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KONINKLIJKE ACADEMIE
VOOR OVERZEESE WETENSCHAPPEN
ACADEMIE ROYALE
DES SCIENCES D'OUTRE-MER

DESERTIFICATION: MIGRATION, HEALTH, REMEDIATION AND LOCAL GOVERNANCE

Guest Editors: André OZER & Danielle SWINNE

Published with the financial support of

Belgian Science Policy

Belgian Development Cooperation .be

FWO VLAANDEREN
Fonds voor Wetenschappelijk Onderzoek

FNRS
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International Conference

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ISBN 978-90-756-5245-1
D/2008/0149/1

CONTENTS

Posters

FOREWORD

In 1996 the United Nations Convention to Combat Desertification (UNCCD) was set up. After ten years' efforts against this scourge of both climatic and anthropic origin, it was important for Belgium to express itself and to present some of its achievements in that field.

Within this scope, the Royal Academy for Overseas Sciences decided to organize a special conference dedicated to such a major issue. This exceptional meeting was supported by the Foreign Affairs, the Scientific Policy and United Nations and, above all, patronized by His Royal Highness, Prince Laurent, who is very much alive to this natural risk, particularly through his support to the "green belt" operation around Nouakchott in Mauritania.

The presentations of Belgian researchers, of experts from international organizations and especially of scientists and decision-makers from South countries affected by desertification have resulted in starting a very constructive dialogue.

Moreover, the presence of many posters showing the work results of young researchers has allowed everyone to exchange views.

Approximately a hundred and fifty people attended the meeting. Therefore, so as not to lose the content of the papers presented, the Royal Academy for Overseas Sciences has decided to publish in its proceedings collection a special volume including most of oral presentations and a few posters' abstracts.

Here are the main topics dealt with:

— Migration and health: environmental changes as a migration factor; dust particles from the Sahara as a source of air pollution and deterioration of human health; water scarcity as a major brake on development; the role of *Médecins Sans Frontières* in the Sahel region.
— Remediation and local governance: quantification of vegetation decline by using physiological tools; promotion of sustainable development in arid lands; understanding of silting-up processes.

Finally, the Royal Academy for Overseas Sciences would like to convey its grateful thanks to all the organizations which financially supported this conference, *i.e.* the FNRS (*Fonds National de la Recherche Scientifique*), FWO-*Vlaanderen* (*Fonds voor Wetenschappelijk Onderzoek*), the Belgian Development Cooperation and of course the Belgian Federal Science Policy Office.

Prof. Dr André OZER
Director Section of Natural and
Medical Sciences
Royal Academy for Overseas Sciences

Opening Session

International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 11-13.

Welcome Address

by

Jean MARCHAL*

Votre Altesse Royale le Prince Laurent,
Votre Excellence M. Armand De Decker, Ministre de la Coopération au Développement,
Mme Brigitte Decadt, représentante du Président fédéral du Conseil de la Politique scientifique,
M. Afsane Bassir-Pour, Directeur du Centre d'Information régional des Nations Unies,
Mesdames et Messieurs les autorités en vos titres et qualités,
Messieurs les Orateurs, Chers Collègues, Mesdames, Messieurs,

Le terme «désertification» est souvent associé dans les esprits à l'avancée du désert dont les dunes de sable envahissent lentement et inexorablement les régions fertiles proches. Cette vision populaire de la désertification a perdu tout fondement dans la plupart des milieux scientifiques: les déserts africains ne poursuivent pas leur inlassable marche vers le Sud, détruisant tout sur leur passage.

On définit aujourd'hui la désertification comme un phénomène surtout socioéconomique où les ressources naturelles se dégradent par les pressions démographiques et des pratiques d'occupation du sol présentant un caractère non durable. Les processus de formation de nouvelles régions désertiques où la diversité se trouve détruite sont fortement corrélés à la dégradation des sols, c'est-à-dire à l'appauvrissement progressif de leurs potentiels physiques, biologiques et économiques. Cette dégradation des sols menace sérieusement la productivité globale et, par conséquent, la subsistance de la population. Elle réduit la diversité de la vie végétale et animale, comme elle

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force les populations à se déplacer et à changer leur mode de vie, ce qui a aussi des conséquences sur la diversité de culture, de langue et de savoir, des communautés habitant la zone dégradée.

C'est vers 1968 que la crise écologique majeure, qui touchait le Sahel et commençait à susciter un émoi considérable à travers le monde, déclencha chez nombre d'experts et autres scientifiques une grande curiosité et donna lieu à une multiplicité de programmes de recherches pour lesquels des milliards de dollars furent dépensés pour arriver le plus souvent à des solutions aussi farfelues que la mise en place de «barrages verts».

En quelques années, on vit la prolifération d'organismes internationaux de surveillance, qui ont davantage surveillé qu'agi, et de bureaux d'études, qui ont dépensé beaucoup d'argent à étudier surtout des propositions irréalistes.

Depuis 1996, on a beaucoup débattu des «indicateurs de désertification», des «savoirs traditionnels» ou encore des «méthodes d'alerte précoce» des grandes sécheresses... et pour beaucoup débattre, les bailleurs de fonds ont été beaucoup sollicités et la désertification n'a pas cessé de progresser et elle s'aggravera encore dans les années à venir: la croissance démographique, même ralentie, se poursuivra au moins jusqu'en 2030; les prévisions sur les conséquences du réchauffement climatique indiquent que des sécheresses plus longues et plus fréquentes surviendront surtout autour des déserts tropicaux et de la Méditerranée.

Desertification is a process whereby land is made unproductive due to several factors such as human activities.

The Global Mechanism (GM) of the United Nations Convention to Combat Desertification was established as an instrument to facilitate the rationalisation of resource allocation and the mobilisation of additional resources to combat land degradation and poverty.

Having used a patch of land for years, one cannot reap as much as one used to from the same patch of land because the soil has lost its fertility.

The goal of a forestry policy must be to sustain the contribution of forest resources to improve the quality of life by keeping resources for the benefit of socioeconomic development.

Another thing that contributes to deforestation is poverty. This is why it is necessary to encourage people to venture into small-scale business.

Apart from human activities such as overgrazing, farming and poor irrigation, deserts are also caused by climatic factors such as prolonged drought. So, there is a need to regenerate trees.

Several research projects and networks of excellence are being carried out in several areas:

— *Research into natural environment, environmental quality and global change* to understand the basic mechanisms of climate and natural systems and their impact on natural resources;
— *Environmental technologies*, in order to develop environmental monitoring and protection technologies, the restoration of deteriorated sectors of the environment, and the management of natural hazards;
— *Space technology applied to Earth observation and environmental research,* in order to determine the planet's state of health from satellite data, requiring the development of specific space instruments;
— *Human dimensions of environmental change*, which include research on the social and economic causes and impacts of environmental change.

Several aspects will be presented and discussed during this one-day international conference.

Many thanks to His Royal Highness Prince Laurent for his presence during this opening ceremony: it confirms his continuous interest in and support to all organizations and activities that contribute to a sustainable socio-economic development. We appreciate the participation of His Excellency Mr Armand De Decker, Minister for Development Cooperation, who again shows his support to the activities of our Academy for he also participated in our International Conference in Phnom Penh last February. Thanks also to the Federal Council for Science Policy for confirming its interest in our scientific activities.

This International Conference is organized on the initiative of our colleague Professor André Ozer and the "Environment and Development" Commission, chaired by our colleague Professor Morgan De Dapper.

My warmest thanks to the United Nations for chairing this conference with us, to the staff of our Academy for the preparation of this event and to all the sponsors for supporting this Conference.

International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 15-16.

Opening Speech

by

H. R. H. PRINCE LAURENT OF BELGIUM*

Monsieur le Ministre, Monsieur le Directeur, Madame la Secrétaire perpétuelle,
Chers Académiciens, Mesdames et Messieurs,

The Royal Academy for Overseas Sciences has kindly invited me to say a few words by way of opening this Conference on Desertification and Migration, and I am very honoured by this invitation.

I dare hope my presence here is not one of pure formality and protocol. Indeed, as some of you have already noticed, the question of desertification and its corollary — land rehabilitation — has received my full attention for many years.

Since 1999, my Institute and myself have been taking an active part in cooperating with Mauritania in the sustainable rehabilitation of the essential greenbelt of Nouakchott, the capital.

The challenge there is quite severe because the existence of Nouakchott itself is threatened by sand movement and dune displacement. With the financial assistance of the Walloon Region of Belgium a series of concrete actions have been undertaken to establish nurseries and fix the sand dunes through the planting of adapted tree species.

The Nouakchott Greenbelt project has taught us a lot of things from the forestry point of view. But, more importantly, it has shown how critical the local participation in making such an activity sustainable in the long run is.

Hence my main message to you: the survival of many people and their well-being is directly threatened by land degradation and desertification; science and technology can help alleviate those problems. Yet, in your

* President IRGT/KINT, Brussels (Belgium).

deliberations of today, do not forget that a sustainable future is best guaranteed by those who have a direct stake in it, by those who — with our help — are the direct actors of their future.

I would therefore like to dedicate this day of scientific discussions to the farmers and the herders of Africa and other regions of the Earth where living conditions are getting harder and harder because of the continuing degradation of their natural resources such as water, soils and vegetation. We must do our best to help alleviate their hardship, and I do hope that this conference will be an additional step in that direction.

International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 17-23.

Introduction

by

Armand DE DECKER*

Your Royal Highness,

The desert is first of all a land of memories. Memory of water, of course, and of swallowed-up rivers, that of tracks towards uncertain courses that follow on the surface. A land of memories of rocky dunes and bushes, of shadows of roads that once crossed lands of abundance. Memories also of ancient traditions that talk, no doubt, about the weight of solitude and sometimes curses, that often sing the joy of herds, the legend of warriors, the beauty of rocks and the reflection of the Moon.

Your presence among us today, Royal Highness, honours us and gives evidence of your constant interest in everything connected with environment, and particularly its human dimension.

It encourages us to pursue, without respite, the Belgian action with international organizations and our partner states in order to maintain a beneficial environment towards mankind, and particularly in order to convince every single person of the crucial importance of respect for the environment for the survival of our planet and of humanity.

In the desert, it is said, one feels the passing of time. The challenges linked to desertification in the field of public health, agriculture, the capacity of man to adapt himself to new conditions, show, on the contrary, that time is not passing without landmarks and that it is urgent to act.

* Minister for Development Cooperation, Brussels (Belgium).

Your Royal Highness,
Excellencies,
Mister President of the Royal Academy for Overseas Sciences,
Madam the Permanent Secretary,
Ladies and Gentlemen Members of the Academy,
Madam the representative of the Presidency of the Federal Council of the Scientific Policy,
Ladies and Gentlemen,

Allow me first to thank the Royal Academy for Overseas Sciences and the United Nations wholeheartedly for the organization of this important international conference in Brussels. I am very pleased to see many eminent specialists in this auditorium, in particular from Africa, as desertification is especially threatening this continent, without sparing the others.

The influence of climate on life, the lack of water and natural resources, the regional rivalries caused by those deficits, the vulnerability of populations confronted with nature and the political antagonism induced by climate, the migrations that they bring about ... lots of problems the world faces today will be dealt with in the following speeches.

When reading the programme of our conference, it is not exaggerated to say that the problems of desertification sum up almost all the problems of underdevelopment. One only has to enumerate the eight Millennium Development Goals to realize that the fight against desertification is in fact a fight to reduce extreme poverty and hunger, to allow children — be they nomads or not — to have access to education, to promote gender equality and women empowerment, to reduce child mortality, to improve public health, to fight against the spread of pandemics, to provide a sustainable environment and to allow, eventually, the establishment and the fulfilment of a true world partnership for development between the North and the South.

Yet, when one makes the effort to read out loud each of the eight Millennium Development Goals, when one goes even further and tries to find in their definition the number of evils they try to correct, the theme of our conference — the fight against desertification — is absent, as if climatic changes, deforestation and the almost unstoppable progress of deserts were not — with other evils also, and for millions of people in the world — at the very origin of the miseries of our time.

Our conference is probably not the place where one should raise those philosophical and epistemological issues, but it seems to me that we are entitled to question these double hiatus. The one of the denunciation of an evil, and the more crucial one of the enunciation of the strategy to defeat it.

These gaps are maybe there to remind us of what we have known since the dawn of time, the truth we find in the Prophets when Ezekiel describes a ravaged desert where no human or animal feet ever pass, or in the text of Ibn Khadum describing those ascetic lands of hardship, those hills of basic survival.

Experts today will explain the cause of desert progress through time and history. Climatic changes are certainly responsible, but through them, of course, as for each of the climatic changes, our global human behaviour. The destruction of the ozone layer or, better, its non-reconstruction or late reconstruction, the consequent greenhouse effect do make deserts progress in Africa as in America, Asia and Europe. Deforestation, itself favoured by the negative evolution of the environment, is another cause, and with it, the soil erosion, the drying-up of the water reserves. Man here claims that nature is a fatality in order to admit his own failures, because it is man, lost in a frenzy of abusive and mercantile exploitation of forests, or driven by the necessity to find energy, and driven by poverty and ignorance, who destroys the forests, who overexploits the fields, who builds without thinking of the long-term consequences of his actions for the environment, the environment where he lives and where, more importantly, the future generations will be forced to survive. Unfortunately, deforestation and disrespectful exploitation of soils that dry up the planet and create deserts are not the only evils. It would indeed be satisfying for the soul, despite the calamities, to persuade oneself that it is the tornadoes and hurricanes, the devastating rains and floods, the earthquakes and tsunamis that shake up the planet in such a way that more than two billion people are affected by extreme dryness and desertification. We are, however, also guilty of our acts. Not the ones I have just denounced — greed, necessity and ignorance — but those, even worse, of violence that never stops, of civil wars that do not say their name, of those regional conflicts that continue without allowing the international community to end them and that — without using those terrible words of genocide and ethnic cleansing — are of such violence and cruelty that they force entire populations to leave their territories, to abandon their fields, to slaughter their livestock, to flea, leaving behind them no land to labour, but fallow fields of death and desolation. What is dramatic, of course, is that the wind and the sun — when they cover the land with sand and dry up the waters — also destroy even the memory of the presence and of the labour of man. The deserts gain ground either because of the foolishness of man or because of the simple power of nature; the consequences are the same: the destruction of human traditions and cultures, the fact that it draws entire families on the road of exile that very seldom leads to new pastures, but far too often to

those megalopoles of the South, whose survivors gather in the misery of slums, or even look further in desperate attempts to join Europe or North America, to find a new reason to live, or at least to hope.

