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Integrated water management for the 21st century: Problems and Solutions

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Abstract

Most of the projected global population increases will take place in third world countries that already suffer from water, food, and health problems. Increasingly, the various water uses (municipal, industrial, agricultural) must be coordinated with, and integrated into, the overall water management of the region. Sustainability, public health, environmental protection and economics are key factors. More storage of water behind dams and especially in aquifers via artificial recharge is necessary to save water in times of water surplus for use in times of water shortage. Municipal wastewater can be an important water resource but its use must be carefully planned and regulated to prevent adverse health effects and, in the case of irrigation, undue contamination of groundwater. While almost all liquid fresh water of the planet occurs underground as groundwater, its long-term suitability as a source of water is threatened by non-point source pollution from agriculture and other sources and by aquifer depletion due to groundwater withdrawals in excess of groundwater recharge. In irrigated areas, groundwater levels may have to be controlled with drainage or pumped well systems to prevent water-logging and salinization of soil. Salty drainage waters must then be handled in an ecologically responsible way. Water short countries can save water by importing most of their food and electric power from other countries with more water, so that in essence they also get the water that was necessary to produce these commodities and, hence, is virtually embedded in the commodities. This "virtual" water tends to be a lot cheaper for the receiving country than developing its own water resources. Local water can then be used for purposes with higher social, ecological, or economic returns or saved for the future. Climate changes in response to global warming caused by carbon dioxide emissions are difficult to predict in space and time. Resulting uncertainties require flexible and integrated water management to handle water surpluses, water shortages, and weather extremes. Long-term storage behind dams and in aquifers may be required. Rising sea levels will present problems in coastal areas.

Key words: Integrated water management, populations, water issues, dams, underground storage, non-point source pollution, sustainability

Introduction

Population growth and higher living standards will cause ever increasing demands for good quality municipal and industrial water, and ever increasing sewage flows. At the same time, more and more irrigation water will be needed to meet increasing demands for food for growing populations. Also, more and more water will be required for environmental concerns such as aquatic life, wildlife refuges, recreation, scenic values, and riparian habitats.Thus, increased competition for water can be expected. This will require intensive management and international cooperation. Since almost all liquid fresh water on the planet occurs underground, groundwater will be used more and more and, hence, must be protected against depletion and contamination, especially from non-point sources like intensive agriculture. While growing populations and increasing water requirements are a certainty, a big uncertainty is how climates will change and how they will be affected by man's activities like increasing emissions of CO_2 and other greenhouse gases, particulate matter, and other contaminants like ozone and nitrous oxides. There still is no agreement among scientists how and when the climate will change, and what changes will occur where. The main conclusion so far seems to be that climate changes (natural and anthropogenic) are likely, that they are essentially unpredictable on a local scale, and that, therefore, water resources management should be flexible so as to be able to cope with changes in availability and demands for water[1,2]. This calls for integrated water management where all pertinent factors are considered in the decision making process. Such a holistic approach requires not only supply management, but also demand management (e.g., water conservation and transfer of water to uses with higher economic returns), water quality management, recycling and reuse of water, economics, conflict resolution, public involvement, public health, environmental and ecological aspects, socio-cultural aspects, water storage (including long-term storage or water "banking"), conjunctive use of surface water and groundwater, water pollution control, flexibility, regional approaches, weather modification and sustainability. Agricultural water management increasingly must be integrated with other water management and environmental objectives.

Global Population and Water Supplies

The present world population of about six billion is projected to almost double in this century. Almost all of this population increase will be in the Third World, where there are already plenty of water and sanitation problems and where about 1400 people (mostly children) die every hour due to waterborne diseases[3]. Also, there will be more and more migration of people from rural areas to cities, creating many large cities including mega-cities with more than 20 million people that

will have mega-water needs, produce mega-sewage flows, and have mega-problems. Already, there is talk that people in these mega-cities should have little gardens where they can grow their own food and recycle their own waste. There would then be little difference between mega-cities with a lot of small garden-type farming and rural areas with dense populations, especially in the suburban fringes of the cities. All these people and their animals living closely together could present serious health problems as viruses and other pathogens that normally affect only animals can be transferred to humans. This could cause epidemics of potentially global proportions because of lack of immunity and vaccines, much like the Ebola and AIDS viruses and the various flu outbreaks caused by swine or chicken viruses. If the animals are also given regular doses of antibiotics to promote faster growth, antibiotic resistant strains of pathogens could be created which could cause serious human pandemics. For adequate living standards as in western and industrialized countries, a renewable water supply of at least 2000 m^3 per person per year is necessary [11]. If only 1000-2000 m^3 is available, the country is water stressed, while below 500 m^3 per person per year it is water scarce. Nomadic desert people can subsist on only a few m^3 per person per year (not including their animals). The global renewable water supply is about 7000 m^3 per person per year (present population). Thus, there is enough water for at least three times the present world population. Hence, water shortages are due to imbalances between population and precipitation distributions. Almost all of the planet's water (97%) occurs as salt water in the oceans [4]. Of the remaining 3%, two-thirds occur as snow and ice in polar and mountainous regions, which leaves only about 1% of the global water as liquid fresh water. Almost all of this (more than 98%) occurs as groundwater, while less than 2% occurs in the more visible form of streams and lakes which often are fed by groundwater. Groundwater is formed by excess rainfall (total precipitation minus surface runoff and evapotranspiration) that infiltrates deeper into the ground and eventually percolates down to the groundwater formations (aquifers). For temperate, humid climates, about 40% of the precipitation ends up in the groundwater. For Mediterranean type climates, it is more like 10 to 20%, and for dry climates it can be as little as 1% or even less [5,12]. These natural recharge rates give an idea of the safe or sustainable yields of aquifers that can be pumped from wells without depleting the groundwater resource. In many areas of the world, especially the drier ones, groundwater is the main water resource. Natural recharge rates are difficult to predict with any accuracy [13] and often pumping greatly exceeds recharge, so that groundwater levels are declining. It is frightening to consider what will happen in these areas when the wells go dry and no other water resources are available.

Water Storage via Dams

Future climatic changes may also include more weather extremes, like more periods with excessive rainfall and more periods with low rainfall that cause droughts. Also, in relatively dry climates, small changes in precipitation can cause significant changes in natural recharge of groundwater. To protect water supplies against these extremes and changes, more storage of water is needed, including long-term storage (years to decades) to build water reserves during times of water surplus for use in times of water shortage. Traditionally, such storage has been achieved with dams and surface reservoirs. However, good dam sites are getting scarce and dams have a number of disadvantages like interfering with the stream ecology, adverse environmental effects, displacement of people for new dam reservoirs, loss of scenic aspects and recreational uses of the river, increased waterborne diseases and other public health problems, evaporation losses (especially undesirable for long-term storage), high costs, potential for structural problems and failure, and no sustainability since all dams eventually lose their capacity as they fill up with sediments [14,15,16]. For these reasons, new dams are increasingly difficult to construct, except in some countries (mostly Third World) where the advantages of abundant and cheap hydro-electric power are considered to outweigh the disadvantages of dams. One of the advantages of dams is that they can be operated to even out the flow in the downstream river, regardless of seasonal or longer-term variations in rainfall. On the other hand, the ease to turn the turbines off and on to meet peaking power or other short-term fluctuations in electricity demands can adversely affect the downstream ecology. For example, as stated by Newcom [17]: "Dams in California have been blamed by scientists and many in the environmental community as being one of the major catalysts responsible for moving salmon species in California - and through the Northwest - to the endangered and threatened lists of the federal Endangered Species Act (ESA). The reasons for the demise of these anadromous fish because of dams are varied and include limited spawning habitat; decreased downstream flows that limit backwater habitats serving as rearing areas for fry and juveniles to mature; increased predation by non-native fish species; entrainment from pumps and turbines; varying water temperatures; reduced nutrient-rich sediment and spring migration flows; and dissolved gases." One way to make dam operation for generation of hydropower environmentally more acceptable and in compliance with environmental laws is to increase the capacity for generation of thermal power so that hydropower that produces undesirable extremes in flows and temperatures of the water below dams can be avoided. For California, such laws are the Endangered Species Act, the California Environmental Quality Act, the National Environmental Policy Act, and the Water Quality Act. Under federal law, non-federal hydropower facilities must be relicensed every 40 to 50 years - a process that can take years to complete [17] .The relicensing process also can mean the end for older, often obsolete dams where modifications to meet new regulations would be so expensive that destroying the dam is the best solution. However, dam decommissioning and demolition often is not a simple process. It can be very complex and expensive [18] and it has been the subject of special short courses [19]. Dams on international rivers require intensive cooperation among the countries involved, so that countries downstream from the dam are not adversely affected and have a voice in the location, design, and operation of the dam. New dam projects require careful planning to minimize adverse environmental, public health, and socio-cultural effects.

Water Storage via Artificial Recharge of Groundwater

If water cannot be stored above ground, it must be stored underground, via artificial recharge of groundwater. Already, more than 98% of the world's fresh liquid water supplies occurs underground [4] and there is plenty of room for more. Artificial recharge is achieved by putting water on the land surface where it infiltrates into the soil and moves downward to underlying groundwater [6,7]. Such systems require permeable soils (sands and gravels are preferred) and unconfined aquifers with freely moving groundwater tables. Infiltration rates typically range from 0.5 to

3 m/day during flooding. With continued flooding, however, suspended particles in the water accumulate on the soil surface to form a clogging layer that reduces infiltration rates. Biological, chemical, and physical actions further aggravate the clogging. Thus, infiltration basins must be periodically taken out of service to allow drying, cracking, and, if necessary, mechanical removal of the clogging layer. Taking drying periods into account, long-term infiltration rates for year round operation of surface recharge systems may be in the range of 100 to 400 m/yr.

Artificial recharge may be implemented with in-channel and off-channel infiltration systems. In-channel systems consist of low dams across the streambed or of T or L shaped levees in the streambed to back up and spread the water so as to increase the wetted area and, hence, infiltration in the streambed. Off-channel systems consist of specially constructed shallow ponds or basins that are flooded for infiltration and recharge. Where streamflows are highly variable, upstream storage dams or deep basins may be necessary to capture short-duration high-flow events for subsequent gradual release into recharge systems. Also, recharge systems can be designed and managed to enhance environmental benefits (e.g., aquatic parks, trees and other vegetation, and wildlife refuges).

Since sand and gravel soils are not always available, less permeable soils like loamy sands, sandy loams, and light loams are increasingly used for surface infiltration recharge systems. Such systems may have infiltration rates of only 30 to 60 m/yr for year round operation. Thus, relative evaporation losses are higher and in warm, dry climates could be about 3 to 6% of the water applied, as compared to about 1% for basins in more permeable soils. Systems in finer textured soils also require more land for infiltration basins. However, the larger land requirements enhance the opportunity for combining the recharge project with environmental and recreational amenities.

Where sufficiently permeable soils are not available or surface soils are contaminated, artificial recharge also can be achieved via infiltration trenches or recharge pits or shafts[6,7]. If the aquifers are confined, i.e., between layers of low permeability, artificial recharge can be achieved only with recharge or "injection" wells drilled into the aquifer. The cost of such recharge often is much higher than the cost of infiltration with basins because wells can be expensive and the water must first be treated to essentially remove all suspended solids, nutrients, and organic carbon to minimize clogging of the well-aquifer interface. Since such clogging is difficult to remove, prevention of clogging by adequate pretreatment of the water and frequent pumping of the well is better than complete well remediation. Increasingly, recharge wells are constructed as dual purpose wells for both recharge and extraction to allow recharge when water demands are low and surplus water is available (i.e., during the winter), and pumping when water demands are high like in the summer. Such SAR (storage and recovery) wells are used for municipal water supplies so that water treatment plants do not have to meet peak demands but can be designed and operated for a lower average demand, which is financially attractive[20]. The big advantage of underground storage is that there are no evaporation losses from the groundwater. Evaporation losses from the basins themselves in continuously operated systems may range from 0.5 m/yr for temperate humid climates to 2.5 m/yr for hot dry climates. Groundwater recharge systems are sustainable, economical, and do not have the eco-environmental problems that dams have. In addition, algae which can give water quality problems in water stored in open reservoirs do not grow in groundwater.Because the underground formations act like natural filters, recharge systems also can be used to clean water of impaired quality. This principle is extensively used as an effective low-technology and inexpensive method to clean up effluent from sewage treatment plants to enable unrestricted and more aesthetically acceptable water reuse (see "Water Reuse" section). The systems then are no longer called recharge systems but soil-aquifer treatment (SAT) or geopurification systems.

Conjunctive Use and Water Banking

Nature's way of storing water is underground, where about 98% of all the world's liquid and fresh water occurs[4]. The other 2% mostly occurs in streams and lakes, which often are fed by groundwater. Groundwater is a dependable source of water and less affected by the vagaries of climate than surface water. Often, surface water and groundwater are used conjunctively, surface water when available, and groundwater when the streams or lakes are low or dry. Where water requirements have been increasing, there often has been a tendency to pump more groundwater with all the undesirable effects such as aquifer depletion, land subsidence, salt water intrusion, and higher pumping costs. The solution then is either to build more dams for surface storage, or to store more water underground via artificial recharge of groundwater. Underground storage is preferred where dams are not feasible and also when the water may have to be stored for long periods (years to decades) and evaporation losses from the dam reservoirs are not acceptable. Such long-term underground storage is often called water banking[2]. Some of the issues in groundwater banking have to do with water rights, especially where surface water and groundwater are governed by different water right systems. For example, surface water may be governed by prior appropriation or the riparian principle, whereas groundwater rights maybe in the hands of the owner of the overlying land[4]. Thus, when surface water is used for groundwater recharge, the question is who owns the water after it has joined the aquifer? Also, after long-term storage (decades, for example), is the recharge water still recoverable from the aquifer or has it moved laterally away from the region over which the recharging entity has jurisdiction? There may also be water quality issues, for example, where the groundwater is of better quality than the surface water used for recharge, or where the recharge water is of good quality and picks up undesirable chemicals from the aquifer such as arsenic, boron, and dissolved salts. Effects on groundwater levels must also be considered to avoid undue groundwater rises during recharge and undue declines during extraction. Some states (California, for example) allow extraction of groundwater in excess of the amount put into the aquifer by artificial recharge. This excess would then consist of the natural recharge. However, such natural recharge is difficult to predict, especially in dry climates where recharge may only be a small percentage (1% for example) of an already very small precipitation[13]. Other states like Arizona, where natural recharge is very low, require groundwater extractions to be no more than 95% of the artificial recharge inputs, thus leaving 5% of the recharge in the aquifer. The best approach is to

monitor groundwater levels in the area of water banking and groundwater pumping so that pumping rates can be increased where groundwater levels are rising, and decreased where they are falling.

