results of an analysis of irrigated agriculture in Africa on the basis of agricultural trends data compiled by FAO as part of its World Agriculture: towards 2030/2050 programme (FAO, 2006a), referred to here as AT2030/2050. he AT2030/2050 study presents a perspective on future agricultural supply and utilization on the basis of national demand and production of the main agricultural products in each country. It is driven by two key variables, population and income. Because the AT2030/2050 analysis is undertaken for 93 developing countries, South Africa is not a part of the detailed projection analysis for individual crops but has been incorporated to prepare the final estimates of irrigated areas and associated costs.

2. This analysis updates the work presented for sub-Saharan Africa (FAO, 2006a) and has been developed from two principal sources:

- The agricultural trends data generated for "World Agriculture: towards 2015/2030 – an FAO Perspective" (FAO, 2003)
- The FAO's AQUASTAT Database which specifies irrigated areas at national level in geographic regions over which there is a degree of physical and climatological homogeneity

3. Current data for agricultural water management was taken from AQUASTAT and is summarized in Table 1 below:

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TABLE 1: AQUASTAT IRRIGATED AREAS, 2008

REGION	AREAS EQUIPPED FOR IRRIGATION area (ha)	% of total	NON-EQUIPPED CULTIVATED WETLANDS AND INLAND VALLEY BOTTOMS area (ha)	% of total	NON-EQUIPPED FLOOD RECESSION CROPPING AREA area (ha)	% of total	TOTAL AREA UNDER WATER MANAGEMENT area (ha)	% of all Africa
Central	122,739	28%	1,000	0%	322,500	72%	446,239	3%
Eastern	616,143	73%	233,195	27%	-	0%	849,338	6%
Gulf of Guinea	542,699	39%	167,238	12%	681,914	49%	1,391,851	9%
Islands	1,132,123	99%	-	0%	9,750	1%	1,141,873	7%
North Africa	6,339,756	100%	-	0%	-	0%	6,339,756	41%
South Africa	1,498,000	100%	-	0%	-	0%	1,498,000	10%
Southern	565,427	75%	181,900	24%	8,510	1%	755,837	5%
Sudano-Sahelian	2,639,728	88%	96,724	3%	257,984	9%	2,994,436	19%
total	**13,456,615**	**87%**	**680,057**	**4%**	**1,280,658**	**8%**	**15,417,330**	**100%**

Table 1 indicates that the whole of Sub-Saharan Africa (all regions except North Africa and Islands) has a total area equipped for irrigation of 5,874,267 ha.

4. However, in order to establish consistency with the regional groupings adopted for Sirte 2008 Conference it has been necessary to cluster country data from both AT2030/2050 as indicated in Table 2 below. Countries shaded in grey are those for which AT2030/2050 data do not exist. Given the importance of South Africa in regional statistics, the current 1.5 million ha of area equipped for irrigation has been added to the projection analysis and expanded at a growth rate of 0.5% per year given the limited land and water availability in the country.

TABLE 2: AFRICA REGIONAL GROUPINGS FOR THE SIRTE CONFERENCE

REGION	COUNTRIES		
Central Africa	• Cameroun • Central African Republic • Congo	• Congo Democratic Republic • Equatorial Guinea • Gabon	• Sao Tome and Principe • Tchad
West Africa	• Benin • Burkina Faso • Cape Verde • Cote D'Ivoire • Gambia • Ghana	• Guinea • Guinea Bissau • Liberia • Mali • Mauritania • Niger	• Nigeria • Senegal • Sierra Leone • Togo
East Africa	• Burundi • Djibouti • Egypt • Eritrea	• Ethiopia • Kenya • Rwanda • Somalia	• Sudan • Uganda
North Africa	• Algeria • Libya	• Morocco • Tunisia	
Southern Africa	• Angola • Botswana	• Mauritius • Tanzania	• Kingdom of Swaziland • Tanzania

REGION	COUNTRIES		
	• Comoros	• Mozambique	• Zambia
	• Lesotho	• Namibia	• Zimbabwe
	• Madagascar	• Seychelles	
	• Malawi	• South Africa	

II. PROJECTIONS

A. IRRIGATED AREAS

5. For every country, the AT2030/2050 projections assume that a food supply utilization account can be closed and demand for calories is met by domestic production and through imports from world markets for all major crop types. Assumptions are made for individual crop yields and cropping intensities to the extent that the areas for rainfed and irrigated production can be projected. These projections assume that current growth trends are maintained and are therefore 'policy neutral' as they make no assumptions about policy changes, constraint removal or trade regimes. The only constraint is that the supply utilization accounts have to close and that physical limits of land and water are respected. The 2030/2050 projections indicate that from a 2000 baseline of 12 816 million ha, an annual growth rate of some 0.9% is maintained. This is in line with actual growth rates recorded for the period 1992-2000 (FAO, 2005). The increases in the areas equipped for irrigation are shown in Table 3 below.