Your Royal Highness,
Ladies and Gentlemen,

The question of desertification is thus less a scientific matter — where geography and anthropology would meet — than a world political problem, as important for the countries of the North as for the countries of the South. It is a political problem that means a challenge to us all, not only in its security dimension — the upholding of peace in the world — but also in its aspects linked to the fight against poverty, the fight for the development of a fair globalised world.

I would like to put the emphasis in my speech on four aspects that seem essential to me to combat the consequences of desertification. I do not pretend to have a magic recipe to win that battle, but it seems to me that we must, that we can act in the field of peace and security, regarding the migrations caused by desertification, that we can also act at the multilateral level, that we must, finally, change the methods of agriculture and forestry in order for us all together, in the North and in the South, to join our efforts to draw up techniques, delaying the progress of sands.

Peace and security first. Peace and security are nowadays at the centre of North-South preoccupations. One could even say that world peace is now determined in the South.

I could mention the Middle East, Iraq, the Great Lakes in Central Africa or Sudan; the evolution in each of these countries or each of these regions is at the centre of talks at the Security Council of the United Nations, at the meetings of the European Council, of the transatlantic dialogue. Peace and security are naturally also the key issue for the social and economic development of the world. Even if the Millennium Development Goals do not retain them as such, the outcome declaration of the Millennium + 5 Summit, which took place at the United Nations one year ago, establishes an essential link between security, peace and development. Without peace and security, development is impossible, and that fundamental principle is reinforced by another concept, as crucial for development, namely the one that falls on each State and which is first and foremost the responsibility to protect its own citizens. To protect them against external threats perhaps, but mainly against internal abuse, exploitation, injustice and violence. This concept is the most binding

as, in the absence of national protection, this responsibility falls on the international community acting on behalf of peace and security. We do not move away from the theme of our conference, by mentioning peace and security, this obligation to protect, as Darfur is under threat, as its populations are submitted to an unacceptable ethnic cleansing, as violence and injustice draw entire populations to exile and transform Darfur into a desert of stones and sand. I am pleased that all the twenty-five member states of the European Union have joined their efforts with the United Nations to put some pressure on the Sudanese government, on the governments that support it, on the other protagonists, in order for them to assume their responsibility to protect or, if not, to accept the continuation and amplification of the mandate of the African Union forces on the ground or, even better, the deployment of a United Nations peacekeeping force. To re-establish the security in Darfur, to bring back civil peace in Sudan, is to recreate the conditions for its development, to guarantee oneself of the non-desertification of huge territories.

The second challenge that one must tackle to counter desertification is very near to my heart. That is the question of migration, the new and positive dialectic one should engage between migration and development. As soon as I was appointed Minister for Development Cooperation I put the emphasis on two concerns that seemed important to take into account in Belgian and European policies as well as from an international point of view. First, the fact, so far too much ignored, that migrations and development policies are indissociable and secondly, the fact that it was necessary to include migration in a national and international dimension, in a pragmatic and reasonable development policy.

Belgium was indeed the first country to organize, last January, the pan-European conference "Migration and Development", and in March 2006, an international conference on the same theme, in the presence of his Majesty the King. Those two events were to become the cornerstones of other international meetings, the Conference of Rabat in July, and the High Level Dialogue of the United Nations General Assembly held last week. The avant-garde role played by Belgium was recognized as it is Belgium that will organize, in 2007, the first international follow-up forum on Migration and Development. Besides those international meetings, I took the initiative of concrete actions on the ground. I would like to mention the "Migration for the Development of Morocco" programme, a programme related to the implication of migrants in development projects in their country of origin, the study of a system aiming at allowing remittances to contribute to development projects, the assistance to migrants from Mali, who stayed in

Morocco on their way to Europe, to return to their country with dignity and work prospects, institutional assistance at last, to the DRC and to Morocco in order to smoothen the rapprochement of origin and transit countries.

The fight against desertification also requires a multilateral framework.

Since the great drought that affect the Sahel in the seventies, the international community has become aware of the need to act together to fight against this phenomenon and to curb the progress of deserts. The historical moments of these international mobilizations are known. In 1977, the United Nations Conference on Desertification in Nairobi, during which the first action plan was adopted; in 1992, the Conference on Environment and Sustainable Development in Rio de Janeiro; the Convention on Global Warming the same year; and in 1994, the adoption of the United Nations Convention to Combat Desertification (UNCCD).

Since then, there was the Kyoto protocol on the reduction of gas emission in 1999; and in 2002, the World Summit on sustainable development in Johannesburg. The UNCCD remains the principal instrument to the drafting of which Belgium actively contributed. We know indeed that the UNCCD is not perfect, or rather, that it is not ratified by enough countries and that it is not enough funded to allow the few 110 countries affected by desertification implement all the programmes leading to a real decrease of the threat.

I do hope that the European Union, in particular the Commission, will be willing to devote an important part of the increased financial resources for cooperation development to the funding of projects linked to the fight against desertification and deforestation.

This leads me to the last aspect of what we can do together, in the North as well as in the South.

Besides huge projects of irrigation and reforestation, it seems to me that simple acts should be encouraged in the communities threatened by desertification. First probably, the regeneration and fertilization of soils, especially the generalization of compost use. Secondly, fighting the wind consequences, through the construction of barriers and by stabilizing the dunes with indigenous plants.

One must also replant forests, which implies a forest management respectful of the environment and of commercial requirements. I had the opportunity in Kenya to visit a tree plantation intended for providing communities with logs for heating. The aim also was to prevent the last natural forests from being definitely cut down to make charcoal, which would lead to an irremediable destruction of soils. Our reforestation policy and forest certification in the DRC aim at the same objectives. To prevent desertification, one must fix the soils through new plantations. Trees cut the wind, fertilize the soils, allow

a better water absorption during heavy rains, contribute to the reduction of the negative effects of climate changes.

We must also insist on the preservation of agricultural biodiversity. This implies the rejection of monocultures, the renouncement of overexploitation and industrial farming. This does not mean a return to ancestral practices or to nomadism, but a good management of the agricultural and pastoral heritage.

Your Royal Highness,
Ladies and Gentlemen,

With our partner countries, we must redefine certain intervention sectors, or redeploy a part of our assistance towards those regions of the South where desertification is a major threat, where despair and misery are the greatest.

Everyone must contribute to this positive approach: the countries in the North by listening better, by a larger opening to new ideas, by greater coherence and more means; the governments in the South through good governance, excellent management, the fight against corruption and by allowing a greater ownership of development programmes by local authorities and populations; the Diasporas in the North who must, with our increased assistance, be more involved in the modernization and sustainable development of the economic and social life of their countries of origin; and, at last, civil societies in the North and the South, with their NGOs, universities, scientific institutions and their citizens, must concentrate their actions more on the regions of the world that need them most.

The desert is not a fatality but a learning process. It teaches us not only the hardship of the world, but its beauty, its intensity, its silence, the breeze of the wind, the stars on territories as beautiful and mysterious as the open sea. What makes a desert beautiful, Saint-Exupéry wrote, is that it must hide water somewhere.

It seems to me that we are all united for the development of the South, to prevent sands from drying up our hearts and blinding our common sight, all united searching for a same water to slake a same thirst of peace, justice and solidarity.

International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 25-31.

Coupled Human-Environment System Approaches to Desertification

by

Eric LAMBIN*, Helmut GEIST**,
James REYNOLDS*** & Mark STAFFORD-SMITH****

KEYWORDS. — Desertification; Human Dimension; Human-Environment System; Land Use; Vulnerability.

SUMMARY. — Whilst desertification has clear biophysical components, the interpretation of change as 'loss' or 'degradation' is dependent upon the integration of biophysical components within the context of the socioeconomic activities of human beings. We first provide the rationale for approaching desertification by integrating biophysical and socioeconomic data, and we then discuss methodologies to achieve that integration, by linking remote sensing data with household survey data. A worldwide review of the causes of desertification has shown that desertification is driven by a limited suite of recurrent core variables, with identifiable regional patterns of causal factor synergies. The Dahlem Desertification Paradigm (DDP) attempts to capture the multitude of interrelationships within human-environment systems that cause desertification within a single, synthetic framework. The establishment of long-term and rigorous monitoring programmes is an effective way to assess the status of natural resources and the evolution of desertification processes. Monitoring the coupled human-environment system as a whole requires methods to link biophysical data to socioeconomic data on land managers. Recent studies have demonstrated the complementarity of remote sensing and socioeconomic survey data for understanding causes, processes and impacts of land-use / land-cover changes.

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1. Introduction

The definition of desertification used by the Convention to Combat Desertification (CCD) makes it clear that, whilst biophysical components of ecosystems and their properties are involved (*e.g.*, soil erosion, loss of vegetation), the interpretation of change as 'loss' is dependent upon the integration of these components within the context of the socioeconomic activities of human beings. The CCD's definition of desertification explicitly focuses on the linkages between humans and their environments that affect human welfare in arid and semi-arid regions.

Unfortunately, the CCD definition of desertification is not amenable to easy quantification, especially as a single number or synthetic index. Most estimates of desertification are derived solely from either biophysical factors (*e.g.*, soil erosion, loss of plant cover, change in albedo) or socioeconomic factors (decreased production, economic loss, population movements, etc.), but rarely both types simultaneously.

This paper is divided into two parts: a first part provides the rationale for approaching desertification by integrating biophysical and socioeconomic data, and a second part discusses methodologies to achieve that integration, by linking remote sensing data with household survey data.

2. Causes of Desertification

Land degradation in drylands is still poorly documented and its causes are hardly understood (LAMBIN *et al.* 2005). On the one hand, proponents of single-factor causation suggest various primary causes, such as irrational or unwise land mismanagement by nomadic pastoralists and growing populations in fragile semi-arid ecosystems. On the other hand, desertification has been attributed to multiple causative factors that are specific to each locality, revealing no distinct pattern. There has also been a great deal of debate on whether the causes of desertification lie in the socioeconomic or biophysical spheres (human-induced land degradation *vs.* climate-driven desiccation).

GEIST & LAMBIN (2004) carried out a worldwide review of the causes of desertification based on a hundred and thirty-two carefully selected case studies. Their aim was to generate a general understanding of the proximate causes and underlying driving forces of desertification, including cross-scalar interactions of causes and feedbacks, while preserving the descriptive richness of these case studies. Results showed that desertification is driven

by a limited suite of recurrent core variables, with identifiable regional patterns of causal factor synergies.

At the proximate level, desertification is best explained by the combination of multiple social and biophysical factors, rather than by single variables. Dominating the broad clusters of proximate factors is the combination of agricultural activities, increased aridity, extension of infrastructure, and wood extraction (or related extractional activities), with clear regional variations. In particular, agricultural activities and increased aridity are associated.

At the underlying level, desertification is also best explained by regionally distinct combinations of multiple, coupled social and biophysical factors, and drivers acting synergistically rather than by single-factor causation. A recurrent and robust broad factor combination implies the interplay of climatic factors leading to reduced rainfall, agricultural growth policies, newly introduced land-use technologies, and malfunct land-tenure arrangements which are no longer suited to contemporary drylands ecosystem management.

It is mostly the interactions between multiple causal factors that lead to desertification. A frequent pattern of causal interactions stems from the necessity for water-related infrastructures that are associated with the expansion of irrigated croplands and pastures. Typically, newly-introduced irrigation infrastructures induce accelerated in-migration of farm workers into drylands, and often stir more commercial-industrial developments as well as the growth of human settlements and related service economies. Irrigation infrastructure is often nested in a system of larger infrastructure extension related to regional economic growth. Commonly, road extension paves the way for the subsequent extension of irrigation, and (semi-)urban land uses. In the developing world, underlying these proximate factors are national policies aimed at consolidating territorial control over remote, marginal areas, and attaining self-sufficiency in food and clothing, with rice and cotton being the key irrigated crops.

3. Consequences of Desertification

Desertification is only a problem if it threatens the short- or long-term welfare of users of affected ecosystems. Actually, the definition of what is a significant change in environmental conditions depends on the use to which the environment is put (LYNAM & STAFFORD-SMITH 2003). Since natural resources are only one of many elements that make up livelihoods, which exist in very complex environmental, social and political environs, the impacts of desertification can only be evaluated in their social context

(WARREN *et al.* 2001). Empirical measures of land degradation must therefore be linked to socioeconomic variables that represent how people collect information to evaluate threats to their natural resources, human behaviour and motivation with respect to resource management, and the capacity of land managers to respond to potential threats through their access to technology, social and economic resources and their risk-avoidance strategies (LAMBIN 2005, WARREN *et al.* 2001).

From the socioeconomic point of view, most consequences of desertification (especially in pastoral systems) are a direct result of the decline in 'productivity' or the capacity of the land to support plant growth and animal production. During early stages of desertification such losses are compensated by the social resilience of local human populations, especially in developing countries, or by economic inputs from governments. However, when certain thresholds are crossed, social resilience or government subsidies may not be enough to compensate for the loss of productivity, and this fuels a battery of socioeconomic changes that range from modifications in trade promoted by lower agricultural production to large population migrations (FERNANDEZ *et al.* 2002). Biophysical and socioeconomic indicators need always to be associated for any meaningful evaluation of the severity, for a given stakeholder, of land degradation.

4. Integrated Approach to Desertification

The simultaneous assessment of biophysical and socioeconomic drivers and consequences of desertification has been recognized as one of the most challenging topics for further research. STAFFORD-SMITH & REYNOLDS (2002) proposed the Dahlem Desertification Paradigm (DDP), which is unique in two ways: it attempts to capture the multitude of interrelationships within human-environment systems that cause desertification within a single, synthetic framework; and it is testable, which ensures that it can be revised and improved upon. The DDP consists of nine assertions, which embrace a hierarchical view of land degradation and highlight key linkages between socioeconomic and biophysical systems at different scales.

The monitoring of desertification is an increasingly important development in the management of dryland areas. The establishment of long-term and rigorous monitoring programmes is an effective way to assess the status of natural resources and the evolution of desertification processes. The challenge is to monitor not just biophysical indicators but the coupled human-environment system as a whole. This requires methods to link biophysical

data to socioeconomic data on land managers, to capture the varying capacity of local agents to cope and respond to a decline in land productivity.

