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Assessing the Effect of Global Climate Change on the Future Jordanian Society (II): Implication

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ABSTRACT

An investigation was made on what strategic policy-making is required under the condition of global climatic change in sectors of energy, water and agriculture in Jordan, using a mathematical model previously developed to assess the future Jordanian society. According to this model, the increase in consumption resulting from the growth of both population and personal consumption was found to greatly exceed the increase of production in all sectors in Jordan throughout this century, especially in the case of climatic change. The introduction of distributed energy sources for insuring energy security, further efficient use of rain water and the introduction of new technologies such as desalinization, for instance, for water security, and the appropriate adaptation for the agriculture were pointed out as for the tactical policies in each sectors. Moreover, the importance of public awareness of the crises of energy, water and food is pointed out. Also, the necessity of building capacities for bringing up leaders to practice the adaptation, and the urgency of making long-term strategic policies in all sectors is emphasized.

Keywords: Future Jordanian Society, Model, Global Climatic Change, Energy, Water Resources, Agriculture, Assessment, Risk Communication, Building Capacities, Strategic Policy Making.

1. INTRODUCTION

The forecast of the Jordanian society, which probably varies under the condition of global climatic change, and the investigation of the possible measures by which we can cope with this change are two essentially important issues from the viewpoint of national policy, because the Jordanian society seems to be very vulnerable to the sort of climate change. The authors have developed a mathematical model to forecast the future society and to assess the effectiveness of policies to be taken under the climate change, where Jordan and its surrounding world were modeled according to the systems concepts (Ohnishi and Tyfour, 2005).

In this model the world was divided into three regions: Jordan, Arab League countries and the other countries including OECD (Organization for Economic Cooperation and Development), between which an interaction was assumed to take place through the exchange of agricultural products. In the region of Jordan, three sectors; energy, water and agriculture were introduced, and the per capita demand and supply, along with the total demand and supply of the quantities relevant to those sectors, were derived from the year 2000 to 2100. In this case, some statistical quantities were assumed to evolve with time with a growth function-like behavior so that the constants and coefficients in this function were evaluated by the least squares fitting to secular data in the past or treated as input parameters.

In the agricultural sector, three types of farm products, such as fruits, field crops and vegetables, were considered for simplicity, and they are exchanged in a worldwide scale by the foreign trade. By imposing a constraint such that the total production of each product over the world is equal to the total consumption in every year, without assuming any stock of the product, the world price of the product was deduced. The production and consumption of the product in Jordan were given in terms of the world price thus derived. To give the effect

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of worldwide homogenization or the globalization via the exchange of technologies, culture, labor force, money, information and materials including those farm products, the economical evolution of Jordan was assumed to follow the same evolutional trajectory as either (1) the Arab countries except for Gulf countries, (2) Arab Gulf countries, or (3) OECD countries. Each of these cases will be referred to as the scenarios 1, 2 and 3, respectively, in the followings.

By using the assessment model as such, this paper investigates the policy implications that can be deduced for the sectors of energy, water and agriculture. Results are discussed in Sects. 2, 3 and 4, and conclusions are presented in Sect. 5.

2. ENERGY SECTOR

The energy sector in the proposed model is of the part to explicitly and rather exogenously deduce the value of GNP (Gross National Product) which is used as the input for the sectors of water and agriculture, by relating it to the energy use in Jordan. The per capita GNP in the model is assumed to evolve along a certain trajectory as described in the previous section, which is given as a function of per capita energy use. The changing feature of the per capita GNP relative to that in 2000 is shown in Fig.1, where the values under the condition of climatic change are represented together with the values under no climate change (referred to as reference values).

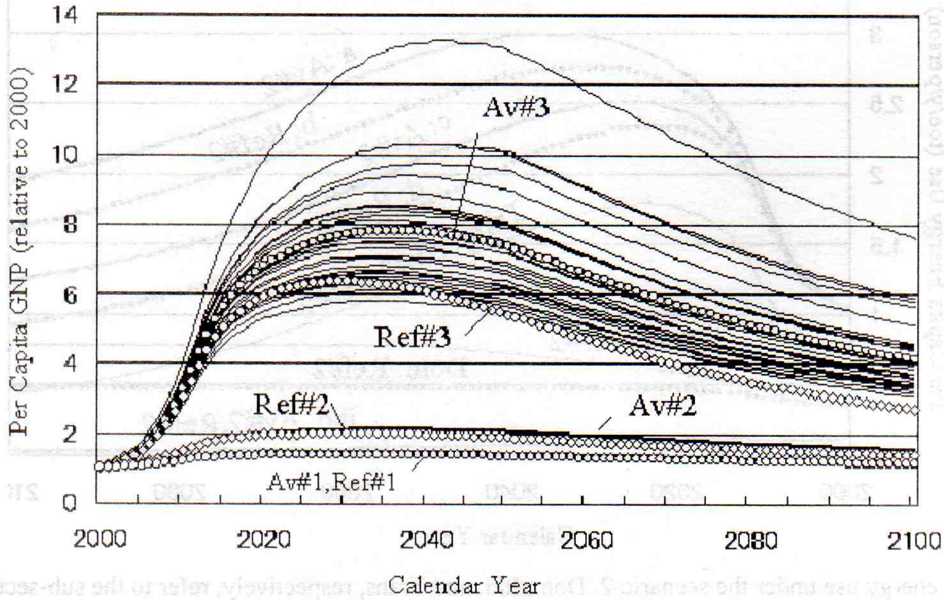

Fig. 1. Per capita GNP relative to the value in 2000. Solid curves represent the results of 30 independent trials under the scenario 3. Av(#i) and Ref(#i), respectively represent the ensemble mean of 1000 trials and the reference value for the case of scenario i (i=1 ~ 3).

The GNP in Jordan continuously increases in this century in all cases of the evolutional scenarios from 1 to 3 (Ohnishi and Tyfour, 2005). Since the population, however, grows with a rate of increase much greater than that of GNP in the second half of this century, the per capita GNP has a maximum at some time in the first half, decreasing afterward to return back in 2100 to almost as the same value as or a little bit larger value than that in 2000. Although in the case of scenarios 1 and 2, the public does not seem to become so wealthy throughout this century, they can prosper in the first half with the income as much as 6 to 8 times the one in 2000 in case of the scenario 3. The per capita energy use from which such a per capita GNP is derived will be studied in what follows.

Figure (2) shows the per capita energy use for the case of scenario 2, together with the individual energy uses of the sub-sectors of domestic, industry and transportation. Only the domestic sector is of the global climate-dependent sub-sectors. The other two sectors are independent on the climate change in the model. The curves (a) and (b) are of the results under such a condition that the energy use efficiency is unchanged throughout this century in all sub-sectors. Almost throughout this century, the energy use for the transportation is dominant over other uses. Moreover, the industry evolves only with a negligibly small rate of growth in its energy use. The improvement of energy use efficiency in the transportation sub-sector, therefore, is the major issue to be settled in Jordan.

The curves (c) and (d) in Fig (2) are the curves under the condition that the energy use efficiency in the transportation sub-sector is improved with time. so that the amount of energy necessary for moving a car by a unit length, which is given by the factor $E_{11}(t)$ in the model, decreases as:

$$E_{11}(t) = 1 - H(a_{E11}, b_{E11}, c_{E11} : t) \quad (1)$$

Where H (a, b, c: t) is a growth function defined by

$$H(a, b, c : t) \equiv c\{1/(1+\exp(-at+b)) - 1/(1+\exp(b))\}. \quad (2)$$

When we set $(a_{E11}, b_{E11}, c_{E11})$=(0.02, 1.0, 1.0), the value of Eq.(2) increases almost linearly with time to become around 0.5 in 2100. This, therefore, corresponds to the case of improvement of energy use efficiency by a factor of 2 during 100 years. In this case, the per capita energy use decreases in the second half of the century by about 0.7 toe/y/person as compared to the case without any improvement of the efficiency, irrespective of the scenarios. This strongly indicates that the improvement of the energy use efficiency in the transportation sub-sector is a crucial point for the energy policy in Jordan, in view of the fact that all Jordan's energy sources depend almost on other countries.

