Agri-environmental indicators for sustainable water management: A proposal for developing countries

Une proposition des indicateurs agro-environnementales pour une gestion soutenable de l'eau dans les pays en voie de développement

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ABSTRACT: *The evident relationship between environmental issues and irrigation in the Mediterranean Region of the EU has been enforced by the change in agriculture policies from productivity to agri-environmental measures. This situation in Spain has been analysed on the basis of a series of specialized reports. Nevertheless the general diagnosis should be based on monitoring programs continuously fed by available, updated and comparable data that can explain all the possible significant effects. A series of indicators for irrigation, categorized by issues and aims, is proposed to attain a real and effective assessment of the irrigation and its environmental links.*

SPANISH IRRIGATION: Modernity and tradition

Spain is a country located within the Mediterranean basin where climate conditions make irrigation a central tool in rural development.

Spanish irrigated land is the widest in the UE, covering around 3.8 Mha (7% of the national surface), while occupies the 15th position in the world *(6).* Only 13% of the cultured area produces the 60% of the National Agrarian Production. Nevertheless, the average water consumption is 6,000 m^3/ha, twice the rest of European Mediterranean countries *(1).*

This unstoppable water need has been crucial to push Spain to get the dams per inhabitant world record and the 6th position in the number of large dams under construction *(10).* More than 22,500 hm^3 of fresh surface water have been yearly abstracted for irrigation purposes in Spain during the last two decades. In the meantime, groundwater abstraction has been harshly reduced from 69% to only 20% during the same period *(2).* It means Spain uses more than 60% of its gross abstraction for agriculture.

Meanwhile, agriculture must also contend against tourism and urbanism for water rights in the third world destination in international visitors, particularly concentrated in semiarid and coastal regions *(3).*

Spain is also one of the richest countries in biodiversity of Europe, thanks to the privileged position of the Iberian Peninsula between Eurosiberian and African Regions. The Balearic and Canary Islands raise even more this assortment of flora and fauna species. As a matter of fact, more than 24% of its surface has been included in the UE Natura 2000 Conservation Network *(8).*

Historically, irrigation has been closely related to Mediterranean civilization rise as natural light and heat conditions induced high crops, always threatened by seasonal rain scarcity (400-600mm). A vast irrigation and drainage net spread all over the Iberian Peninsula as Iberians, Romans and Arabs grew their lands, building a high value heritage from the agricultural, historical, ethnological and environmental point of view *(4).*

This complex mixture of tradition and modernity can also be found in many developing countries where economical efficiency requirements meet high value nature conservation needs *(5).*

IRRIGATION INDICATORS

Despite all the assorted reports and the multi-task monitoring, there is yet a large amount of effects that cannot be assessed using a single frame taken now and then. The cumulative and synergic impacts demand a continuous surveillance.

Public participation assures not only that most of the relevant aspects will be monitored, but also the management will be commonly accepted by the involved stakeholders. Further the previously studied issues (biodiversity, water, economy) there are other ones as soil, waste or landscape that also deserve indicator design. After issue selection, an aim agreement must be obtained to guarantee indicator continuity. Stakeholders should be invited to show their opinion.

Surprisingly, even if answers could be completely different, at least the dilemma generally gets a common diagnosis. Too many times, complexity awareness and lack of data have discouraged indicator designers *(9).* Key characteristics should include not only significance but also data availability and frequent update *(7).* Nevertheless, as far as it is possible, neither issue nor goal should be left out since the possibility of loosing a precious feature of the whole scenery is not affordable. A series of indicators, categorized by issues and aims, is proposed to attain a real and effective assessment of the irrigation and its environmental links in the next table

CONCLUSIONS

- ***Core aspects to be monitored are conservation of high value nature areas and water resources management. Interrelated to them, the socio-economic factors control is needed to ensure the sustainability of irrigation activity.***
- ***Unavailability of separately restricted data for rain fed and irrigated agriculture prevents further opportunities of specific agri-environmental indicators for the second kind.***
- ***Among the most significant and highly developed agri-environmental indicators are the categories of water, habitat, biodiversity and social economy.***
- ***The collaboration of farmers can be as important as the improvement of research on environmental issues in the relevant data collection.***
- ***The variability of Spanish irrigation can be a pertinent example to other countries with complex mixture of modern and traditional irrigation embedded in a high biodiversity environment.***