Groundwater and Salinity Control for Sustainable Irrigation

There are many serious cases of pollution of surface water and groundwater by point-sources (e.g., sewage and industrial wastewater discharges, leaking ponds or tanks, and waste disposal areas). However, point source pollution is, at least in principle, relatively simple to control and prevent. A much greater threat to the planet's liquid fresh water resources is non-point source pollution of groundwater. A significant non-point source of groundwater pollution is agriculture, with its use of fertilizer, pesticides, and salt containing irrigation water that contaminate the drainage water as it moves from the root zone to the underlying groundwater. The problem can be expected to get worse in the future as agriculture must intensify (including use of more agricultural chemicals) to keep up with the demands for more food and fiber by increasing populations. Pollution of groundwater also causes pollution of surface water wherever the contaminated groundwater moves into streams where it maintains the base flow, and also into lakes and coastal waters.

In humid areas with rainfed agriculture, the main contaminants in the drainage water from the root zone are nitrate and pesticide residues[8]. In irrigated areas, the drainage water also contains the salts that were brought in with the irrigation water. To avoid accumulation of salts in the root zone, excess irrigation water must be applied to leach the salts out of the soil so as to maintain a salt balance in the root zone. For efficient irrigation systems, the excess water may be about 20 % of the total irrigation water applied. In dry climates, this means that the salt concentrations in the drainage water are about five times higher than in the irrigation water, which often is much too high for drinking and for irrigation of all but the most salt tolerant crops. For more efficient irrigation, the salt concentrations in the drainage water will even be higher. For less efficient irrigation, and also where there is significant rainfall, the salt concentrations in the drainage water will be lower. Recent successes in genetically altering plants to make them more salt tolerant offers hope for widening the choice of crops that can be grown with salty water[21].

Where groundwater levels are high, drains need to be installed to remove the drainage water from the soil and to avoid waterlogging and salinization of the soil. Discharges from the drains then contain salt and residues of agricultural chemicals and, hence, they are a source of water pollution. The least undesirable ultimate disposal of this water may be in the oceans. Inland disposal can degrade surface water. Disposal in evaporation ponds requires considerable land for "salt lakes" that could eventually become environmental hazards. Use of the salty drainage water for sequential irrigation of increasingly salt tolerant plants (including trees like tamarisk, eucalyptus, and salt tolerant poplars) and ending with halophytes like salicornia and certain grasses will concentrate the salts in small volumes of water[22]. The volume of the final drainage water may then only be a few percent of the original irrigation water so that salt concentrations could be 20 to 100 times higher than that in the original irrigation water. Disposal into evaporation ponds will then require much less land. Another alternative is desalination of the drainage water by, for example, reverse osmosis. The desalted water can then be used for potable and other purposes, but the process still leaves a reject brine that requires disposal. Concentrating the salts into smaller volumes of water by sequential irrigation, evaporation ponds, or membrane filtration also reduces the cost of transporting the salty water to oceans, salt lakes, or other places for "final" disposal. Leaving the water in evaporation ponds will eventually cause the salts to crystallize, which can then be disposed as solid waste in designated landfills.

Where groundwater levels are deeper (often due to prior groundwater pumping), the drainage water will move down to the groundwater and reduce its quality to the point where it becomes useless for drinking and general irrigation. Without desalting of groundwater, the further use and pumping of groundwater will stop. If irrigation is continued, groundwater levels then will rise (typically about 0.3 to 2 m per year) and eventually threaten underground pipe lines, basements, gravel pits, landfills, cemeteries, deep-rooted old trees, etc. Finally, they can cause waterlogging and salinization of the soil, so that nothing will grow anymore and the areas become salt flats. Inability to control groundwater below irrigated land has caused the demise of old civilizations and is still the reason why so much irrigated land in the world is losing productivity or is even being abandoned today[16]. To prevent this waterlogging and salinization, groundwater pumping must be resumed or deep agricultural drains must be installed to keep groundwater levels at safe depths. The salty, contaminated water from these wells or drains must then be managed as discussed in the previous paragraph. Irrigation without groundwater control ultimately causes waterlogging and salinity problems, and irrigation can only be sustainable if salts and drainage water are adequately removed from the underground environment and managed for minimum environmental damage.

An intriguing possibility is to use the evaporation ponds as solar ponds to produce hot water for heating and/or electric power generation. In an experimental solar pond project in El Paso, Texas, the pond is 3 m deep with a 1 m layer of low salinity water on top, a 1 m layer of medium salinity in the middle, and a 1 m layer of high salinity (brine) at the bottom[23]. Sun energy is then trapped as heat in the bottom layer while the lighter top layers prevent thermal convection currents and act as insulators. The hot brine from the bottom layer is pumped to a heat exchanger where a working fluid like iso-butane or freon is vaporized which then goes through a turbine to generate power. The working fluid is condensed in another heat exchanger that is cooled with normal water which is recirculated through a cooling tower. The working fluid then returns to the brine heat exchanger where it is preheated by the brine return flow from the heat exchanger to the pond before it is vaporized again. The El Paso pond has a surface area of 0.3 ha and generates 60 to 70 kW. At this rate, a solar pond system of about 5,000 ha could generate about 1,000 megawatts of electricity, which is typical of a good sized power plant. There is enough heat stored in the hot brine layer to also generate power at night. Sequential irrigation, membrane filtration, and solar ponds for power generation have the advantage that they treat the salty water as a revenue producing resource that helps offset the cost of final disposal

of the salts. Where sewage effluent is used for irrigation, a whole new spectrum of pollutants can be added to the soil [7]. If not attenuated in the root zone, these pollutants can show up in the drainage water at much higher concentrations than in the effluent (about five times higher for efficient irrigation in dry climates, less for inefficient irrigation and/or areas with significant rainfall). Thus, in addition to the usual nitrates and salts, the drainage water could also contain disinfection byproducts (DBPs) like trihalomethanes (THMs) and haloacetic acids (HAAs) that were formed in the drinking water when it was chlorinated for public water supply and the chlorine reacted with natural dissolved organic carbon in the water to form chloroform, bromodichloromethane, and other DBPs [24]. Then, when it became sewage effluent and was chlorinated again and this time with high chlorine doses and long contact times to kill all the pathogens, a whole new suite of DBPs could be formed. There is great concern about cancer, adverse pregnancy outcomes, and other health effects of DBPs in drinking water. The U.S. Environmental Protection Agency will lower the maximum contaminant level for THMs from 100 ng/l to 80 ng/l , and for HAAs to 60 ng/l , with further reductions being expected [24]. A recently discovered DBP is N nitrosodimethylamine (NDMA), which is an extremely carcinogenic compound formed by the reaction of chlorine with dimethylamine (DMA). The California Department of Health Services has set an NDMA drinking water action level of 20 ng per liter [25] and has recently lowered it to 10 ng/l . However, adequate dose-response relations for humans are not available. Thus, while chlorination effectively kills bacteria and viruses to avoid infectious disease outbreaks from sewage irrigation, it also creates chemicals that may have adverse long-term health effects. Alternative disinfection procedures that do not use chlorine, like ultra-violet irradiation, soil-aquifer treatment, or "time" should be considered.

In addition to DBPs, the treated sewage effluent and, hence, the waters into which it is discharged can also be expected to contain pharmaceuticals, industrial chemicals like PCBs and others that may have biological effects, and personal care products. These chemicals enter the wastewater with discharges from pharmaceutical and other industries, hospitals and other medical facilities, households where unused medicines are flushed down the toilets, and human excreta which contain incompletely metabolized medicines [26,27,28,29].

Pharmaceutically active chemicals also include certain industrial chemicals like dioxin, pesticides and chlorinated organic compounds. While not directly toxic or carcinogenic, these chemicals may produce adverse health effects by interfering with hormone production (endocrine disruptors), by weakening immune systems, and by other biological responses. So far, most studies of pharmaceuticals and pharmaceutically active chemicals have been carried out on aquatic animals where adverse effects on hormone production and reproductive processes, including feminization of the males, have been observed[30]. Since their long-term and synergistic effects on humans are not known, pharmaceuticals and similar chemicals should be kept out of the water environment as much as possible[31]. Farm animals with their ingestion of hormones, antibiotics and veterinary medicines, can also be a source of pharmaceuticals in water as their manures and wastewater from animal feeding operations are spread on land from where they can run off into surface water or percolate down to groundwater [27].

Other potential contaminants in the drainage water from sewage irrigated crops and plants are humic substances like humic and fulvic acids. These are known precursors of DBPs when the water is chlorinated. The humic substances are formed as stable endproducts wherever organic matter is biodegraded. Since effluent with its nutrients can be expected to produce lush vegetation when used for irrigation, there will be more biomass on and in the soil which upon biodegradation could produce increased levels of humic substances in the drainage water and, eventually, in the underlying groundwater. When this water is pumped from wells and chlorinated for potable use, increased levels of DBPs can then be expected in the drinking water. Thus where sewage effluent is used or planned to be used for irrigation, careful studies should be made of the potential effects on groundwater, especially where the groundwater is, or will be, used for drinking.

Water Pollution and Total Maximum Daily Loads (TMDLs)

Pollution of natural waters will become increasingly serious as growing populations demand more high quality water while at the same time producing more wastes that will often be returned to those waters. Until recently, the focus in the USA has been mostly on point sources of water pollution (discharges of sewage effluent and industrial water) which are controlled through discharge permits under the authority of the 1972 Clean Water Act and specified in the National Pollutant Discharge Elimination System (NPDES). While this program has led to considerable improvement in surface water quality, fishable and swimmable conditions have not always been met. As a matter of fact, the report "Assessing the TMDL Approach to Water Quality Management" recently published by the National Research Council mentions that the USA still has about 21,000 polluted river segments, lakes, and estuaries making up over 300,000 river and shore miles and 5 million lake acres[32]. Thus, whereas until now pollution control has been based on controlling effluent discharges, the next phase will also control non-point sources of pollution, mainly due to urban and agricultural runoff, drainage of groundwater into surface water, and atmospheric fall-out. The main pollutants of concern are nutrients and sediment, but they could also include certain pesticides, pharmaceuticals, and other chemicals of emerging concerns. Control of these contaminants will be based on entire watersheds and it will be achieved by establishing TMDLs for the entire system. The TMDL approach was already included in the 1972 Clean Water Act as Section 303d. However, it was largely overlooked until EPA in response to lawsuits and other pressures from environmental groups developed TMDL regulations that were promulgated on 13 July 2000. Cost estimates by EPA for implementing the TMDL program range from $900 million to $4.3 billion per year [33], which primarily would be borne by dischargers. TMDLs could also be developed for groundwater, especially where it drains into surface water such as gaining streams or groundwater-fed lakes.

The TMDL concept is a dramatic switch from effluent based standards to ambient water standards, and from controlling point sources to controlling entire watersheds. In view of the high cost of implementing the program, attainment of the desired water quality may be questionable, particularly since

the underlying scientific principles may not be fully understood. However, while attainment may be an issue, there is interest in moving ahead with the program while practicing adaptive management to make adjustments in the program where the results are not as expected [34,35,32] and to minimize administrative complications [36]. Others, especially those who will be financially affected by TMDLs, favor delay or modification of TMDLs and their implementation [35]. For agriculture, this may mean more use of best management practices for control of erosion, and of nutrients and pesticides in runoff water. Vegetated buffer strips on a watershed scale also may be effective in controlling nonpoint source pollution of surface water [37,38,39].

Global Change

Few issues have received so much attention and have generated so much controversy as the effects of increasing concentrations of CO_2 and other greenhouse gases in the atmosphere on temperature and climate. Predictions range from serious effects on ecosystems and our health[40], increased flooding, and desertification [41] to everything is normal and just part of the natural climate fluctuations that have been going on for ages as a result of the dynamic nature of planet earth. Sometimes it appears that conclusions are based primarily on consensus and majority opinions. What all this controversy shows, however, is that it is not known to a sufficient degree of accuracy what is going to happen in space and in time. Thus, it is difficult to make adequate plans. In addition to gradual, long-term climate changes, more abrupt changes within the span of a human generation may also happen [42]. Models for predicting global precipitations are based on models for predicting global temperatures in response to increasing CO_2 concentrations in the atmosphere. However, the temperature predictions are fraught with uncertainties (Kimball, in press), which makes precipitation prediction very difficult. The models don't even do well in predicting present precipitation patterns (Kimball, in press). However, because temperatures are projected to rise globally, average evaporation from oceans and other bodies of water will also increase, and therefore, globally averaged precipitation will also increase.However, the precipitation patterns may change[43]. Over the higher latitudes, precipitation is predicted to increase. Decreases are projected for Central America in the summer and for South Africa and Australia. Over much of the United States, projections are inconsistent, but with small increases indicated for winter in both Western and Eastern North America. Albritton et al.[43] also note that a strong correlation exists between inter-annual variability and mean precipitation. Consequently, future increases in mean precipitation are likely to lead to increases in precipitation variability.

It is not surprising that some countries, especially small ones with little geographic and hydrologic diversity, are concerned about future water resources management and have tried to make some predictions as to what may happen to them in the long term. Such countries include The Netherlands which is concerned about increased flooding caused by the Rhine due to larger peak flows and rising sea water levels, and Israel which is concerned about water resources. The Dutch predictions[44] are based on estimated average temperature increases (4°C by 2100), from which they estimate precipitation increases (4% in summer and 25% in winter) which then go in their hydrological model to predict flood flows. These predictions are useful for long-range planning and they indicate that for the next 20 years, flood control dikes will still be feasible. As time proceeds, climate and climate science will develop further so that more detailed and reliable climate scenarios can be formulated. Sea level rises by the year 2100 are predicted to be in the range of 20 to 110 cm. Analyses such as these are useful for long range planning for other river basins. If, indeed increasing flood flows are expected, raising levees ultimately may no longer be feasible and construction of parallel flood ways may be the best approach. Normally, these flood ways would be farmed and there would be no expensive structures, so that when they are used for flood control and the "green" rivers become real rivers, there is minimum damage.