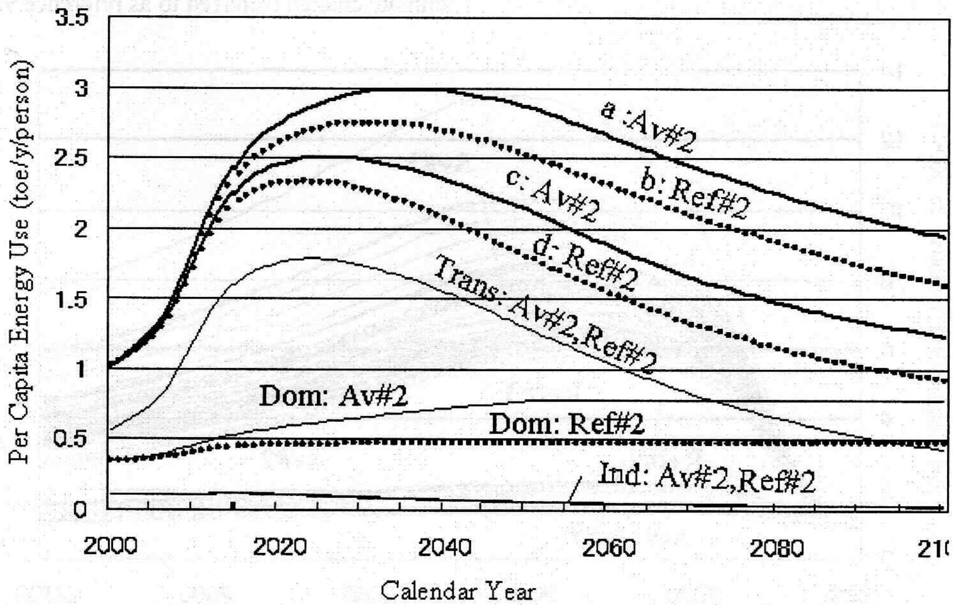

Fig. 2. Per capita energy use under the scenario 2. Dom, Ind, and Trans, respectively, refer to the sub-sectors of domestic, industry and transportation. The curves a and b are of the cases without any improvement in energy use efficiency, whereas c and d with its improvement.

Figure (3) represents the total energy use in Jordan, which has a quite different feature from the per capita energy use; Fig. (2). It increases with time to become within a range of $3 \sim 6\times10^7$ toe/y in 2100 depending on the scenarios. This is about ten times the value 5.1×10^6toe/y in 2000 (Department of Statistics, 2003). About 95% of Jordanian energy is imported at present. All Jordanians, therefore, should recognize the rapidly increasing energy demand as such to be a very serious problem for themselves. The regulation of energy use by requiring the cooperation of the public for energy saving through the control of energy price may be one of the possible ways to cope with this situation, although the public approval is a prerequisite for such an action.

Figure (4) shows the energy cost relative to the year 2000 to be set when the restriction is conditioned such that the per capita energy use throughout this century never to exceed the one in 2000, namely

$$E_J(t)/P_1(t) \le \lambda E_J(0)/P_1(0), \quad (3)$$

Where λ(=1.0) is a constant, $E_J(t)$ and $P_1(t)$ are, respectively, the total energy use and the population, both at the time t, and t=0 corresponds to the year 2000. In this case, we have tacitly assumed that the domestic costs of energy in all the sub-sectors are equal to each other and that the base price of energy does not vary with time for simplicity. According to the result, although the cost is required to be raised in the years $2020 \sim 30$ to $40 \sim 50$

times (in the case of scenario 2) and 60 ~ 90 times (scenario 3) the cost in 2000, it can be reduced gradually with time after that. Compared with the per capita GNP given in Fig.1, the rate of increase of the cost is almost ten times the one of the per capita GNP in 2020 ~ 30, indicating a compulsion of a quite severe financial load on the public. The appropriate enforcement of energy's subsidies is strongly required in this regard, together with the procurement of firm agreement of the public on this issue.

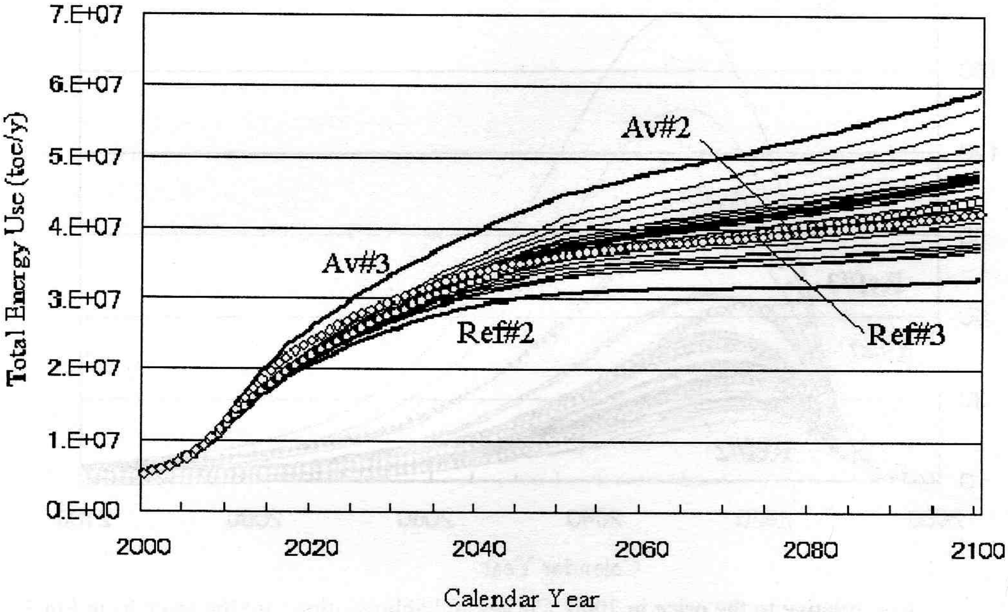

Fig. 3. Time evolution of the total energy use in Jordan. Solid curves represent the results of 30 independent trials under the scenario 2. Av(#i) and Ref(#i), respectively, represent the ensemble mean of 1000 trials and the reference value for the case of scenario i (i=1 ~ 3).

The agreement of the public should include the following contents:

(1) The agreement on raising energy cost in general.

(2) The agreement on executing some relief measures appropriate for the poor to raising cost.

(3) The agreement on executing some energy taxes with regard to the use of energy for excessive energy users. Such taxes are, for instance, the CO_2 tax or the environmental tax for releasing harmful gases into the environment, and the tax imposed for the cost of Prepairing and maintaing the infrastructure of transportation system such as roads and parkings. The latter tax is to make the internalization of external cost.

As for the countermeasures to be taken against the growing energy demand, the following two items are to be pointed out, except for the increase of import from the outside and for the enforcement of restriction of energy use;

(1) Making pervade the concept of energy saving throughout the Jordanian society, by informing the public about the energy crisis of this country and about the effective use of energy by means of various types of media. Offering and transmitting such information to the public is called risk communication (Lundgren and McMakin, 1998). It will become a quite significant issue in the field of public relations. The success in obtaining the public's understanding and support regarding energy saving in the future depends on the success or failure of the risk communication to be taken from now on.

(2) Promoting the development and the introduction of new energy sources, in view of energy security of Jordan. It is important to raise the energy self-sufficiency, even if it is a small amount. In addition to expanding the use of usual solar and wind energies, new type of energy sources should positively be introduced, which are usable in sparse local region such as the biomass energy system and various types of fuel cells. On the other hand, the search and development of fossil fuels in Jordan should also be continued. With regard to the electricity generation, the advanced gas-burning thermal power plant and even the nuclear power plant of the small-sized and intrinsically safe type

should be considered for insuring energy security by diversifying energy type.

