Land Reclamation in Egypt - a critical external review

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Introduction

The area of the Egyptian state totals about 1 million km^2, 96% of which is desert and barely 4% is cultivated land. This means that c. 40,000 km^2 are available as effective Lebensraum for its approximately 63 million inhabitants. Restricted predominantly to the Nile Valley and the Nile Delta, this cultivated area is one of the most densely settled areas on earth, carrying more than 1,575 inhabitants per km^2. The scarcity of living space in this country is even more striking when seen in the context of the effectively managed area used for agriculture. With an agricultural utilised area of altogether 2,607 million hectares, at present about 0.048 hectares of agriculturally used area is available per inhabitant. For years Egypt has been presenting an almost explosive population growth, with a growth rate of around 2.8% p.a. Recently the growth started to decline. What is giving cause for concern is the fact that for years the growth rate of agricultural production, especially foodstuffs, has not kept pace with the population growth. Increased agricultural production has therefore represented the most important economic policy aim of all Egyptian governments since the 1952 revolution.

A rise in agricultural production in Egypt can be achieved by raising the cultivation intensity (by intensification of irrigation, fertilising, plant protection, drainage etc.) and by raising organisational intensity (like substituting tuber crops and vegetables for grain), as well as through extending the agricultural area by cultivating part of the huge desert area. Over past decades Egypt has sought to make use of all three of these options for raising agricultural production, with the government making particular efforts in the field of desert cultivation and opening up of new land. The latter tend to involve expansion of the agricultural area into desert areas, i.e. into a natural area which is difficult to manage. In what follows, the history and the development problems of the newly reclaimed areas will be presented and analysed - not only in order to explain the difficulties Egypt meets with in its endeavours to expand the scope for food growing, but above all in order to draw attention to the problems in general which occur today with the expansion of the agriculturally utilised areas, even in over-populated agricultural countries.

The history of desert cultivation and the reclamation of new land in Egypt

In Egypt efforts to open up new land have a history that reaches back into antiquity. These efforts tended to concentrate in the valley and delta of the Nile, or on directly adjacent areas. In the last two centuries in particular attempts were made to reclaim land for agricultural use through perennial irrigation and drainage measures.

Measures to reclaim new land up to 1952

In the early 19th century the agriculturally used area of Egypt included c. 2 million feddans (840,000 hectares), c. 250,000 feddans (c. 105,000 hectares) of which were restricted to summer use only. Under the regency of Mohammed Ali efforts to reclaim new land and to extend field use in summer were markedly intensified. Already in about 1830, c. 600,000 feddans (c. 250,000 hectares) were also available for summer use and in 1848, by the end of Mohammed Ali's regency, the agriculturally used area of Egypt had risen to c. 2.6 million feddans (1,092,000 hectares). During that time efforts to open up new land were concentrated above all on the amelioration of saline clay soils in the northern delta between the two arms of the Nile. With the help of more or less forced labour the government mainly constructed irrigation canals and main drainage channels, whereas the opening-up of the individual plots was left to private initiative. Attempts to cultivate the desert remained modest, and the results questionable, especially in the oases of the Western Desert (Busche, 1979: Meyer, 1978; Wolff, 1983).

In the third quarter of the 19th century, measures to reclaim land in the northern delta not only continued, but at the same time were extended to include central Egypt as well. In the year 1880 approximately, the agriculturally utilised area had increased to c. 4.7 million feddans (1,974,000 hectares). By the end of the 19th century, additional investments in the irrigation system, especially in the construction of delta barrages, had led to an increase in the agriculturally utilised area to c. 5.2 million feddans (2,184,000 hectares).

