EDUCATION, RESEARCH AND TRAINING FOR SUSTAINABLE USE OF WATER RESOURCES IN AGRICULTURE

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Abstract

It is well recognized that development has to be reoriented to effectively respond to the population growth, increased urbanization, problems of poverty, hunger and malnutrition, and the expectations of the young generations and of the less developed regions. Questions relative to water play an essential role because water demand is increasing, the resource is scarce and water quality is degrading. Competition for water is therefore threatening agricultural water use since agriculture has the highest demand but with low efficiency and low cost recovery. However, the food supply of the growing population requires irrigated agriculture.
The use of water in agriculture imposes that the concept of sustainable development fully applies: conservation of natural resources, adoption of appropriate technologies, environmental friendliness, economic viability, institutional adequateness and social acceptability and awareness. This implies innovative approaches for the orientation of high education, research and training. Priority areas of concern include those related to environmental and health impacts, water quality management, modern irrigation systems, technologies for use of waste and saline water, basin wide integrated planning of land and water resources, water saving techniques, economics of agricultural development, and social, institutional and policy issues.

Résumé

Il est devenu claire que le développement doit prendre de nouvelles orientations pour bien répondre à la croissance de la population, à l'urbanisation, à la pauvreté et à la famine, et aux expectatives des nouvelles générations et des regions moins developpées. Les questions relatives à l'eau jouent un rôle essentiel dans ce contexte parce que la demande pour l'eau va en augmentant, la resource est limitée et la qualité des eaux se dégrade. La compétition pour l'eau affecte les usages agricoles tant plus que la demande agricole est la plus grande, que l'efficience est basse et que la couverture des coûts est faible. Pourtant, la production d'aliments pour la population toujours croissante exige l'irrigation.
Le concept de développement durable doit s'appliquer à l'utilisation agricole de l'eau: conservation des resources naturelles, adoption de technologies appropriées, équilibre avec l'énvironnement, viabilité économique, adéquation institutionelle et acceptabilité sociale. Cela implique de nouvelles approches en matière d'éducation, recherche et formation. Les domaines prioritaires sont ceux des impactes sur l'environement et la santé, la gestion de la qualité des eaux, la modernisation des systèmes d'irrigation, les technologies pour l'utilisation des eaux usées, la plannification des utilisations des sols et des eaux à l'échelle des bassins versants, les techniques pour l'épargne de l'eau, l'économie du développement agricole et les innovations concernant l'environnement social, les institutions et les politiques.

The increased pressure on the natural resources, water and soil in particular, the population growth, the wide changes in agricultural policies and practices, the improved recognition of environmental problems, the globalization of the economy, the need for fair social and socio-economic balances, impose to rethink the issues of development. The concept of sustainable development has been therefore introduced and widely accepted.

In case of agriculture, this concept has particular implications on the relationships between agricultural activities, environment preservation and resource conservation. The water resources are becoming more scarce, not only in quantity but because of the degrading quality. Meanwhile, competition for its use is increasing. The land resource, which is not renewable for the next generations, is also threaten by degradation and loss of soil productivity, particularly in areas where population growth is intense. New perspectives are required to manage both the soil and water. This requires technologies appropriate to improve and enhance the land and water use, the maintenance of biodiversity and natural and environmental balance, as well as changes in the social perception of development. Despite progress on technological and managerial tools we still have many gaps in knowledge and in transferring scientific and technological knowledge into practice thus in training and research.

This paper focus on the need for considering the implications of sustainable development when developing education and training for sustainable agriculture.

Sustainable agriculture

The concept of sustainable development is supported by a large number of definitions. The WCED (1987) introduced the concept as the «development which meets the needs of the present without compromising the ability of future generations to meet their own needs». Going further on the implication of this fundamental concept, the WCED (1987) proposed a more specific definition: «sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations».

The concept of sustainability relates therefore to the human legacy that present generations received from the past ones and should not destroy but enhance for the future. This has strong components under the perspectives of resource use, conservation and preservation, of economical nature, of technological and scientific progress, of social and institutional arrangements, of environmental equilibrium and of human development. This fully applies to agricultural and rural development.

The FAO (1990) revised concepts proposed by many authors and formulated its own definition focusing on agriculture, forestry and fisheries: «sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for the present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable». This is an excellent definition for sustainable agriculture.