Informal monitoring by land managers tends to focus on those factors that they perceive readily and that vary from day to day as a result of the variable external environment — *i.e.* 'fast' variables such as rainfall, grass growth, animal condition, market prices (LYNAM & STAFFORD-SMITH 2003). However, there is a growing acceptance that a small number of 'slow' variables act as the critical determinants in human-environment systems (GUNDERSON & HOLLING 2002). Monitoring systems of desertification should therefore be designed around these slow variables — *e.g.*, shrub encroachment, cropland expansion, change in land tenure, opening of new export markets for agricultural products.

5. Linking People to Pixels

Recent studies demonstrated the complementarity of remote sensing and socioeconomic survey data for understanding causes, processes and impacts of land-use/land-cover changes. Creating a direct link between spatially-explicit land-cover information, as derived by remote sensing, and information on land-use change processes requires the development of new methods and models which are merging landscape data with data on human behaviour (LIVERMAN *et al.* 1998). Several studies combined socioeconomic household survey data and remote-sensing data to better understand processes of land-use change. One of the major challenges of merging these data from heterogeneous sources concerns the definition of the appropriate spatial observation units, *i.e.* the appropriate level of aggregation of information derived from the domains of social phenomena and natural environment. In remote sensing, the spatial unit of observation is not directly associated to any unit of observation in social sciences, *e.g.*, individuals, households or communities.

RINDFUSS *et al.* (2003) provide an in-depth discussion of the methodological and practical problems in designing a study linking household and remotely sensed data, including issues of ephemeral households, boundaries of farms and villages, prospective or retrospective study designs, differences in sampling between land-to-people or people-to-land approaches, connection with households through land use or land ownership, plot and pixel size mismatch, sample size, etc. One of the biggest problems is the difficulty to protect the identity of surveyed households, for obvious confidentiality reasons, once their plots have been georeferenced. Releasing survey data with geographic coordinates associated with the plots used or owned by every

household is tantamount to disclosing the identity of the respondent households.

6. Challenges of Linking People to Pixels in Drylands

Land use in drylands is characterized by a number of features that make the fine scale linking of socioeconomic and remote-sensing data particularly difficult: extensive agriculture (including pastoralism) practised over large plots with fuzzy boundaries and communal ownership; often complex and flexible tenure arrangements regulating land access across space and time; mixture of natural vegetation and managed rangelands or croplands (*e.g.*, tree cultivation); multifunctional landscapes (*e.g.*, grazing in crop fields after the harvest); mobility of households and their livestock in transhumant or nomadic farming systems: households move across the landscape in search of forage and water, in the face of environmental uncertainty and seasonal fluctuations; large interannual variability in climatic conditions; and risk-avoidance land-use strategies that can only be understood by adopting a long-term perspective, cutting across several climatic cycles.

A few pioneer studies have taken place in rangelands. They have combined socioeconomic with remote-sensing data following different approaches: (i) socioeconomic survey to explain or supplement observed patterns of land-cover change; (ii) overlay of spatially-explicit socioeconomic and land-cover data, and proximity analyses; (iii) interpretation of spatial patterns of land use in terms of land-use practices; or (iv) joint statistical analysis of spatially-explicit household survey and land-cover data.

7. Conclusion

This paper has first provided compelling reasons for an integration of biophysical and socioeconomic variables to assess desertification status. This is related to the nature, causes and consequences of desertification. It then discussed new methodologies linking remote-sensing data to household survey data to achieve this goal. These methodologies have still to be widely developed and applied to land use in drylands, which poses particularly difficult challenges.

Understanding complex human-environment dynamics in drylands requires moving beyond simple map overlay approaches. Remote sensing can add to the broader human ecological analysis and spatial analysis must be informed

by the more complete understanding of causal connections uncovered by detailed field work (TURNER 2003). Remote sensing is just one step towards a broader, more comprehensive methodology.

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International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 33-37.

Convention des Nations Unies sur la lutte contre la désertification

par

Hama Arba DIALLO*

Excellence, Mesdames, Messieurs,

J'ai l'honneur et le grand plaisir de m'adresser à cette auguste assemblée à l'occasion de la Conférence internationale sur la lutte contre la désertification organisée par l'Académie Royale des Sciences d'Outre-Mer.

Permettez-moi, au nom de la Convention des Nations Unies sur la lutte contre la désertification (UNCCD), d'exprimer ma sincère gratitude au professeur Danielle Swinne, Secrétaire perpétuelle de l'Académie, pour l'invitation qui nous est adressée à prendre part à cet important événement.

Je félicite également l'Académie pour l'opportunité d'une telle rencontre, car, comme vous le savez, cette conférence se tient à un moment où l'Année internationale des déserts et de la désertification est célébrée dans différentes régions du monde.

*
* *

La désertification reste un phénomène beaucoup trop souvent éloigné des préoccupations des grands décideurs et du large public, y compris en Europe. Le terme même de désertification est souvent confondu avec le désert.

La Convention des Nations Unies sur la lutte contre la désertification a comme premier mérite de parvenir à une définition universellement acceptée de la désertification, laquelle est définie comme «la dégradation des terres

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dans les zones arides, semi-arides et subhumides sèches par suite de divers facteurs, parmi lesquels les variations climatiques et les activités humaines».

Près de quarante pour-cent (40 %) de la surface émergée du globe est affectée ou directement menacée par la désertification. Apprécié sous l'angle du nombre de personnes touchées, plus d'un milliard d'êtres humains vivent aujourd'hui sur des terres déjà dégradées ou sujettes à la désertification et aux cycles récurrents de la sécheresse.

En raison de leur position géographique, les pays les plus affectés par la désertification sont également ceux classés parmi les plus pauvres de la planète. Les activités créatrices de richesse de ces pays dépendent étroitement de la fertilité de leur terre, que ce soit pour l'agriculture, le pastoralisme, voire l'exploitation économique des ressources naturelles renouvelables comme les produits forestiers.

Dès lors, le lien désertification-pauvreté se révèle dans ces pays sous la forme d'une insécurité alimentaire chronique; des flux migratoires difficiles à planifier et à maîtriser; des dysfonctionnements sociaux graves, voire des conflits sur l'utilisation des ressources rares, qui peuvent comporter parfois une dimension déstabilisatrice de fragiles institutions politiques.

C'est fort de ce constat que la communauté internationale s'était mobilisée au début des années 1990 pour négocier, adopter et signer la CCD. Cette volonté politique est désormais symbolisée par l'adhésion de cent nonante et une Parties à ce traité. Ce faisant, les pays touchés par la désertification et ceux qui ne le sont pas s'engagent à appliquer rigoureusement les dispositions de ce traité, dans le but de permettre l'avènement de conditions de vie décentes dans plus de cent dix pays qui sont directement concernés.

Il est à souligner que la dimension novatrice de la CCD est certainement son approche intégratrice, caractérisée par l'effort visant à internationaliser la lutte contre la désertification dans les stratégies nationales de lutte contre la pauvreté. Les programmes d'action nationaux qui sont formulés par les pays touchés, constituent des cadres de référence qui définissent les orientations principales à entreprendre, avec l'implication active de toutes les catégories d'acteurs, y compris les appareils des Etats, les institutions académiques et les membres de la société civile.

Dans le prolongement de la Déclaration sur les objectifs du Millénaire (2000), la Communauté internationale avait également identifié la CCD, lors du sommet mondial sur le développement durable (2002), comme un instrument de lutte contre la pauvreté. Les opportunités dérivant de la Convention constituant, de fait, les véritables socles d'un développement qui ambitionne de réconcilier les besoins socio-économiques et le respect d'une certaine rationalité écologique.

En effet, le fait que l'économique, le social et l'écologique soient à prendre en compte durant la phase de mise en œuvre des programmes de lutte contre la désertification permet de s'attaquer aux réelles priorités, telles que le développement de systèmes de production agricole adaptés, la gestion intégrée des ressources en eau et la couverture satisfaisante de besoins alimentaires.

Bien entendu, l'application des dispositions de la CCD à l'échelle des pays est du ressort des pays concernés. Ces derniers ont l'obligation, en tant que Parties, de remplir toutes leurs responsabilités vis-à-vis de la Convention. C'est la raison pour laquelle le Secrétariat que nous représentons collabore avec tous les pays concernés, non seulement pour leur apporter les avis techniques souhaités, mais aussi pour davantage faire comprendre aux décideurs que, dans bien des cas, le rétablissement des équilibres économiques d'un pays touché par la désertification passe par une meilleure prise en compte des orientations préconisées dans la Convention à l'endroit des zones arides, semi-arides et subhumides sèches.

Il convient aussi de souligner que les actions prioritaires ne se situent pas uniquement au niveau national. C'est ainsi que des programmes prioritaires sont également développés aux niveaux sous-régional et régional. Ces derniers niveaux ont l'avantage de mieux appréhender la question d'une meilleure gestion des ressources naturelles partagées.

Si le lien désertification/pauvreté n'est plus à prouver dans la majorité des pays touchés, tout n'est pas encore suffisamment mis en œuvre, loin s'en faut. Je voudrais citer ici, pour exemple, le fait qu'en Afrique, région la plus gravement touchée, rares sont les pays qui consacrent 10 % de leur budget national à l'agriculture, alors que les populations actives de ces pays sont en grande majorité des acteurs ruraux.

Des secteurs clefs, comme la gestion intégrée des ressources en eau, la promotion de systèmes de production agricole durables, une meilleure gestion des ressources pastorales, demeurent ainsi des domaines d'activités insuffisamment considérées dans les plans nationaux de développement.

La raison principale en est que les zones arides, semi-arides et subhumides sèches sont souvent assimilées, à tort, comme des zones «inutiles» au sens économique du terme. S'il est vrai que la productivité des terres y est plutôt faible, il n'en demeure pas moins vrai que la technologie disponible et l'état des connaissances permettent aujourd'hui de faire de ces zones de véritables pôles économiques, à même de valoriser des produits uniques comme la gomme arabique et le dattier, ce qui leur donne un avantage comparatif inégalé.

A la CCD nous œuvrons beaucoup à la promotion des opportunités économiques tirées de zones arides, semi-arides et subhumides sèches, lesquelles

dépendent en grande partie d'une certaine cohérence des politiques économiques nationales.

C'est ainsi que, durant la phase de formulation et d'adoption des programmes d'action nationaux de lutte contre la désertification, nous encourageons les pays pauvres touchés à opérer un travail d'internationalisation de leurs activités de lutte contre la désertification dans leurs programmes nationaux de lutte contre la pauvreté. Il s'agit là d'une étape importante, qui permet une meilleure recherche d'adéquation entre l'économique et l'écologique.

De même, nous pensons que le binôme terre-eau doit constituer le pilier d'une politique de développement durable dans les zones touchées par la désertification. Par conséquent, les Etats nationaux des pays concernés doivent se doter d'orientations politiques spécifiques sur le régime foncier et la gestion des ressources en eau, qui demande des investissements importants et soutenus à moyen et long terme.

Les Etats nationaux doivent non seulement parvenir à la mise en place d'un cadre législatif précis dans ces domaines, mais encore, ils se doivent de les appliquer et au besoin de consentir des mesures incitatives dont l'objectif final reste de réhabiliter des terres dégradées et de maintenir une certaine capacité de renouvellement des ressources naturelles, nécessaires au fonctionnement du système de production en milieu rural notamment.

A cet égard, des mécanismes financiers adaptés, tels que l'accès au crédit, les facilités d'équipement en outils de production, sont des instruments indiqués pour permettre aux utilisateurs de la terre de travailler dans des conditions plus efficaces.

De même, la garantie des prix aux produits et un meilleur accès aux circuits commerciaux, y compris au niveau international, sont des facteurs de développement de produits venant spécifiquement des zones arides.

La Convention sur la lutte contre la désertification représente dans beaucoup de pays touchés une réponse aux défis multiples à relever dans le cadre de la lutte contre la pauvreté. Pour cette raison, les actions à entreprendre doivent s'inscrire dans le cadre de réformes structurelles qui induisent des remises en question, jusque dans la relation entre l'homme et l'utilisation de la ressource naturelle.

A ce jour, plus de quatre-vingts pays touchés ont accompli ce travail parfois très complexe de formulation de leurs programmes d'action nationaux. Il semble toutefois que les moyens dont disposent les pays concernés, souvent parmi les plus pauvres de la planète, constituent la contrainte majeure à une mise en œuvre efficace des actions envisagées.

Dans le cadre des consultations entre pays Parties à la Convention cette question est régulièrement évoquée. Il convient de reconnaître cependant

que les intentions, souvent affichées au sortir de ces consultations, tardent à se matérialiser.

C'est ici qu'il me semble utile d'insister sur l'importance que revêt la coopération au développement dans le contexte de la mise en œuvre de la CCD.

De nombreux pays en développement touchés dépendent encore lourdement de l'aide au développement pour mettre en œuvre leurs programmes d'action de lutte contre la désertification.

Les pays développés, ainsi que les organisations internationales telles que la Banque mondiale, le Fonds pour l'Environnement Mondial, la Commission européenne, représentent les principaux partenaires de ces pays. A ce niveau également, il semble bien que toutes les réformes n'aient pas encore été envisagées pour faire de la lutte contre la désertification une véritable composante de leur politique de coopération au développement et de la lutte contre la pauvreté.

La CCD demeure, à mon avis, un instrument puissant qui peut efficacement aider les pays touchés à sortir de l'ornière de la pauvreté. Pour cette raison, cette Convention, qui bénéficie déjà d'un soutien politique universel, doit désormais faire partie des outils majeurs à utiliser par tout décideur intervenant dans la lutte contre la pauvreté.

Le Secrétariat de la Convention continue, de ce point de vue, à faire tout ce qui est possible, dans le but de promouvoir la CCD et amener les différents acteurs du développement, tant au niveau des pays du Nord que du Sud, à utiliser cet instrument dans leur politique de développement.

J'ose espérer que cette importante conférence de l'Académie Royale des Sciences d'Outre-Mer contribuera à faire avancer la cause de la Convention sur la lutte contre la désertification, et nous sommes, bien entendu, disposés à envisager, avec tous les partenaires et amis ici présents, les voies et moyens d'une collaboration permettant de mieux soutenir les efforts en cours dans les pays touchés.

Migration and Health

International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 41-54.

Coping with Desertification: Migration as a Forced Choice and a Livelihood Strategy

by

François GEMENNE*

KEYWORDS. — Sahel; Forced Migration; Livelihood; Vulnerability; Adaptation.

SUMMARY. — Environmental disruptions are generally recognized as an increasingly important factor of migration. While these environmental disruptions can be extremely diverse, brutal or slow-induced, natural or man-made, they often have in common to affect the populations which are the most vulnerable and cannot adapt to a changing environment. Among these environmental migrations, this paper aims at studying the ones triggered by desertification.