In the beginning of the 20th century the construction of a barrage, the building of various feeder canals in central Egypt, and the completion of the first Aswan dam, the level of which was raised twice - though only leading to a modest increase in the area under cultivation-, nonetheless had the effect of a marked intensification of the utilisation of the available area, chiefly by expanding the area under perennial irrigation. However, construction of a drainage system of appropriate dimensions, matching those of the measures described above, was omitted. This resulted in increased occurrences of fields becoming marshy and salty, and to a subsequent reduction in the productivity per feddan. From the turn of the century to the 1952 revolution measures to reclaim new land only succeeded in extending the agriculturally utilised area of Egypt by c. 125,000 feddans (c. 52,500 hectares). The major part of this area was opened up by private investors. The government mainly concentrated on the completion of the drainage network during the period (Hopkins et al., 1988; Wolff, 1980 and 1986).

Measures to reclaim land and cultivate desert areas since 1952

The revolution of the year 1952 presents a turning-point in the governments policy towards land reclamation and desert cultivation. In post-revolutionary Egypt the relatively small area available for agricultural utilisation and the rapid growth of the population resulted in according high priority to the opening-up of new land. In this, the corresponding government measures were often directed primarily towards the physical reclamation of new land for cultivation, whilst neglecting the necessary raising of productivity by of plot amelioration measures. The occurrence of a food deficit in the late-60s, which deepened steadily in the following decades, together with the negative agricultural trade balance as a consequence of this deficit, led to special attention always being paid to the opening-up of new land in the following years and up to the present.

In recent decades the definition of the term "reclamation" or "new land development" has undergone several changes. In its comprehensive form the term describes the development of the entire infrastructure affecting production, the development of village social and physical infrastructures, as well as the improvement of soil fertility to so-called positive marginal productivity. The comprehensive development package has been slimmed down several times in the course of recent decades. Even the concept and philosophy of the policy of new land reclamation has undergone several amendments, or even fundamental change. In the 1950s priority was given to the provision of land and the improvement of the living conditions of the growing proportion of landless people among the population. Raising agricultural production was seen as being of comparatively secondary importance. In the early days of the post-revolutionary new land reclamation, co-operative or mutually beneficial forms of land use were attempted in the new land areas. Entirely novel, "modern" forms of rural society were to be created. Expectations were very high: extremely ambitious, large-scale programmes for the opening-up of new land and extending over an area of c. 1 million feddans were decided upon and tackled. In reality, however, only 80,000 feddans were reclaimed in the period up to the late-fifties. Co-operatives, which took over the distribution of land and the means of production, as well as the buying of production means and the marketing of produce, were set up; However, co-operative or mutually beneficial farming was not introduced (Voll, 1980; Wolff, 1983; Hopkins et al., 1988).

In the sixties, until the war with Israel in 1967 to be precise, the new land reclamation made good progress. The construction of the Aswan High Dam in particular had a stimulating effect. Admittedly, the corresponding efforts were substantially directed towards the actual work of reclamation, whilst the transformation of the reclaimed areas to permanently productive cultivation areas was not undertaken with the requisite emphasis. A large part of the reclaimed area was run as state farms with an army of workers, or remained in the care of national development companies. During this phase, areas not exceeding 5 feddans were leased to peasants, but rarely turned over to them. In principle, however, it was assumed that large state farms were better suited to mechanised cultivation of the land and better placed to obtain foreign exchange by careful management of fruit and vegetable production for export. This change in policy of land reclamation influenced not only the new schemes, but also affected the areas which - though reclaimed - hat not yet been assigned to those peasants for whom they had been originally intended. Henceforth the aim of land reclamation was no longer to meet the wishes of landless people for a small plot of their own, but to expand agricultural production and grow marketable surpluses, thereby increasing state revenues and above all foreign currency earnings.

In the years up to 1966 a total of 307,000 hectares of new land was opened-up to cultivation in various parts of Egypt. Most of these areas - 122,500 hectares - were in the Nile areas, followed by Tahir Province with 62,500 hectares, and the desert areas with 59,900 hectares. Other major foci of new land reclamation during this period were in Upper Egypt, in the so-called Nubian Settlement Area (16,300 hectares) and in the districts of Kuta, Kom Ashim and Abis (15,200 hectares). Official statistics for the period up to 1966, moreover, include wasteland (30,900 hectares) in all parts of the country which had been brought back into cultivation by reclamation (Wolff, 1983).