The NRC (1991), analysing definitions of sustainable agriculture, states that «virtually all of which incorporate the following characteristics: long-term mainte-

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nance of natural resources and agricultural productivity, minimal adverse environmental impacts, adequate economic return to farmers, optimal crop production with minimized chemical inputs, satisfaction of human needs for food and income, and provision for the social needs of farm families and communities». Innovations in technology and management have then to be capable of responding to the requirements above: they have to be based on the knowledge of processes which can lead to resource degradation and to the maintenance of natural resources; have to consider production objectives together environmental impacts, thus the technologies which control resource degradation and enhance productivity; non-productive uses of the land and water should be given a value, as well as to environmentally friendly and improved uses of land and water which help degradation processes to be reversed (Serageldin and Steer, 1994a, b). Appropriate institutional solutions for land and water management have to be implemented and combine the capabilities for enforcing policies and rules with the social acceptability of decisions and measures, and the satisfaction of human needs and aspirations.

Challenges on soil and water resources use and management

The pressure on using the water resources makes their availability to be reduced and quality to be deteriorated (Engelmann and LeRoy, 1993). A global perspective of the water resources availability is given by the World Bank (1992) showing that in most of the regions the annual withdrawal represents a relatively small part (less than 20%) of the total annual internal renewable water resources. However, in the Middle East and North Africa region, the share is estimated to be in average 73% of total water resources. This indicates severe problems of water scarcity and drought. Forecasts for next 30 years show that water scarcity or water stress are increasing in many parts of the World and may affect a very large number of countries (Engelmann and LeRoy, 1993).
Agriculture has the highest share of water resources in low-and middle-income countries, while industry is the most important user in developed countries. A very high agricultural share of total water withdrawals also occurs in European Mediterranean countries.
The water quality is an expanding problem. Surface waters become more polluted: low dissolved oxygen, heavy metals and increased faecal coliforms. This is mainly caused by affluents from the industry and urban settlements. However, agriculture is also a cause for pollution, particularly groundwater pollution (Logan, 1990; Bogárdi and Kuzelka, 1991).
Water pollution makes health problems particularly acute. 900 millions of people are affected by diarrhea each year (The World Bank, 1992) due to problems of water supply and sanitation. Several other diseases are related to water like malaria, filarasis, bilharziazia, schistosomiasis (Birley 1989; Tiffen, 1989; Hespanhol, 1994). This brings to the first line the problems of availability of safe water and sanitation. These areas became prioritary for funding agencies (Petit, 1994).
The analysis of the growth of the world population (The World Bank, 1992) shows that population would more than double in the next 40 years if present annual growth rates would be maintained. The highest rates of population growth occur in Sub-Saharan Africa and Middle East and North Africa, where population is expected to more than double by 2030. Most of population growth will occur in developing countries, reducing to only 10% the population of OECD countries by 2030. Such growth of the population will put more pressure on land and water resources in these regions, which happen to be those facing major problems of water scarcity and, unfortunately, also degradation of land resources. It is known that a large part of the world population has not enough food. Famine is not only originated by war, droughts or floods. It is also a consequence of living in fragile environments, cultivating unsuitable areas and crowding the neighbourhoods of large cities with poor access to work in industry and services. About one fourth of the human population is below the poverty line, with associated problems of food shortage. Mankind has to provide food for more 3.6 billions persons by 2030 but also to overcome food shortages of one fourth of the population. Estimates indicate that world's food production has to double in the next 40 years, but more than double in areas of large population growth.
During the last 30 years increases in cereal production in developing countries amount for 118%. 92% is attributable to increase in average yields. Fortunately, already available technologies allow for much higher average yields than those currently available when an optimized combination of seeds, farming practices, fertilizing, and irrigation would be utilized (Waggoner, 1994). Current average cereal yields in developed countries are now over 4 ton/ha, while in developing countries are 2.3 t/ha, with only 1.4 t/ha in the Middle East and North-Africa region. However, to improve the food supply to feed the growing population will require new land and water resources management. Uncertainties associated with global climate changes have also to be overcome (see Rosenzweig and Parry, 1993).
Urbanization is another aspect of particular importance because growth of population is associated with urbanization. Half of world population is now living in cities when 25 years ago near two thirds was rural population. By 2030 near three-quarters of the world population will be urban. This rises several questions: the increase of poverty in crowded neighbourhoods of large cities, the use of agricultural land to extend these neighbourhoods, the increase in the water demand for domestic and industrial uses, the growing need for safe water and sanitation, the increased demand for energy, the decrease of manpower for the traditional cropping systems, the growing distance between human environments and nature.
Worldwide, water is the major factor limiting crop yields and food production. Irrigation has been critical to increase crop yields and production by eliminating or reducing plant water stress. While only one-sixth of the world's cropped land is irrigated, this area produces approximately one-third of the world's food supply (Wagooner, 1994). Over one-half of the increase in food production over the last 25 years has come from irrigated land (Rangeley, 1990). Irrigation will continue to play a critically important role in assuring the food security of the world's expanding population. Irrigation also contributes significantly to poverty alleviation and general improvement in the quality of rural life. Further, it enhances the productive capacity in otherwise harsh environments and reduces the need for horizontal expansion of rain-fed agriculture onto marginal lands. Irrigation also has potential negative effects, mainly waterlogging and salt affected soils (Jensen, 1993). Arid and semi-arid water stressed areas are particularly sensitive to those detrimental effects (Agnew and Anderson, 1992).