The green river concept can also be applied to small rivers or streams. An example is the Indian Bend Wash in Scottsdale, Arizona, which drains a watershed of about 500 km^2 of urban and mountainous areas with short concentration times. Rainfall averages about 20 cm/year with occasional downpours of 2 to 5 cm in a few days. For the last 15 km, the wash runs through urban Scottsdale before it discharges into the Salt River. This normally dry wash is about 150 m wide and was an eyesore of weeds, old tires, discarded washing machines, etc. that flooded every few years or so and made level street crossings unpassable. In the 1960s flood control plans were developed which started with the usual approach of a concrete channel with levees on each side and houses and other urban developments right up to the levees. However, this plan was opposed by the public who did not want a Los Angeles-type "concrete canyon" and instead opted for a greener solution with a soft edge channel and recreational facilities. The result was a green river about 150 m wide with levees along the outer edges, a meandering low-flow channel a few m wide in the middle, and lakes, golf courses, sports fields, picnic areas, playgrounds and hiking and biking trails in the rest of the wash. The area now is a prime, high density and very popular recreation facility, and an example of what can be achieved with normally dry stream beds in urban settings. Small floods occur every few years, and large floods that cover most of the green river about every 20 years. The 100-year flood is 850 m^3/sec. The flood of record so far is 570 m^3/sec, which occurred in 1972 and has a recurrence interval of 70 years. Floods are short lived. They reduce or interrupt recreation for only a few days to about a week, and cause little or no damage. Israel also has made predictions of future climates for various scenarios based on local climatic trends and on national and regional climatological research and models [46]. The projected changes between now and for the year 2100 are: mean temperature increase 1.6 - 1.8°C; reduction in precipitation 4 - 8%; increase in evapotranspiration 10%; delayed winter rains; increased rain intensity and shortening of the rainy season; greater seasonal temperature variability; increased frequency and severity of extreme climatic events, and greater spatial and temporal climatic uncertainty.

Because of the uncertainties in global change predictions, especially in space and in time, the best policy for water resources management is flexibility so as to be able to handle floods and droughts, and surpluses and shortages. This is best achieved through integrated water management, as defined earlier. Global change may also affect infectious disease outbreaks. The occurrence of such diseases already shows

distinct geographical distributions and dependancy on seasonal variations. Thus, prediction of climate changes and their effects on disease outbreaks will be useful in developing appropriate public health programs to prevent or control such outbreaks [45]. For irrigation, the effects of climatic changes on water supplies must also be considered in relation to the effects of increasing CO_2 concentrations in the atmosphere on crop water use efficiencies and yields. As stated by Kimball (in press) : "The degree of influence of global change on future water resources is difficult to predict because various components are likely to be affected in opposing ways. Global warming [surface temperature projected to increase 1.2 to 5.8°C (mean of 3.5°C) by 2100, depending on CO_2 emissions scenario and on the particular general circulation model (GCM) used for the projection] would tend to increase evapotranspiration (ET) rates and irrigation water requirements. At the same time, precipitation is projected to increase globally, which would both decrease irrigation water requirements and increase water supplies, although regional pattern changes are very uncertain. The direct effects of elevated CO_2 (projected to reach 540 to 950 µmol mol^{-1}, depending on CO_2 emissions scenario) on plants likely will cause increases in stomatal resistance (about 20-40% for a 350 µmol mol^{-1} increase in CO_2 concentration for most herbaceous plants, with woody plants affected less), which will also tend to reduce evapotranspiration. At the same time, the elevated CO_2 will stimulate increases in plant leaf area (probably on the order of 10% in peak leaf area index for a 350 µmol mol^{-1} increase in CO_2 concentration for C_3 plants with C_4 plants responding less) and canopy temperature, both of which increase evapotranspiration. The sensitivity of "reference" ET for alfalfa to the several opposing future influences was examined using a form of the Penman-Monteith equation that is under consideration for adoption as a standard by the American Society of Civil Engineers. For constant future relative humidity, annual reference ET at Maricopa, Arizona, would increase 2.1%/°C (or 7.1% for the projected mean 3.5°C rise in global temperature). Increasing stomatal resistance reduces ET 0.16%/% (or 3.0 to 5.7% for a 20 to 40% increase in resistance), whereas increasing leaf area increases ET 0.16%/% (or 1.6% for a 10% increase in leaf area). The combined effect of these three influences would be a net increase of 2.7 to 5.7% in ET. However, irrigation requirement is the difference between seasonal ET for a well-watered crop and the amount of water available from precipitation and soil storage, and the latter two likely will also be affected by global change. Modeling studies which have been done using scenarios of future weather projected by various GCMs predict that irrigation requirements will increase substantially, on the order of 35% for the U.S. overall but with wide variability depending on GCM, region, and crop. Fortunately, overall precipitation is also projected to increase, which will have favorable effects on runoff or streamflow or irrigation water supply. One study projected global runoff to increase 10%. However, the regional variability is large and uncertain, and another study predicted water yields for 2030 to decrease in Southern U.S. and the Great Plains and to increase in the East and Far West, whereas for 2095 they predicted no change to substantial increases for much of the U.S. Another aspect of global warming is that greater proportions of annual precipitation will fall as rain rather than snow and that snowpacks will melt faster, which means that some important agricultural regions in the U.S. may lose a substantial part of a huge free snowpack "reservoir" that presently stores winter precipitation at higher elevations for summer irrigation at lower elevations. Both the projected climate changes and the direct physiological effects of elevated CO_2 on plants likely will cause shifts in optimal production regions for many crops. Further, human economic and social factors likely also will cause changes in land use and associated demands for irrigation water. In addition, there likely will be shifts in natural vegetation on the upstream watersheds, which may change the supplies of water available for irrigation in the future.

In conclusion, global change very likely will affect future irrigation and water resources. The effects of climate and CO_2 on seasonal crop water use are relatively well understood slight increases (2-6%) are predicted for plausible scenarios of future temperature and CO_2. The effects on irrigation requirements and on water supplies are much more uncertain due to the uncertainties in projected precipitation patterns. It behooves future water resource planners and future growers to try to be as flexible as possible."

Most of the studies of the effects of elevated CO_2-concentration in the atmosphere on crop yield and water requirements have been done with pure CO_2. In reality, however, concentrations of other gases in the atmosphere may also increase. Some of these could have adverse effects on crop yields. For example, levels of ozone have more than doubled in the past 100 years and are predicted to continue rising at an even faster rate in the future [47]. In one experiment, yield increases in potatoes induced by elevated CO_2 levels in the air were substantially reduced by the presence of elevated ozone [48]. Another consequence of increasing temperatures and global change is rising seawater levels, primarily due to melting of polar ice sheets and thermal expansion of oceans [49]. As stated by Anderson et al[50]: "Coastal change occurs in response to natural processes that operate across a wide range of spatial and temporal scales. Long-term, century-scale impacts of climate change that will affect coastal environments include decimeter-scale sea-level rises; shifts in sea-surface temperatures, which will likely influence tropical storm tracts, as well as storm frequency and magnitude; and precipitation variations that may impact sediment flux to coastal areas. Other effects may include changes in coastal and ocean currents and wave regimes".

In many parts of the world, people have been migrating toward coastal cities, which already causes serious stresses on coastal environments that can only get worse as rates of global sea-level rise increase. In addition to direct flooding of low areas, additional backing up and flooding problems can be expected where surface water and wastewater (pipelines) are discharged into the ocean. Groundwater levels in coastal areas will also rise as natural discharge of groundwater in the ocean is reduced. Salt water intrusion into coastal aquifers can also increase, especially where groundwater is pumped from wells.

Carbon emissions can be reduced by conservation and efficient use of energy, by using non-fossil energy sources (hydropower, wind, solar, nuclear, and ethanol or other biofuels) and by growing more plants for carbon sequestration in biomass and soil [51]. Biofuels still emit carbon into the atmosphere but, unlike carbon from fossil fuels, it is recycled carbon via photosynthesis. Oceans also hold considerable

amounts of carbon [51]. This requires international cooperation as reached at the 1997 Kyoto and the 2001 Marrakech conferences where delegates from 165 countries agreed to limit carbon emissions or cut them to below 1990 levels.

Water Reuse

All water is recycled through the global hydrologic cycle. However, planned local water reuse is becoming increasingly important for two reasons [9,10]. One is that discharge of sewage effluent into surface water is becoming increasingly difficult and expensive as treatment requirements become more and more stringent to protect the quality of the receiving water for aquatic life, recreation and downstream users. The cost of the stringent treatment may be so high that it becomes financially attractive for municipalities to treat their water for local reuse rather than for discharge. The second reason is that municipal wastewater often is a significant water resource that can be used for a number of purposes, especially in water short areas. The most logical reuse is for non-potable purposes like agricultural and urban irrigation, industrial uses (cooling, processing), environmental enhancement (wetlands, wildlife refuges, riparian habitats, urban lakes), fire fighting, dust control, and toilet flushing. This requires treatment of the effluent so that it meets the quality requirements for the intended use. Adequate infrastructures like storage reservoirs, and canals, pipelines, and dual distribution systems are also necessary so that waters of different qualities can be transported to different destinations. Aesthetics and public acceptance are important aspects of water reuse, especially where the public is directly affected. Treatment plant processes for unrestricted non-potable reuse are primary and secondary treatment followed by tertiary treatment consisting of flocculation, sand filtration and disinfection (ultraviolet irradiation or chlorination) to make sure that the effluent is free from pathogens (viruses, bacteria, and parasites). Such tertiary effluent can then be used for agricultural irrigation of crops consumed raw by people or brought raw into the kitchen, urban irrigation of parks, playgrounds, sports fields, golf courses, road plantings, etc., and urban lakes, fire fighting, toilet flushing, industrial uses, and other purposes. The tertiary treatment requirement was developed in California and is followed by most industrialized countries [9]. The California tertiary treatment is relatively high technology and expensive and is, therefore, often not feasible in Third World countries. To avoid use of raw sewage for irrigation, and to still make such irrigation reasonably safe from a public health standpoint, the World Health Organization[52] has developed guidelines that are based on epidemiological analyses of documented disease outbreaks and that are achievable with low-technology treatment such as in-series lagooning with long detention times (about one month). While this treatment does not produce pathogen-free effluent, epidemiological studies have indicated that use of such effluent for irrigation of crops consumed raw greatly reduces health risks compared to untreated sewage. As a precaution, however, the vegetables and fruit grown with such effluent should only be consumed raw by the local people that hopefully have developed some immunity to certain pathogens. Tourists and other visitors from the outside should not eat the local raw fruits and vegetables, and the produce should not be exported to other markets. Also, the lagooning treatment must be viewed as a temporary solution and full tertiary treatment plants should be built as soon as possible, especially when the lagoons become overloaded, detention times become too short for adequate pathogen removal, and the lagoon system cannot be deepened or expanded. Additional treatment of secondary or tertiary effluent and lagoon effluent can also be obtained by using the effluent for artificial recharge of groundwater where underground formations function as natural filters that can significantly reduce concentrations of suspended solids, nitrogen, phosphorus, organic carbon, trace elements, and microorganisms [9,7,6]. The resulting soil-aquifer treatment (SAT) greatly enhances the aesthetics of water reuse because the purified water comes from wells and not from sewage treatment plants and, hence, has lost its identity as "treated sewage." Water after SAT also is clear and odorless. SAT is especially important in countries where there are social or religious taboos against direct use of "unclean" water [53,54] or where expensive advanced treatment plants are not feasible.

Potable use of sewage effluent basically is a practice of last resort, although unplanned or incidental potable reuse occurs all over the world where sewage effluent is discharged into streams and lakes that are also used for public water supplies[55] and where cess pits, latrines, septic tanks, and sewage irrigation systems leak effluent to underlying groundwater that is pumped up again for drinking. In-plant sewage treatment for direct potable reuse requires advanced processes that include nitrogen and phosphorous removal (nitrification/ denitrification and lime precipitation), removal of organic carbon compounds (activated carbon adsorption), removal of dissolved organic and inorganic compounds and pathogens by membrane filtration (microfiltration and reverse osmosis), and disinfection. Even when all these treatment steps are used and the water meets all drinking water quality standards, direct potable reuse where the treated effluent goes directly from the advanced treatment plant into the public water supply system (pipe-to-pipe connection) may never be practiced. People see this as a "toilet-to-tap" connection and public acceptance will be very difficult to obtain. Rather, to protect against accidental failures in the treatment plant and to enhance the aesthetics and public acceptance of potable water reuse, the potable reuse should be indirect, meaning that the effluent should first go through surface water (streams or lakes) or groundwater (via artificial recharge) before it can be delivered to public water supply systems. The surface water route has several disadvantages, including algae growth that can cause taste and health problems since some algal metabolites are toxic. To minimize algae growth, the wastewater may then have to be treated to remove nitrogen and phosphorus, which increases the reuse costs. Also, water is lost by evaporation and the water is vulnerable to recontamination by animals and human activities. These disadvantages do not exist with the groundwater route, where the water also receives SAT benefits. Groundwater recharge also enables seasonal or longer storage of the water to absorb differences between water supply and demand, and mixing of the effluent water with native groundwater when it is pumped from wells. Water reuse basically compresses the hydrologic cycle from an uncontrolled global scale to a controlled local scale. Since all water is recycled in one way or another, the quality of the water at its point of use is much more important than its history.

Virtual Water

Water-short areas can minimize their use of water by importing commodities that take a lot of water to produce like food and electric power, from other areas or countries that are blessed with more water. The receiving areas then are not only getting the commodities, but also the water that was necessary to produce them. Since this water is "virtually" embedded in the commodity, it is called virtual water [56]. For example, for every kg of wheat imported, the country also gets about one m^3 of virtual water at much less cost than the price or value of local water resources, if available, in the country itself. Using a lot of water just to satisfy a national pride of being self sufficient in food production (especially staple foods) will then not be economical if these foods can be imported much cheaper from water rich countries [57]. More and more areas in the world will face serious water shortages with little prospect of having adequate water for their inhabitants, even by trying to move more water to people or more people to water. Imports of virtual water embedded in food and other commodities may then economically and politically be a very good solution, and probably the easiest way to achieve peaceful solutions to water conflicts.

As economies and trade become more and more global in scope, global movement of food from water rich to water poor countries should be just as feasible as moving petroleum products from oil rich to oil poor countries. To ensure that global distribution of food will not be used as political weapons, it should be internationally controlled with representation of the importing countries. Other opportunities for saving local water resources by importing virtual water include import of electric power from areas with more abundant water for cooling of thermal power plants, with dams for hydro-electric power production, or with coastal areas that provide ocean water for cooling. The virtual water concept could also be useful in protecting wetlands of international ecological significance against water diversions and drying up to produce more irrigation water, such as the Sudd wetlands in the Sudan and the Okovanggo Basin in Botswana [16]. International cooperation could then be established to develop eco-tourism in these areas that will provide revenues for import of staple foods and the virtual water therein. Moving virtual water will be much cheaper than moving the water itself, which is also being considered. Proposals range from building huge pipelines or aqueducts to hauling water in tankers and towing icebergs from polar regions or large rafts with fresh water from river discharges into oceans [58,59]. For water rich countries, such water exports can be a significant source of revenue.

Conclusions

Increasing populations and uncertain climatic changes will pose heavy demands on water resources in the future. Holistic approaches, integrated water management principles, and international cooperation will be necessary to develop sustainable systems and prevent catastrophes. Agricultural water management must be integrated with other water management practices, since the actions of one user group will affect the water interests of others. More research needs to be done to make sure that management of water and other resources is based on sound science and engineering. Much greater local, national, and international efforts, cooperation, and expenditures are needed to meet future food and water requirements in sustainable, peaceful, and environmentally responsible ways. The challenges are there.