After 1966 the area of newly reclaimed land in Egypt increased at first only slightly, and almost exclusively in the Nile area, where a further increase of around 70,000 hectares had been registered by 1974. The main reason for the slow-down, or even

standstill, in the opening-up of new land are thought to be the military conflicts with Israel in the year 1967 and the subsequent years of economic recession (Meyer, 1978).

In 1975 the reclamation of new land reached its peak after the 1952 revolution, when a total of 411,000 hectares had been reclaimed; but it also reached its first critical phase, since only about 259,000 hectares , i.e. 63% of the reclaimed area was agriculturally used. Even the further development of the actually utilised areas proved to be quite problematic. In almost all the new land areas it took a disproportionately long time to reach even marginal productivity - that is, a production level at which the cost of production is covered by the resulting yields. Not inconsiderable parts of the new land areas have still not reached even marginal productivity.

In the seventies the reclamation of land was restricted to the completion of the on-going projects; next to no new projects were started. However, the policy of opening-up new land, i.e. the distribution and utilisation of areas already reclaimed, once again underwent change at this time. The low productivity of the state farms showed that under Egyptian conditions large state farms were evidently unsuited to the management of new land areas. The intensive cultivation of the new land areas by peasants, and the higher yields produced by them, led to a return to greater peasant-orientation in respect of opening-up and, above all, distributing already reclaimed areas. Attempts to retain state farms for the production of high quality fruit for market of fresh produce and industrial processing were confined to the western delta and the adjacent areas. At the same time a programme was set up in the mid-seventies, which made land for individual cultivation available to graduates.

In the Spring of 1978, the Egyptian government, notwithstanding these and other problems, announced the start of a "Green Revolution" for the country. Besides increased intensity of cultivation, this "green revolution" aimed at substantial expansion of the agricultural area. In a highly euphoric estimate of the production potential of Egyptian desert areas and the useable water resources, the "Egyptian Master Water Plan" provided for an expansion of the agricultural area by the year 2000 of about 1.24 million hectares, i.e. by about 44% of the area under cultivation in the early-eighties (Samaha, 1980). If this goal was to be reached c. 62,000 hectares of new land per year would have had to be opened up. Considering the fact that in the first phase of new land reclamation (1952 - 1966) an average 20,000 hectares were reclaimed per year, and that the areas available for reclamation in the late-seventies were much more difficult to open up, the Egyptian ideas as set out in this plan did not seem very realistic. Furthermore, the development problems of areas hitherto reclaimed could in no way be regarded as solved (Hopkins et al., 1988).

Thus, after a period of resignation in the seventies, new efforts were made to expand the Egyptian agricultural area. The announcement of the so called "Green Revolution" by the Egyptian Government is seen as a turning point in reclaiming new lands. That's why lands reclaimed before 1978 are termed "old new lands", while the post 1978 reclaimed lands are known as the "new new lands". From 1978 onwards the opening-up of new land formed an essential part of various five year plans, and almost 40% of the total investments of the agricultural budget were set aside for this field. However, due to financial bottlenecks in the country's budget, it became more and more difficult to fulfil the planing states from one year to the next. The actual expenditure in the period 1982/83 to 1986/87 turned out to be only 50% of that budgeted for new land reclama-

tion. In the period 1978 - 1988 the area of newly reclaimed land increased by 242,634 hectares, i.e. by c. 24,000 hectares a year. The original goal of 62,000 hectares a year was not reached. The five year plan for 1987 - 1992 had envisaged the opening-up of a total of 315,000 hectares. 14.700 hectares of this were situated in the so-called "New Valley", and are to be irrigated with groundwater. 300,300 hectares were scheduled to be irrigated with Nile water. By the year 1997 1,092,000 hectares had been reclaimed since the beginning of the fifties, but still only 672,000 hectares were under agricultural production at that time.