Migrations induced by slow-onset environmental change, such as desertification, are particularly difficult to apprehend, since many other socioeconomic factors often mingle, resulting in the migration choice. This paper shows how the migration decision can be envisioned both as a forced choice and as a livelihood strategy, and how thin the borderline between forced and voluntary migration can sometimes be. Drawing from some cases of farmers' migration in Sahel, the migration trajectories as well as their impact on development patterns will be related to environmental vulnerability and adaptation.

The issue of the legal status and protection of these migrants will also be addressed. Absent from the Geneva Convention, and despite a situation that is sometimes very similar to those experienced by refugees, these migrants are not recognized as refugees by international law and cannot claim any specific protection. Furthermore, this kind of migration does not necessarily involve the crossing of an international border, and many of these migrants are therefore labelled as 'Internally-Displaced People' (IDP). The last section of this paper will address the possible schemes of international cooperation that would provide an adequate protection to these 'refugees' forgotten by international law and policy-makers.

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1. Introduction: The Tricky Linkage between Environment and Migration

Massive population displacements triggered by natural disasters have recently made headlines all around the world. The tsunami that hit the coasts of Southeast Asia at the end of 2004, or the hurricane Katrina, which flooded the city of New Orleans, have forced thousands to flee and relocate, sometimes with very low expectations of return. These emergency, brutal evacuations attracted a considerable amount of media attention. Slow-induced migrations such as those triggered by desertification, however, are less likely to draw media attention. These flows, despite sharing many characteristics with brutal displacements, have a far less powerful visual and emotional impact. They affect more people and more regions of the world though, deeply transforming many societies.

Debates about the interconnections between environmental change and forced population displacement are relatively new, and little academic research has so far been produced on this topic. While it is likely that human settlements have always been faced with environmental changes, the extent to which these changes induce migration is still largely unknown. However, environmental disruptions are generally recognized as an increasingly important factor of migration. In a preparatory meeting for the June 1992 Rio Summit of the United Nations Conference on Environment and Development, Sadako Ogata, UN High Commissioner for Refugees, stated that environmental degradation had increasingly become both a cause and a symptom of massive population movements. Since then, the linkage between population displacement and environmental change has been a topic of growing concern to the international community. The concept of 'environmental refugees' appeared in a 1985 UNEP report (El-Hinnawi 1985), and has led to controversies in the scientific community since then.

Environmental disruption is recognized as both a cause and a consequence of population movements (Black 1998). It is a cause when people can no longer gain a secure livelihood in their homelands and are obliged to flee, having no other alternative. It is a consequence when environmental degradation results from the mass movement of people, both in the departure and the receiving areas. In the departure areas, damage may occur when farmers leave behind fields and pastures they have worked for centuries. In Casamance, highly developed irrigation systems have broken down because of lack of maintenance. It has led to erosion and the loss of fertile soil. Environmental degradation can also occur in receiving areas when large numbers of refugees concentrate in camps, generating heavy pressure on surrounding natural resources.

As one can see, environment and migration interact in a highly complex relationship — a relationship that also bears many policy applications. Migration in itself is an increasingly complex process (CASTLES & MILLER 2003). People rarely move for a single reason, or to a single country. The motivations to migrate, the intertwining of the 'push' and 'pull' factors are increasingly complex, and so are the trajectories and itineraries of the migrants. Migration is also an individual decision: facing the threat of a natural disaster, some people might want to leave, while others will choose to stay. It also depends on the livelihoods of people, their familial constraints, etc. Volcano eruptions provide good examples of these individual decisions: hours before the eruption, in a way that seems sometimes surreal, some people are still reluctant to evacuate. Sometimes they simply cannot do so. When the evacuation of the city of New Orleans was ordered, days before the hurricane Katrina hit, the authorities forgot that many people had no car and could not leave the city by themselves. The environmental factor is usually not the sole factor at stake: it mingles with economic and political factors. Environment is the root of an increasing number of regional conflicts, especially when access to water is at stake, and environmental disruption is often linked with a weak economic structure. Desertification, for example, is often associated with land property issues, poverty, or regional conflicts.

2. Environmental Change and Forced Displacements

Most of the research and media attention is devoted to South-North and East-West migration flows. However, one should not forget that most of the flows happen in the South: from a rural area to a town or city, then possibly from this conurbation to a neighbouring country. Only a small minority — those who can afford it — choose to migrate towards Europe or the United States. Migration trajectories are usually indirect and comprise different, progressive steps (CASTLES & MILLER 2003). If often takes the form of an internal migration; migration to another country is far less frequent, and migration to another continent is the exception. Those who can make it to Europe or America are usually supported by their families, while the poorest of the poor are stuck in their country or in their village.

Environmental change plays an important role in the decision to migrate (UNRUH *et al.* 2004). While the number of conventional refugees reached an historical low of 8.4 million at the end of 2005 (UNHCR 2006, p. 3), the number of environmental migrants keeps increasing, even if the scientific community is divided about the extent of the increase. Many believe the

number of environmental migrants to be around 25 million [1]*, a number that equals the sum of 'conventional' refugees and internally displaced people. Climate change is expected to make this number dramatically bigger. A recent report on the economics of climate change, commissioned by the UK Treasury, revealed that as many as 200 million people could be at risk of being driven from their homes by flood or drought by 2050 (STERN 2006).

However, these alarming figures must be taken with great caution: the figure of 200 million 'refugees' corresponds to the number of people whose homelands are at risk of being affected by climate change if nothing is done to slow down its pace. It is therefore a potential, artificial figure that does not correspond to an actual migration. One cannot forecast the strategies that will be developed by the populations affected by climate change, and their capacity to adapt is certainly a key factor in predicting the number of migrants. Moreover, these figures also bear a political meaning: they are produced with the aim of convincing governments to act to fight climate change. Without going as far as saying that they are artificially inflated, this is an element that must be kept in mind.

2.1. A PARTICULAR TYPE OF MIGRANTS

The environmental disruption leading to the migration process can take many forms: brutal or slow-onset, natural or man-made, due to a single or cumulative changes, etc. The International Organization for Migration (1992, p. 11) has ranked these disruptions into six categories:

- Environmental disruptions prompted by climatic or geological forces which include cyclones, volcanoes, earthquakes, floods and other 'natural disasters';
- Biological disruptions initiated by pathogens, insects (mainly locusts), pests and flora, which cause major population movements, particularly where they affect production of staple food item;
- Slow-onset disruptions which include global warming effects, deforestation, land degradation, erosion, salinity, and may contribute to drought and famine;
- Accidental disruptions, an inevitable by-product of the industrial revolution;

* Numbers in brackets [ ] refer to the notes, p. 53.

— Disruption caused by development programmes such as dams or environmental policies and urbanization; and finally
— Environmental warfare when the environment becomes a major target in times of conflict.

Is it possible to gather all people displaced by these varied causes under the umbrella label of 'environmental migrants'? The linkage between disruption and migration is not always direct, and is difficult to identify, since it often mingles with socioeconomic factors. Migration can be the result of cumulative and intertwined changes, and is seldom the result of a single change. Most environmental migrants do not cross an international border, and are therefore classified as 'Internally Displaced People' (IDP). Unlike conventional refugees, environmental migrants do not flee their country, but their immediate environment. This is another reason why their number is so imprecise: data on migration flows can only be produced when the crossing of an international border is recorded.

Furthermore, environmental migrants are not recognized as refugees under the provisions of the Geneva Convention. The Convention stipulates that a person must cross an international border and flee a persecution linked to his/her race, religion, political opinion, sexual orientation or belonging to a particular group in order to qualify for a refugee status. Environmental migrants obviously do not fulfil these conditions, and thus cannot claim any legal status or specific protection. CONNISBEE & SIMMS (2003, p. 30) call them 'legal gypsies' and argue that environmental disruptions should be considered as political persecutions.

The difficulty to identify and to count environmental migrants makes the drafting of relevant policies an almost impossible task. There is an obvious lack of empirical research in this field, and more research will be needed before adequate policies can be adopted.

2.2. FORCED AND VOLUNTARY MIGRATION

As for now, most of the research addressing environmental migration has assumed that these migrations were forced, and not voluntary. It is of course always the case with natural disasters and emergency evacuations. Even if they are reluctant to do so, migrants have no other choice than leave. In the case of slow-onset environmental changes, however, the situation can be different. The migration can then be, in some cases, a coping strategy, a routine mechanism used to cope with resource scarcity. In these cases, the 'push' and 'pull' factors are mixed: some migrants are at the same time

forced and willing to leave. The border between forced and voluntary migration is blurred and this bears great importance for migration policies.

We argue that in the case of desertification, migration can be a forced choice as well as a coping strategy, conceived as such by migrants. It can also be a necessary relief to alleviate the demographic burden, and therefore can also help fight desertification. We propose to also consider this aspect of desertification-induced migration, which we will develop in the next section.

3. Desertification and Migration

Desertification is a worldwide process, affecting all continents. According to the Secretariat of the United Nations Convention to Combat Desertification (UNCCD), "over 250 million people are directly affected by desertification, and about one billion people in over one hundred countries are at risk" [2]. In many regions, this desertification process is closely associated with migration flows. In China, the Gobi desert is progressing at a pace of 10,000 square kilometres per year, forcing people to relocate in the provinces of Inner Mongolia, Ningxia and Ganzu. In Mexico, desertification draws thousands to attempt to cross the US border. Cities like Quetta, the capital of Pakistan's Baluchistan province, is expected to face severe water shortages in the next decade. But the most severe problem lies in Africa, where it is estimated that up to 60 million people could be displaced by desertification.

At this stage, one should distinguish between droughts and desertification. In the case of droughts, migration is directly related to a short-term natural disaster. In the case of desertification, things are more complex: migration is indirectly linked to a slow-onset, man-made, cumulative process. This makes the migration process more complex, longer, and allows us to differentiate between different cycles. These cycles coexist, and produce different types of migration:

— Very long-term cycles: aridification. This process is linked to climate evolution, and will be aggravated by climate change. It involves very slow and progressive population displacements, over several generations.
— Mid-term cycles: desertification. Migration is here linked to a cumulative process, and often circular. In this case, migration can be a livelihood strategy.

— Short-term cycles: droughts. The displacement, here, is a forced one, linked to a short-term disaster. A possibility of return exists.
— Seasonal cycles: seasonal migration, which is part of a social routine.

The migration process is cumulative and circular: while it can be a coping strategy for food insecurity, it is no longer the case with droughts. Migration ceases to be age and sex selective, and becomes a forced choice.

Migration impact is not restricted to the individual level. We have seen how migration could be induced by environmental change. However, migration also has an impact on the environment itself, at the macro-level: it can be a consequence of environmental change, but also a cause. While emigration alleviates the demographic burden, immigration can induce and aggravate environmental problems: land property issues, over-exploitation of the soil, etc. This process induces a circular relationship between environment and migration: environmental change induces a migration, which in turn causes another environmental change, etc. This is particularly the case with desertification: migration flows, if not properly managed, can induce land degradation and water shortage problem, and lead to new migration flows.

3.1. A Few Examples in Africa

For a long time, Sahelian populations have used migration as a coping strategy for food insecurity. Herders have always included spatial mobility in their way of life. During the 1983-85 droughts, a shortage of food supply forced them to move southwards. In this case, migration had ceased to be a coping strategy to an ecological crisis, and affected entire families instead of being age and sex selective. Herders and their families had no other choice.

Edmond Bernus (1999) relates that during the 1983-85 drought in Niger, the Tuaregs Illabakan were obliged to leave their traditional grazing lands when degradation reached crisis proportions. They left to the south towards an unknown destination. Most of the group left for a trip that lasted two months. They responded primarily to 'push' factors, and the 'pull' factors' role was very limited. The same situation is described by Mounkaila (2002), talking about the departure of most families from the village of Mogonana in Niger to settle in Niamey. In this case, they abandoned the idea of returning; the movement itself was the core of the problem. They could certainly be considered as true environmental 'refugees'. Their movement affected entire families and uprooted individuals. It was unforeseen and unwelcome.

They either were regrouped in camps or moved to the slum areas of the city, and were in crucial need of protection as well as assistance.

As one will see, the issue of legal status and protection is primordial. When nomadic Peul and Tuaregs crossed the border of Niger to take refuge in Ghana, they were not recognized as refugees, and their arrival was unwelcome. ESSUMAN-JOHNSON (1996) compares the situation of those nomadic herders with Liberian refugees who arrived in Ghana at the same time. Though both groups arrived in Ghana at the same time and under the same conditions of destitution, assistance and protection were not the same. Sahelian refugees who were victims of a degraded environment were not considered as refugees, but seen as economic migrants and were left destitute. On the other hand, Liberian refugees were given *de facto* refugee status and regrouped in a camp where they received assistance and protection from the international community. This salient difference between two comparable situations perfectly illustrates the issue of the legal status and protection of environmental migrants: though they can experience situations very similar to those of conventional refugees, they are not entitled to the same benefits.

4. Protection and Status

The concept of 'environmental refugees' dates back to the 1970s, when Lester Brown, from the World Watch Institute (an environmental think tank), used it in various speeches. Jodi Jacobson contends that the term was first used in reference to the Haitian boat people (JACOBSON 1988). She argues that land degradation in Haiti induced perilous displacements to South Florida. But it is only in 1985 that a report from the United Nations Environment Programme (UNEP) specifically addressed the issue (EL-HINNAWI 1985). It appeared at the time of the great drought in Sahel, when the world became aware of an environment increasingly threatened. These threats had already been raised during the Stockholm Conference in 1972, and would be raised again at the Rio Summit of 1992, as well as at the Johannesburg Summit of 2002. Later on, the concept has been frequently used in various international conferences, such as the 1997 Kyoto Conference on Climate Change. High-profile officials, such as former US President Bill Clinton or UN former Secretary-General Boutros Boutros-Ghali, also used the term, facilitating its recognition in the media. Since then, advocacy groups, environmentalists, NGOs, and a few social scientists, have produced quite a lot of grey literature on this 'new' kind of migrants. The concept has enjoyed an increasing visibility in the

media, and has attracted more attention from policy-makers than from researchers.