While many of these can be minimized or avoided altogether by better planning, or mitigated by appropriate measures, questions have arisen as to whether irrigation is capable of continuing the high levels of agricultural production in the long run without undue damage to the environment. To feed the rapidly growing population, food production must be increased by enlarging the area served by irrigation, or by intensifying agricultural production on the existing irrigated and rain-fed lands. Much of the additional agricultural production has been achieved through the development of new irrigation projects and products, and the use of high-yielding varieties, which require optimum management of land and water. Unfortunately, growth in grain production has slowed during the past few years. These trends point to the danger of a decline in per capita agricultural production, which will become even more dramatic with the increasing world population. Hence, the world food and water problems may worsen with time. The growth in demand exceeds that of production in the developing countries, and further, this spread may increase when accounting for the increased expectations of future generations.

During the past four decades, development of irrigated agriculture provided a major part of the increase in production necessary to meet food population demands. On a global basis, the average rate of irrigation expansion was about 1 percent per year in the early 1960s and reached a maximum of 2.3 percent per year from 1972 to 1975 (Waggoner, 1994). The rate of expansion began to decrease in the mid-1970s and is now about 1 percent per year (Jensen, 1993). The reasons for this decrease in expansion are many, including the high cost of irrigation development and the decline of the world price for major cereals. Further, and perhaps most importantly, as much of the land suitable for irrigation development and available water supplies have already been developed, progressively more expensive, economically less favourable and environmentally more sensitive areas are left for further expansion. However, authors like Crosson (1993) admit that irrigated areas may be increased by 50%.

Scarcity of water is a major constraint for further irrigation development. However, these finite water supplies face an ever expanding demand from many competing water users. As the competitive demands for water continue to increase it is imperative that this limited resource be used efficiently for agricultural and other uses (Hennessy, 1993). In some scarce areas, more water will be diverted from agriculture to meet expanding needs for domestic and urban uses because of population growth. The use of unconventional water resources in agriculture will also expand. Existing irrigation methods and practice are being placed under increased scrutiny from many fronts. Irrigation research must now focus on other alternatives such as increasing crop production per unit of irrigated land and per unit of water consumed by evaporation. Yet, the fact remains that new irrigation development and improved management of existing soil and water resources, must be capable of providing needed food and fibber production while at the same time addressing key environmental and social issues.

Need for innovative issues

Priorities for sustainable water resources utilization in agriculture

Problems identified above call for new innovative issues in water management in such a way that development not only sustains the fast growing and urbanized population, but be sustainable, i.e., resource preserving, environmentally non-degrading, technically appropriate, economically viable, socially acceptable and human oriented.