As seen in Fig. (3), the energy demand in Jordan certainly and necessarily continues to grow in this century, irrespective of the difference of social evolution and of the extent of global climatic change. Planning and constructing energy infrastructure such as the power generation system requires a long lead time. It should be recognized, therefore, that policy making for securing energy crisis in Jordan is an urgent matter.

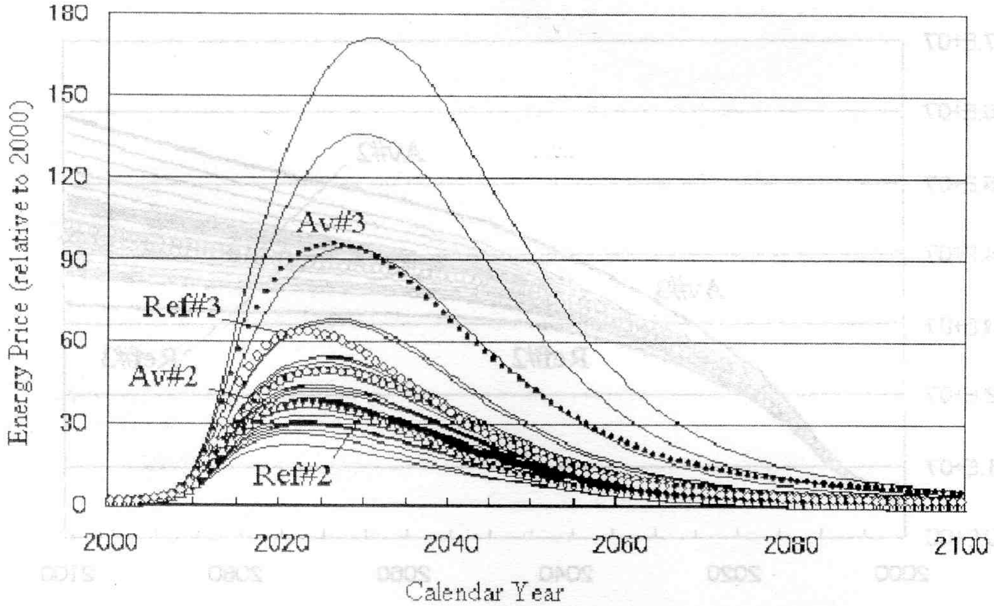

Fig. 4. Energy price relative to the price in 2000. Curves and abbreviations are the same as in Fig.3.

3. WATER RESOURCES SECTOR

The water supply in Jordan is now on the verge of a cliff; so that it can barely satisfy the water demand even at present. In view of the indisputable population growth in the future, issues regarding water in Jordan will become more and more serious social problems.

Figure (5) shows the secular variation of the per capita demand of water. Here we have assumed that, in the field of agriculture, the irrigation area increases to be 4/3 folds during the coming 100 years in Jordan, and that the water demand is not changed even when new agricultural technologies, regional measures and water harvesting strategies are introduced as adaptation to the climate change. Here the adaptation means: *the adjustments that are possible to be made in practices, processes, or structures of systems to a projected or actual change of climate. It can be spontaneous or planned, and can be carried out in response or in anticipation of change in climate condition* (Burton, 2004).

In the three sub-sectors: agriculture, domestic and industry, agriculture consumes about 70% of the total use of water at present (Department of Statistics, 2003), the remainder being used by the other two sub-sectors although the industrial use is much smaller than the domestic one. According to our calculation, under the condition of climate change, the domestic use in 2050 increases to about 1.7 times and 2.0 times the present value in case of the scenarios 2 and 3, respectively. Such an increase is due to the rises of both the temperature and the living standard of the Jordanians. The per capita water use in the agriculture, however, decreases with time due to the growth of population despite the slight increase of irrigation area; so that the per capita water use in the domestic becomes dominant over the agriculture after around 2050. In the case of no climate change, the quantity in the agriculture sector decreases more rapidly with time than in the case of climate change because of no extra irrigation water due to temperature rise.

Figure (6) shows the total water demand in Jordan. It increases almost linearly with time mainly due to the increase of population. In the case of climate change, the total demand grows to 3.8×10^9 and 4.0×10^9 m^3/y in 2100 for the scenarios 2 and 3, respectively, which are 5.5 and 5.8 times the demand in 2000. Whereas in the case of no climate change, it is 2.3×10^9 m^3/y in 2100 irrespective of scenarios.

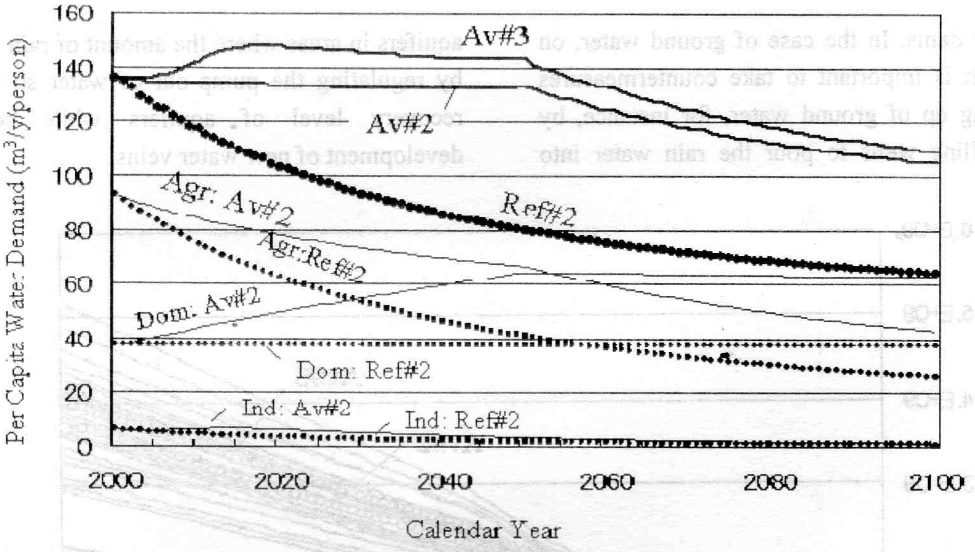

Fig. 5. Per capita water demand, together with its components of agricultural (Agr), domestic (Dom) and industrial (Ind) sub-sectors. Abbreviations are the same as in Fig.3.

Figure (7) shows the time variation of per capita water supply, together with the evolutional feature of the amounts of two components: surface and ground waters. The per capita water supply decreases in 2050 and 2100 to about 28 and 21% of the present value, respectively, in the case of climate change, and in 2100 to about 40% even in the case of no climatic change. Such decrease by time is mainly due to the population growth. This indicates the tendency to a decrease in the public's quality of life to a considerably low level unless extra measures are applied to develop other types of water resources. The appearance of a maximum in the supply of surface water in around 2030 is due to the assumption of the efficient use of rain water by constructing new dams, and a further efficient use of river water, whose effects in the model are taken into account through the factor $W_{11}(t)$. The values of constants in the hypothetical growth function $W_{11}(t)$ are $(a_{W11}, b_{W11}, c_{W11})=(0.05, 2.0, 1.0)$, in which the $W_{11}(t)$ reaches 1.38, 1.70 and 1.83 in the respective years 2040, 2070 and 2100. The smaller amounts of both surface and ground waters available for the case of climate change compared to the case of no climate change are due to the increased evaporation under high temperatures and to the decreased precipitation.

Figure (8) shows the total water supply in Jordan. Gradual increase in water quantity by time under the condition of no climate change is owed, together with the effect of the above-cited factor $W_{11}(t)$, to the increase in the amount of ground water due to the development of new wells, whose effect is taken into account through the factor $W_{14}(t)$. For the constants in $W_{14}(t)$, we adopted the same values as $W_{11}(t)$ as $(a_{W14}, b_{W14}, c_{W14})=(0.05, 2.0, 1.0)$. In the case of climate change, on the other hand, the amount of water supply cannot increase despite the effort for developing surface and ground waters, since the direct influence from the decrease of the inflow of rain water into rivers and ground aquifers overcomes the positive effects.