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Fisheries development issues and their impacts on the livelihoods of fishing communities in West-Africa: an overview

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Abstract

Fisheries (in particular small-scale fisheries) provide a vital source of food, employment, and economic well-being for rural people throughout the world. In West Africa several million households along the coast and also inland are critically dependent on fishing for their livelihoods. However, fishing communities are often characterised as being amongst "the poorest of the poor". The main objective of this paper is to review the major issues relating to the development and management of small-scale fisheries in West Africa and to examine their impacts on the livelihoods of the fisheries-dependent communities of the region. Several major issues are identified, discussed and briefly illustrated using numerical examples or extracts of official documents. Globally, it appears that the fisheries sector, despite its potential role as a powerful lever for poverty reduction, is often neglected by national or supra-national decision-makers. Since 1999, however, a number of international initiatives (sponsored by Donor Agencies) have attempted to overturn this negative perception.

Key words: Small-scale fisheries, west Africa, development policies, livelihoods, poverty.

Introduction

The fact that fisheries provide a vital source of food, employment, trade and economic well-being for people throughout the world is widely recognised. In West Africa, several million households along the coast and also inland are critically dependent on fishing for their livelihoods. However, fishing communities have often been characterised as being amongst "the poorest of the poor". Poverty in fishing communities is indeed a major and on-going issue which has been a focus for International Development Organisations over the last 50 years. The main objective of this paper is to review the major issues relating to the development and management of small-scale fisheries in West Africa and to examine their impacts on the livelihoods of the fisheries-dependent communities (FDCs)[†] of the region[‡] ([†] In this review, the term "fisheries-dependent communities" (FDCs) is used in a broad sense and includes any group (family, village, community, etc.) whose livelihoods is partially or totally dependent on fisheries-related activities (fishing, processing, trading, packing, boat or gear retailing or repairing, etc.). This therefore includes individuals involved in full-time professional fishing activities, full-time or part-time crew members, but also (women) processors or traders, retailers, seasonal –or even opportunistic-river or floodplain agro-fisher communities, fish transporters, etc);([‡] In this review no distinction is made between coastal and inland (continental) fisheries, for the origin and causes of the problems affecting FDCs in West-Africa are sufficiently similar between the two types of fisheries).

The paper is structured as follows: The main information which underpins the review has been collated and summarised in one table (Table 1), the content of which is then explained more in depth in the rest of the paper. In order to keep the whole review concise and focussed, the information has been synthesised very thoroughly. A series of boxes are placed throughout the text to illustrate its content using numerical examples or extracts of official documents.

The Issues and Their Impacts on FDC Livelihoods

The issues relating to the development and management of small-scale fisheries in West-Africa are varied, complex and for the most, interdependent. Table 1 below attempts to summarise these issues. Column II characterises the nature of the issues and associated constraints (grouped into 8 'generic' points initially listed in column I) and Column III highlights their specific implications in terms of FDC livelihoods and vulnerability to poverty. The rest of the paper presents in more detail the different points enumerated in Table 1. For clarity, the headings used for the following 8 sections correspond to the 'generic' points listed in column I of the table.

Fisheries: an economic sector integrated into a wider system: Although a significant proportion of the households who depend on fisheries in West Africa are still relying to some degree on a subsistence-based system, West African fisheries and their communities have not evolved in isolation. Today, the fishery, as an economic activity but also as a 'social matrix', is totally and irreversibly integrated into a wider system through local, regional and international socio-economic and commercial links [1]. Too often in the past, however, fisheries have been considered from a narrow sectoral perspective, where both the analysis of the issues and the policies proposed to address these issues were identified and conceived using a mono-sectoral approach [2]. Today both academics and –unfortunately still to a lesser extent- decision-makers have started to realise that the fishery sector can only

be considered as an integrated part of a more general socio-economic system.

This necessity to widen the analysis and the way policies are conceived, is also applicable to the problem of the reduction of poverty in FDCs. Until very recently, the general perception about the cause(s) and nature of poverty in FDCs has been (over)simplistic and essentially based on a Maltusian model. Poverty in FDCs was usually related to the open-access nature of the fisheries and assumed to derive from the following sequence of events: open access Þover-exploitationÞ reduced catch Þlow income = poverty [3]. Following recent progress made by the international community (donors, academics, practitioners) in analysing poverty, the perception of poverty in fisheries has dramatically evolved. It is now understood that the causes of poverty in FDCs have complex origins, are multi-dimensional, and are very often related to constraints which are not specific to the fisheries sector (Box 1).

Box 1. Poverty in FDCs: a multi-dimensional issue
.Recent field-based participatory assessments [5 - 7] conducted in Ivory Coast, Guinea and Senegal have shown that the main development constraints faced by FDCs are not related to the level of abundance of the resource but to the following factors:
* Shortage of infrastructure, in particular lack of roads
* Limited access to drinking water, sanitation and electricity
* Lack of schools, health infrastructure, and other social services
* Inadequacy of storage and cold-storage infrastructure for fisheries products
* Lack of communications equipment (e.g. phones lines)
* Lack of credit facilities

Poverty of FDCs cannot, therefore, be addressed exclusively through intra-sectoral approaches [4]. Poverty assessments, but also the actions aiming at poverty reduction in fisheries sector, must in contrast be designed and implemented through a multi (or trans)-sectoral approach.

Different functions and contributions at different levels of the economy: In West Africa, the fishery sector offers different contributions and plays different roles in local and national economies. Its role is crucial for many rural populations (often relatively isolated geographically) for which this activity represents the basis of their economic well-being, in terms of employment, incomes, and food security (Box 2)

Box 2. Fishery and food-security
.It is estimated that 19% of the protein intake of the developing countries in the World is provided by fish. This share can exceed 25% in the poorest countries, and up to 100% in isolated parts of coastal or inland areas (where river, floodplain or lake related fishing activities take place). For instance in West Africa, the proportion of animal protein consumed derived from marine products is 47% in Senegal, 62%, in Gambia and 63% in Sierra Leone and Ghana [8, 9].

But fisheries can also represent the central activity –or even the "activity of last resort" -for a large segment of urban households for which alternative activities may be rare or even lacking. Globally it is estimated that in West Africa more than 15 million people depend on this activity to ensure part, or the totality, of their daily income.

At the national level, the fishery sector also makes an important contribution to the economic development of West African countries. In some, the fisheries sector ranks first amongst the primary sector activities (agriculture, forestry, fisheries, etc.) in terms of GDP and is the premier export sector, ensuring a large part of government revenues (Box 3).

Box 3. Contribution of fisheries to the national West African economies.
The contribution of the fisheries sector in Cape Verde stands at over 40% of export earnings and 5% of GDP. The decline of the mining industry and the lack of diversification of the Mauritanian economy created a situation where the fisheries sector alone accounts for approximately 25% of the State revenues and over 50% of export earnings. Senegal has revealed the extent to which fisheries are important to national development: some 600 000 people earn incomes and make their livelihoods from the fisheries sector, which has now become the premier export sector (almost 30% of total earnings) [6, 9].

For those countries highly dependent on fisheries, the development and viability of this sector has become a national priority, both economically and socially.

Different Views and Perceptions, and Divergent Objectives

The socio-economic importance of fisheries is acknowledged (to a certain extent) in numerous official documents and declarations made by West-African countries or regional institutions (Box 4).

Box 4. The recognition of the importance of fisheries for the livelihoods of people
.In its 2002-2010 Strategic Action Plan [10], the Sub-Regional Fisheries Commission (SRFC) [composed of Cape Verde, The Gambia, Guinea, Guinea Bissau, Mauritania, and Senegal] acknowledges: "The development of the fishery sector has been extremely important for the sub-region since the 70s. Nowadays, the sector strongly contributes to the economic and social development of the countries of the sub-region. It plays a crucial role in central domains such as food-security, employment and wealth, as well as the balance of payment of these countries" (p.4-5)

However, in reality, the fishery sector is often neglected by government decision-makers. Usually relegated in the national budget behind other economic sectors, fisheries –and in particular small-scale fisheries- do not often receive a high national priority. Limited or no budget at all, restricted or inadequate human resources, the discrepancy is large between the effective contributions of this sector to the local and national economies, on one hand, and the resources or budgets allocated by governments on the other. For illustration, in 1999, the annual budget (not including staff salaries) of the Chadian Department of Fisheries and Aquaculture (DPA) was 5 million CFA (» US$ 7000) to ensure the functional and operational activities (monitoring, implementing, reinforcement) for the entire country [11]. One of the reasons for this neglect is that the contribution in terms of livelihoods and national well-being of fisheries is usually poorly understood at all levels (micro to macro). In fact, fisheries are often considered by national decision-makers purely and solely as an income-generating sector. This is particularly the

case for those countries which enter into Fisheries Agreements with other countries (Fisheries Agreements are commercial arrangements between Developing Countries and other countries, e.g. European countries, People's Republic of China, Korean, Japan) which allow the latter to exploit the coastal resources of the formers in return for financial compensation).

For illustration, in the 2000 version of their Poverty Reduction Strategy Paper (PRSP) [12], the authorities of Mauritania (a country with significant fisheries agreements) explicitly recognised "*As far as fisheries is concerned, the strategy of the government is to optimise the economic rent generated by this sector*" (p. 21). At the same time, however, (and like the majority of the other West African coastal nations) Mauritania is calling for urgent actions to protect its national aquatic resources which appear to be declining rapidly, threatened by over-exploitation. Ironically, it is now recognised that this overexploitation is mainly due to the highly-subsidised foreign (Italian, Spanish, French) fleet which exploits the Mauritanian Exclusive Economic Zone under the Fisheries Agreements [13]. This example is, unfortunately, just one of the many contradictions which characterise the situation of West African fisheries. It illustrates, in particular, the increasing number of constraints and underlying issues of policy coherency that face governments (at the national level) and International Institutions (at the regional or international levels) [14].

Weak and Ill-Adapted Institutions

In terms of management, the fisheries sector in West Africa is under the responsibility of a range of institutions, acting from the local to the national (or even supra-national) levels. The structures, roles, and objectives of these institutions appear, at best, redundant and overlapping, and at worse, contradictory and conflicting. These multiple layers of institutions and organisations make the overall functioning of the system particularly opaque (according to the actors themselves), inoperable and rigid, and not prepared for the constant adaptations imposed by the rapid ecological, economic and/or social changes affecting the sector.

The consequences of this incapacity to manage the whole system are serious, and particulalrly for those natural resources which appear to be increasingly over-exploited (Box 5).But the repercussions of these institutional malfunctions are also severe for the fishing communities. Despite various decentralisation and co-management programmes launched over the last decade in West Africa (e.g. Mali, Ivory Coast, Senegal) in order to improve the managerial situation, these institutional reforms do not seem to have led to a better governance in the fishery sector of these countries. In particular they failed to improve the representation of the FDCs within the planning and decision-making processes. A large number of fishers (individuals or even whole communities) are still totally excluded from these decision-making processes. Furthermore –as also observed in other circumstances- this inequality usually benefits the strong and powerful groups or communities to the detriment of the poorest and most vulnerable (generally those who are already marginalized) (Box 6).

Box 5. The over-exploitation of aquatic resources in West Africa.

In its 2000 State of World fisheries and Aquaculture [14], the Food and Agriculture Organization estimates that the situation in the Tropical Atlantic Zone is "serious".

Likewise the SRFC [15], based on various recent stock assessments concludes to:

"- the overexploitation of the fishery resources with high commercial values (coastal demersal and deep species), inducing a level-off of the total capture volumes; a clear decline in the capture volumes of certain species; and a reduction in the size of the fish landed."

*"- a level of exploitation close to the maximum level for the coastal pelagic resources, with a level of exploitation variable depending on the areas and species". (p.*5)

Box 6. Lack of representation and transparency in fisheries management.

Kassibo, in his analysis of the Malian fishery in the High Diaka region, reports [16]:

"... the non-resident fishers have been excluded totally from the fisheries committees by the local fishers influenced by the traditional leaders. These traditional leaders (...) used the legitimate authority delegated [by the central government] through the decentralisation process to appropriate all the top-positions in these committees. (...) They then used this [newly devolved power] to privilege the interests of their lineages to the detriment of the principle of equity. The non-resident fishermen were left out from the new decisional bodies by some fraudulent manipulations." (p.86 and 91)

Fisheries and Poverty: A Strong Correlation

Since the early 1960s, a large number of International Development Programmes have been launched to address the issue of poverty and underdevelopment in fisheries. Up to the mid-80s, this underdevelopment (generally understood as low productivity) was attributed to the limited production capacities of the fisheries, i.e. the lack of effective means of production (e.g. inefficient fishing gears, poor port and landing infrastructures, inadequacy or lack of processing technologies, etc.). For more than three decades, the International and Bi-lateral development agencies have therefore promoted fishery development through productivity-oriented programmes based on the introduction of new, 'modern' (and capital-intensive) boats, fishing gears and equipment [2].

Has the economic or social situation of the fishermen and their family been positively affected by these productivity-oriented programmes? Has the livelihood of the FDCs been improved by the introduction of these new fishing gears? It seems that even if some positive results can be observed in the short run, globally in the longer term, the answer is: No. In fact, beyond the apparent correlation between poverty and fisheries, a series of questions -which have so far been only addressed partially or even ignored- need to be answered: what sort of poverty are we talking about here? What are the real causes, what is the real nature, of this poverty? Does poverty affect all fishermen 'equally' or does it affect only a part of the community? Is poverty intrinsically related to the fishing activity, or is it the result of external mechanisms or circumstances reinforced by sector-specific constraints? Those are some of the key questions that need to be addressed urgently if there is to be an improvement in the livelihoods of African FDCs in the future.

The Impacts of External Factors and Extra-Sectoral Policies

As emphasised earlier, fishing is not an economic activity isolated from the rest of the national or trans-national economic systems. In fact, fisheries are part of a more global organization which is, itself, complex and characterised by different (economic, social, political) dynamics functioning at different scales (local, meso, national, international). Unfortunately, in addition to the weaknesses of the local institutions which often make the most marginalized individuals or groups 'voiceless' at the local level, the decisions relating to macro-economic policies at the national or international levels are usually taken without inviting fishery stakeholders (in particular those of small-scale fisheries) around the discussion table. For illustration, the fishery sector is totally absent from the current version of most PRSP prepared by national African experts/economists (with the notable exception of Senegal) under the supervision of the World Bank, even if the fishing sector –due to the number of people concerned and the degree of deprivation faced by certain FDCs- should represent a major entry point for any programme on poverty reduction.This issue of poor representation unfortunately does not only concern the local or national levels. It is also noticeable at the (sub)-regional level, as illustrated by the total absence of reference to the small-scale fishery sector in official documents of economic organisations such as ECOWAS or UEMOA (Box 7).