TABLE 3: PROJECTIONS OF AREAS EQUIPPED FOR IRRIGATION BY REGION

	Projection Year				
Region	2000	2030	2050	Increase 2000-2030	Increase 2000-2050
	(1 000 ha)			(%)	
Central	84	98	113	14.3%	25.7%
West	923	1 197	1 502	22.9%	38.5%
East	5 807	7 403	8 057	21.6%	27.9%
North	2 721	3 251	3 546	16.3%	23.3%
Southern	3 281	3 740	4 244	12.3%	22.7%
All Africa	12 816	15 689	17 462	18.3%	26.6%

B. ASSOCIATED COSTS

6. Assumptions on unit costs have been compiled from the FAO AQUASTAT database and applied across an investment typology similar to that used for the CAADP estimates prepared in 2003 (NEPAD, 2002). These unit costs, at 2008 prices, are presented below in Table 4.

TABLE 4: COST ESTIMATES AND DISTRIBUTIONS OF DIFFERENT TYPES OF AGRICULTURAL WATER MANAGEMENT

TYPE OF INVESTMENT	LOCAL COST (MOSTLY LABOUR) %	NON LOCAL COST (CAPITAL) %	CENTRAL AFRICA	WEST AFRICA	EAST AFRICA	NORTH AFRICA	SOUTHERN AFRICA
	UNIT COSTS ($US/ha)						
Large scale irrigation development	25	75	10,000	12,500	12,500	6,000	9,000
Large scale irrigation rehabilitation	25	75	3,000	4,000	4,000	2,000	3,000
Small scale irrigation development	50	50	3,000	3,500	3,500	2,000	2,500
Wetland development: inland valley bottoms etc.	65	35	600	600	600	600	600
Water harvesting, soil and water conservation	70	30	300	300	300	300	300
Land improvement	100		100	100	100	100	100
	DISTRIBUTIONS (% of total area)						
Large scale irrigation development			2.36	1.71	2.16	19.41	3.12
Large scale irrigation rehabilitation			5.87	8.19	8.63	22.84	7.26
Small scale irrigation development			9.64	5.33	6.41	9.41	7.98
Wetland development: inland valley bottoms etc.			16.57	10.90	11.62	0.00	6.62
Water harvesting, Soil and water conservation			9.98	23.14	22.69	7.01	23.44
Land improvement			55.59	50.73	48.48	41.34	51.58

7. The overall investment estimates (at 2008 costs) required to bring the additional AT2030/2050 projected irrigated areas into production and also maintain them through at least one cycle of rehabilitation are calculated at approximately USD 56 billion for the whole African continent. The assumptions are that current trends in irrigated and rainfed production are maintained and that the entire 2000 baseline is rehabilitated during 2000-2030, split between large and small scale, and that 50% of the entire resulting 2030 baseline is rehabilitated between 2030 and 2050.

TABLE 5: COST ESTIMATE ASSUMPTIONS BASED ON 2008 COSTS

		Costs (USD 1 000)		
REGION		Increment to 2030	Increment to 2050	
Central	New	64 218	62 117	
	Rehabilitation	109 907	64 586	
West	New	1 462 255	1 626 089	
	Rehabilitation	1 572 039	1 019 980	
East	New	8 983 289	3 680 455	
	Rehabilitation	10 454 881	6 664 767	

North	New	2 033 651	1 132 057	
	Rehabilitation	3 480 668	2 079 276	
Southern	New	2 046 172	2 244 321	
	Rehabilitation	4 868 327	2 775 192	
All Africa	New build	14 589 586	8 745 039	23 334 625
	Rehabilitation	20 485 822	12 603 801	33 089 623
TOTAL		35 075 408	21 348 840	56 424 248

III. ANALYSIS

A. IRRIGATED AREAS

8. As a guide, physical water scarcity becomes apparent when withdrawals begin to exceed 40% of the annually renewable resource ($ARR_{40\%}$). With the exception of North Africa and several of the drier Sahelian countries, the projected growth is within available land and water limits, although expansion of irrigated areas in already committed river basins and aquifers needs to be avoided or alternative sources of water supply sought.