The total deficit of water in Jordan is shown in Fig.(9), which can be derived from the amounts of supply and demand. Under the condition of climatic change, the water deficit increases to 2.7×10^9 and 3.0×10^9 m^3/y in 2100 for the cases of scenarios 2 and 3, respectively, these being about 4 or more times the total water supply (6.9×10^8 m^3/y) in 2000 (Department of Statistics, 2003). It is a quite significant matter for Jordan to think by what measures such a vast amount of water is to be made available from a finite amount of water resources. It is a serious matter closely related not only to the public's quality of life, but to the economical vitality or national power of Jordan.

Under the condition of no climate change, on the other hand, there appears to be no extra water stress. It should be noted, however, that such a situation is realized only when we continue to develop both the surface and ground waters with such a pace as their available amounts in 2100 become 1.8 times the value in 2000, as already described. It will never be an easy task to satisfy such a severe water demand in Jordan where water development seems to approach the limit. In the development of surface water, more effective accumulation of rain water must be realized from a much wider range of land than by constructing new dams. In the case of ground water, on the other hand, it is important to take countermeasures against the drying up of ground water, for instance, by constructing refilling wells to pour the rain water into aquifers in areas where the amount of rain fall permits, or by regulating the pump-out of water so as to hold the recovery level of aquifers while continuing the development of new water veins.

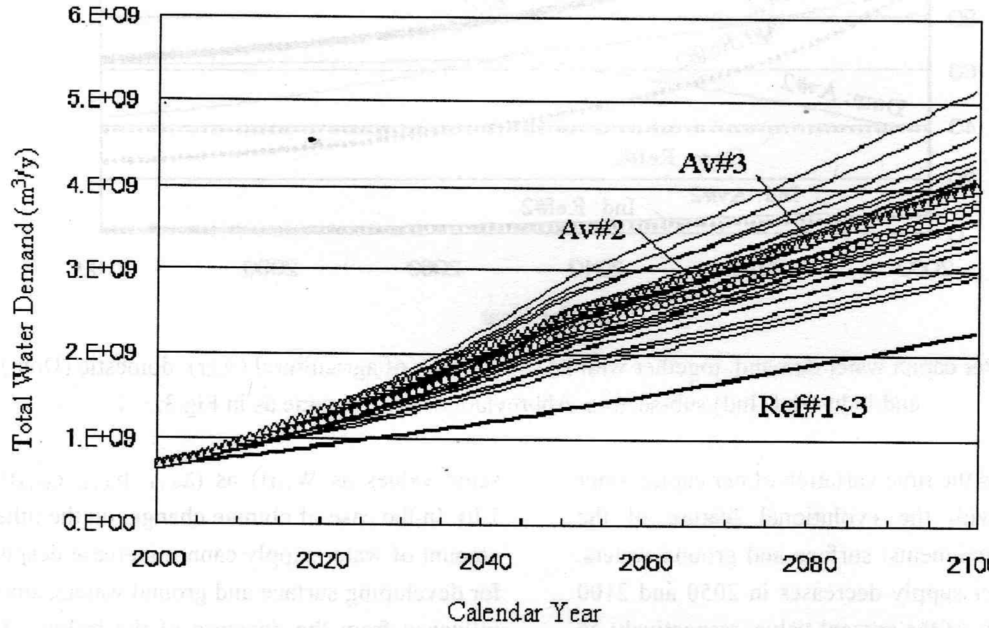

Fig. 6. Time evolution of total water demand in Jordan. Curves and abbreviations are the same as in Fig.3.

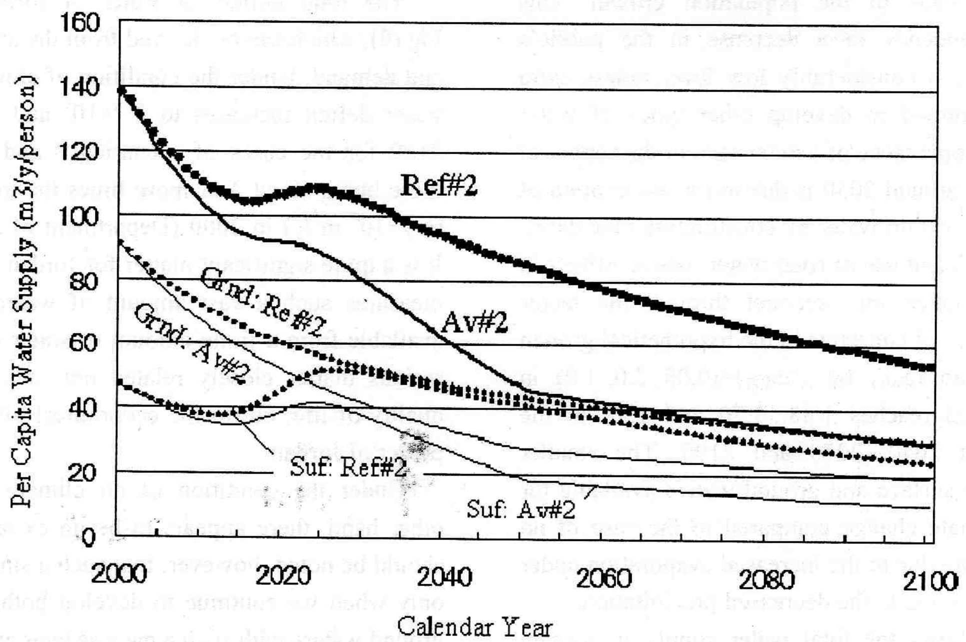

Fig. 7. Per capita water supply, together with its components of surface (Surf) and ground (Grnd) waters. Abbreviations are the same as in Fig.3.

In mitigating water shortage or keeping water security in future Jordan, the following two measures, at least, should be seriously considered:

(1) Effort of water saving in all sub-sectors in Jordan.
(2) Developing water resources other than the surface and ground waters.

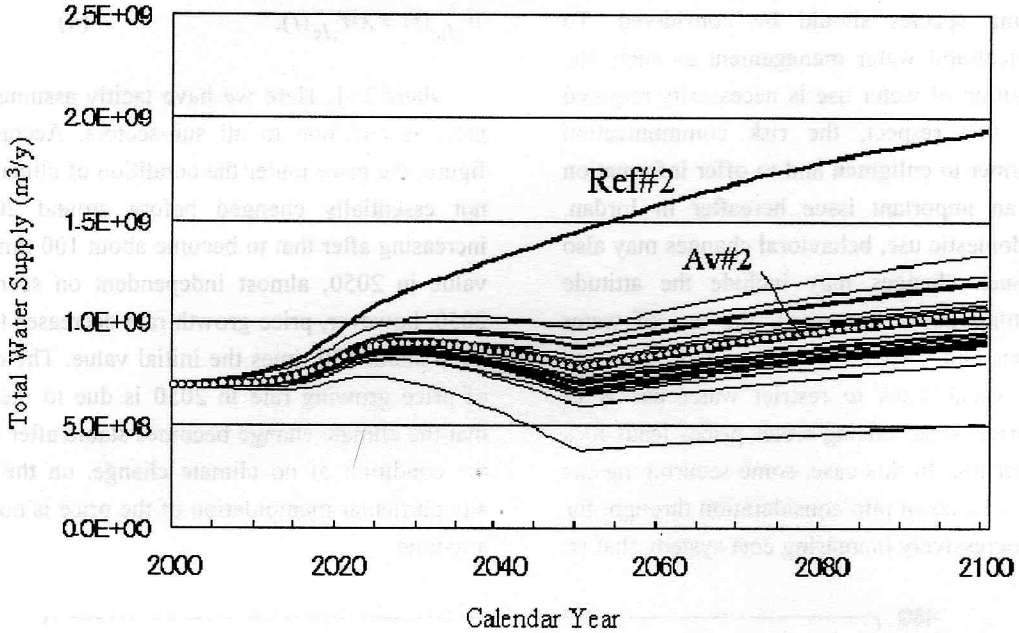

Fig. 8. Time evolution of the total amount of water available in Jordan.
Abbreviations are the same as in Fig.3.