Box 7. Small-scale fisheries and Sub-regional Economics Institutions.
Although separate entities, UEMOA (West African Economic and Monetary Union) and ECOWAS (Economic Community of West African States) are very similar in terms of their objectives, actions and policies [17]. Ultimately their goal is to encourage growth and development in West Africa through the promotion of co-operation and market integration and the creation of an economic and monetary union between their respective (and sometimes common) state members. As such, they do not develop specific policies addressing directly fisheries and FDCs issues. It is only through market integration, harmonisation of commercial and economic policies, and trade liberalisation schemes that those organizations may expect to have impacts on the livelihoods of FDCs. Unfortunately, these types of policies appear to be neutral-poor (i.e. non-redistributive) and it is now widely recognised that the factor which characterises specially the poor (as individuals or groups) is precisely their inabilities to benefit from neutral policies and programmes.

Inevitably, in these circumstances, the specific needs of FDCs are not taken into account. Fisheries are therefore affected by extra-sectoral factors and policies whose externalities (positive and/or negative) appear to have extremely important impacts on the livelihoods of the FDCs. This is palpable, in particular, through the impacts that the various structural adjustment programmes (SAP) –either those initially imposed by the World Bank or the latest schemes voluntarily adopted by national governments- have induced indirectly within the FDCs over the last two decades (Box 8).

Box 8. The indirect impacts of SAP on West African FDCs.
What the exact economic role of SAPs has been on the national economies of West African countries is hard to tease out. What is clear, however, from an increasing number of reports and document (including documents from the Bretton Woods institutions) is the negative social and ecological impacts of these SAPs. Under budget restrictions imposed by these SAPs, central governments find it more and more difficult to allocate the (human and financial) resources necessary for the research, management planning, capacity building and implementation of tasks related to the sustainable use of natural resources. With respect to fisheries, SAPs may not have influenced directly the way fisheries have been managed over the last decade (decentralisation and co-management programmes were already being taking place in an attempt to address governance and management issues). However, it is indisputable that SAPs have had indirect negative impacts on livelihoods of rural communities and therefore on FDCs through the reductions in the other public sectors' expenditures. These include restricted access to health service and education, and limited expansion in infrastructure and communications. The last, of course, have major implications for distribution (notably between rural and urban populations). More directly, cuts in the public sector also limit the resource available for the development of social and human capital in fisheries (and other rural) communities, especially the more vulnerable and poorest of these communities [7, 18]

Rapid and Destabilizing Changes

Acknowledging the institutional weaknesses of the sector, or the impacts of external policies to 'explain' the critical status of both the aquatic resources and the communities which dependent upon these resources, should not mask another fundamental aspect of the problem: The speed and amplitude of the social, economic and political changes that have taken place in West-Africa over the last four decades (post-independence period). Commercialisation, increasing urbanisation, demographic growth, rapid technological changes, trade internationalisation, etc., all these factors have, to a great extent, also contributed to the weakening or destabilisation of local or national institutions, or even led to their complete disappearance in some parts of Africa [19].

Difficulties in Seizing and Analysing the Problem

Finally, can one reasonably expect to achieve a correct understanding and representation of the problem of fisheries development at all? And, more pragmatically, can one expect to be able to integrate and address all the different aspects of this problem into a coherent policy aimed at improving the livelihoods of the thousands of people depending on fishery activity in West-Africa? These are the two underlying and fundamental questions that ultimately needed to be answered, acknowledging humbly that the responses, so far, have been piece-meal, sectoral, and based on mono-disciplinary approaches. It is on the basis of these lessons that various International Development Organisations have recently launched a series of new initiatives. In 1999, the UK Department for International Development (DFID), in collaboration with the United Nation Food and Agricultural

Organization (FAO) initiated the US$ 34 million "Fisheries Sustainable Livelihoods Programme" (SFLP). This programme includes 25countries in West Africa and specifically aims at addressing the issue of poverty in West Africa FDCs [20]. In November 2001, an international Workshop on "Small-Scale Fisheries, Poverty and the Code of Conduct for Responsible Fisheries" was also organised in Cotonou (Benin) by the SFLP and FAO [21]. More recently the FAO Advisory Committee on Fisheries Research organized a "Joint Working Party on Poverty in Small-Scale Fisheries" in Rome (April 2002), and the European Commission (DG-DEV) initiated the EC "Working Group on Fisheries Development Issues".

Is the future of fisheries-dependent communities in West Africa necessarily brighter thanks to this new, 'revitalised' focus by the International Donors community? This is certainly what we would like to observe, but the complexity and scale of the issues and the lessons from the past should keep us away from contented, too large optimism. A long, laborious way is still ahead.

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Table 1. The main issues of fisheries development and management and their impacts on the livelihoods of fisheries-dependent communities (FDCs)

I Generic Issues / characteristics	**II** Nature of the issue - General implications	**III** Implications for FDCs
Fisheries : an economic sector integrated in a wider system.	* Development and management policies generally sectora * Lack of integrated / multi-sectoral approach both at the analysis (diagnostic) and intervention (policy) levels.	* Incorrect diagnostics of the opportunities and constraints faced by FDCs. * Incorrect and oversimplistic perception of the nature and causes of poverty in FDCs. * Inappropriate and poorly adapted fishery development policies.
Different functions and contributions of the fishery sector at various levels of the economy.	* Fisheries represent a central element of livelihoods (income, food security, employment) especially for the poorest individuals / groups (safety-net, "activity of last resort"). * Important contribution to the national economy (export revenues, fisheries agreement revenues, hard currency, etc.) in particular for the poorest countries (e.g. The Gambia, Guinea Bissau, Mauritania).	* Mis- or under-evaluation of the contribution of fisheries to the livelihoods of FDCs. * Role of fisheries generally evaluated in terms of production capacities (captures volumes and commercial values).
Stakeholders and intra / extra-sectoral institutions have different views and objectives.	* Different perceptions of the stakeholders about the nature of the issues and the potential role of fisheries. * Different and often divergent perceptions by institutions and other outside-sector actors (frequently in contradiction with the views of the stakeholders within the fishing sector).	* Interests of FDCs generally under-represented or even deliberately ignored by policy-makers. * Impacts generally negative on FDC livelihoods.
Lack of widespread and appropriate institutions for fisheries management.	* Lack of credit and human resources. * Mis-management / over-exploitation of the aquatic resources. * Lack of representation / participation of the local stakeholders. * Institutions unable to adapt to changing factors.	* Decline of the FDC sustainable livelihoods. * Exclusion and marginalisation of the poorest. * Degradation of the living conditions of the more vulnerable individuals / groups

Table 1 (continued).

I Generic Issues / characteristics	**II** Nature of the issue - General implications	**III** Implications for FDCs
Fisheries and poverty are strongly correlated	* Situation of extreme poverty / vulnerability of certain communities. * Difficulty to properly diagnose nature and causes of poverty * .Incorrect fishery development policies.	* Unawareness of the real causes of FDC poverty. * Absence of pro-poor and poverty reduction policies.
Strong impact of extra-sectoral factors and policies	* Fishery stakeholders seriously affected by extra-sectoral policies that they cannot control/influence (e.g. structural adjustment reforms). * Lack of representation of the different actors (local, national) in the national or supra-national decision-making processes. * Fisheries absent from PRSP * Issue of policy coherence (both at the national and international levels.)	* Impacts globally negative on the most vulnerable FDCs (generally those weakly or not integrated into the market dynamics).
Fisheries have to face rapid and dramatic changes (internal, external)	* 'Global' scale of changing factors (international) * Fishers and FDCs unable to cope. * Fisheries institutions (local, national) unable to cope * Negative impact overall.	* Marginalisation of the (economically and politically) weakest within the FDCs. * Marginalisation of the less-active / more isolated FDCs (also generally the more disadvantaged in terms of social capital).
Difficulty in analysis and integrating the problem.	* Multi-dimensionality, transectoral, and complex nature of the problem. * Strong influence of mono-disciplinary paradigm/approach. * Analytical framework and policies usually mono-sectoral. * Difficulty to adopt and implement multi-disciplinary approaches. * Piece-meal solutions.	* Problem of identification of pertinent poverty reduction policies * .Un-coherency of fishery development policies.

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Rough terrain: forest management and its discontents, 1891-2001

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Abstract

The history of scientific forest management in the United States is relatively brief, about 125 years or so. But it has been rife with debate and controversy, and there is no reason to supposed that this will change with the introduction of biotechnology to this well-wooded land. This article tracks the varied challenges offered by and different tactics protesters have selected over time to fight against innovations in land management. By tracing the fights that broke out over the creation of the first National Forests in the early twentieth century, clear-cutting practices in the post-World War Two era, and the more violent reactions to government conservation agencies at the turn of the twenty first century, we will better understand some of the hostility that has emerged in response to genetic engineered trees and food.

Key words: Conservation, earth liberation front, forest management history, genetic engineering, natural resources.

Introduction

They came in the middle of the night, broke into Merrill Hall, site of the Center for Urban Horticulture on the campus of the University of Washington, and set incendiary devices within and around the office of researcher Terry Bradshaw; then they stole away before the fiery blasts ripped through the building. The subsequent conflagration destroyed Bradshaw's facility and gutted much of the rest of the complex, causing damage estimated at $3 million. But that figure only encompassed the burned-out physical infrastructure; it has been impossible to calculate the loss of the results of decades of scientific research on such subjects as wetlands restoration, endangered plant species, urban landscaping, and genetic hybridization[2]. It was Bradshaw's work on hybrid poplars that had been targeted for destruction. So admitted the Environmental Liberation Front (ELF) in a post-fire communiqué, in which it claimed credit for the May 21, 2001 assault. Bradshaw, it asserted, is "the driving force in G.E. [genetic engineering] tree research," and was thus responsible for unleashing "mutant genes into the environment that [are] certain to cause irreversible harm to forest ecosystems."[3] The perceived threat of his work not only sanctioned this attack, but any subsequent ones. "As long as universities continue to pursue this reckless 'science' they run the risk of suffering severe losses," ELF warned. "Our message remains clear: we are determined to stop genetic engineering"[3].Their determination and that of like-minded environmentalists had been manifest in earlier attempts to disrupt Bradshaw's research; in 1999 some of his trees were cut down as part of protests associated with that year's World Trade Organization meetings held in Seattle. Others had zeroed in on the work of Oregon State geneticist Steve Strauss, chopping down approximately 900 of his hybrid poplars in March 2001; and on the same night that Merrill Hall went up in flames, ELF also torched a poplar tree farm in Clatskanie, Oregon[2] . Biologists at Michigan Tech, whose research was also slated for immolation, proved more fortunate: just before dawn on November 5, 2001 campus police stumbled upon large containers of flammable liquid, complete with electrical detonators, planted outside the school's forestry building and a nearby USDA Forest Service laboratory; a Michigan State Police bomb squad successfully dismantled the devices[4] .

Whatever the connections between these various incidents, and whatever their outcomes, realized or foiled, it is clear that the scientific innovations associated with hybrid research and genetic engineering have escalated some people's fear of the unknown. Their anxiety is bound up with a unshakable distrust of technology and its experts, and gives shape to their worries about the emergence of a Frankensteinish world portending the end of nature. But their attacks on engineered foods and forests is not just driven by an aesthetic distaste for the manufactured and the modified, although the desire to preserve wildness owes much to late-eighteenth-century Romantic disgust with a then-industrializing world. The stakes now appear much higher, more fundamental, and thus seem to sanction more visceral reactions. As one ELF supporter wrote in the wake of the Merrill Hall fire: Bradshaw's research was "[t]ampering with the fundamental blueprint for life—the genetic code," and as such "crosses an...ominous threshold"[5]. So threatening was this prospect that only "[s]wift and decisive action" by "dedicated Earth warriors" could halt these "emerging technological menaces before they escape the lab"; only late-night incendiarism would "protect this beautiful planet"[6]. Pacific ends, ELF and its above-ground followers insist, justify violent means. This declaration is not unique to ELF, or even to the relatively short history of scientific forest management in the United States. Since the late-nineteen-century importation of European ideas about how best to manage New World forests, many of the innovations in the human ability to manipulate the forested estate have been met with doubt, suspicion, and, occasionally, violence. By tracing some of the environmental concerns, social challenges, and political controversies that have swirled around attempts to manage this well-wooded land, we will gain a better understanding of the conflicted context in which genetic engineering has emerged in the early twenty-first century.

Discussion

Conservation and the Nation State, 1870-1910

The 1870s were a turning point in the development of a new perception of how Americans might better live on and within the land. Among the seminal texts that helped them redefine their place in nature was George Perkins Marsh's *Man and Nature: The Earth as Modified by Human Action* (1864), a

shrewd analysis of the environmental devastation that the Industrial Revolution unleashed, and a clarion call for a new-found conservative stewardship that would protect the Earth from human excess. Marsh warned of a coming apocalypse that could only be held off by a shift in attitude and behavior in the United States. Some who heeded his prophetic words founded the American Forest Association (1875), read widely in the European literature that Marsh himself had depended on to make his case, visited and studied with British, French, and German foresters to determine if their conceptions could be transferred across the Atlantic, and began to publish their findings in *Garden & Forest*, one of the new periodicals devoted to the cause of conservation[7]. Out of this initial intellectual energy came a small bureaucratic breakthrough—the opening of the Division of Forestry in the Department of Agriculture—and a series of legislative initiatives to create national forest reserves, which finally bore fruit in 1891. Shortly thereafter, the profession of forestry surged into being, with the creation of a clutch of forestry schools, the launching of the Society of American Foresters, and the publication of the *Journal of Forestry*. By 1905, National Forests, totaling more than 85 million acres, had been carved out of the public domain. A new agency, the USDA Forest Service, was founded 1905 with the mission of managing these forests and regulating their resources[8]. None of these changes could have occurred without the simultaneous transformation of the nation-state itself. Indeed, the implementation of forestry principles on the ground depended on what Bernhard Fernow, third chief of the Division of Forestry, had argued was the essential creation of a paternal government whose power trumped local rights and governance[9].That preeminence was precisely what Fernow's successor, Gifford Pinchot, pursued when, after President Theodore Roosevelt had tapped him to be the first chief of the new Forest Service, he hired Forest Rangers to patrol the vast lands under the agency's control, and fought (and won) in the courts for the rangers' right to enforce user fees for grazing, mining, and lumbering. In sanctioning these actions, the U.S. Supreme Court extended the federal government's sovereignty and legitimized a new politics of conservation, the slogan of which Pinchot coined as "the greatest good, for the greatest number for the longest run"[10].