In the context of the drawing-up of the so-called "Land Master Plan" in 1986, 2.6 million feddans (1.09 million hectares) were identified as suitable for reclamation under certain conditions. 997,000 hectares of these require water supplies from surface waters, i.e. the Nile, whilst 92,000 hectares are thought to be within reach of groundwater reserves. The Egyptian government aims at present to open up 1.43 million hectares up to the year 2017 and from thereon an other 2.18 million hectares; though the question of where the water for irrigation of these areas is to come from remains. The question will be addressed in greater detail below. For the present, the fact is to be noted that, in the face of the dramatic population growth in Egypt, the opening-up of the new land will for the foreseeable future continue to play an important role in the framework of Egyptian agricultural policy. This was among others stated in a more recent speech by President Hosni Mubarak on the launching of the Upper Egypt New Delta Project. In his speech President Muhammad Hosni Mubarak pointed out that "It is time for Egypt to be released from captivity within the narrow valley to stretch out into the vast expanse of its entire territory, in pursuit of a better tomorrow, gleaming with hope for all Egyptians." And in the Egypt State Information Service Web Site "Egypt in the 21st Century - Vision 2017" the following is stated under the heading "Development Strategy Outline" as the first development objective:

> *Extend the scope of development to the entire area of the country, explore its wealth and provide opportunities for settling millions of Egyptians outside the narrow valley, which accounts for maximum 5.5% of the total area of the country, thus raising the ratio of inhabited space to 25%. The next twenty years represent an important phase for such expansion. Areas rich in national resources are to be opened, and increasingly utilized, population is to be settled down at locations which will be integrated and interlinked in the long run.*

Making use of the fast desert areas will stay high on the agenda in Egypt for the years to come, despite the limitations of expanding agricultural activities into the desert.

Perspectives for the future

Considering the limitations of the world's agricultural area, Andreae (1977) in his *Agricultural Geography* notes that "with expectation of rising income and living standards, higher agricultural yields are necessary. And this is why in the course of development, land which has been regarded until now as fairly productive will become marginal land, and previously marginal land will go out of production". The application of this general statement to the Egyptian case confirms the fact that agriculture already displays a tendency to withdraw or to stay away from marginal locations. The abandoning of cultivated land in the Wadi El-Natrun (Wolff and Bliss, 1980) and the fact that some of reclaimed land does not reach marginal productivity is an unambiguous example of this.

The growth rate of private measures for land reclamation which, to name just a few examples, occurred along the Cairo - Alexandria desert road, in Nubaria, in the countryside around Cairo and elsewhere, does not contradict this development trend. Many of these private reclamation measures are the result of speculative considerations and the very high prices for agricultural property in Egypt, although numerous investors have been complaining in Egypt for some years about the inadequate profitability of the farming activities within the reclamation schemes. Even with crops of relatively high market value (fruit, vegetables), it is exceedingly difficult to achieve sufficient profitability in the predominantly marginal areas. In addition there is a relatively high capital requirement for water supplies and distribution at farm level as well as for the improvement of the fields. It is an open question whether the investors will keep interest in new land developments on a medium and long term basis. Because of the apparent success of some large scale and highly specialised farming operations in new land areas this farming systems are seen as the future for the development of Egypt's new lands.

Since the marginal locations of agricultural production in Egypt tend to be new land areas, the development outlined above runs counter to the government's policy of land reclamation and to the euphoria of private investors over recent years. By contrast with those in the old lands, unalterably low yield levels in most new land areas do not raise expectations that these areas will ever become, in the long term, fully adequate locations. They will in comparison to the Nile Valley and Nile Delta always remain marginal locations, and it is to be expected that they will cease to be competitive in the course of further economic development or be forced to rely on high state subsidies to survive. The latter already applies to the majority of the sub-projects of the New Valley as it does to many other new land areas. Every further new land reclamation in Egypt contains, at least potentially, the danger of a rise in state subsidy payments for the new land areas, and thus of the withdrawal of state investments in areas of the Egyptian economy which have development potential.