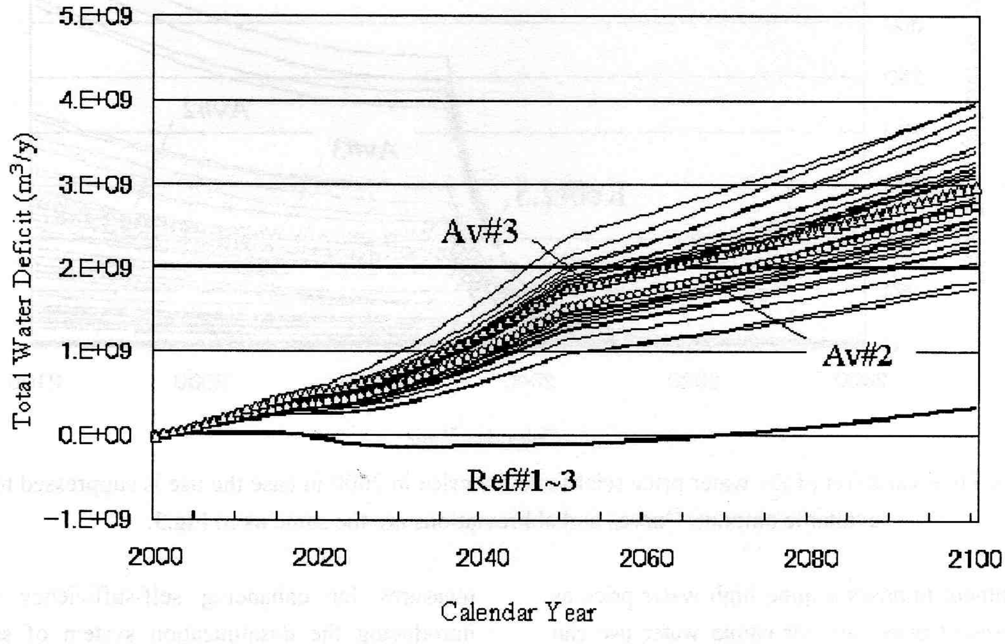

Fig. 9. Time evolution of the total deficit of water in Jordan.
Curves and abbreviations are the same as in Fig.3.

The first thing to be done regarding item (1) is to improve the public awareness of the water crisis in Jordan and to emphasize the significance of water saving. In this respect, the public is expected to acquire the attitude of water saving. It, therefore, seems to be important to make risk communication for the general public as in the case of energy risk communication. With regard to water saving, it is also important to change the excessive waterfeeding irrigation into more effective methods; for example the basin irrigation which is pervasive now in Jordan can be replaced by using sprinklers. Moreover, changing of the varieties of farm products into more water conserving species should be considered. To change the agricultural water management as such, the farmer's recognition of water use is necessarily required to change. In this respect, the risk communication targeting the farmer to enlighten and to offer information also becomes an important issue hereafter in Jordan. Regarding the domestic use, behavioral changes may also be required. Such changes may include the attitude towards swimming pools, car wash, the use of water saving equipment, and ...etc.

One of the usual ways to restrict water use is to control water price, since raising water prices leads to a decrease in water use. In this case, some securing means for the poor must be taken into consideration through, for instance, the progressively increasing cost system, that is, price-consumption proportionality. Figure (10) shows the water price to be set at a given time when the total demand $W_{Ju}(t)$is restricted just to the total amount available at that time $W_{Js}(t)$. Namely;

$$W_{Ju}(t) = \lambda W_{Js}(t), \quad (4)$$

where λ=1. Here we have tacitly assumed that water price is common to all sub-sectors. According to this figure, the price under the condition of climatic change is not essentially changed before around 2020, rapidly increasing after that to become about 100 times the initial value in 2050, almost independent on scenarios. After 2050, however, price growth rate decreases to become in 2100 about 130 times the initial value. The discontinuity of price growing rate in 2050 is due to the assumption that the climate change becomes stable after 2050. Under the condition of no climate change, on the other hand, any particular manipulation of the price is not required at any time.

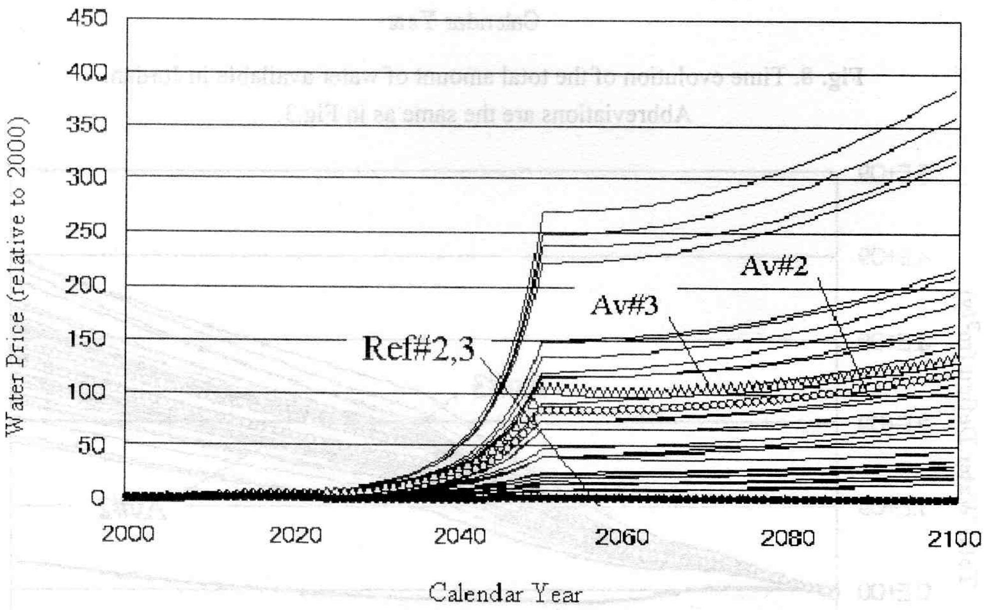

Fig. 10. Time variation of the water price relative to the price in 2000 in case the use is suppressed to the available amount. Curves and abbreviations are the same as in Fig.3.

If the government imposes a quite high water price as 100 times the present price, the per capita water use can certainly be reduced to about 1/3 of the present use. The quality of life of Jordanians, however, indisputably will be inferior in this case. To mitigate such an unpleasant situation, it is necessarily required to measure (2), suggested above, at the same time. Although importing water from neighboring countries can be conceivable as one of the solutions, it is highly desirable to take the measures for enhancing self-sufficiency of water by introducing the desalinization system of sea water, for instance, in view of water security in Jordan.

Meanwhile, the water supply in Amman is at a marginal state at present. Such a situation is a result of the excessive concentration of population in the capital to such an extent that it becomes impossible for the water administration to manage. It can be dared to say that the water problem in Amman moves to be irresolvable if further concentration of population proceeds in this city hereafter. Noticing that there exist some municipalities which somewhat have a margin for water veins, regulating the accumulation of population in urban areas by the planned allocation of growing population over the local municipalities is proposed as one of the possible solutions for the water problem. It should be noted that water problem in Jordan is fundamentally the problem of urban planning.

4. AGRICULTURAL SECTOR

With the increase of population, the assurance of food security also becomes more and more a serious concern to Jordan. Since the aggravation of food self-sufficiency can not be denied unless some innovative method for extensively reclaiming arable land is developed, the increase of food import will become inevitable. In our model, three types of farm products such as fruits (referred to as the type 1 product, hereafter), field crops (the type 2 product), and vegetables (the type 3 product) are taken into account, for each of which lemons, wheat and tomatoes being considered as representative products, respectively.