Revolt in the West, 1905-1920

Not everyone accepted this as the prevailing definition, let alone ceded to the Forest Service's exclusive assumption of professional expertise, scientific legitimacy, and political authority. Throughout the west, site of all the then-extant National Forests, ranchers, miners, and timber-cutters rose up in opposition to the agency's implementation of federal conservationism. Some took the law into their own hands—violence flared, as forest rangers were shot at, beaten, or threatened with lynching when they attempted to uphold National Forest boundaries or to tax resource use[11].

The political arena was only slightly more restrained. To bolster their position, enraged westerners championed state rights as the only means to blunt what they perceived to be an aggressive executive branch; they branded its enforcement actions as "Pinchotism." One of many moments in which they came together to rail against the Roosevelt administration's actions was the 1907 Denver Public Lands Convention; the mid-June confab attracted an estimated four thousand delegates from the west, and its raucous proceedings underscored western frustration with the new conservation ethos[11, 12].

Upset that the administration was expanding the size and number of National Forests over the West's repeated protests, those at the Denver gathering demanded a showdown with the federal government to determine whether the states or the executive branch held ultimate sovereignty over public lands. A Colorado newspaper denounced the arbitrary character of the Roosevelt-Pinchot edicts. "Very few of the autocratic monarchs of the world," the Steamboat Pilot asserted, "would so dare to set aside the will of the people this way." The Rocky Mountain News published a mocking cartoon that depicted Pinchot as a throne-sitting, mace-wielding czar, behind whom was six mounted forest rangers brandishing whips, markers of unchecked authority. In the foreground kneel abject westerners, hats in hand; deferential and impotent, they are no longer masters of their own fates[12]. To defuse the charged atmosphere, Roosevelt sent Pinchot to the Denver convention, but from the start his work there was complicated: in the two days before he spoke, anti-government rhetoric built up as each of those addressing the crowd fed off his predecessor's animosity; speech after speech excoriated the Roosevelt administration and its conservation agenda. "We cannot remain barbarians to save timber," boomed Senator Henry Teller of Colorado. "I do not contend that the government has the right to seize land, but I do contend that we have the right to put it to the use that Almighty God intended"[12]. His contentious language emboldened the audience, so that when Pinchot finally strode across the stage of Denver's Brown Theater, it erupted in a vociferous round of catcalls and jeers. Hoping to deflect the hecklers' anger with a joke—"If you fellows can stand me, I can stand you,"—Pinchot gave little ground. The cornerstone of his address was what he identified as the critical relationship between national forests, conservation practices, economic growth, and political equity. "[G]overnment-regulated timber auctions prevented monopoly and the consequent excessive price of lumber," they stabilized markets and insured that there was "no question of favoritism or graft." The environmental benefits were no less important: forested lands protected "watersheds of streams used for irrigation, for domestic water and manufacturing supply, and for transportation". For these reasons alone, he asserted, "the protection of irrigation throughout the west would justify the president's forest policy"[12]. It was further justified by the fact that federal conservation took local needs into account. Grazing, for example, "is primarily a local issue and should always be dealt with on local grounds. Wise administration of grazing in the reserves is impossible under general rules based upon theoretical considerations," Pinchot noted[12]. Being sensitive to different landscapes meant that "[l]ocal rules must be framed to meet local conditions, and they must be modified from time to time as local needs may require"[12].

Citizen participation in defining the mission of the national reserves also constrained federal power. In "The Use of the National Forests," a 1907 Department of Agriculture pamphlet released to coincide with the Denver meetings, Pinchot declared that public lands "exist to-day because the people want them. To make them accomplish the most good the people themselves must make clear how they want them run"[13]. But no interest, individual or combined, could or would be allowed to dominate Forest Service policy. "There are many great interests on the National Forests," and of necessity these

"sometimes will conflict a little" [13]. To secure the necessary consensus that will insure a rational use of the land it "is often necessary for one man to give way a little here, another a little there". In this new Rooseveltian age, there "must be hearty cooperation from everyone"[13]. Nature would compel their cooperation in any event, he believed, for the carrying capacity of the land was the first and final arbiter of how and when a landscape would be utilized. "The protection of the forest and the protection of the range by wise use," Pinchot reminded his Denver audience, "are two divisions of a problem vastly larger and more important than either." This is "the problem of the conservation of all our natural resources," for if "we destroy them, no amount of success in any other direction will keep us prosperous." Private, short-term interests must give way to public, long-term needs[12] .

Local Control v. National Sovereignty, 1920-1990

Many of Pinchot's listeners were not persuaded by his assertions, and western resistance to the imposition of federal conservationism continued long after he left the Forest Service in 1910. These eruptions have been dubbed the Sagebrush Rebellions, and have been characterized by efforts to disrupt the Forest Service's capacity to manage the National Forests, or to dismantle the National Forest system outright. In the 1920s, for example, Secretary of the Interior Albert Fall, a New Mexico rancher who chafed at federal grazing regulations, failed in his attempt to transfer the Forest Service (and its woods) to his department; critics believed Fall was attempting to strip the agency of its regulatory authority and perhaps sell off some of its prime lands[14]. Similar worries surfaced in subsequent decades, a tradition that pitted state rights against federal sovereignty, placed ranchers in opposition to conservationists, and framed the struggle as one between economic development and environmental preservation. When in the 1950s, Bernard DeVoto railed against the power that the western livestock industry wielded in Congress to attack federal conservationism—"They have reversed most of the policy, weakened all of it, and opened the way to complete destruction"[15] he did so in language that drew off of what amounted to a half-century legacy of political tension. Forty years later members of the so-called Wise-Use movement, encouraged by President Ronald Reagan's anti-environmentalism and his rhetorical assaults upon government regulation, and goaded by right-wing, vitriolic talk-radio commentators, moved to assert local control over federal land. In Nevada, county commissioners crashed bulldozers through Forest Service fences to lay claim to the disputed terrain. In other parts of the interior west, ranger district offices were fire-bombed, agency equipment vandalized, and, in at least one incident, a ranger discovered a pipe-bomb under his truck parked in the driveway of his home[16]. These explosive episodes, however much tied to the particularities of time and place, were also part of a long-standing pattern of western political protest, a pattern with which Progressive Era conservationists such as Theodore Roosevelt and Gifford Pinchot had had considerable experience.

Environmentalism emerges, 1945-1970

Other late-twentieth century controversies over land management would have been less recognizable to those who had established conservationism as a key element in the American political landscape. And they would not because those who earlier had founded the major conservation agencies in the Departments of Agriculture and Interior—among them, the Forest Service, National Park Service, Fish & Wildlife Service— could not have anticipated the escalating resource demands associated with the post-World War Two economic boom, or the range of political responses they generated. With the close of war come an upsurge in spending on consumer items, most notably homes and automobiles. The rapid construction of new housing stock on the urban fringe, the laying down of high-speed expressways to connect these suburban developments with the metropolitan economy sparked a swift shift in timber-cutting practices. During the Great Depression of the 1930s, there had been little pressure to harvest large quantities of wood from public or private forests. Global conflict and later peace-time development changed that situation, leading the federal government and industry to initiate clear-cutting practices on their respective woodlands. System-wide production on national forests soared from 3 billion board feet (BBF) in 1945 to nearly 12 BBF in the late 1960s; in the same time period, on National Forests located in the Pacific Northwest, harvests went from less than two BBF to five BBF[17].

The houses these escalating cuts built sheltered the Baby-Boom generation, whose parents took their numerous children on vacation to the American Wonderlands—its stunning national parks and forests. There, they encountered some of the costs associated with the suburban landscape they lived within: once-spectacular forested vistas marred by cut-overs. They also confronted reminders of the world they temporarily had left behind: lines of automobiles snaked along mountain roads and packed valley parking lots, and crowds of people queued up for lodging, restaurants, and other amenities. The motoring masses had brought the city to the wilderness[18]. The inescapable tension between the desires for economic growth and open space escalated in the 1950s and 1960s, one consequence of which was that the federal land-management agencies found themselves confronted with a newly energized environmental movement; it challenged the prevailing scientific assurances that intensified resource production would not damage forest and land health, and generated an ever-more intense level of public scrutiny of their failure to protect treasured landmarks. Organizations such as the Sierra Club, Wilderness Society and National Resource Defense Council funded lawsuits that stopped the damming of some free-flowing western rivers and halted some clear-cutting of eastern and western forests; they also successfully lobbied for legislative initiatives to protect wilderness and endangered species, promote clean air and water, and sustain riparian and wetland habitats. When these political victories and congressional legislation were combined with a clutch of favorable legal mandates and a new-found expertise based on the ecological sciences, the post-war environmental movement swelled in size, political power, and cultural significance. One marker of its stature was the creation 1970 of what has become a global celebration: Earth Day[16].

Political Backlash

Within a decade, however, some environmentalists would conclude that these manifold efforts were too little, too late. They feared that the Reagan administration would roll back critical environmental legislation, were riled by the unchecked militancy of the Wise-Use movement, and were dismayed that

now-mainstream environmental organizations appeared incapable of countering these renewed threats to Mother Earth. Those who broke off into splinter groups such as EarthFirst!, and later, the Earth Liberation Front, adopted their organizational names to signal their disaffection with what they took to be their predecessors' more anthropocentric agendas; their tactics in turn were (and are) designed to shock, bloody, and disrupt those forces arrayed against what they define as planetary health and survival. Taking their early cues from Edward Abbey's novel, *The Monkey Wrench Gang* (1975)[19], in which fictional activists pulled up survey stakes for highway construction, disabled road-building machinery and timber-cutting equipment, and unfurled a large banner simulating a crack in the Glen Canyon Dam, real-life protesters followed suit. In time, they have graduated to potentially more deadly forms of sabotage (spiking trees slated for harvest), and more destructive forms of property damage (firebombing scientific laboratories). This escalation was signaled in 1998, when ELF incinerated three major buildings and four ski lifts in Vail, Colorado, a response to Vail, Inc.'s plans to expand into threatened lynx habitat. To further mark its repudiation of mainstream environmental rhetoric and activism, ELF posted a photograph of the flame-engulfed mountain resort on its web page with the following inscription: "Every Night is Earth Night!"[20].

That such language offers no room for compromise is intentional. ELF has no interest in reaching consensus with an economic system, business culture, and scientific research agenda that it believes must be destroyed. In an January 2002 communiqué following its attack on the construction site of the University of Minnesota's Microbial and Plant Genomics Research Center, a project funded in part by the Cargill Corporation: "we are fed up with capitalists like Cargill and major universities like the U of M who have long sought to develop and refine technologies which seek to exploit and control nature to the fullest extend under the guise of progress"[21]. Setting fire to heavy equipment and a on-site trailer is described as step in ELF's wider war to bring about "the end of capitalism and the mechanization of our lives"[21].

Conclusions

The ELF's combative stance mirrors those adopted by some western insurgents at the turn of the twentieth century who reacted violently to what they perceived as a life-threatening imposition of federal regulatory controls on grazing, lumbering, and mining. It evokes as well the actions of ELF's more-immediate contemporaries on the radical right, who in the late 1980s and early 1990s lashed out at agents of the regulatory state they despised. Marginal though each of these groups may have been (and are), their marginality nonetheless has helped shape the broader context in which each era has debated the intersection of politics and science, social change and environmental health. Dave Foreman, founder of EarthFirst!, recognized that one role the radical left of the environmental movement has played has been "to make the Sierra Club or the Wilderness Society look moderate"[22].

Contending organizations, by whatever means they choose, inevitably define and defend themselves in relation to their ideological competitors, a dynamic that will become ever more clear as the battle over genetic engineering in the fields and forests unfolds with the twenty first century.

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Estimating visual perception of rural landscapes: the influence of vegetation. The case of Esla Valley (Spain)

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Abstract

Vegetation can be considered an important factor in landscape planning and its effect needs to be analysed in the landscape model. Some problems, such as vegetation extension and distribution at the plot scale, are detected in the modelling process. In order to facilitate the handling of long series of data, we propose the use of computer simulation tools that could help to solve some of the problems. The Geographic Information Systems (GIS) are computer programs especially designed to enter, stock and represent territorial data. They are provided with user interfaces to facilitate the relationship between professionals and computers. The power of the GIS calculation module makes it possible to implement programming routines to run commands automatically. Vegetation could be incorporated in Digital Elevation Model (DEM) of the terrain, and therefore the landscape's visual properties could be analysed from a three-dimensional point of view. This modelling process could be a useful tool for architects, planners and designers working on landscaping activities.

Key words: Visual impact, visual perception, vegetation model, GIS, DEM, visual elements.

Introduction

There are several definitions of landscape. In this work, we consider landscape as the visual surroundings from the viewpoint.[1] A perceived scene comprises natural elements and human interventions, of which buildings are the most important. The perceived scene is studied not only as a whole but also as relationships between its components. The application of the term to a reproduced image (in this case a photograph) demonstrates the ambivalence of a word that covers both a three-dimensional reality as well as a two-dimensional representation of it[2]. This substitution process contains a solid psychological mechanism of assimilation of perceptual schemes, so that the observer can perceive different landscapes of the same scene when observed from different viewpoints. Buildings always entail the suppression of surfaces in their natural state and, at times, the introduction of extraneous elements in their place. This incorporation of "singular elements" requires planning in the execution and the study of building design criteria for their integration within the landscape. Consequently, a proper study is required anticipating environmental problems and avoiding incompatibility between conservation and development.

Materials and Methods

This study was conducted in the Esla Valley, a rural region between the provinces of León and Zamora, in Spain. It is crossed by a highway called *"La Ruta de la Plata",* "the Silver Route". Over the last few years, there has been widespread proliferation of new agro-industrial buildings that are a threat to the quality of landscape.

We have considered the following parameters:

Space as a Visual Element : Space, as a visual component of a scene, is defined as the three-dimensional layout of landscape objects and areas making up the scenic composition, arranged according to the relationship between its components (scenic composition and scenic background)[3]. By studying the scenic composition we will analyse the criteria that affect the choice of location of a specific building. A building's location has a considerable influence on its perception, because it is possible to modify the perception of the building as a greater or lesser centre of attention within the scene.

Vegetation screens: One way of blending buildings into their surrounding is by creating vegetation screens, which totally or partially conceal the buildings. Covering all the buildings with a vegetation screen does not always turn out to be the best solution. Sometimes a partial concealment is preferable because this produces a variation in the visual characteristics of the buildings. And so its shape, line or scale is seen to be better integrated with its surroundings.

The relationships between the visual elements of the building and those of its surroundings can give rise to visual continuity, diversity without contrasts, and compatible or incompatible contrasts. Vegetation is used to eliminate or reduce these contrasts and to achieve a better integration of the building [4].