In Egypt agriculture may retreat to the most productive locations, which in accordance with Andreae's hypothesis is to be expected; in connection with the rise in the cultivation intensity it may also come up against a limiting factor in respect of the limited scope to expand food supply given the explosive growth of population.

Due to the surplus on the world's agricultural markets and the relatively low price levels, as well as high qualitative demands, it cannot be expected that Egypt will succeed in exporting agricultural products on a large scale, and thereby making land use in the new land areas more profitable. In view of this fact the author suggests the following three measures for raising the agricultural and the overall economic capacity as being of greater importance for Egypt than the reclamation of new land:

- improving and sustaining the production capacity of the old land areas through measures affecting cultivation techniques, the agrarian structure and the sustainability of the natural resource base;
- opening-up and developing alternative branches of the economy, i.e. especially in industry and services;
- increasing investments in human development as the Egyptian people are the most valuable resource of the country.

Limitations of new land reclamation in Egypt

Limiting factors

New land reclamation in Egypt has its limits, especially in regard to the availability of fertile soils and suitable water resources (Wolff, 1992). Although land seems to be abundant, properties and fertility of the newly reclaimed soils and of the ones left for reclamation are marginal. Most of the newly reclaimed soils are sandy and calcareous. Sandy soils are structureless. Field capacity and wilting point are low (8 - 9 and 2 - 3% of soil moisture content, respectively), and the soil is poor in organic matter, and the macro- and micronutrient content is low. The average pH value is 7.7, and EC values range between 0.2 and 0.5 dS/m. Calcareous soils have totally different chemical and physical properties. They are high in CaCO3 content (26 - 59%) while organic matter percentage ranges between 0.23 and 1.50. The cation exchange capacity is relatively higher than that of the sandy soils and pH values are between 7.8 and 9.6. The EC is less than 4 dS/m (Bedier et al., 1998).

Water resources to reclaim the vast desert lands of Egypt represent the most critical constraint. As mentioned above: Egyptian agriculture depends entirely on a fixed supply of water annually from the River Nile, while groundwater is limited in quantity and quality at certain locations. Egypt's expected water balance in the year 2000 has been calculated by Abu-Zaid (1989) on the basis of a continuation of the Water Master Plan (Table 1).

Egypt's water balance, as presented in Table 1, shows reserves of 1.7 billion m^3 in 1990/91. It is doubtful whether all of these reserves have actually existed, as not all of the new new land hitherto reclaimed had reached full productivity, and consequently it had not called upon the full amount of water which had been earmarked for them.

Table 1. Water balance for the Arab Republic of Egypt in the years 1990/91 (actual) and 2000 (expected)

	1990/91 (actual) billion m^3	2000 (expected) billion m^3
Available water supply	55.5	55.5
Release Aswan High Dam	53.8	
Contribution Upper Nile Projects		2.0
Evapotranspiration	36.6	38.9
Domestic use, industry[1]	1.5	4.8
Evaporation losses	2.0	2.7
Drainage to the Mediterranean	12.1	11.8
Shipping, water power	1.6	0.3
Surplus	1.7	-1.0

[1]non-recyclable water; actual requirements are much greater
Source: Abu-Zaid, 1989; v.d. Molen, 1997

In future, it might become increasingly difficult to satisfy the actual demand for water, especially if the ambitious policy of the Egyptian government to reclaim new land is carried out as planned, and hitherto reclaimed areas are fully utilised. As it cannot be assumed that the Jonglei Canal Scheme in the Southern Sudan will be operating by the year 2000, or that the so-called Winter Water Project will be effective, i.e. that the unexploded discharge of 2.8 billion m^3 can be calculated for the year 2000.

Some thoughts on agricultural water use in Egypt under special consideration of new land developments

To judge the availability of water for an encroachment of Egypt's irrigated agriculture into the unexploded desert areas of the country a calculation , based on a similar calculation of van Leeuwen (1997), was carried out with the following results.