In the model, both the producer and consumer prices of farm products in Jordan are assumed to be given by the world price of the product common to all countries, the agricultural subsidy factor intrinsic to Jordan, and the marketing margin factor, the latter two factors being assumed constants and independent on time for simplicity (Ohnishi and Tyfour, 2005). In this case, both the producer and consumer prices in Jordan become proportional to the world price, which is determined strongly depending on the amounts of production and/or consumption in the region where the production and/or consumption are remarkable. Namely, those prices are determined, in our case, depending on the production and consumption in OECD countries. Many OECD countries are situated in the region of middle latitude where most global climate models predict higher summer temperatures and more winter precipitations in case of climatic change than ever (McCarthy et al., 2001). Since those meteorological conditions, together with the fertilization effect due to enhanced CO_2 concentration, lead the positive effect for the vegetation, the per capita agricultural production in OECD countries seems to increase under the condition of global climatic change, despite the increase of population in those countries. This leads the reduction of the world prices of farm products under the climate change. In the case of no climate change, on the other hand, the price increases because the growth of population surmounts the growth of agricultural production. Such a situation is shown in Fig. (11) of the previous paper for the case of type 1 product (Ohnishi and Tyfour, 2005). The variation of the prices of type 2 and 3 also shows a similar trend as of type 1.

Since we showed the time behavior of the quantities related to the type 1 product in the previous paper (Ohnishi and Tyfour, 2005), features regarding the products of type 2 and 3 are mainly to be shown below.

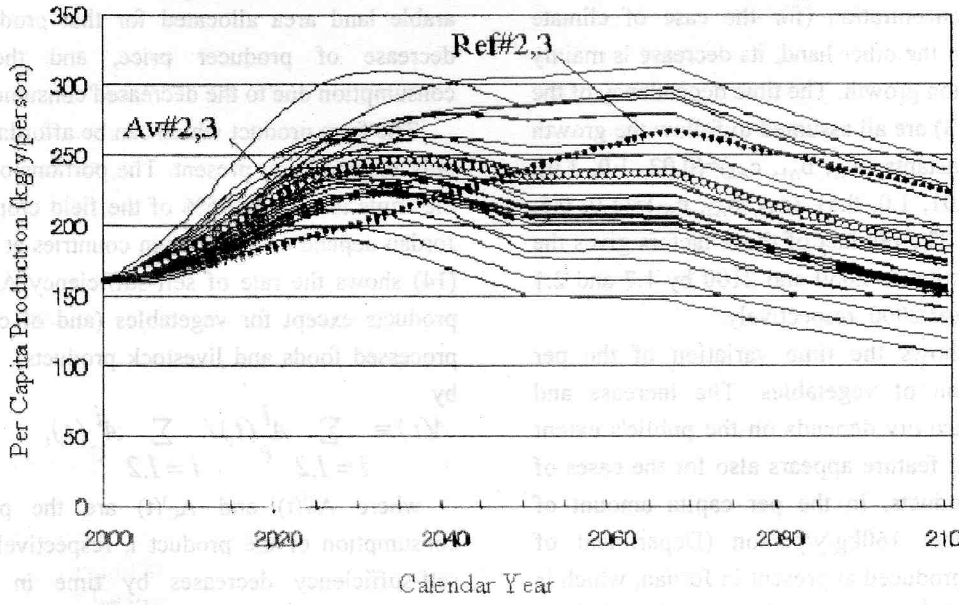

Fig. 11. Per capita production of the farm product of type 3. Curves and abbreviations are the same as in Fig.3.

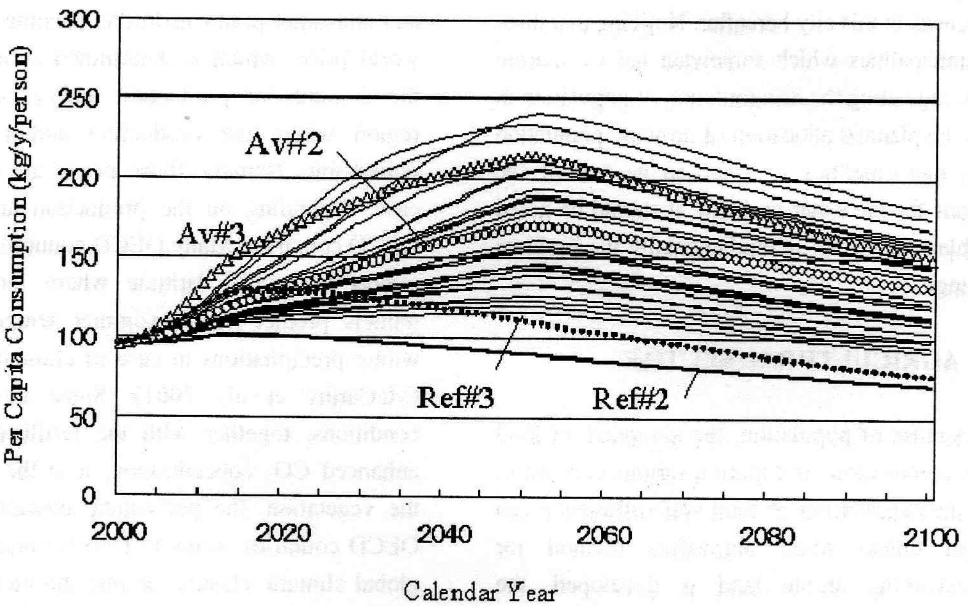

Fig. 12. Per capita consumption of the farm product of type 3.
Curves and abbreviations are the same meanings as in Fig.3.

Figure (11) shows time evolution of per capita production for the type 3 product, vegetables. The increase of this quantity by time is due to the increase of improvement in agricultural technologies through the factor A_1^{ki} ,defined in the previous paper (Ohnishi and Tyfour, 2005), the increase of the area of arable land allocated for that product due to the increase of producer price (A_2^{ki}), the increase of productivity due to improvement in the method of irrigation (A_3^{ki}), and the positive effect for the vegetation due to high temperature and high CO_2 concentration (for the case of climate change). While, on the other hand, its decrease is mainly due to the population growth. The time dependency of the factors A_j^{ki} (j=1 ~ 3) are all assumed to follow the growth functions with constants (a_{A1}, b_{A1}, c_{A1})=(0.02, 1.0, 1.0), (a_{A2}, b_{A2}, c_{A2})=(0.01, 1.0, 0.5), (a_{A3}, b_{A3}, c_{A3})=(1.0, 0.5, 0.5), respectively. The product of those factors gives the increase of production in 2050 and 2100 by 1.7 and 2.1 times that of the year 2000, respectively.

Figure (12) shows the time variation of the per capita consumption of vegetables. The increase and decrease of the quantity depends on the public's extent of income. Similar feature appears also for the cases of type 1 and 2 products. In the per capita amount of vegetables of about 160kg/y/person (Department of Statistics, 2004), produced at present in Jordan, which is equivalent to 9.0×10^5tons/y in total, the portion of about 60% is consumed within Jordan while the remainder is exported.

Figure (13) shows time evolution of the total amount of export of vegetables. This quantity gradually increases from the value of about 3.3×10^5tons/y in 2000, its increasing rate becoming remarkable after around 2030, to be $5 \sim 6\times10^6$tons/y in 2100 in case of no climate change. Under the condition of climate change, on the other hand, the amount of export does not show any trend of increase, remaining almost flat throughout this century. This is the manifestation of a synergetic effect coming from the shortage of irrigation water, the decrease of arable land area allocated for that product due to the decrease of producer price, and the increase of consumption due to the decreased consumer price.