However, their definition of an 'environmental refugee' as someone fleeing from environmental decline is very wide. Here is the definition proposed by Essam El Hinnawi: "...Environmental refugees are defined as those people who have been forced to leave their traditional habitat, temporarily or permanently, because of a marked environmental disruption (natural and/or triggered by people) that jeopardized their existence and/or seriously affected the quality of their life" (EL HINNAWI 1985, p. 4). This very large definition includes three types of ecological refugees:

— Those who have been temporarily displaced because of an environmental stress (usually a natural disaster);
— Those who have to be permanently displaced and resettled in a new area; and finally
— People who migrate within their own national boundaries because "the resource base in their original habitat has deteriorated to such a degree that it can no longer meet their basic needs" (EL HINNAWI 1985, p. 5).

This definition was criticized by SUHRKE & VISENTIN (1991), who stated that "it is so wide as to render the concept virtually meaningless... Uncritical definitions and inflated numbers lead to inappropriate solutions and compassion fatigue. We should not, however, reject outright the concept of environmental refugees. Instead we should formulate a definition that is more narrow but more precise". They proceed to make a distinction between environmental refugee and environmental migrant. The latter is someone who "makes a voluntary, rational decision to leave a region as the situation gradually worsens there". On the contrary, environmental refugees are "people or social groups displaced as a result of sudden, drastic environmental change that cannot be reversed". They are compelled to flee. Another distinction is between the truly desperate and vulnerable who cannot expect support from their own governments and are therefore refugees, and those with more resources, contacts and time to plan for their migration.

The concept of an 'environmental refugee' is still very controversial. JoAnn MCGREGOR (1993) argues that "the category 'environmental refugee' confuses rather than clarifies the position of such forced migrants, since it lacks both a conceptual and a legal basis". Still labelled as economic migrants, many of such forced migrants fall outside the categories protected by instruments of international refugee law: environmental decline is not yet recognized as a legitimate cause of refugee movements.

4.1. A Refugee Status?

The lack of legal status for environmental migrants might first appear as an injustice that needs to be corrected. Some authors, such as Conisbee & Simms (2003), argued that environmental migrants should be given a refugee status, and many call for the creation of a new category of refugees. Hans Van Ginckel, Under-Secretary General of the United Nations, recently declared [3] that the United Nations "should prepare now, however, to define, accept and accommodate this new breed of 'refugee' within international frameworks". Other national and local initiatives also call for the international recognition of 'environmental refugees'. A resolution [4] passed by the Belgian Senate on 20 April 2006 asks the Belgian government to support the international recognition of 'environmental refugees' within the framework of the Geneva Convention, and Australia's Labour Party published a brochure recommending that Australia "should be working at the UN to ensure appropriate recognition of climate change refugees in existing conventions, or through the establishment of a new convention on climate change refugees" (Sercombe & Albanese 2006). On the field, the UN High Commissioner for Refugees (UNHCR) has recently helped the victims of a natural disaster on two occasions: the tsunami that hit Southeast Asia at the end of 2004, and the earthquake that struck Pakistan in October 2005. These two operations are quite significant, since the UNHCR mandate does not normally cover the people displaced by natural disasters. These operations were justified by UNHCR's expertise and presence in the region, but, as Ruud Lubbers, then UN High Commissioner for Refugees, declared it after the tsunami operation, "it was indeed a very special situation".

These initiatives are, of course, an appealing prospect. However, an international recognition of 'environmental refugees' would be problematic in many regards. Many scholars in the field of migration studies still regard the Geneva Convention as the paramount of protection [5] and fear that a legal recognition of environmental refugees would water down the Convention and the very concept of 'refugee'. The trend of immigration policies in Europe and in the United States is one of restriction, and not of extension of rights. Hence, there is a real risk that any change to the Geneva Convention would bring further restriction to asylum rights, instead of extending them.

Isolating the environmental factor might lead to the oblivion of other causes of migration, which often mingle with environmental degradations. The environment needs to be considered in its global dimension, and not as an isolated factor driving migration. Singling out the environmental factor could also lead to the oblivion of the very causes of these degradations:

environmental disruptions are seldom purely natural. Desertification provides a good example of environmental factors mingling with political and economic ones.

Through the terms 'environmental refugees', we tightly associate refugees and environment. This link extremely simplifies a complex situation; it implies that forced departure is rooted in degradation of natural resources, without mentioning the multiple factors, others than natural ones (demographic, economic, development), which are responsible for this situation. Environmental degradation is caused by deeper-rooted problems based on political, economic and social inequality. Responsibility of governments in producing environmental refugees is thus forgotten if the sole environmental factor is considered.

For these reasons, the term of 'environmental refugee' is misleading, and possibly harmful for the refugees themselves. We have also shown that environmental migration, especially in the case of desertification, was not always forced, but could also be a coping strategy: for those who are not compelled to flee, a refugee status would not make any sense. Given the current state of research, it is still difficult to differentiate between the different types of migrants. More empirical research will be needed before an efficient protection system can be implemented for those environmental migrants in need of such assistance.

5. Conclusion: A Modest Proposal

Whether these migrants are eventually recognized as refugees or not, the issue of financial compensation will remain. Any protection for environmental migrants would require consequent funding. As said before, the number of people that could fall into this category would outnumber the current amount of conventional refugees. New instruments, new agencies, new programmes would be needed. In order to fund these instruments, international cooperation would be a necessary, but not sufficient, condition. A scheme for a global environmental responsibility should also be designed. As a framework for such mechanism of international cooperation, we propose to use the theory of public goods.

Global environment can certainly qualify as a global public good. The first studies on public goods were conducted in the 1950s by Samuelson, who defined public goods as being non-rival and non-excludable goods, meaning that it was impossible to exclude an individual from consuming a certain good, and that the consumption of this good by the said individual

was not harming another individual's consumption of the same good. More recently, research funded by the UN Development Programme (UNDP) has pushed the concept forward, and has elaborated the concept of 'global public goods'. In a milestone book published in 1999, Kaul, Grunberg and Stern define global public goods as 'goods whose benefits extend to all countries, people, and generations' (KAUL *et al.* 1999). Global environment clearly fulfils the criteria of this definition, and can therefore be considered as a global public good.

If global environment is a global public good, any damage to this good can certainly be considered as a global public 'bad'. Reasoning by analogy with global public goods, I will here attempt to define a global public bad as a good whose costs extend to all countries, people and generations. If we accept this definition, desertification, by its considerable extent, by the huge and durable impact it has on populations all around the world, certainly qualifies as a global public bad.

In one way or another, most countries will eventually be affected by desertification and the migration it induces, either as a sending or as a destination country. International cooperation is thus needed to fight desertification, but also to address the plight of migrants who are forced to abandon their homelands. The United Nations Convention to Combat Desertification (UNCCD) provides a framework for an international cooperation in fighting desertification, but could also be used to provide mechanisms of burden-sharing for the migrants induced by desertification. The extent of these migration flows calls for mechanisms of regulation, such as burden- and responsibility-sharing schemes.

The UN Framework Convention on Climate Change (UNFCCC) contains an appendix aimed at constituting a global adaptation fund that would meet the costs of adaptation to climate change. The costs of migrations induced by climate change can certainly be considered as 'costs of adaptation'. Article 4.4 of the Appendix states that "developed country Parties and other developed Parties in Annex II shall also assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects". Despite repeated pledges, this part of the Kyoto Protocol is still in limbo. A similar mechanism, which would probably need to be more stringent, could be implemented within the UN Convention to Combat Desertification. This would guarantee a better protection for those affected by desertification, without creating the legal precedent of a new refugee category.

Desertification is a global issue, and not just a local problem. Therefore, a global environmental commitment needs to be acknowledged, and regional

solutions need to be implemented. One country alone cannot bear the burden of desertification-induced migration. Regional burden-sharing schemes are needed to alleviate the burden, and environmental migration needs to be recognised as a human cost of desertification. If desertification is a certainly forgotten cause of migration, migration is also a forgotten cost of desertification.

NOTES

[1] This figure was initially produced by the Red Cross, and has been frequently re-used, including by the Institute for the Environment and Human Security of the United Nations University.

[2] As stated on their website: http://www.unccd.int

[3] *As Ranks of 'Environmental Refugees' Swell Worldwide, Calls Grow for Better Definition, Recognition, Support.* Press release of the United Nations University's Institute for Environment and Human Security, 12 October 2005.

[4] «Proposition de résolution visant à la reconnaissance dans les conventions internationales du statut de réfugié environnemental», proposal lodged by the Belgian Senator P. Mahoux on 3 February 2006.

[5] See for example BLACK (2001) and CASTLES & MILLER (2003).

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International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 55-74.

Dust in the Wind and Public Health: Example from Mauritania

by

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KEYWORDS. — Air Quality; PM_{10}; Dust Storms; Horizontal Visibility; Sahara; Mauritania.

SUMMARY. — The Sahara largely contributes to the global injection of mineral dust into the northern hemisphere. Since the onset of the drought in the Sahel and the environmental degradation in the arid and semi-arid belts surrounding the Sahara, the frequency and intensity of dust storms have dramatically increased. It is now irrefutable that air pollution caused by large amounts of respiratory particulates or Particulate Matter less than 10 μm in aerodynamic diameter (PM_{10}) has numerous undesired consequences on human health. Air quality degradation far away from the African continent, in the US and in Europe, caused by high concentration of African dust is seen as a major health threat, although most of these countries are very distant from the Sahara. Surprisingly, no estimates of PM_{10} levels near the Saharan dust source are available. Based on horizontal visibility observations, which are reduced by the presence of dust in the atmosphere, PM_{10} levels are estimated at the station of Nouakchott, Mauritania, by using relations found in the literature. It appears that excessive concentrations of particles are very important, both in magnitude and frequency, as the 24-hour PM_{10} thresholds established by the US EPA National Ambient Air Quality Standards and the EU Limits Values for Air Quality were systematically exceeded. The average yearly concentration is far above air quality standards. These very high particulate levels are likely to represent an important public health threat and should be considered as a major environmental risk. In this paper we present a first comparison between monthly respiratory diseases data and PM_{10} concentrations due to dust storms.

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1. Introduction

Growing populations and unsustainable land-use practices are causing the world's deserts to expand, swallowing previously productive lands and placing millions of lives in jeopardy. According to the United Nations' Millennium Ecosystem Assessment, desertification threatens dry land areas that make up 34 % of the Earth's total land area and are home to about two billion individuals. It is occurring all around the globe, but has dramatic impacts in vulnerable developing countries, including many countries in western Africa. In these areas, pressure from population growth, climate change, and poor agricultural practices can cause these fragile ecosystems to become degraded. This degradation can cause massive dust storms, famine, mass migration, and political instability, all of which may contribute to significant health problems in affected regions. To draw attention to this growing problem, the United Nations has declared 2006 the International Year of Deserts and Desertification. In recognition of this year, the United Nations will work to raise awareness of the problems caused by this phenomenon and encourage local governments to take steps to protect or restore dry lands by implementing sustainable land management strategies. In the framework of the International Conference on "Desertification: Migration, Health, Remediation and Local Governance", the purpose of this paper is to make an overview of health impacts of dust storms globally, and to focus on this thematic in West Africa, a region where this topic is unstudied.

The Sahara largely contributes to the global injection of mineral dust into the northern hemisphere (PROSPERO *et al.* 2002, WASHINGTON *et al.* 2003). Yet it is estimated that the Sahara and its margins yearly inject amounts of dust into the atmosphere varying between 600 and 900 10^6 tons (D'ALMEIDA 1986, MARTICORENA *et al.* 1997, CALLOT *et al.* 2000), about half of the yearly global mineral dust production (GINOUX *et al.* 2004).

For the last decade, mineral dust has become a major topic in environment studies. The increase of aeolian processes observed in most arid and semi-arid areas of the world over the last decades is thought to be a response to environmental stresses and global climate change (TEGEN & FUNG 1995, LANCASTER 1996, ROSENFELD *et al.* 2001, OZER 2002). Since the onset of the drought in the Sahel and the environmental degradation in the arid and semi-arid belts surrounding the Sahara, dust storms' frequency and intensity has dramatically increased (OZER 2000, PROSPERO & LAMB 2003). This increasing formation of dust storms, in turn, could affect cloud formation and induce aridification of drylands (ROSENFELD *et al.* 2001). Since climate models used

to simulate the future climate of the Sahel suggest that the dramatic droughts of the 1970s and 1980s may become permanent by 2050 as a result of increasing greenhouse gases (HELD *et al.* 2005), and as most indicators tend towards further degradation of the Sahelian environment (OZER & OZER 2005, HOUNTONDJI *et al.* 2006), dust storm processes are not foreseen to decline in coming decades.

In addition, there is a growing evidence that air pollution caused by increasing concentration of Total Suspended Particulates (TSP) and respirable particulates, *i.e.* those smaller than 10 μm (PM_{10}), have many local to global environmental and human-related consequences, most of which are adverse (GOUDIE & MIDDLETON 2001). Wind-borne dust may also carry bacteria, allergens and fungi (KELLOGG *et al.* 2004, PROSPERO *et al.* 2005) and can be contaminated with pesticides (O'HARA *et al.* 2000) or even radioactivity (PAPASTEFANOU *et al.* 2001).

Saharan dust is often transported far away from the sources (MIDDLETON & GOUDIE 2001). As a result, air quality deterioration caused by high concentrations of respirable African mineral dust has been reported in various regions of the world, such as the Canary Islands (VIANA *et al.* 2002), Spain (BALDASANO *et al.* 2003; RODRIGUEZ *et al.* 2001, 2003; SALVADOR *et al.* 2004; MORENO *et al.* 2005; VAUTARD *et al.* 2005), the United Kingdom (RYALL *et al.* 2002), the Middle East (ALPERT & GANOR 2001), the West Indies (RAJKUMAR & CHANG 2000) and the south-eastern United States (PROSPERO 1999).

2. Dust and Health: a Short Review

Such mineral particulate matter air pollution is a serious health threat in various regions of the world because it may promote respiratory infection, cardiovascular disease and other ailments (GRIFFIN & KELLOGG 2004, KUEHN 2006, OZER *et al.* 2006).

High concentrations in mineral PM_{10} are cause of morbidity and mortality. Yet, in Seoul, Korea, a close association between the Asian dust events and deaths from cardiovascular and respiratory causes (+ 4.1 %) suggests that persons with advanced cardiovascular and respiratory disease may be susceptible to dust storms (KWON *et al.* 2002). Similar results were obtained in Taipei, Taiwan, where an increase of 7.66 % of respiratory diseases (+ 1.12 % per 10 $\mu g\ m^{-3}$ increase in PM_{10}) and 4.92 % of the total mortality (+ 0.72 % per 10 $\mu g\ m^{-3}$ increase in PM_{10}) was recorded during Mongolian dust outbreaks (CHEN *et al.* 2004).