Assuming the challenges above, a Research Agenda on sustainability of water resources utilization in agriculture evolved from group discussions in a NATO Advanced Research Workshop held at Vimeiro, Portugal, March 1994 (Pereira *et al.*, 1994). The resulting primary issues and priorities are listed below:

Priority	Issues
1	Environmental and health impacts
1	Water quality management
2	Rehabilitation and modernization of irrigation systems
3	Technology and rules for use of waste and saline water
3	Policy issues
3	User participation for planning and managing irrigation and drainage systems
4	Basin wide integrated water resources planning
4	Human resources development
5	Irrigation and drainage system performance
5	Water savings methodologies
6	Rainfed agricultural water management and water harvesting
6	Economics of development of both irrigated and rainfed agricultural schemes
7	Land and water institutional issues

These issues concern the different components and implications of sustainability such as: resource conservation; technical appropriateness; environmental concerns; economic viability; and social and institutional adequacy. They also relate to: management techniques; innovative technologies; evaluation, assessment and monitoring methodologies; and measures, rules, guidelines and training tools. They cover broad areas of concern, of interest both to the developed and developing countries.

The development of the priority topics listed above is presented in the following subheadings and is based on the refereed Research Agenda (Pereira *et al.*, 1994; Pereira, 1995).

Environmental, health and water quality

These aspects have been considered with first priority.

Environmental and health impacts include:

(a) evaluating the potential of irrigation as a means for environmentally sustainable land use and food production, as well as the potential adverse environmental impacts resulting from neglecting or abandoning irrigation systems;

(b) the development of appropriate tools for assessing and controlling the impacts of using low quality water in irrigated agriculture, and appropriate techniques for the maintenance of waste water systems;

(c) the control of water-related diseases, including monitoring health hazards environmental management for vector control, and expand the epidemiological studies of agrochemical waste water and drainage water reuse;

(d) improve land evaluation criteria and methodologies for irrigation planning to include the assessment of the impacts on the environment.

Water quality management concerns:

(a) water quality monitoring, including the development of reduced cost methods of assessment and standards for chemical, physical and biological loads, and the aspects relative to pollution from agrochemicals;

(b) economic and effective mechanisms for disposal or reuse of drainage water, salts and agricultural wastes, particularly in arid and semiarid lands;

(c) appropriate methods for waste water treatment for agriculture reuse;

(d) best management practices to minimize water quality degradation in irrigated agriculture.

Technical issues

High priorities should be given to the technical aspects oriented to modernize irrigation and drainage systems and to provide for appropriate use of saline and unconventional water.
Concerning *rehabilitation and modernization of irrigation systems*, main aspects relate to:
(a) procedures for integrated planning and management of irrigation and drainage systems;
(b) development of locally-adapted water-efficient on-farm irrigation technologies, i.e., the improvement of on-farm irrigation performances;
(c) integrated irrigation and fertilizer management including fertigation, chemigation and irrigation scheduling;
(d) low cost technologies for canal construction and improvement, and appropriate techniques for improved water regulation and control;
(e) strategies for sustained increases in output per unit input of water and land;
(f) control sediment in irrigation and drainage systems;
(g) enhanced methods for field evaluation of on-farm and off-farm system performances and system monitoring, including water supply, water quality, salinization and environmental, economic and social impacts.
The appropriate *use of saline and waste water* requires:
(a) improved knowledge on salinity and solute processes under irrigated agriculture;
(b) methods, techniques and guidelines for use, control and management of low quality water for irrigation;
(c) expanded research on adaptation of crops and cropping systems to use low quality and saline water;
(d) criteria and guidelines for the use of saline water and for saline water table management.

Institutional and policy issues

Innovative issues are required to make water management effective. They concern the mechanisms to improve user's participation and to strengthen the institutions involved in water resources planning and management, as well as the laws and regulations relative to water policies.
Issues to enhance *user's participation* in management of irrigation and drainage systems include:
(a) the improvement of programs aiming at the transfer of responsibility from government to users relative to the operation, maintenance, and management of irrigation and drainage systems;
(b) guidelines for user organizations to administer water for different uses;
(c) the recognition of indigenous knowledge, human reluctance to change, and traditional social arrangements;
(d) mechanisms which can improve the coordination and division of responsibility between government, public and water user institutions and the irrigation industry.
The *policy issues* for water management relate to:
(a) appropriate procedures for allocation of surface and ground water for different purposes and uses;
(b) water laws and rights which provide for equity in water distribution and allocation;
(c) legal instruments and procedures for implementing water conservation and efficient management practices.
The institutional building issues mainly concern *human resource development*:
(a) training, at all levels, of personnel involved in planning, construction, operation, maintenance and management of agricultural, irrigation systems;
(b) technology transfer at all levels of irrigation and drainage management, including farmers;
(c) improved mechanisms to promote and assure dialogue among water users, water user associations and water authorities;
(d) research and training on modernizing surface irrigation systems, both on- and off-farm;
(e) institutional arrangements which enable appropriate training and technology transfer on water management;
(f) enhanced financial, institutional and other infrastructure which provides support services to farmers.