The farm product which can be affordable in Jordan is only vegetables at present. The portions of about 20% of the fruits and about 95% of the field crops consumed in Jordan depend on the foreign countries at present. Figure (14) shows the rate of self-sufficiency Λ(t) of the farm products except for vegetables (and of course, also for processed foods and livestock products), which is given by

$$\Lambda(t) \equiv \sum_{i=1,2} A_P^i(t) / \sum_{i=1,2} A_C^i(t), \qquad (5)$$

where $A_P^i(t)$ and $A_C^i(t)$ are the production and consumption of the product i, respectively. The rate of self-sufficiency decreases by time in any scenario, indicating the realization of a quite serious state of food security in the future. In the case of climate change, Jordan is to import farm products of the types 1 and 2 amounting 1.5 ~ 2.0×10^{7}tons/y in 2100, depending on the scenario. Since it was 1.7×10^{6}tons/y in 2000, that amount in 2100 is about 10 times the value in 2000. The total sum of money for the import, which is defined by $\Sigma_{i=1,2}$(imported amount)$_i$×(world price)$_i$, amounts to 1.1×10^{9}dollars in 2100, which is about 1.2% of the GNP in the case of scenario 2. On the other hand, although the self-sufficiency in the case of no climate change decreases by time, the extent of its decrement is not so severe as for the case of climate change. Such a tendency in case of no climate change is originating from the varied attitude of the public towards voluntarily cutting down the food consumption, due to the increase of consumer price. This indicates that when the government interferes to suppress the rise of domestic price by some type of subsidies for the imported products, the domestic consumption increases to lead to further increase of import even in the case of no climate change.

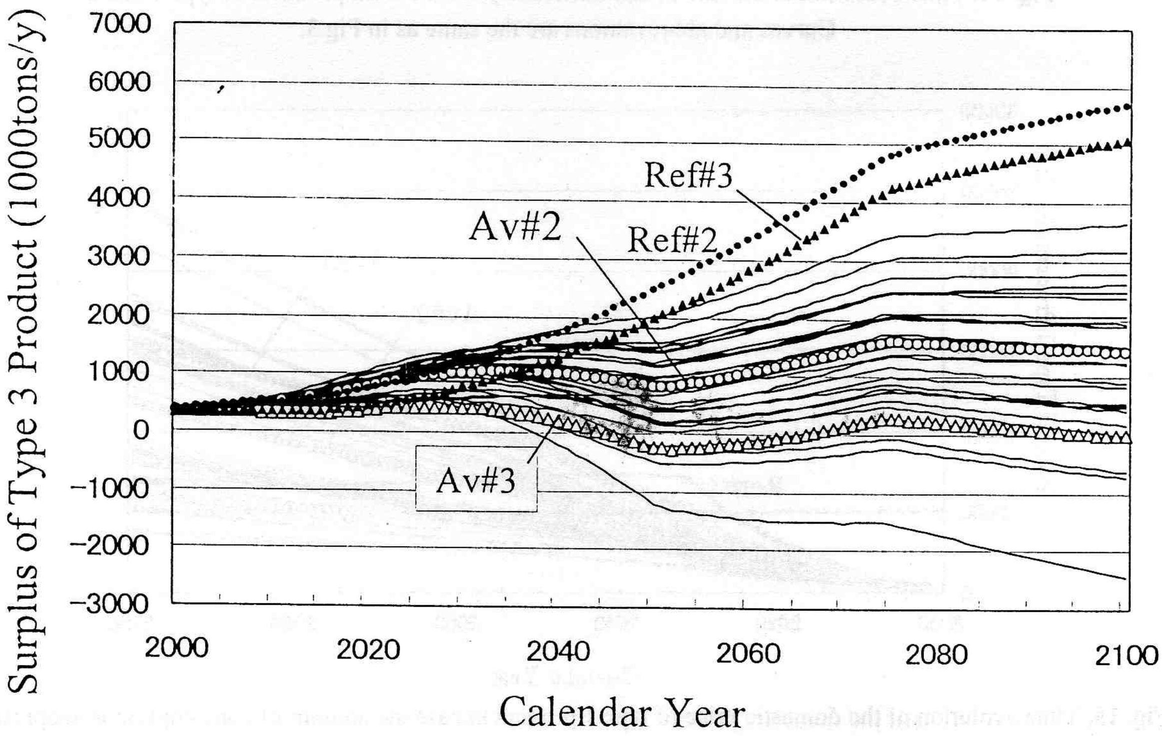

Fig. 13. Total amount of surplus, that is, the export of the farm product of type 3. Curves and abbreviations are the same as in Fig.3.

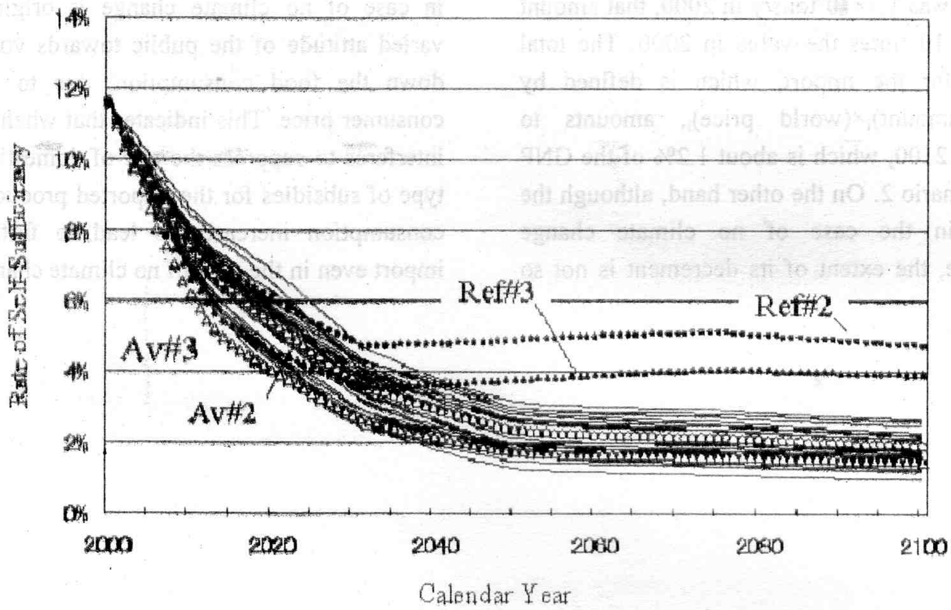

Fig. 14. Time evolution of the rate of self-sufficiency for the farm products of type 1 and 2. Curves and abbreviations are the same as in Fig.3.

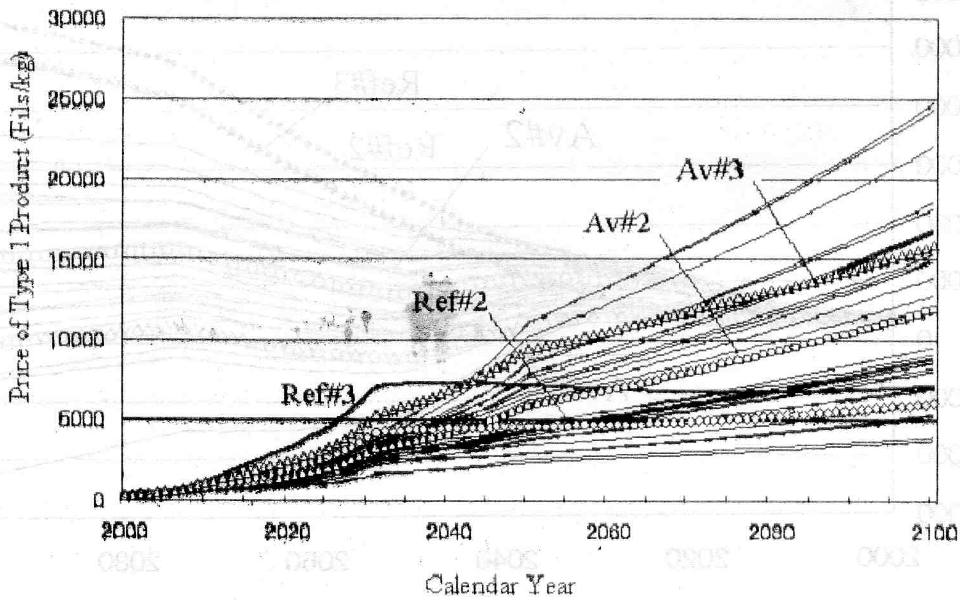

Fig. 15. Time evolution of the domestic price of type 1 product in case the amount of consumption is suppressed just to the amount of production. Curves and abbreviations are the same as in Fig.3.