9. However, high volumes of water can be seasonal, meaning that they cannot be used without storage. Given the increasing demand for energy, it is likely that some water will be allocated for hydropower generation for which operating rules may be inconsistent with the seasonal demands of irrigation; and from which evaporation losses may be significant. This challenge is particularly relevant in the African context given that much of the irrigation potential is situated upstream of the hydropower potential. Because irrigation is a consumptive use of water, uncontrolled expansion can compromise existing generation capacity or reduce hydropower potential. However, wherever irrigation potential lies downstream of the hydropower potential, and despite evaporation losses from the reservoir surface, the dams may be designed and operated in such a way that downstream irrigation can be expanded.

10. The nature of the national production data used in AT2030/2050 prevents any meaningful assessment of temporal, or vertical expansion of irrigation (by increasing cropping intensities). Without annual hydrographs and local cropping patterns, it is difficult to be sure about the possibilities of multi-cropping. However, where storage is already in place, or planned, the possibility of multiple cropping is increased.

11. A comparison between the total potential irrigable areas (AQUASTAT) and those projected in the 2030/2050 data showed that only Madagascar's projections exceeded the available land while remaining within water resource limits. For all other countries the projections are generally consistent with current rates of growth. Further, it is clear that the assumed increases in equipped areas are modest with some 70% of all countries equipping 55% or less of their potential areas.

B. YIELD GAP CLOSURE

12. Closing yield gaps on existing irrigated areas still needs to be seen as the first step towards increased productivity and food security, agriculture based economic growth and market stimulation. To this end, the analysis shows that simply closing prevailing yield gaps could save a total of more than 922,000 ha new build by 2030, and additionally more than 866,000 ha by 2050. It is emphasized, however, that these projections are based on target yields only for a range of

selected crops. Yet, the potential benefits of yield gap closure will be clear, even if the actual target yields are not achieved.

C. REGIONAL TRADE

13. Regional trade of surplus production or the allocation of water amongst riparian countries according to specific technical comparative advantage in a particular crop could be a complement to domestic production.

14. An example of the regional trade of surplus production can be derived from FAO projections to 2015 (FAO, 2003) for the countries of the Eastern Nile Basin (Egypt, Ethiopia and Sudan). These projections included estimated country shortfalls which have yet to be provided for the AT2030/2050 projections. These are needed for an assessment of regional trade potential. This shows for instance that in this region:

- Surplus rice grown in Egypt could be more than enough to satisfy demand in Sudan and Ethiopia;
- Surplus sorghum (already irrigated in all three countries) grown in Sudan could fill shortfalls in Ethiopia
- Ethiopia's coffee surplus could satisfy demand in Egypt and Sudan

15. The deployment of technical comparative advantage can occur if a nearby country can increase its production of a specific commodity with greater natural resource efficiency. Wheat provides an example of how this may works.

16. Under business-as-usual conditions, the data indicates a total shared deficit for wheat of over 8.5 million tonnes in the Eastern Nile Basin. In 2007 production in this region was as follows:

- Egypt produced 7,379,000 tonnes on 1.139 million ha (6.478 t/ha)
- Sudan produced 642,000 tonnes on 0.250 million ha (2.568 t/ha)
- Ethiopia produced 3,000,000 tonnes on 1.353 million ha (2.217 t/ha)

17. This gives a weighted average yield of just over 4,000 tonnes/ha. At this level of yield, regional self-sufficiency would require an additional 2.1 million ha of cultivated land. Although the weighted yield includes rainfed and irrigated production, even Egypt's high yielding irrigated wheat would require over 1.3 million ha of additional land under irrigation. This suggests that prospects for regional trade in wheat under conditions of business-as-usual are limited to nil. A similar calculation confirms that this also holds for maize and sugar. These together with wheat comprise the three biggest deficits in the Nile Basin.