Planning and socio-economic issues

Innovations in these areas are required not only concerning the methodologies to be utilized but under the conceptual approaches derived from the sustainability requirements relative to economic viability, social acceptability and human oriented development.
In which concerns planning, main issues relate to *basin-wide integrated water resources planning*:
(a) political economy of water resources development for agriculture and rural areas;
(b) criteria, policies and procedures for transboundary basin planning and management;
(c) development of basin-wide integrated water resources planning and management including soil and water conservation;
(d) strategies for water harvesting on arid and semi-arid lands;
(e) drought mitigation methodologies;
(f) monitoring and controlling surface and ground water salinity;
(g) technologies for water reuse in developing countries.
New issues related to the *economic and social aspects* of water management refer to:
(a) evaluating the role of irrigation in meeting global food requirements;
(b) determining the social and economic aspects of increasing water use efficiency in agriculture;
(c) impacts of water pricing on water demand and consumption;
(d) economic and macroeconomic criteria for irrigation investment including public *versus* private investment;
(e) criteria to ensure the economical viability of existing irrigation schemes, including water pricing and financial responsibility of users, as well as mechanisms to ensure financing of maintenance and rehabilitation of irrigation systems;
(f) analysis of the subsidies system for irrigated agriculture and the financial vulnerability of irrigated agriculture to external changes such as prices of agricultural products and natural disasters;
(g) innovative methodologies for assessing benefits of soil and water conservation and water harvesting.

Education and training for sustainable agriculture

Attitudes

From the analysis above one may perceive that implications of sustainability in developing education and training programmes are of several nature: (1) agricultural yields have to increase but environmental balances shall be maintained or restored; (2) the use of soil and water resources should go together with conservation and control of resource degradation; (3) economic values should not dominate over social and human values; (4) greater emphasis on management issues is however limited by the available technologies; (5) the implementation of technical issues - technological and management tools - require an adequate institutional framework. In other words, these implications make the process of education and training more complex and demanding. This could be contrary to the increased de-

mand for education and training.
One key to overcome such contradiction could be the attitude of teaching in such a way that the process of learning becomes a process of perception of the sustainability implications and challenges. In fact, there is not very much differences in subjects to be taught when the concept of sustainability is or is not considered. The physical, biological, economic and social processes are the same. The differences come from the objectives to be attained and from the need to understand the interrelationships between agricultural production and environment, use and conservation of resources, economic feasibility and social acceptability. Hence, *the first requirement in education and training for sustainable agriculture is the teaching and learning attitude* in order to favour the full perception of the sustainability challenges and implications.