We consider in the next place the case when the price is politically controlled by the government in view of the food security so as to satisfy the self-sufficiency. Figure (15) shows time variation of the price of type 1 product, lemons, for instance, under the policy such that the domestic consumption is suppressed just to the amount of the domestic production in every year. Under the condition of climate change, the price of lemons, being assumed as 320 fils/kg in 2000, increases with time to become 12000 and 16000 fils/kg in 2100 for the scenarios 2 and 3, respectively, while it varies within the range of 450 ~ 750 fils/kg after around 2030 in the case of no climate change. In any of these cases, the per capita consumption is only 10 ~ 30% of the per capita demand at any time, so that the quality of life is greatly aggravated.

It is utterly impossible to intend the self-sufficiency for the type 2 product, field crops, because of the shortage in its production in Jordan. It should be noted, however, that from the political viewpoint, it is significant to put a great deal of effort into the production of the type 3 product. Without depending on the extent of climate change, the following points is to be considered as one of the tactics of the no-regret policy for the Jordanian agriculture:

(1) Gradually changing the varieties of products into the water conserving ones.

(2) Gradually decreasing the area of arable land for the crops, while increasing the area for vegetables by importing low priced crops from the outside, because the world price of crops is expected to decrease in the case of climate change.

(3) Making effort to bring up the Jordanian vegetables to a high commercial values, which means high quality, to be able to compete in the world market.

(4) Diversification of the varieties of vegetables, without accumulating the effort to produce a single product, for instance, tomatoes. This can lead the dispersion of risk coming not only from the world market, but also from the unexpected and abrupt change of meteorology in the case of global climate change.

(5) Gradually changing the agricultural concept from the conservative one to the variation-oriented one through the introduction of adaptive means, such as the change of farming practices, the change of land allocation, the change of irrigation method, the application of biotechnologies, and the introduction of planning for each unit of farm according to a long-term agricultural policy.

(6) Bringing up more specialists to be able to educate the farmer on the adaptation practices and suitably manage these practices, that is, building capacity for the adaptation to the climate change (Eade, 1997).

5. JORDANIAN AUTHORITIES AWARENESS AND STRATEGIES

It seems that authorities in Jordan are aware of the qualitative size and nature of the problem of resources in the different sectors. This awareness is driving force behind strategies, research, and study projects. For example, in the sector of water resources, the Ministry of Water and Irrigation has approved a water strategy which includes sub-strategies on resource development, resource management, legislation and institutional set-up, shared water resources, public awareness ...etc. For more information on Jordan's water strategy, reader is referred to the website of the Ministry of Water and Irrigation (http://www.mwi.gov.jo/Misc/Misc.aspx).

Another example is the number of studies on water resources in north Badia (Al-Adamat, 2004; Al-Adamat, 1996). Likewise, the Government has undertaken a number of feasibility studies and test programs on oil shale, coming out with promising results. All tests proved that burning Jordanian oil shale is very stable, emission levels are low and carbon burn-out is high. Furthermore, research on catalytic gasification was undertaken, coming out with positive results. Solvent extraction of organic matter was the subject of a joint study by the Jordanian Natural Resources Authority and the National Energy Research Center. For further details, reader is referred to the publications of the World Energy Council (http: //www.worldenergy. org/ wec- geis/publications/).

Technical and economical studies on other renewable energy resources including solar and wind energy in Jordan have, also, been the subject of recent research. Example of such studies is found in (Al-Smairan, 2006).

Relating the type of strategies, research and studies discussed above with the implications of climatic change predicted by the model and discussed in this paper may form a good tool for decision makers in Jordan.

6. CONCLUSION

The model used as a tool in this paper is just only one of many possible methodologies for assessing the future society. Many of the values of constants and coefficients used in the example calculation are only default values which may not stand on firm bases. Moreover, the uncertainty regarding the climate change is still very large at present. The results in our calculations, therefore, cannot necessarily tolerate quantitative discussion. They are, however, meaningful when comparing the relative magnitude between quantities or study the time behavior of quantities qualitatively. Even when the discussion is restricted to a qualitative form, the realization of seriousness of Jordan future situation in the fields of energy, water and agriculture cannot be denied. This is fundamentally due to the high increasing rates of population and of the per capita consumption which highly exceed the rate of production, irrespective to the extent of climate change. To mitigate and cope with such a situation, firm policies should promptly be made and implemented. With this regard, and according to this study, the following suggestions can be made:

(1) It is significant, not only for policy makers, but also for all Jordanians, to have a common recognition regarding the crises of energy, water and foods in the future. Moreover, each Jordanian is also expected to have a clear vision of future Jordan regarding what desirable state Jordan should evolve hereafter. To make the realization of such matters possible, it is important to continuously inform the public on the future crisis through various media, that is, the risk communication and social education all over the country. Without holding common cognition as such, it will be impossible for the public to cooperate with and to respond to the governmental appeal of energy and water savings, for instance. It is also important to educate the children at school on the reality of the future of energy, water and food in Jordan, including the significance of environment and finite natural resources. It is encouraging that such an education seems to have already started in this country (Al Shannag and Schreier, 2001).

(2) The adaptation of energy, water and agriculture resources most appropriate for each local region is one of the many important issues to be tackled in future. A group of specialists should be brought up to monitor not only the local meteorological change but also the state of local society, along with methods of tactical adaptation most suitable for the local community. Such a capacity building must be accompanied by encouraging the research activities in the field of the strategic, long-term adaptation intrinsic to Jordan to create the base for the adaptive practices in a community scale.

(3) Policies must possess firm objectives with firm target dates and firm numerical goals. Long lead times are required in general to make plans and to construct infrastructural facilities of energy and water, indicating the requirement of strategic policies with a long-time horizon. In this context, there should be no-regret policies which consider the possibility of the global climate change as one of many uncertain factors to which Jordan is confronting at present, so that the policies can be durable even when the climate change does not attack Jordan.

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تقييم تأثير التغير المناخي العالمي على مستقبل المجتمع الأردني (2): التبعات

*تيرواكي أوهنيشي ووائل رضوان طيفور**

ملخـــص

تم القيام بتحريات لمعرفة ماهية السياسات الاستراتيجية الواجب اتباعها في قطاعات الطاقة والماء والزراعة في الأردن تحت تأثير تغير المناخ العالمي، وذلك باستخدام نموذج رياضي تم تطويره لتقييم مستقبل المجتمع الأردني. واعتماداً على هذا النموذج فقد وجد ان زيادة الاستهلاك التي ستنجم عن النمو المتزايد في أعداد السكان، وكذلك عن زيادة الاستهلاك الفردي، ستفوق بكثير الزيادة في الإنتاج في جميع القطاعات في الأردن خلال هذا القرن.

إن إدخال مصادر طاقة منوعة لضمان الأمن في مجال الطاقة، إضافة إلى فاعلية استخدام مياه الأمطار، وإدخال تقنيات جديدة مثل تقنية تحلية المياه، واستخدام أساليب زراعية ملائمة، كلها تعد سياسات تكتيكية لكل قطاع. هذا إضافة إلى أهمية زيادة ثقافة المجتمع حول أزمة الطاقة والمياه والزراعة.

أما في مجال بناء القدرات فتؤكد الدراسة ضرورة تنشئة قادة قادرين على ممارسة التكيف مع الظروف ووضع السياسات الملائمة، كما تؤكد الدراسة ضرورة أن تكون السياسات الاستراتيجية في جميع القطاعات طويلة الأمد.

الكلمـــات الدالـــة: التغير المناخي العالمي، الطاقة، الزراعة في الأردن، مصادر المياه، السياسات الاستراتيجية.

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