Irrigation water requirements under special consideration of further new land developments - Irrigation requirements of new land developments

The net evapotranspiration of an average cropping pattern in the Nile Delta amounts to 1,200 mm/year. The cropping pattern in New Valley is supposed to be adapted to desert environment and will exclude crops with a very high consumptive use. However, this will still be offset by higher temperatures and advection (horizontal heat flux from desert to arable land) that will increase the evapotranspiration rate with about 10 to 20%

Assumption 1: Evapotranspiration in New Valley: 1,600 mm/year
Net water consumption of 1 feddan: 6,700 m^3 /feddan/year

Surface irrigation water from lake Nasser contains 250 mg/l total dissolved salts. The maximum permissible salt concentration in soil moisture is 2,500 mg/l (Ece = 4 dS/m). This requires a leaching ratio of 250/2,500 = 10%.

Assumption 2: An additional 700 m^3/feddan/year has to be supplied for leaching

Evaporation losses from open canals, field ditches and spill areas are estimated to amount to 5 % of the net irrigation application (evapotranspiration + leaching fraction).

Assumption 3: An additional 300 m^3/feddan/year has to be supplied to cover unavoidable evaporation losses.

It is assumed that only modern irrigation methods and distribution systems will be applied in the New Valley Project. This will include provisions to recirculate tail losses and other spills from the supply network.

Assumption 4: The gross irrigation supply for one feddan amounts to the sum of the three above mentioned requirements being a water duty of: 7,700 m^3/feddan/year.

During the first stage of the Project, some 500,000 feddans will be reclaimed for irrigated crop production.

Assumption 5: Annual water supply for 500,000 feddans amounts to 3.85 billion cubic metres.

Assumption 6: Irrigation of 500,000 feddans in New Valley will generate 350 million cubic metres drainage water, with a salinity that is too high for other uses. This drainage water will either percolate to the groundwater, or has to be disposed of in a drainage sump of the same size as the Wadi Rayan Lakes (120 – 150 km^2).

Proposed conjunctive use of groundwater
The present abstraction of groundwater from the Nubian aquifer in the New Valley is estimated at 1 billion cubic metres per year. According to studies of the Groundwater Research Institute of Egypt's Water Research Centre, the potential abstraction could be about 2 billion cubic metres per year. It is proposed to use the additional 1 billion cubic metres of groundwater in the presently reclaimed areas only during the peak periods in irrigation demand. This means that during the summer season conjunctive use of surface- and groundwater will be applied and that during the winter season only surface water will be applied.
The application of this option might result in the reduction of the canal capacity and thus saving considerable investments.

Effect on the water and salt balance of the Nile Valley and Delta
At present, the Aswan release is 55.5 billion cubic metres per year. This water carries a saltload of 14 million tons of dissolved salts. It is estimated that an additional 1 – 2 million tons of salt is added from agricultural chemicals, industrial waste and domestic effluents. In the northern fringe of the Delta an unknown quantity of salt enters the hydrological system through seawater intrusion.
The Drainage Research Institute Reuse Project estimated that a total saltload of 20 million tons has to be evacuated to the sea per year.

Assumption 7: When the salt concentration of percolation water (leachate) or other drainage effluent exceeds 2,500 mg/l, then it will not be recoverable for reuse and must be discharged to the sea, or other safe disposal sites.

Assumption 8: Disposal of 20 million tons saltload requires a minimum drainage flow to the sea of 8 billion cubic metres per year.

With the current 55.5 billion cubic metres the following water allocation can be realised:

Net domestic consumption	2.5	billion cubic metres
Net industrial consumption	2	billion cubic metres
Unavoidable evaporation losses	2	billion cubic metres
Saltload disposal to sea	8	billion cubic metres
Net evapotransporation of crops	41	billion cubic metres

Assumption 9: The potential area for crop production, based on the availability of 41 billion cubic metres and a net evapotranspiration of 5,100 cubic metres per feddan and year amounts to 8.0 million feddan.