Other studies in Taipei and in Korea showed that Asian dust events are impacting on the respiratory symptoms of subjects with bronchial asthma (PARK *et al.* 2005, YANG *et al.* 2005a) and indicated a statistically significant association between Asian dust storm events and daily primary intracerebral haemorrhagic stroke admissions three days after the event (YANG *et al.* 2005b). Other works in Taipei demonstrated an association between Mongolian dust storms and clinic visits for conjunctivitis (YANG 2006), daily hospital admissions for cardiovascular disease (CHEN & YANG 2005), daily clinical visits for allergic rhinitis (CHANG *et al.* 2006). However, none of these associations were statistically significant.

In Australia, a number of dust events were significantly associated with changes in asthma severity, but general relationships could not be determined (RUTHERFORD *et al.* 1999). And as far as the Caribbean island of Trinidad, African dust clouds have been associated with increased paediatric asthma accident and emergency admissions (GYAN *et al.* 2005).

Regarding health impacts of dust storms in West Africa, little information is available in the literature. But this does not mean no problems are perceived by local populations. In forty-one villages across Niger, a survey was undertaken by BIELDERS *et al.* (2001) to assess farmers' views about the relative importance of perceived constraints to agricultural production. Against all odds, wind-erosion related health problems were of more concern than crop damage or loss of topsoil by wind erosion. Other studies on meningitis in Africa correlated the incidence of meningococcal disease with dry and dusty conditions (BESANCENOT *et al.* 1997, MOLESWORTH *et al.* 2003). The human health threat of mineral dust is therefore likely to be real, despite statistical evidence from West-African studies because particulate air pollution data are currently inexistent (WHO 2000, BALDASANO *et al.* 2003).

3. Data

Based on horizontal visibility measurements reduced by mineral dust in the air, PM_{10} concentration levels are estimated at Nouakchott, Mauritania, by using a strong relation found in the literature. Comparisons with air quality standards from various sources are realized and discussed. In addition, a first comparison between respiratory diseases and concentrations of particles due to dust storms will be presented.

The meteorological horizontal visibility is one of the elements worldwidely identifying air mass characteristics. In synoptic stations, horizontal

visibility is observed on a hourly basis and defined as the greatest horizontal distance at which a black object of suitable dimensions, located near the ground, can be seen and recognized when observed against a background scattering of hydrometeors (rain, snow, fog, mist) or lithometeors (dust processes) (WMO 1992). Synoptic stations usually use enough targets (buildings, towers, mosques, etc.) with well-measured distance to the point of observation to estimate horizontal visibility. In the scope of this paper, we used data collected in Nouakchott-Airport, Mauritania, for the period 2000 to 2005.

The international synoptic surface observation code (SYNOP code, WMO 1996) allowed the identification of four classes of dust-related conditions:

— Dust being raised from the ground at the time of the observation (SYNOP codes 07 and 08) and reducing horizontal visibility to less than five kilometres (blowing dust).
— Dust storms resulting from turbulent wind systems entraining particles of dust into the air, at various degrees of intensity (SYNOP codes 09 and 30 to 36) reducing horizontal visibility to below one kilometre.
— Dust suspended in the air but not being raised from the ground at the time of observation (SYNOP code 06), remnants of earlier deflation events reducing horizontal visibility to less than five kilometres. Dust deposition is noticed at the time of the observation.
— Haze (SYNOP code 05, presumably caused by dust) reducing horizontal visibility to less than ten kilometres. In this case, no dust deposition is observed, which suggests that dust particles have been raised from the soil at a considerable distance away.

Further detailed information on dust-related conditions used in the literature can be found in OZER (2000).

Only dust processes reducing horizontal visibility to five kilometres and below were taken into account. Horizontal visibility data were selected on a three-hourly basis, *i.e.* at 03:00, 06:00, 09:00, 12:00, 15:00, 18:00, 21:00 and 24:00 UTC. Other horizontal visibility data were not used because only one target is available above this distance and may induce large imprecision.

Monthly health data related to Acute Respiratory Infections (ARIs) were made available from the *Direction de la planification, de la coopération et des statistiques du Ministère de la Santé et des Affaires Sociales* (MSAS) for Mauritania in 2003.

4. Methods

4.1. Relation between Horizontal Visibility and TSP or PM10

Very few studies on the relation between horizontal visibility and PM_{10} levels of mineral dust mass concentration were carried out in West Africa.

Here, we will refer to previous works of D'Almeida (1986) to estimate PM_{10} mineral dust mass concentration. D'Almeida (1986) made a correlation analysis linking observed aerosols turbidity, horizontal visibility and mineral dust mass concentration. This was developed on a turbidity network based on eleven stations set up in the Sahara, in the Sahelian belt and in the surrounding southern area during two years (1981 and 1982). Used visibilities range from 200 metres to 40 kilometres and the obtained relation is:

$$C_{PM10} = 914.06\ VV^{-0.73} + 19.03 \qquad (r^2 = 0.95) \qquad \text{[Eq. 1]}$$

where C is the PM_{10} concentration in $\mu g.m^{-3}$ and VV is the horizontal visibility in kilometre.

Comparative suspended mineral dust concentration data for atmospheric dust processes linked with visibility measurements are very scarce in the literature. Reduced visibility to 1.9 km during a yellow sand storm in Kwangju, Korea, was associated with PM_{10} concentrations of 602 $\mu g\ m^{-3}$ (Kim *et al.* 2001). For this visibility reduction, D'Almeida's relation estimates a concentration in PM_{10} of 591 $\mu g\ m^{-3}$.

This relationship (Eq. 1) is applied to the visibility data of Nouakchott-Airport in order to retrieve PM_{10} estimates. Obtained results are presented at the daily, monthly and derived yearly scale.

4.2. Air Quality Regulations

Several guidelines and regulations have been adopted to define air quality levels. The World Health Organization (WHO) considers Guideline Values (GV), the US Environmental Protection Agency (EPA) defines the National Ambient Air Quality Standards (NAAQS), and the EU labels the Limit Values for Air Quality (LVAQ). A recent compilation of the air quality regulation status around the world has shown that no such criteria exist in Africa (Baldasano *et al.* 2003).

For annual average PM_{10} concentrations, the current strictest value is 40 $\mu g\ m^{-3}$ in the EU and in New Zealand. Elsewhere, when regulations exist, the limit is usually established at 50 $\mu g\ m^{-3}$. In the EU, the limit value of annual PM_{10} will be lowered to 20 $\mu g\ m^{-3}$ in 2010.

For daily particulate matter, Total Suspended Particulates (TSP) concentration has been one criterion to monitor air quality in developed countries during the 1980s and the 1990s and is still used in many developing countries where PM_{10} concentration measurements are not undertaken.

For PM_{10}, the EU-LVAQ is the strictest limit, with 50 $\mu g\ m^{-3}$ not to be exceeded thirty-five days per year and seven days per year from 2010. Other 24-hour standard concentrations range from 100 to 150 $\mu g\ m^{-3}$ (BALDASANO *et al.* 2003). In the USA, the EPA-NAAQS established that the 150 $\mu g\ m^{-3}$ threshold cannot be exceeded more that once per year, averaged over three years. In addition to these daily limits, the US EPA developed the Air Quality Index (AQI) as a tool to provide people with timely and easy-to-understand information on local air quality and on whether it poses a health concern (US EPA 1999). As shown in table 1, the AQI scale has been divided into six categories, each corresponding to a different level of health concern. The first two AQI categories (good and moderate, < 155 PM_{10} $\mu g\ m^{-3}$) have no impact on health, while the last AQI category (hazardous, > 424 PM_{10} $\mu g\ m^{-3}$) is associated with a serious risk of respiratory symptoms and aggravation of lung disease, such as asthma, for sensitive groups, and with respiratory effects likely in general population.

Table 1
US EPA Air Quality Index (AQI), associated 24-hour PM_{10} ($\mu g\ m^{-3}$) concentration, and related health effects (US EPA 1999)

AQI Category	AQI Values	PM_{10} ($\mu g\ m^{-3}$)	Health Effects
Good	0-50	0-54	None.
Moderate	51-100	55-154	None.
Unhealthy for sensitive groups	101-150	155-254	Increasing likelihood of respiratory symptoms and aggravation of lung disease, such as asthma.
Unhealthy	151-200	255-354	Increasing likelihood of respiratory symptoms and aggravation of lung disease, such as asthma; possible respiratory effects in general population.
Very unhealthy	201-300	355-424	Significant increase in respiratory symptoms and aggravation of lung disease, such as asthma; increasing likelihood of respiratory effects in general population.
Hazardous	> 300	> 424	Serious risk of respiratory symptoms and aggravation of lung disease, such as asthma; respiratory effects likely in general population.

Estimated PM_{10} concentrations will be systematically compared with threshold values established by US EPA-NAAQS or EU-LVAQ.

5. Results

5.1. Daily Particulate Matter Concentrations due to Saharan Dust

Estimated profiles of mean daily PM_{10} concentrations due to mineral dust processes are presented in figure 1 for Nouakchott-Airport for the years 2000 to 2005. Horizontal lines indicate the thresholds established for daily concentration.

The major number of affected days by low air quality mainly occurred from January to April, with 50.3 %, 55.2 % and 68.0 % of the yearly number of days above the 24-hour EU-LVAQ and US EPA-NAAQS PM_{10} regulations, and the hazardous air quality, respectively.

Frequency distribution of estimated daily PM_{10} concentration at Nouakchott-Airport is presented in figure 2. Results suggest that, on average, 67.7 % of days were free of mineral dust, with minimum and maximum frequencies of 62.2 % and 72.6 % observed in 2000 and 2001, respectively. Air

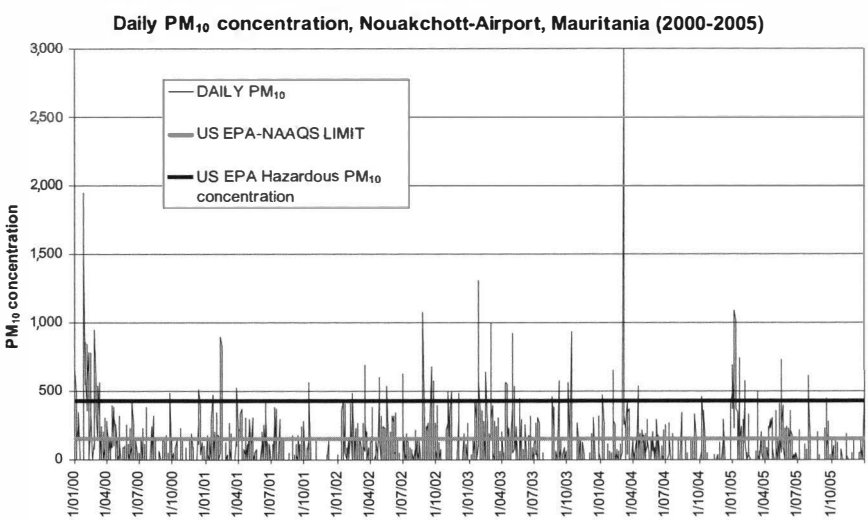

Fig. 1. — Variations of estimated daily mean concentrations of PM_{10} ($\mu g\ m^{-3}$) due to Saharan dust events at Nouakchott-Airport from 2000 to 2005.

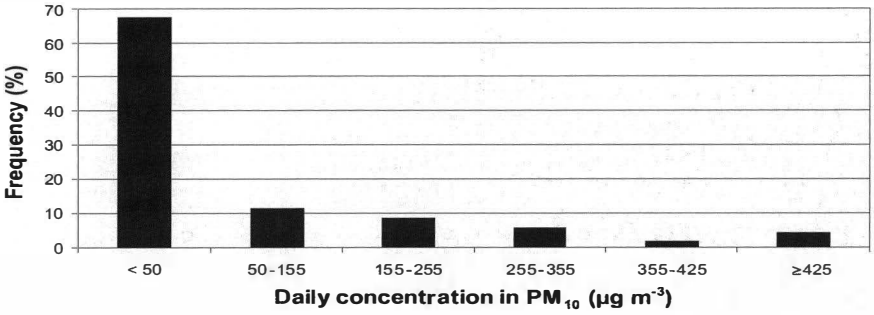

Fig. 2. — Distribution of the frequency of days with selected pollution gradients in PM_{10} ($\mu g\ m^{-3}$) that are associated with health effects (Nouakchott-Airport, 2000-2005).

quality is deteriorated all other days, with 11.6 % of days in the 50-150 $\mu g\ m^{-3}$ range. Compared with threshold daily PM_{10} concentrations established by the EU-LVAQ, the number of polluted days is, on average, 3.4 times above the permitted number of days with >50 $\mu g\ m^{-3}$, and 17 times higher than the legislation on air quality to come into force by 2010. Regarding the comparison with the US EPA-NAAQS, seventy-six days exceed the 150 $\mu g\ m^{-3}$ limit value, with minimum and maximum number of polluted days observed in 2001 (sixty days) and 2000 (eighty-seven days).

Compared with the US EPA-AQI, on average, thirty-one days (8.5 %) may be considered as unhealthy for sensitive groups, twenty-one days (5.7 %) as unhealthy, seven days (1.9 %) as very unhealthy and seventeen other days (4.6 %) may be qualified as hazardous. A total of 20.7 % of days was therefore likely to impact human health in Nouakchott during the 2000-2005 period because of the high frequency of mineral dust processes.

If hazardous air quality (> 424 $\mu g\ m^{-3}$) is on average met seventeen days per year, it varies from nine (2001) to twenty-two days (2000). More striking are the very large concentrations in PM_{10} that may be measured some days during severe dust storms. Yet, two relatively short episodes with extremely high density of PM_{10} are observed (fig. 1). One occurred on January 28 and 29, 2000, with PM_{10} concentrations of 1942 and 1531 $\mu g\ m^{-3}$, respectively. The second one was recorded on March 4, 2004, with a PM_{10} concentration of 2998 $\mu g\ m^{-3}$.