Total concealment vegetation screens: When, owing to the morphological characteristics of the buildings, it is not possible to blend them well into the landscape, the option of totally concealing buildings with a vegetation screen should first be studied. In this respect we consider that:

(a) The length of the vegetation screen should be greater than the length of the building to be concealed.
(b) The height of the screen is to be staggered using different species of varying appearance and stature so as to avoid contrasts produced between the line of the natural landscape, the building and the vegetation screen to be introduced.
(c) The purpose of the central zone of the screen is to conceal the building and so would comprise dense foliage tree species that are evergreen (if possible) with a medium-sized or large crown.

(d) On each side of this central zone there would be a vegetation zone with medium-sized crowns, of lesser stature than those of the central zone. The species used in the lateral zones should be trees and shrubs of medium stature and foliage density. On either side of these zones (at either end of the screen) species of shrub would be planted progressively diminishing in size from medium to small away from the centre.

Partial concealment vegetation screens: Vegetation screens used for partial concealment can modify the perception of some of the characteristics defining the agro-industrial building, such as line, shape and scale. Both the line and shape elements are affected by the orientation of the building. The line element is also influenced by its clarity, and the shape element, by its geometry. On the other hand, the scale element is defined by the space occupied and the scale contrasts. The perception of line, shape and scale can be indirectly influenced by the vegetation acting upon the previously stated parameters, reducing contrast and thus providing an optimum solution for integration.

Incorporation of vegetation effects in DEM: The model of territory is a very complex digital result made by GIS.[5] A simple part of it is the Digital Elevation Model (DEM), that can be obtained from satellite and aerial data.

In the incorporation process, the vegetation could be considered an accident of the terrain model[6]. For this task, it is important to establish a list of hypotheses under consideration:

(a) The vegetation is dense enough to be impenetrable to view. There are no filter effects to the visual calculation process.
(b) Only trees and shrubs can be modelled.
(c) The highest point of each tree or shrub is the same for a polygon in the digital cartography.
(d) The maximum volume of the vegetation is the same in the base and at the highest point.

To develop the model it is necessary to operate with ARC and INFO modules of ARC/INFO GIS (ARC/INFO is the name of GIS software used). There are three phases:

(a) Generation of polygon coverage from vegetation coverage. The value of each polygon is the mean height of the trees or shrubs.
(b) Construction of a new Digital Terrain Model (DTM) of the vegetation areas called Digital Vegetation Model (DVM).
(c) A new DEM coverage incorporating the vegetation DTM is obtained and called DEMv.

The general methodology for site selection: The location study of new rural buildings can be broken down into two processes with different aims[7]:

(a) A complete planning analysis based on G.I.S. to decide optimal locations of buildings according to the planning criteria of the area. The first phase is to study the territorial system making an initial selection of the possible sites. In the analysis and diagnostic sequences the study area can be characterized by its physical-natural, socio-economic, human establishment and institutional-legal subsystems[8].
(b) The evaluation of a building's spatial location by G.I.S. for its landscape integration. In this way we can evaluate the impact a construction will have on the landscape, and select the points where this impact will be least.

These two methodological procedures are successive. Optimal locations could be decided amongst those selected (according to planning criteria) with minimal visual impact. The aim of this paper is the modelling of vegetation effects as part of the general methodology.

Results and Discussion

The result of the vegetation modelling is visual coverage obtained from the scenic composition calculation process. A correlation can be made between scenic composition and landscape perception. Filtering scenic composition is the lowest value of rural landscape perception. It is possible to make filtering scenes by introducing vegetation screens (Figs 1 and 2). The perception of buildings, roads, sheds and other human interventions in rural landscapes is mitigated by the effects of vegetation. GIS are worthwhile tools to measure the scenic composition of rural areas[9].

Figure 3 shows visual coverage of the pilot study zone. The value of scenic composition depends on the vegetation effects in the visible and non-visible area. In this case, the landscape surrounding the building (arrow) has vegetation areas influencing the visibility of the different elements that make up the scene.

From the outline above, it can be concluded that whenever it is necessary to include vegetation elements or screens in order to improve the visual quality of the setting, various types of tree and shrub species can be used. They should be adapted to the area (and whenever possible be evergreen species), of different statures, heights and foliage density, and their dimensions should avoid any excessive symmetry or regularity that might otherwise produce a sense of artificiality or obvious human intervention.

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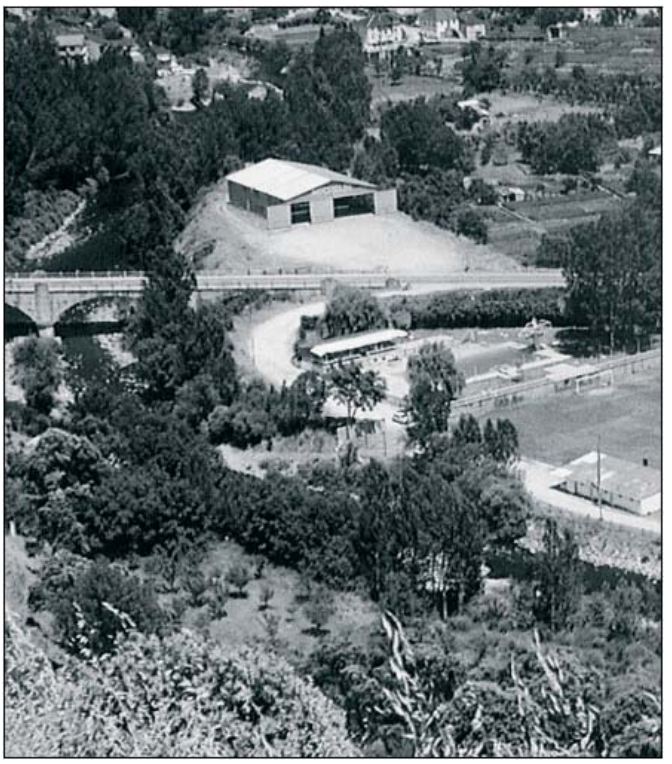

Figure 1. View of a storage shed, León, Spain.

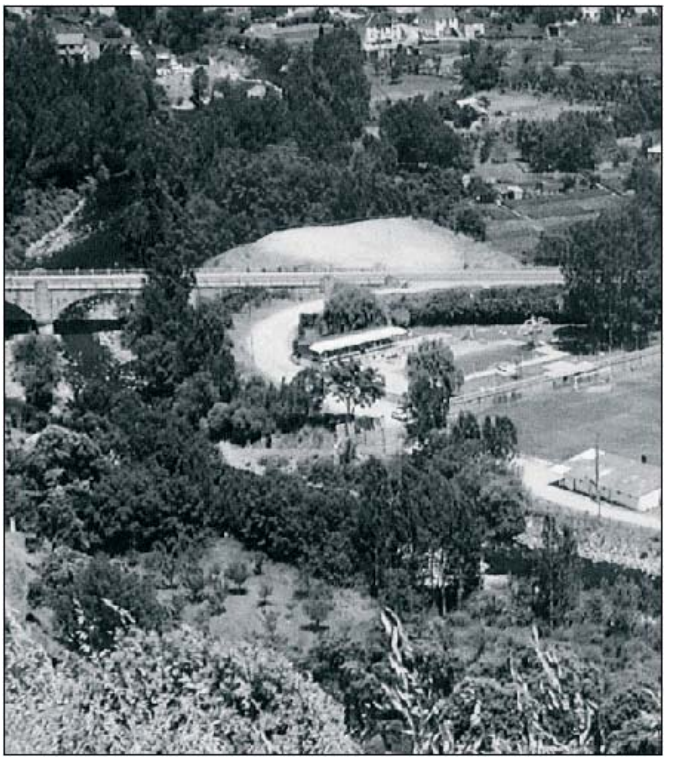

Figure 2. Photo-realistic simulation of a vegetation screen, León, Spain.

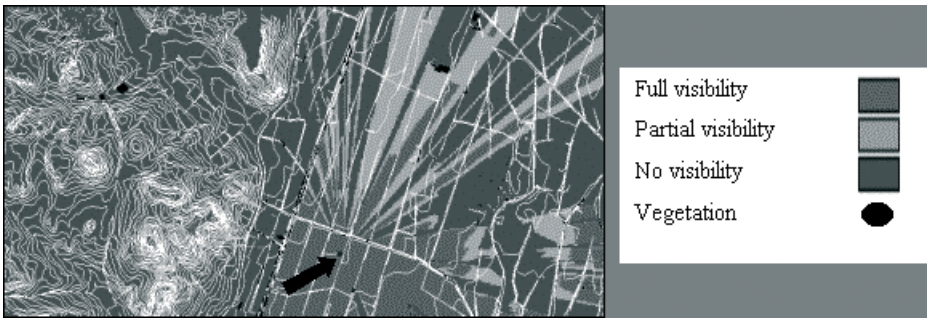

Figure 3. Scenic composition with vegetation screens calculated by G.I.S, Zamora, Spain.

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Conserving wild bees for crop pollination

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Abstract

A substantial proportion of the worlds crops rely on insect pollination, yet for many we have little or no information as to which pollinators are most effective. Pollinator management has traditionally focussed exclusively on one species, the honeybee, *Apis mellifera*. Yet this bee is not able to adequately pollinate some crops, and is an unreliable pollinator in cold and wet climates. Natural populations of wild bee species and other insects probably contribute greatly to pollination of many crops. Yet many of these insects have declined greatly in the last 50 years as a result of agricultural intensification. It seems certain that the yield of some crops is now limited by inadequate pollination, and that opportunities for diversification into novel crops may be reduced through a lack of suitable pollinators. Agri-environment schemes provide an opportunity to enhance pollinator populations in farmland, but at present little is known as to which schemes are most suitable. Large-scale field trials are needed to assess how best to encourage and sustain populations of wild pollinators on farmland.

***Key words**:* Bumblebee, floral resources, farmland biodiversity, crop yield.

Introduction

It is exceedingly hard to estimate the total value of bee pollination in crop production, but various estimates have been produced and all agree that the contribution made by bees is vast. Estimates for the USA vary from $1.6 billion to $40 billion per year[1,2]. Gill[3] estimated the value to be A$156 million for Australia, while Winston and Scott[4] put the value for Canada at C$1.2 billion. A comparable estimate for the EC suggests that insect pollination was worth 5 billion ECUs in 1989, of which 4.2 billion was ascribed to honeybees[5]. More than a third of all human food is thought to depend upon insect pollination[6]. Remarkably, we are ignorant of the pollination requirements of a great number of crops despite the fundamental and well-appreciated relationship between pollination and yield[7]. In Europe, a region better studied than most, about 250 plant species are grown as crops. Of these, about 150 are thought to be insect pollinated, but for most we do not know which insects pollinate them, or whether yields are being limited by inadequate pollination[7,8]. The current drive to diversify arable production is leading to the introduction of yet more crops, many of which require insect pollination, yet whether we have sufficient appropriate insects to pollinate them is unknown.The honeybee, *Apis mellifera*, is overwhelmingly the most widely managed pollinator of crops, and many farmers are entirely unaware that there are other insects that are capable of pollination. The economic value of pollination is often credited entirely to honeybees[9], and is frequently used to justify public subsidising of honey bee keeping. Even the scientific literature is frequently blinkered in this respect[10,11]. For example honeybees were promoted for pollination of alfalfa up until the 1980's even though Henslow noted in 1867 that honeybees were incapable of tripping the flowers. There is now growing appreciation that there are alternatives to the honeybee, and that in some situations the alternatives may be better[12]. In cold conditions, and when it is raining, honeybees will not forage[13]. In an unpredictable climate such as that of Northern and Western Europe this can be important, particularly when growing crops such as apples that flower early in the year when a spell of poor weather is likely. Honeybees are not able to adequately pollinate some crops, such as those with deep flowers (e.g. red clover) or those requiring buzz pollination (e.g. tomatoes and potatoes). Reliance on a single species for pollination of crops is an inherently risky strategy. This was made all too clear during the recent epidemic of the mite *Varroa destructor*, which all but exterminated the honeybee through vast parts of its range. Similarly, the invasion of the USA by Africanized honeybees has greatly reduced the availability of commercial hives for crop pollination[10].

In contrast, native pollinators are adapted to local conditions; for example bumblebees will forage in very cold conditions and even when it is raining[13]. Different wild pollinators suit different flowers, and between them they can pollinate a range of crops. For example short tongued bumblebee such as *Bombus terrestris* are important pollinators of oilseed rape, while species with medium or long tongues (*B. pascuorum* or *B. hortorum*) are needed to pollinate field beans and red clover[14]. Bumblebees and many other wild bee species are capable of buzz pollination.

Declines in Pollinator Populations

At a time when appreciation that wild insects can be important as crop pollinators is growing, these insects are declining in abundance. The available evidence suggests that many wild pollinators have declined dramatically in recent decades, both in the UK, in continental Europe and in North America[15-18]. These declines are almost certainly the result of intensification of farming practices during the latter half of the 20th century[15,19]. Notable changes include the loss of unimproved flower-rich grasslands (formerly valued as pasture and for hay production), loss of hedgerows, and the widespread use of insecticides and herbicides (the latter removing food sources for insects). Boyle and Philogène[20] counted only 5 bumblebees in a 3-year census of orchard pollinators in Ontario. Bumblebees are abundant in other parts of Ontario, but are thought to have been driven from the fruit-growing regions

by intensive use of pesticides. These crops now rely solely in pollination by honeybees. Similarly, native populations of bumblebees are rarely adequate to pollinate cranberries in North America[21,22]. Cranberry farmers are forced to rent honeybees colonies to effect pollination[1], but, as with tomatoes, honeybees do not favour cranberry flowers and from preference will forage elsewhere[22]. If field sizes are very large then there may simply not be enough wild bees to go around[23]. Farms with large field sizes necessarily have a low proportion of hedgerows or other field margins, and since these are the places that provide nest sites and floral resources for wild pollinators when crops are not flowering, then farms with large fields will have relatively few pollinators (regardless of the pesticide regime adopted). Yield of crops may be limited if there are insufficient bees to visit all of the flowers. For example in fields exceeding 12 ha in size the yield of field beans was reduced through inadequate pollination by long-tongued bumblebees[24]. Similarly, if field sizes exceeded 5 ha then yield of red clover in New Zealand declined through a shortage of bumblebees[25]. At present the area of land in the EC and USA under entomophilous crops is increasing, and some researchers have predicted that we will soon be facing a serious shortage of both wild and managed bees[5,26]. Ifpollination is inadequate then farmers may be tempted to switch to growing crops that do not require insect pollination[27]. For example red clover is now rarely grown for seed production in Europe because yields are poor, probably because of a lack of appropriate pollinators. The introduction of novel crops may also be limited by pollinator availability. A diversity of new crops have been introduced in Europe in recent years, as yet grown only on a small scale. Many are insect pollinated; for example lupins (*Lupinus* spp.), borage (*Borago officinalis*), camelina (*Camelina sativa*), cosmea (*Cosmea maritima*), cuphea (*Cuphea* spp.) and niger (*Guizotia abyssinica*)[7]. The potential of these crops may never be realized if yields are limited by a paucity of suitable insects needed to pollinate them.