The present net cropped area is estimated at 6.8 million feddan. It should be noted that many of the new reclamation areas did not yet realise their targets and have only between 50 and 70 percent of the designated area under crop production.

The planned expansion of reclamation areas in Sinai (240,000 feddans), West and East Delta (360,000 feddans) and completion of the areas in existing reclamation projects (200,000 feddans) will result in a total cropped area of 7.6 million feddans. This leaves only a potential of 400,000 feddans for future expansion.

Water savings, made through improvements in the irrigation system do not contribute to additional water resources. The only real saving that can be made is the reduction of non-productive losses from evaporation. Reduction of tail-end losses, percolation losses and surface run-off result in almost the same reduction of drainage water. On the other hand, the reduced dilution of drainage water with irrigation losses, will result in a higher salinity of the drainage water.

With respect to the proposed savings from rice and sugar cane, only the lower net evapotranspiration of the substitute crops should be accounted and not the difference in gross water duty. The evapotranspiration rate of rice and sugar cane is about 1.4 times more that that of alternative crops.

Assumption 10: The proposed conversion of 800,000 feddans rice and sugar cane to other, less demanding crops could result in a decrease of evapotranspiration of some 450 mm/year, corresponding to a total water saving of 1.5 billion cubic metres per year.

It remains doubtful, that farmers will accept the reduction of their rice area. The government has no capacity to inforce their decision on cropping patterns, like 10 years ago. The solution of this problem should be a rather radical one: Revoke the import ban on rice and sugar and import large quantities of cheap rice from S.E. Asia and sugar from America, in order to swing the market to an over-supply situation.

Future situation
Abstraction of 6 billion cubic metres for New Valley has the following impact on the water and salt balance of the Nile valley and delta.
Salt loads: Influx of salt at Aswan will be reduced with 1.5 million tons. Total salt load to be disposed of (including seawater intrusion): 18.5 million tons at a concentration of 2,500 mg/l, requires a drainage flow of 7.4 billion cubic metres.

Assuming that the net water saving from rice and sugar cane can be partially realised, some 1 billion cubic metres will be available. Without rice and sugar cane, the net evapotranspiration of the average cropping pattern will be about 5,000 cubic metres per feddans and year.

For the short-term it is assumed that domestic and industrial consumption remains the same amount.

Substituting these new figures in the water balance results in an availability of 36.6 billion cubic metres for net crop evapotranspiration.

Assumption 11: In the new situation some 36.6 billion cubic metres available for net evapotranspiration could sustain crop production in some 7.4 million feddans in the Nile Valley and Delta.

Assumption 12: The developments in Sinai and reclamation schemes in West and East Delta are jeopardised if the proposed abstraction of 6 billion cubic metres is released. The limit of abstraction for New Valley should not exceed 4.5 billion cubic metres.

Development of the additional groundwater potential will add 1 billion cubic metres per year. About 50% of this water could be used for domestic and industrial consumption, while the other 50% is for conjunctive use during the winter season.

Assumption 13: The total net available supply for crop production in the New Valley will not exceeded 5 billion cubic metres per year, including groundwater. This amount limits the irrigated arable land to 740,000 feddans.

Concluding remarks

All this implies that, according to the present state of knowledge, a marked water shortage is to be expected in Egypt in the years to come. Though the calculation of the water balance deficit above was based on the assumption that the discharge conditions of the Nile will not change in the foreseeable future, i.e. that the other countries bordering on the Nile will not draw larger quantities of water, in which case the water deficit in Egypt would be even more severe.

The water balance presented above and the calculation carried out show that it is an illusion to believe that the Egyptian agricultural area can be expanded to the planned extent, especially since it cannot be assumed that the other states sharing the Nil will agree to a substantial increase in the drainage of Nile waters through their canalisation and wetland drainage. Moreover, Egypt has no groundwater resources which could be renewed by natural precipitation.

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