This huge PM_{10} concentration recorded on March 4, 2004, was due to a very large dust storm that is well documented by satellite images. On March 3, very strong winds carrying large quantities of dust were recorded in north-eastern Mauritania and northern Mali (fig. 3). This huge dust plume

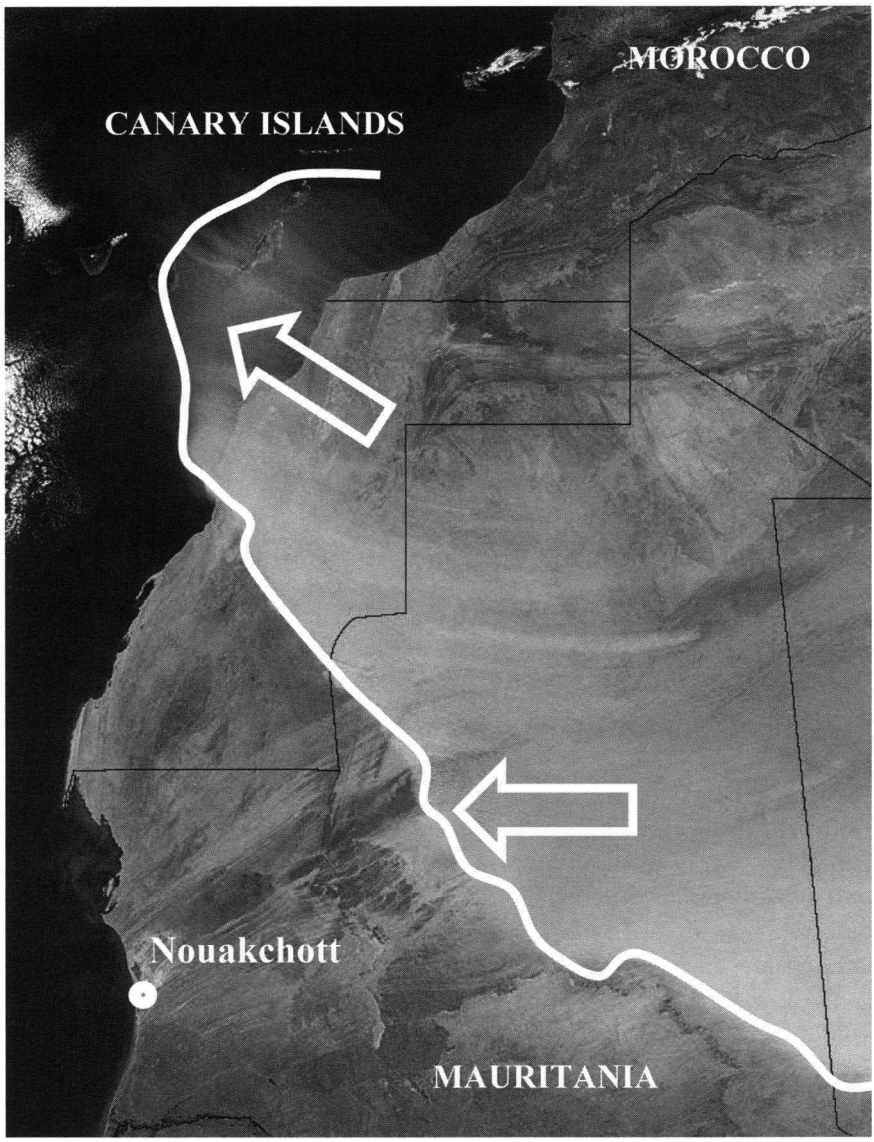

Fig. 3. — Aqua satellite image of the dust storm across western Sahara, March 3, 2004, acquired at 14:15 UTC (source: http://earthobservatory.nasa.gov/, WWW1).

reached Nouakchott on March 4, at 5:25 UTC, with horizontal visibility lower than 50 metres from approximately 8:00 to 16:00 UTC, with wind speeds reaching 12 m s^{-1}. Later that same day, Terra satellite image showed the progression of the Saharan dust off the west coast of Africa (fig. 4). This extraordinary dust storm did affect all West Africa, until Nigeria (WWW3), and was systematically associated with horizontal visibility below 200 metres.

Such very high concentrations are not uncommon during very dense dust storms. In the inland Niger delta region of central Mali, GILLIES *et al.* (1996) reported a daily atmospheric dust concentration of 13,735 μg m^{-3} measured during a dense dust haze. In Beijing, China, daily TSP concentrations greater than 4,000 μg m^{-3} were observed during explosive sandstorm (CHUNG *et al.* 2003b). Regarding daily PM_{10}, CHUNG *et al.* (2003a) recorded a 1,779 μg m^{-3} concentration in Chongwon-Chongju, Korea. In Beijing, PM_{10} concentrations above 1000 μg m^{-3} were reported during dust storms (FANG *et al.* 2003). In Kuwait, DRAXLER *et al.* (2001) measured PM_{10} air concentrations exceeding 1800 μg m^{-3} during severe dust storms.

5.2. MONTHLY AND SEASONAL PM_{10} VALUES DUE TO SAHARAN DUST

Monthly PM_{10} values estimated at Nouakchott-Airport for the 2000-2005 period are presented in figure 5. Results show that air quality degradation due to Saharan dust strongly varies during the year. A maximum value is recorded during the months of January to April, which concentrate 55 % of the annual mineral dust air pollution. Average monthly PM_{10} concentrations are above 100 μg m^{-3} with a maximum in January (146 μg m^{-3}) and a lower value in April (119 μg m^{-3}). A decline in dust activity usually starts in May to remain relatively low from June to December, with a minimum value in August (33 μg m^{-3}). A similar monthly pattern of estimated TSP and PM_{10} concentrations has been observed in Niamey, Niger, where the January-to-March period represents 61% of the annual mineral dust air pollution, with monthly values ranging from 160 to 200 μg m^{-3} in PM_{10} (OZER 2005). In Gouré, eastern Niger, monthly data showed a much higher PM_{10} concentration in January 1984 with 900 μg m^{-3}, but this was at the time of the great drought that affected all the Sahel (OZER *et al.* 2005).

Similar high monthly PM_{10} concentrations (100 to 200 μg m^{-3}) were measured in Iraq, Kuwait and Saudi Arabia during the dust season (DRAXLER *et al.* 2001). On the Aral Sea shore, monthly PM_{10} concentrations up to 400 μg m^{-3} were reported in August, the most intense sandstorm period (WIGGS *et al.* 2003).

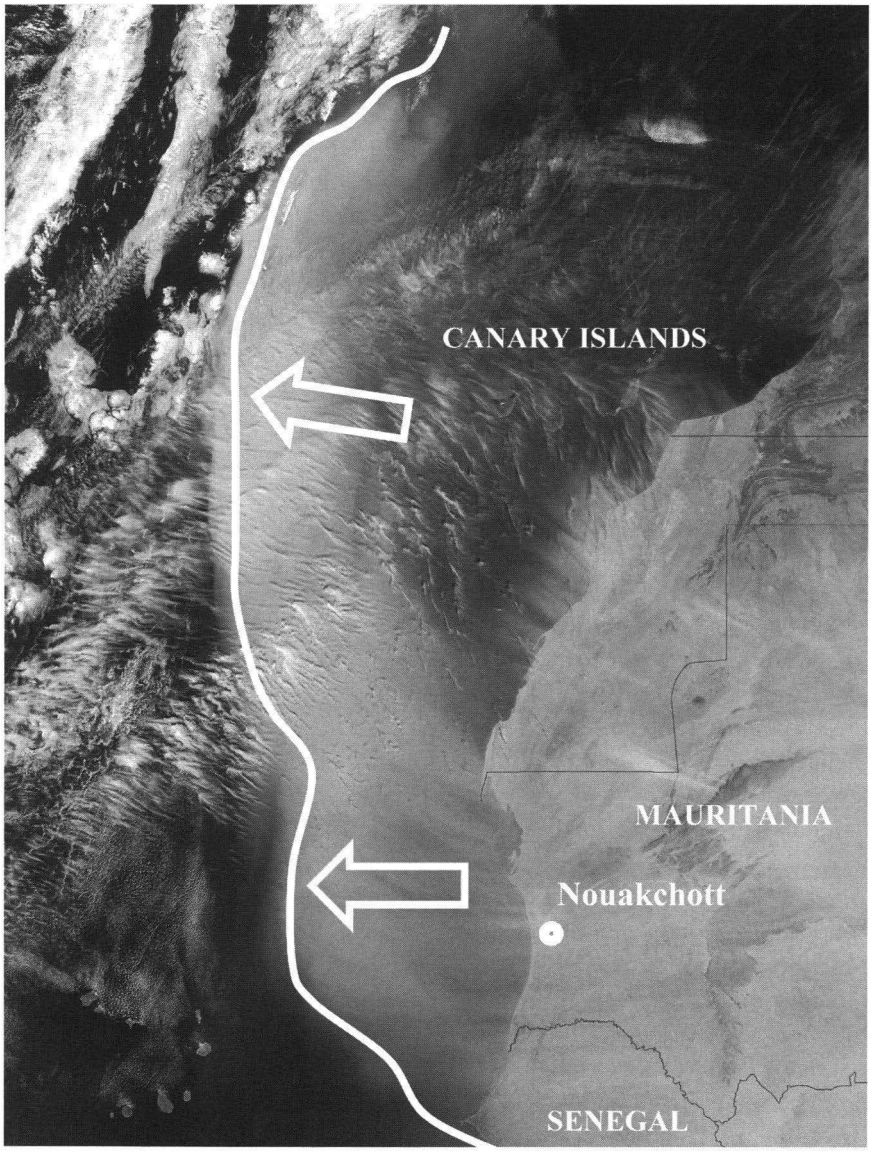

Fig. 4. — Terra satellite image of the Saharan dust off the west coast of Africa, March 4, 2004, acquired at 11:55 UTC (source: http://earthobservatory.nasa.gov/, WWW2).

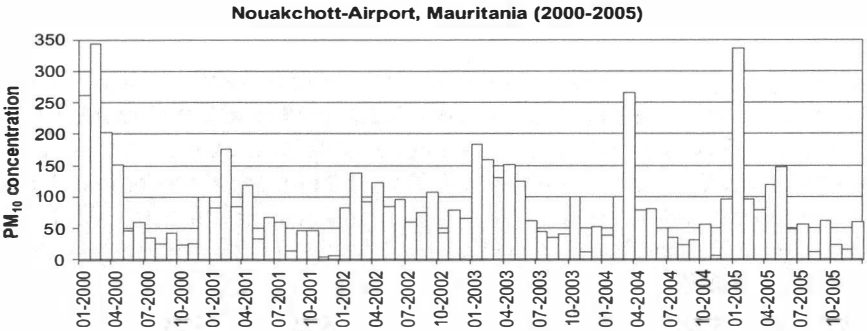

Fig. 5. — Monthly concentration in PM_{10} ($\mu g\ m^{-3}$) at Nouakchott-Airport from 2000 to 2005.

5.3. Yearly PM_{10} Values due to Saharan Dust

The average annual mean estimated PM_{10} concentration is 86 $\mu g\ m^{-3}$ at Nouakchott-Airport for the 2000-2005 period only for natural dust exposure, with yearly variations from 108 $\mu g\ m^{-3}$ in 2000 to 63 $\mu g\ m^{-3}$ in 2001. This figure is far above the norms adopted in developed countries as it is almost twice the threshold value established by the US EPA-NAAQS and four times higher than the limit of the EU-LVAQ yearly mean PM_{10} concentration to come into force by 2010. No comparison can be made with other African data as no measurements are available in the recent compilations of air quality data (Baldasano *et al.* 2003). However, estimated annual mean PM_{10} concentration from visibility impairments in Niamey, Niger, was 67 $\mu g\ m^{-3}$ in 2003 (Ozer 2005) and 344 $\mu g\ m^{-3}$ in Gouré, Niger, during 1984 (Ozer *et al.* 2005). From all annual mean PM_{10} concentrations reported by Baldasano *et al.* (2003), only the city of Tegucigalpa, Honduras, exceeds the Nouakchott value with 157 $\mu g\ m^{-3}$. It is worth mentioning here that no records of PM_{10} concentration are available in arid regions from developing countries.

Such values do not estimate the urban air pollution of the city of Nouakchott, where the activities of rapid urban population growth (558,000 inhabitants in 2000 against 135,000 in 1977, WWW4) do produce large quantities of particulate matter. This urban air pollution mainly results from increasing traffic of old and badly-maintained vehicles on sandy roads, and from individual fires for cooking purposes.

6. PM_{10} Concentrations and Acute Respiratory Infections

Although adverse public health impacts of anthropogenically-derived particulate matter have been well documented, with measurable increases in both morbidity and mortality rates associated with high particulate matter pollution events, there is nothing in the literature for West Africa. In order to assess if dust storms are associated with significant risk to public health in Nouakchott, monthly health data related to Acute Respiratory Infections (ARIs) were made available for the year 2003, a normal year which recorded annual mean PM_{10} concentration of 92 $\mu g\ m^{-3}$ and a maximum monthly PM_{10} concentration of 185 $\mu g\ m^{-3}$ in January.

Figure 6 presents the association between PM_{10} concentrations and ARIs. Results suggest an augmentation of 2.79 % of ARIs per 10 $\mu g\ m^{-3}$ increase in PM_{10}. Although the relation is not very strong (R = 0.60), this association could strongly improve if daily data on ARIs were available, but such data do not exist.

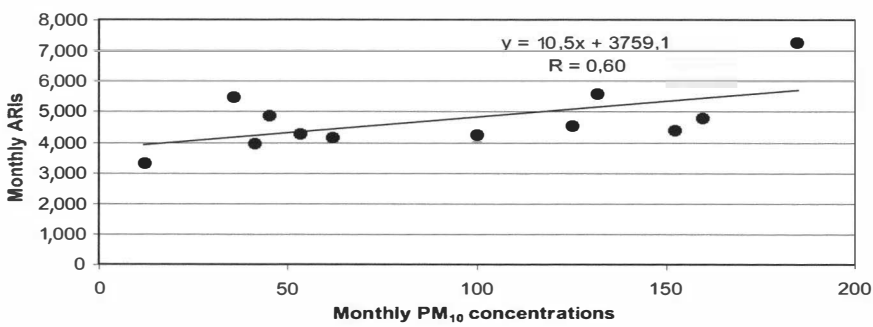

Fig. 6. — Association between PM_{10} concentrations ($\mu g\ m^{-3}$) and Acute Respiratory Infections (ARIs) at Nouakchott in 2003.

Comparison between PM_{10} concentrations and ARIs shows that the most dusty month of January is linked to a strong increase of ARIs as 7,253 people consulted health care officers, *i.e.* 53.4 % more than the monthly mean (4,727 people).

During Mongolian mineral dust outbreaks observed in Taipei, Taiwan, an augmentation of 1.12 % per 10 $\mu g\ m^{-3}$ increase in PM_{10} was recorded for all respiratory diseases (CHEN *et al.* 2004). Our data suggest a higher effect of PM_{10} on the ARIs.