Programmes

Education and training programmes have to be designed according the audience. The same technological subject has to be taught following different approaches when it is given to undergraduates or graduates, to professionals or to users. Following the analysis by Collins - Jones (personal communication, 1995) these four types of audiences require that teaching be oriented in a different manner:
– for *undergraduates*, the focus should be conceptual, i.e. providing the fundaments of processes involved and how concepts are applied in the practice. Since students are being trained to become professionals, examples or exercises of application are required;
– for *graduates*, following M. Sc or Ph. D programmes, the state-of-the-art approach is the most appropriate, hopefully provided under an advanced perspective. Students are supposed to have the background on the physical and biological processes and, then, concepts should build on it;
– for *professionals*, which include future trainers and extensionists, one may consider two perspectives: (1) when the subject is not directly related to the professional activity of the trainee, a conceptual approach should prevail, supported by case studies; (2) when the subject falls in the professional field of the trainee, than the approach is a specialist course at state-of-the-art level, including applications and specifications, economics and quality control;
– for *users*, which currently have a lower background level, the approach has to be oriented for the benefits and limitations, assurance in application and codes of practice.
Unfortunately, not all «curricula» are designed with full consideration of these programmes implications. Very often graduates and professionals attending courses in a new subject have very different backgrounds. Then a mixture of conceptual and application approaches is currently provided, which does not ensures enough advanced or specialized learning processes.
This may be particularly difficult for advanced training on sustainable irrigated agriculture, where trainees mainly have two distinct backgrounds: the biological one for the agronomists and engineering for agricultural engineers. The compromise of building a course for both is extremely difficult and results are often far from expectations.
An interesting example is that of the Irrigation course at Istituto Agronomico Mediterraneo, Bari (IAM-Bari). Post-graduation is provided at two levels: a first year specialization course, common to agronomists and engineers, and a second year M.Sc. thesis for candidates selected from the first year. The specialization course provide a common training, conceptual through lectures and applicative through several weeks design. It is not intended that agronomists become engineers nor the engineers become plant production specialists but only that both improve knowledge and kills on irrigation science and engineering in their own fields of activity.

«Curricula»

Sustainable use of water resources in agriculture is one facet of sustainable agriculture. Main water use is for agricultural production and secondary uses are those for human and farm activities. Water use for crops is both rainfall and irrigation water but human intervention is mainly oriented to irrigation. Therefore, any «curriculum», while adopting its specificity, has to combine:
– the fundamentals of crop production which can help understanding crop growth and yield, as well as water use efficiency;
– the soil resource, the soil as support for crop production, the processes favouring soil degradation and erosion, the issues for soil conservation and restoration, as well as soil management issues;
– the water cycle, the processes occurring both in the atmosphere and in the earth, with emphasis on the soil-plant-atmosphere relationships;
– the processes to control rainfall impacts, i.e. the consequences of both excessive rainfall – non structural flood mitigation, runoff control to minimize waterlogging and erosion – and scarce rainfall, including water conservation and drought mitigation measures;
– the crop water and irrigation requirements, oriented for planning and management of irrigation systems and for farm irrigation scheduling;
– the farm irrigation techniques – design and evaluation – under a perspective of environmental friendliness, water application efficiency and economic profitability;
– the drainage for waterlogging and salinity control;
– the management of irrigation systems, including regulation and control solutions, improved delivery schedules to match on-farm demand, the conservation of the resource and the control of environmental impacts;
– the processes of water and solutes transfer in the soil, both in rainfed and irrigated agriculture, and the related issues to control the quality of ground- and surface waters;
– the environmental and health problems associated with the use of saline and brackish water and wastewater, including questions relative to water treatment and standards of water quality;
– monitoring of systems under operation to control both quantity and quality problems of water and soil resources;
– economic and social aspects of development, including water pricing, farmers organizations, turnover of responsibilities from the state to the farmers;
– farmers participation in the decision processes and farmers behaviour in relation to modernization.
Themes listed above can be dealt with greater or smaller detail according the programme for which a «curriculum» is designed. Difficulties in dealing with such (non exhaustive) list of topics relate to several aspects:
(1) Background of students: most of these subjects require the background in disciplines relative to physics and mathematics. Difficulties are greater for students of Agronomy sciences.
(2) Orientation of the training: if there is a tendency to emphasize management all engineering aspects will be poorly dealt and training will be definitely biased. The same applies if only engineering is the objective.

(3) Conceptual vs. descriptive teaching: trainees must learn how to do but also why any solution is selected. Real life requires a constant adaptation of solutions. This requires appropriate capabilities to formulate the problems, identify issues and select solutions.
(4) Need for case studies, which help to understand the concepts and why given solutions some times do apply and sometimes do not apply.
(5) Need for incorporating models: most of processes are now described by models. Their use give a logic to understand the process. However, to apply models requires both a good perception of the process and of the limitations, capabilities and requirements of the model.

Conclusion

This paper provides ideas for discussion. It just focus on one aspect of sustainable development. Efforts to improve high education responding to sustainability challenges are worthwhile. This implies new attitudes, innovation and strong knowledge on processes related to irrigated agriculture. Higher education should provide the society with good engineers and agronomists who could be able to be good professionals and also understand the environment and the society. ●

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