Encouraging Native Pollinators

Government policies in Europe now place emphasis on combining the goals of agriculture and conservation[28,29], and subsidies are currently available to remove land from arable production. The primary aim of these schemes when they were first introduced was to reduce agricultural production, but there is growing emphasis on using land that is taken out of production to encourage farmland biodiversity. In the UK, farmers can now choose to adopt any of a range of schemes which aim to reduce yields and increase farmland wildlife. Similar schemes are in operation elsewhere. Options include new hedge-planting, repair of existing hedgerows, conservation headlands (field margins that are not treated with fertilizers or pesticides), beetlebanks (strips of tussock-forming grasses planted across fields), uncropped field margins (either allowed to regenerate naturally or sown with wildflower seed mixtures), and set-aside, whereby the land is left fallow for variable periods of time[30-32]. As yet little is known as to the relative value of these various forms of management for wildlife, and they are likely to differ between faunal or floral groups. However, there is no doubt that broadly the schemes do benefit wildlife. For example hedgerows and beetlebanks provide overwintering sites for beetles, and so boost the overall populations on farmland[29]. They also provide a home for small mammals and nesting sites for bird[33,34]. Conservation headlands have been shown to increase abundance of farmland butterflies and hoverflies[35,36]. All of these schemes increase the abundance and diversity of flowers that are available. For example studies of uncropped field margins (6 m wide field margins that are not sown with crops or treated with agrochemicals) have found that they support approximately six times as many flowering plant species, ten times as many flowers, and attract ten times as many foraging bumblebees as equivalent cropped field margins[37]. Any form of management that increases floral resources and reduces the area of crop is likely to benefit wild pollinators. Appropriate management of uncropped areas to encourage wild pollinators may prove to be a cost-effective means of maximising crop yield. Depending on the crops that they grow, farmers may wish to encourage particular species. For example if they grow field beans in the UK then they require healthy populations of the long-tongued bumblebees *B. pascuorum* and *B. hortorum*. To encourage them, the farmer might sow wildflower strips containing deep flowers such as white deadnettle (*Lamium album*) and red clover (*T. pratense*)[38]. Of course the crops themselves provide vast areas of forage, but only for short periods. However, planting a succession of crops that flowered at different times could greatly enhance pollinator abundance while simultaneously maximising yields. Management of farmland with the specific aim of enhancing wild pollinator populations is in its infancy, and at present is largely based on educated guesswork. Large scale experimental trials are urgently needed to establish which methods are most cost effective, and must take in to account the costs of lost crop area and establishment and management of bee resources, versus the financial benefits gained through improved yields. Enhancing populations of wild bees is likely to be most successful if it is carried out at a landscape scale, which would require cooperation and coordination at a regional level.

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Agriculture and the environment in free trade agreements

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Abstract

The inclusion of environmental issues in trade liberalization agreements has become a major issue since they were included in NAFTA and recognized by the Uruguay Round GATT agreement. However, the exact role and nature of these remains contentious with many WTO members opposed to an extensive role for environmental issues in multilateral trade agreements. Nonethe-less, the declaration that established the Doha Round recognizes a role, albeit a limited one, for the environment in negotiating the next trade liberalization agreement. The exact nature of environmental issues in the Doha Round will be the result of extensive negotiations and compromises.

Key words: Trade and environment, agricultural trade, trade liberalization, Doha round.

Introduction

The North American Free Trade Area (NAFTA) was the first trade agreement to explicitly and strongly encompass environmental issues. This came about, in part, due to a General Agreement on Trade and Tariffs (GATT) decision about U.S. regulations that prohibited the importation of tuna caught by methods that killed large numbers of dolphins. The loss energized environmentalists, led to widespread demonstrations, and threatened ongoing Uruguay Round negotiations. The final version of new agreement explicitly recognized the environment, with an objective to protect and preserve the environment in its preamble and with environmentally related provisions in other sections of the agreement. Environmental concerns then became important under the World Trade Organization (WTO) and have an important but controversial role in the Doha Round undertaken in 2001.

Concerns and Issues

There are a large number of both trade and multilateral environmental agreements (MEAs), which contain provisions affecting each other. Many analysts, especially economists, think that it is not appropriate to continue to address environmental issues in trade agreements,[1] while many environmentalists think that it is essential to address relevant environmental issues trade agreements[2]. The basic arguments for utilizing separate agreements are that free trade results in increased incomes, higher incomes increase the demand for improvements in the environment and will result in increased expenditures on the environment, environmental regulations in trade agreements become trade barriers which restrict trade and reduce incomes, and, thus, environmental issues should be left to domestic policies and multilateral environmental. The arguments for including environmental issues in trade agreements are that trade and environmental issues are interdependent, trade produces harmful effects on the environment, free trade procedures and agreements ignore or are biased against the environment, in disputes about environmental issues MEAs tend to lose and, thus, are not effective in protecting the environment, will attract polluting industries, and produce irreparable environmental damage. Thus, environmental protection must be incorporated into the trade agreements so that production will be kept sustainable. However, this now appears to be a moot issue, since it now seems inevitable that environmental issues will be addressed to some extent in future multilateral trade agreements due, in part, to increased concerns about these issues. The arguments are focused on the nature and extent to which the environment will be addressed.

An important issue affecting environmental issues in the WTO negotiations is the position and concerns of the less developed nations. They tend to view this as just another way the developed nations are imposing trade barriers to the goods produced by the world's low income countries which cannot afford to undertake the costly environmental programs being imposed on them as conditions to export products to the industrialized nations[3,4]. This was specifically stated by Argentina in a position paper to the CTE[5]. However, Article XX of GATT permits regulations to protect animal life, which includes endangered species.

The WTO and the Environment

Environmental issues had not been important in the several rounds of GATT negotiations that preceded the Uruguay. The Group on Environmental Measures and International Trade in 1971 to focus on issues of industrial pollution, but had not met[6]. It finally met in response to the threat the tuna decision posed for concluding the Uruguay round[7]. Meetings resulted in a Chairman's Report with conclusions that its activities remain within the GATT mandate, there is no necessary contradiction between upholding the principles of multilateral trade and environmental protection, trade rules should not present an unjustified obstacle to environmental policy making, and an open and secure trading system can facilitate environmental protection. Environmental issues became an established part of the multilateral trading system with the establishment of the WTO. According to a note prepared by the WTO Secretariat: "At the end of the Uruguay Round, Trade Ministers adopted the Decision on Trade and the Environment which anchored environment and sustainable development in WTO work" [6] (p. 67). With implementation of the WTO agreement, the Committee on Trade and Environment (CTE) was established and given a mandate over most aspects of the

trade and the environment. Nordström and Vaughan (pp. 2-7) concluded that trade barriers generally make poor environmental policy and that it is not necessary to harmonize all environmental standards. Additionally, they found that public accountability and good governance are essential to good environmental policy and that international cooperation is required to protect the environment

Agriculture and the Environment in the WTO

The multilateral trade discipline and produced the Uruguay Round Agricultural Agreement (URAA). The WTO incorporates environmental issues in a number of places, including the preamble to the Marakesh Agreement Establishing the WTO, GATT Article XX, Technical Barriers to Trade (TBT) Agreement, Agriculture Agreement, Intellectual Property (TRIPS) Agreement, and Services: General Exceptions of GATS Article XIV (WTO 2002). These tend to indicate that domestic laws on the environment or to protect human, animal and plant life and health can be exceptions to prohibitions to trade barriers. The agricultural agreement contains provisions with environmental implications, although these are not its primary purpose. It deals, rather, with border measures, export subsidies, market access, domestic support measures, and product attributes such as sanitary/ phytosanitary provisions[8]. Many analysts argue that the provisions of the URAA were designed to have minimal current effects on agriculture[9]. Its importance is in bringing agriculture into the agreements with the prospect that agricultural trade would be further liberalized in the following round of WTO negotiations. The URAA has important implications for the environment in provisions dealing with domestic subsidies and product characteristics. The agreement limited and required reductions in agricultural subsidies that were deemed to be trade distorting. Payments for conservation, environment, infrastructure, and domestic food aid are classified non- or minimally trade distorting. Several governments, including the U.S. and EU, adjusted their agricultural policies to take advantage of such payments to their farmers. In the U.S., for example, the 1996 Federal Agricultural Improvement and Reform (FAIR) Act largely decoupled farm subsidies from current production, although the loan deficiency payments portion of the subsidies are tied to production, although the loan deficiency payments under FAIR and the 2002 farm legislation are not eligible since they are not accompanied by production control measures and, thus, are reported under the amber box. The impacts of the act are yet to be determined, but are viewed negatively by other countries[10]. The sanitary-phytosanitary measures and other provisions dealing with product characteristics recognize the legitimacy of domestic laws and regulations to protect human, animal and plant life and health, provided that such regulations are based on science and, thus, are not imposed as trade barriers to protect domestic industries. Such regulations must apply equally to both domestically produced and imported products.

Environmental Issues in the Doha Round Negotiations

The Ministerial Declaration from the Doha meetings mandates environmental negotiations in the round announced in November 2001[11,12]. The Committee on Trade and the Environment (CTE), as part of the Trade Negotiation Committee (TNC), has responsibility for these negotiations as outlined in paragraph 31:

31. With a view to enhancing the mutual supportiveness of trade and environment, we agree to negotiations, without prejudging their outcome on:

(i) the relationship between existing WTO rules and specific trade obligations set out in multinational environmental agreements (MEAs). The limitations shall be limited in scope to the applicability of such existing WTO rules as among parties to the MEA in question. The negotiations shall not prejudice the WTO rights of any member that is not a party to the MEA in question;

(ii) procedures for regular information exchange between MEA Secretariats and the relevant WTO committees, and the criteria for granting observer status;

(iii) the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services.

Thus, the charge to the CTE is specific and fairly strictly circumscribed, but the negotiating process is contentious, at least as discussed in the CTE meeting March 21-21, 2002. The European Union (EU) is the primary group contending that environmental issues should be included in Doha negotiations[13].

The CTE is also to consider information exchanges with the MEAs and observer status for nonmembers and this has resulted in a number disputes[3]. Issues include which of the MEAs to include and the role of the CTE in determining observer status. There appears to be some reluctance to permit the MEAs to participate in the special negotiating sessions. Finally, the CTE is to determine what is to be included in environmental goods with some members, e.g., the EU, wishing to include those produced in environmentally friendly ways or that are environmentally sound (recyclable). Other members are not supportive of including this approach, which they believe to relate to production processes. This, along with the other issues, will be the subject of future meetings of the CTE.

Conclusions and Implications

Environmental and trade issues are interrelated with important implications and effects within the global economy. The tuna-dolphin case and the protests at Seattle delayed the start of the next round of WTO trade negotiations and resulted in environmental issues being recognized and integrated into the negotiation process, although to a relatively limited extent. These negotiations are contentious due to the very different views of the EU, U.S. and developing countries with respect to the role to the environment in the international arena. However, while environmental protection is not apt to receive the support that most environmentalists would like to see in the WTO, it will continue to be an important part of the process with the WTO involved in more coordination with international environmental agreements, which will continue to be the more important venue for handling and resolving environmental issues.

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Editor: R. Dris and S.M. Jain; Publisher: WFL Publisher
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11-Somatic Embryogenesis in Woody Plants-Gymnosperms, Vol 3, 1995. S.M. Jain, P.K. Gupta and R.J. Newton (eds.). Kluwer Academic Publishers, Dordrecht, The Netherlands. 392 pp.
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2002

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-The III Valencian Congress on Organic Farming : For further details email to: vituria20@teleline.es

2003

-AFA 9th International Annual Conference : For further details email to: info@afa.com.eg
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-2nd Workshop on Food, GI-Tract Functionality and Human Health Cluster PROEUHEALTH: For further details email to: paula.bergqvist@vtt.fi
-International Conference on Animal Nutrition (ICAN) : For further details email to: miramlah@mardi.my.
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-5th International Conference on Artichockes :For further details email to: JSanz@itga.com
-7th International HCH and Pesticides Forum Towards the Establishment of an Obsolete Pesticides POPs/Stockpile Fund for Central and Eastern European Countries (CEEC) and New Independent States (NIS) , For further details email to:john.vijgen@get2net.dk
-1st International Conference for "Turfgrass Management and Science for Sport Fields". For further details email to: pan@aua.gr or select@internet.gr
-7th International Conference on Productivity, Public Goods and Public Policy: Agricultural Biotechnology Potentials: For further details email to: icabr@economia.uniroma2.it
-1st FEMS Congress of European Microbiologists: For further details email to: peter.raspor@bf.uni-lj.si
-International ISHS Symposium on Managing Greenhouse Crops in Saline Environment :For further details email to: ISHS.Pisa2003@agr.unipi.it
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-21st IIR International Congress of Refrigiration. For further details email to: MMenzer@ari.org or gcgroff@worldnet.att.net
- 4th International Symposium on Irrigation of Horticultural Crops: For more details email at:taheta@ucdavis.edu
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-The International Society for Food, Agriculture and Environment (ISFAE): Meetings: to be announced on the print and online journals,please visit time to time the web site www.isfae.org , ISFAE -Executive Secretariat, Meri-Rastilantie 3 C, FIN-00980 Helsinki, Finland. For more details please visit our web site:www.isfae.org , e-mail:Isfae@isfae.org
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2004

International meeting (including exhibition) : Silicon in Food, Agriculture and Environment
Period: July-August 2004
Scope and aims: Si is a second widespread element on the Earth. In present, industry widely uses different Si compounds. Active forms of Si can be used in agriculture for increasing crop productivity and quality, in veterinary, environment protection, and medicine. This is conditioned by high biological activity of Si and its compounds and the ability to increase stress resistance of living organisms. The removal of Si together with harvested crop results in formation of Si deficiency in the soil. As a result, the lack in Si plant nutrition and soil degradation processes are intensified. The degradation of soil cover increases the risk for chemical pollution of ecosystems and reduces plant resistance to biogenic and abiogenic stresses. Numerous types of industry have a lot of Si-rich by-products. Using these by-products as sources of active Si has high potential benefits for both industry and agriculture. These materials also can be used for environment protection against pollution and for rehabilitation, purification, and restoration of degraded and polluted lands. The desertification and salinity problems are foreground tasks in the world today. Using active Si can help in resolving these problems. The main objective of the conference is reviewing and coordinating fundamental and practical investigations of role and function of Si in sustainable development of environment and economy. For more details please take contact with Prof. Matichenkov, Vladimir, email: VVMatichenkov@mail.ifas.ufl.edu or Isfae@isfae.org

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