ISSUES	AIMS	INDICATORS
WATER	REDUCTION OF THE CONTAMINATION OF GROUND AND SURFACE WATERS	EFFECTS OF NITROGEN FERTILIZERS USE ON GROUNDWATER QUALITY
		OVERALL RIVER WATER QUALITY IN LINKED SECTIONS
		SURFACE WATER EUTROPHICATION FROM FERTILIZERS SOURCES
		NUTRIENT BALANCE
	DECLINE OF IMPROPER WATER CONSUMPTION	PUMPING AQUIFER OVER-EXPLOITATION
		IRRIGATION MODERNIZATION AND IMPROVEMENTS
		WATER USE EFFICIENCY
		WATER RE-USE AND DESALINATION FOR IRRIGATION
SOIL	REDUCTION OF EROSION AND PROMOTION OF SUITABLE AGRICULTURAL SYSTEMS	SOIL EROSION ON IRRIGATED LAND
		WATER RETENTION CAPACITY
	DECREASE OF THE CHEMICAL, PHYSICAL AND BIOLOGICAL DEGRADATION	ABANDONED LAND FOR SOIL DEGRADATION
HABITATS AND BIODIVERSITY	CONSERVATION OF GENETIC BIODIVERSITY	*EX SITU* AND *IN SITU* CONSERVATION OF SPECIES GROWN UNDER IRRIGATION
		LOSS OF GENETIC RESOURCES
		GENETIC MODIFIED IRRIGATED CROPS
	CONSERVATION OF SPECIES RICHNESS	POPULATION CHANGES OF BIO INDICATORS
		PROTECTED SPECIES UNDER IRRIGATION
	CONSERVATION OF THE BIODIVERSITY OF ECOSYSTEMS	USE OF IRRIGATED HABITATS BY WILD SPECIES
		HABITAT FRAGMENTATION INDEX
	CONSERVATION OF HABITAT DIVERSITY	CONSERVATION OF HABITATS OF INTEREST TO THE LOCAL COMMUNITY
		EXISTENCE OF NATURAL WATER PATHWAYS
		WETLANDS ALTERED BY IRRIGATION
		WETLANDS CONSERVATION
LANDSCAPE	PRESERVATION OF AGRICULTURAL LANDSCAPES	ROLE OF IRRIGATION INTO THE LANDSCAPE CULTURAL CHARACTER
	MONITORING OF THE CHANGES TO THE MORPHOLOGY OF THE AGRICULTURAL LANDSCAPE	CHANGES TO THE GEOMETRY IN IRRIGATION ACTIVITY
		CHANGES TO LAND SURFACE THROUGH IRRIGATION
CLIMATE CHANGE	PROMOTION OF THE USE OF RENEWABLE ENERGY	CONTRIBUTION OF IRRIGATION TO BIOMASS AND BIO-FUELS PRODUCTION
	REDUCTION OF EMISSION OF GREENHOUSE GASES	GROSS EMISSIONS OF GREENHOUSE GASSES IN IRRIGATION
AGROCHEMICALS	REDUCTION OF ENVIRONMENTAL RISKS CAUSED BY PESTICIDES	PESTICIDE CONSUMPTION IN IRRIGATION
WASTE	REDUCTION OF INORGANIC WASTE GENERATION	RECYCLING OF PLASTIC WASTE AND CONTAINERS
	INCREASE IN ORGANIC WASTE USE	ORGANIC WASTE BALANCE
MANAGEMENT	ENVIRONMENTAL IMPROVEMENT IN THE IRRIGATION MANAGING PRACTICES	ORGANIC FARMING UNDER IRRIGATION
		SURFACE AREA OF IRRIGATION RECEIVING AGRO-ENVIRONMENTAL SUBSIDIES
	INCREASE IN THE ENVIRONMENTAL MANAGEMENT CAPACITY	PUBLIC COST OF THE ENVIRONMENTAL IMPROVEMENT
		LEVEL OF ENVIRONMENTAL TRAINING OF FARMERS USING IRRIGATION
SOCIAL ECONOMY	MAINTAINING PEOPLE IN THEIR RURAL ENVIRONMENT THROUGH IRRIGATION	NEW FARMERS INCORPORATION TO THE SECTOR
		IMPROVING THE SOCIAL STRUCTURE OF THE RURAL ENVIRONMENT THROUGH IRRIGATION
		SOCIAL IMBALANCES RELATED TO IRRIGATION

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