18. So far, the discussion has focused on trade between countries that are located within the same sub-region. FAO's Water Report N° 31 (FAO, 2006b) applies a similar analysis to the prospects for trade between regions and finds that if target yields can be achieved by 2030, then for instance:

- barley shortfalls in Central and East Africa could be improved by increased production in West Africa;
- millet shortfalls in West Africa could be improved by increased production from the other regions;
- rice shortfalls in South Africa could be improved by increased production elsewhere in the Southern region; and
- sorghum shortfalls in Central Africa could be improved by increased production in East Africa;

19. In each case, the producing region may have a clear technical comparative advantage for the crop in question, but realization of physical trade could be severely limited by transport infrastructure.

D. CLIMATE CHANGE

20. Although the various climate change models have yet to show convergence with respect to rainfall and periods of drought, temperature projections are generally more reliable and will have pronounced implications. Increased evaporation and evapotranspiration with associated soil-moisture deficits will impact rainfed yields. In addition increased open water evaporation on stored water can be expected to reduce water availability for irrigation and hydropower generation. While ocean-atmosphere coupling is generally reliable and indicates increased precipitation in areas influenced by monsoonal circulation, it is the unreliable land-atmosphere coupling over areas such as the West which give rise to uncertainty over future rainfall trends. Modeling of the emission scenarios with respect to rainfall already justify the adoption of some key operational principles when planning new irrigation – on the assumption that there would be ‘no regrets’ since they would contribute to overall resource management in any event.

21. First, the possibility that schemes could be provided in areas where water resources may be compromised by reduced precipitation and hence run-off. There is therefore a real risk of investing in schemes that fail due to water shortages. This risk can be offset, however, by selecting investments that can be supported at a later stage, by seasonal or trans-annual storage, subject to satisfactory social and environmental impact assessment.

22. Second, another effect of reduced water resources is increased competition for their use. This could increase their resource price and/or, where storage proves necessary, the added value or service cost. When this becomes the case, it may become economically inefficient to use scarce, valuable water for additional production.

23. Third, the need to think ahead and avoid building schemes that will be difficult to retro-fit with more precise water management technology at a later stage.

24. Finally, it is also necessary to think ahead in areas that are expected to become wetter, with more extreme hydrological events becoming the norm, not just because of climate change itself, but also due to the expected increases in soil moisture which in turn will both increase and intensify run-off. In such locations it will be necessary to include adequate drainage facilities when new schemes are built, and in all likelihood to retro-fit the same to existing schemes. With this in mind, paradoxically it is also necessary to note that good drainage facilities should also be provided in the areas expected to become drier. This is in order to increase return flows for re-use downstream.

IV. CONCLUSIONS AND RECOMMENDATIONS

25. Notwithstanding the assumptions of the AT2030/2050 projections, three principle conclusions can be drawn. First, the projections are conservative in comparison to the natural resources available for the continent as a whole. In most cases, growth can be accommodated within available land and water limits if adequately planned with respect to basins and aquifers where resources are not already stretched. However, the land and water scarcity in both North Africa and South Africa in particular are expected to constrain the AT2030/2050 projections significantly.

26. Second, irrigation development is only one path, among others, towards increased production, regional food security and overall economic growth. Other options include yield gap closure and regional trade, which could be complementary to irrigation development. Regional trade could also lead to increased economic growth as result of the livelihood diversification that is usually associated with increased market size and activity.

27. Finally, the prospect of climate change will need to be anticipated through more flexible and adaptive water management practices that allows irrigated production to respond to more variable water supply inputs and buffer greater volatility of rainfed production.

28. Following these conclusions several recommendations emerge.

- Food security can be assessed on a regional or transboundary basis to mobilise comparative advantage in specific staple crops and thereby spread production risk and lower economic costs.
- There is potential for improving the productivity of existing equipped irrigated areas. Where appropriate, this approach should be prioritised before new-build is contemplated. Accordingly, it is recommended that capacity building becomes an essential component of any irrigation based food security and economic growth strategy. Further, such capacity building should not concentrate on the “traditional” skills of engineering and agronomy, but also extended to institutional initiatives that respond to demand and add value, including water pricing, market research and adaptive programme financing.
- Where there is competition between irrigation and hydropower, then multi-objective operating rules can allow expansion of irrigation while maintaining planned generation capacity.
- The private sector should be encouraged to play a larger role in irrigated production and irrigation service delivery. There is a lot that governments can do to increase private sector involvement by establishing policy-backed enabling environments, appropriate incentives and transparent risk sharing mechanisms. Public-private partnerships should be forged to allow the continent escape hunger and poverty.

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