A study of a Gobi desert dust event in the Greater Vancouver region of British Columbia, Canada, in the spring of 1998, showed that naturally-derived particulate matter is more benign than particulate matter of anthropogenic origin, and thus poses a low risk to health for the general public (BENNETT *et al.* 2006). But the maximum daily PM_{10} concentration only reached 47 $\mu g\ m^{-3}$ in the Vancouver region, while people living in Nouakchott breathe larger to much larger PM_{10} concentrations a hundred and eighteen days per year.

7. Conclusions

Developed countries are building up strategies in order to reduce air pollution. On the contrary, most African countries have neither air quality regulations, nor the tools to monitor air pollution. It is known that acute respiratory infections among children are one of the major causes of mortality in developing countries, especially in Africa (BLACK *et al.* 2003, ROMIEU *et al.* 2002, SMITH *et al.* 1999). However, no study of the impact of mineral dust on human health in West Africa has been carried out due to the lack of air quality data.

We have used estimations of PM_{10} concentrations derived from horizontal visibility observations as a first approach to assess the impact of mineral dust resulting from aeolian processes on air quality degradation in Nouakchott, Mauritania, during the 2000-2005 period.

A mean annual PM_{10} concentration of 86 $\mu g\ m^{-3}$, which dramatically exceeds all various norms established in developed countries, is alarming since only natural particulates are considered. The EU-LVAQ limit 24-hour PM_{10} concentration (>50 $\mu g\ m^{-3}$) was exceeded a hundred and eighteen days, *i.e.* seventeen times the legislation on air quality to come into force by 2010. The 150 $\mu g\ m^{-3}$ limit value established by the US EPA-NAAQS was exceeded seventy-six times, with seventeen days that may be qualified as hazardous according to the US EPA-AQI.

Regarding public health, our results suggest an augmentation of 2.79 % of acute respiratory infections per 10 $\mu g\ m^{-3}$ increase in PM_{10}.

ACKNOWLEDGEMENTS

I am very grateful to Mohamed Béchir Ould Mohamed Laghdaf and Sidi Ould Mohamed Lemine from the *Société des Aéroports de Mauritanie* (SAM) for giving free access to the meteorological database. Special thanks also to the *Direction de*

la planification, de la coopération et des statistiques du Ministère de la Santé et des Affaires Sociales (MSAS) for providing data related to Acute Respiratory Infections (ARIs). Jean Gassani also helped the author in the collection of all those data.

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International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 75-87.

L'eau: une arme contre la paix ou un instrument de coopération

par

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MOTS-CLES. — Hydropolitique; Mauvaise répartition; Options unilatérales; Options coopératives.

RESUME. — L'eau est vitale dans toutes les économies. C'est à cause de son rôle prépondérant pour la survie que les relations politiques autour des bassins et des fleuves internationaux tendent à être particulièrement épineuses. Actuellement, la mauvaise répartition de cette ressource pose un sérieux problème du fait qu'elle est gérée en fonction de stratégies politiques et non en fonction des réalités hydrologiques régionales. L'eau sera-t-elle, comme on l'entend de plus en plus, au cœur des conflits du XXIe siècle? Les études qualitatives et quantitatives de l'eau, dans une grande partie des Etats du monde, ont permis d'expliquer les enjeux politiques, économiques, idéologiques et stratégiques de cette ressource et de mettre les sociétés face à leurs responsabilités. Car ce sont bien toutes les sociétés qui sont concernées. Une chose est certaine: il est temps de commencer à agir pour gérer une rareté croissante; il ne reste que peu d'années avant que la rareté de l'eau ne devienne un frein majeur au développement et un catalyseur de tensions.

1. Introduction

«Plutôt que d'être nécessaire à la vie, l'eau est la vie elle-même», disait Saint-Exupéry. L'eau est la ressource la plus abondante de la planète. Selon une étude de la Banque mondiale (1994, p. 1), cette ressource couvre 70 % de la superficie terrestre. Mais, 97 % de cette ressource est enfermée dans les océans et possède une teneur en sel trop élevée. La majeure partie, soit 87 %, des réserves en eau douce — 3 % du total de l'eau — est localisée

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dans les glaciers et les calottes glacières des pôles, l'atmosphère, le sol ou dans les aquifères très profonds.

Seulement 13 % de cette ressource — 0,4 % du total de l'eau — est mobilisable pour les usages des sociétés humaines. Pourtant, cette quantité d'eau douce disponible représente 6 900 m^3 par personne et par an, soit 6,9 fois le seuil de rareté fixé par l'Organisation Mondiale de la Santé (OMS) à 1 000 m^3 par personne et par an. Or, derrière ce chiffre global se cachent de très grandes disparités en termes de qualité et une mauvaise répartition dans l'espace.

Cette ressource est vitale dans toutes les économies. C'est à cause de son rôle prépondérant pour la survie que les conflits politiques autour des bassins et des fleuves internationaux tendent à être particulièrement épineux.

L'eau et la guerre sont deux termes de plus en plus associés. Les fleuves et les bassins qui représentent, environ, deux cent cinquante lignes de partage des eaux couvrent plus de la moitié de la surface terrestre du globe et touchent 40 % de la population.

«L'eau est une ressource qui ignore les découpages politiques, qui évolue dans l'espace et dans le temps, qui génère des exigences multiples et contradictoires quant à son usage, et dont le droit international est peu développé, contradictoire et non exécutoire» (WOLF & HAMMER 1998). En conséquence, beaucoup de spécialistes, de journalistes et de chefs d'Etat désignent l'eau comme la cause de conflits armés au XXIe siècle.

La réalité est tout autre que celle présentée par les défenseurs des scénarios des «guerres de l'eau». Dans l'histoire moderne, les questions de partage des eaux n'ont provoqué que quelques conflits mineurs. Inversement, plus de trois mille six cents traités ont été signés concernant différents aspects du partage des eaux, dont beaucoup sont entrés en vigueur et respectés par les différentes parties signataires.

Etant donné le rôle essentiel de ces accords de partage des eaux, il est étonnant que le processus qui aboutit à leur nécessité, leur négociation et leur structure ait été si peu étudié, tandis que les thèses des défenseurs des scénarios apocalyptiques ont fait l'objet de beaucoup d'études et ont été très médiatisées.

2. L'eau: une grande disparité en termes de qualité

Garantir, en matière d'eau et d'assainissement, des services sûrs et fiables pour tous est un des grands défis que doit relever le développement durable. Dans la quasi-totalité des pays de l'Organisation de Coopération et de Développement Economiques (OCDE), 100 % de la population est

raccordée à un réseau de distribution d'eau potable, et la majorité à un système d'épuration des eaux usées (OCDE 2006). Seuls quelques progrès très timides ont été faits dans les pays en développement. En conséquence, plus d'un milliard de personnes dans le monde n'ont toujours pas accès à l'eau potable et 2,6 milliards à un assainissement de base. Résultat: près de 40 000 décès chaque jour dans le monde — l'équivalent d'un Nagasaki ou d'un Hiroshima tout les deux jours —, dus à des maladies infectieuses, sont imputables à la consommation d'eau contaminée.

Sans mesures particulières, 130 millions de personnes mourront de maladies transmises par l'eau entre 2006 et 2020.

Même en mettant en œuvre les mesures préconisées par les Nations Unies, soit en diminuant de moitié la part de la population qui n'a pas accès à l'eau potable, on doit déplorer 45 millions de décès dus à ces maladies.

3. L'eau: des inégalités dans l'espace

Derrière cette abondance globale de la ressource en eau se cachent des inégalités spatiales. Alors que certains pays et territoires disposent de quantités considérables, d'autres, au contraire, doivent composer avec la rareté de la ressource (tab. 1).

L'Asie, qui rassemble 61 % de la population mondiale, ne dispose que de 36 % des ressources en eau utilisables. De plus, même à l'intérieur de ce continent, les disparités entre pays sont frappantes: 5 494 m^3/hab./an en Ouzbékistan, 4 700 m^3/hab./an en Irak, 149 m^3/hab./an à Singapour et 53 m^3/hab./an dans la Bande de Gaza.

L'Europe abrite 13 % de la population mondiale, mais 8 % des ressources mondiales en eau.

L'Australie et l'Océanie abritent 1 % de la population et 5 % des ressources en eau douce mobilisables du globe.

Le continent américain abrite 14 % de la population mondiale et 41 % des ressources en eau. En Amérique du Sud vit 6 % de la population mondiale, mais on y trouve 26 % des ressources hydrauliques mondiales. L'Amérique latine détient le record mondial de la disponibilité en eau avec 23 103 m^3/hab./an. Le Brésil, avec le cinquième des ressources en eau du globe, est, de tous les pays, le plus riche en eau. Toutefois, la géographie, la pollution et les inégalités sociales déséquilibrent les conditions d'accès à l'eau des Sud-Américains, et la plupart d'entre eux sont loin de consommer la totalité de la part qui leur revient.

L'Amérique du Nord et l'Amérique centrale disposent de 15 % de la richesse en eau douce mondiale et abritent 8 % de la population mondiale.

Tableau 1
Distribution des ressources en eau par région et par habitant

	Ressource en eau par an (milliards de m^3)	**Population** (millions)	**Ressources en eau par habitant et par an** (m^3)
Océanie	769	21	36 619
Amérique latine	10 766	466	23 103
Europe de l'Est et Asie centrale	5 379	287	18 742
Afrique	7 256	495	14 659
Europe de l'Ouest	4 184	559	7 485
Europe de l'Ouest	1 985	383	5 183
Asie	9 985	3 041	3 283
MENA*	355	284	1 250

Source: World Development Report (1995), World Ressource (1992-1993).

* MENA: Middle East and North Africa. Ce calcul ne tient pas compte de la Turquie, ce qui nous semble être une absurdité pour l'hydropolitique régionale.

L'Afrique, qui abrite le même nombre d'habitants que l'Europe, dispose de plus d'eau que le continent européen, soit 11 % de la quantité d'eau douce disponible sur terre. D'où vient l'idée selon laquelle l'Afrique en manque cruellement? Cette idée serait complètement erronée. C'est en tout cas le constat que fait, régulièrement, la FAO. Souvent, les défenseurs de scénarios apocalyptiques en matière d'hydrologie africaine mettent en avant la région du Sahel, voire le désastre du lac Tchad, pour étayer leurs thèses. Loin de minimiser les effets du surpâturage, de la déforestation et des grands projets d'irrigation non durables qui ont réduit la superficie de ce lac de 90 % depuis 1960. Pour donner une image fidèle de la réalité hydraulique africaine, il faut tout d'abord bien séparer les pays du Maghreb, de l'Afrique de l'Est, de l'Afrique de l'Ouest et ceux de l'Afrique noire. Contrairement à ce que certains disent, l'Afrique subsaharienne ne manque pas d'eau. Nous pouvons citer pour exemple le cas de la République Démocratique du Congo, où il y a suffisamment d'eau — 275 700 m^3/hab. — et de terres cultivables pour pouvoir nourrir tout le continent africain. Se focaliser sur un pays comme le Mali, où 80 % de la population a une activité agropastorale et où l'on a du mal à faire face aux problèmes posés par la pénurie d'eau, serait très réducteur pour parler du problème d'eau en Afrique.

4. L'eau est-elle vraiment rare?

La population mondiale a plus que doublé en cinquante ans, passant de 2,5 à 6,1 milliards d'habitants, mais dans le même temps, la consommation d'eau a été multipliée par quatre, pour passer à 790 m^3 par personne et par an. En conséquence, selon le Conseil mondial de l'eau et l'Organisation Mondiale de la Santé, quatre-vingts pays, représentant 40 % de la population mondiale, sont confrontés à des pénuries chroniques, sans disposer, au début du XXIe siècle, de services d'assainissement appropriés (COSGROVE & RIJSBERMAN 1999).

Toutefois, en examinant les situations pays par pays, on se rend compte qu'à ressources comparables, certains pays parviennent à s'adapter, tandis que d'autres peinent à assurer les besoins de tous les secteurs. Ainsi la Jordanie, qui bénéficie de 179 m^3/hab./an, est-elle confrontée à une situation de pénurie aiguë, alors que Singapour, avec 149 m^3/hab./an, n'est pas confronté à l'obligation d'imposer de douloureux rationnements. Avec 79 m^3/hab./an, Malte n'est pas au bord de la catastrophe sociale, mais l'Egypte, avec une ressource de 859 m^3/hab./an, commence à manquer durablement d'eau.

Ces différences tiennent, tour d'abord, aux structures de prélèvement, au niveau de technologie et au degré de sensibilisation de la population de chaque pays.

5. La guerre de l'eau n'aura pas lieu

Trente-deux pour-cent des frontières mondiales sont formées par l'eau. En conséquence, pas moins de deux cents zones de conflit potentiel ont été identifiées par l'Organisation des Nations Unies (ONU). Une partie très importante se trouve en Asie.

Beaucoup d'experts et d'observateurs tirent la sonnette d'alarme en signalant que sur les deux cents zones répertoriées par l'ONU, treize, dont la majorité se trouve au Moyen-Orient, risquent d'être le champ d'une «bataille pour l'eau», si rien n'est fait politiquement pour l'empêcher. WOLF (1996) fait remarquer que toutes les caractéristiques d'un conflit violent pour l'eau au Moyen-Orient sont présentes: un climat aride, le fait que les riverains des fleuves et des bassins sont déjà engagés dans une confrontation politique et que la demande en eau de la population approche ou dépasse l'offre annuelle.

Ces craintes d'un conflit généralisé avec le risque d'embrasement dans toute la région sont aussi exprimées par BULLOCH & DARWICH (1993). Ces derniers font remarquer que le manque d'eau n'est pas un problème spécifique au

Proche-Orient, mais que c'est dans cette région que le problème est le plus dangereux. Ce danger est lié au fait que les pays de la zone possèdent de vastes réserves financières, un large éventail d'armements, une force aérienne, des missiles et, dans certains cas, la capacité nucléaire. Ils ont aussi une tradition historique qui les prédispose à régler les disputes par des moyens militaires.

Les hommes politiques ne sont pas restés indifférents à la menace qui pèse sur la rareté de cette ressource. Boutros Boutros-Ghali, l'ex-Secrétaire général des Nations Unies et le négociateur des accords de paix israélo-égyptiens, n'est pas connu pour son alarmisme ni pour sa rhétorique extrême. Il déclare pourtant que la prochaine guerre au Proche-Orient pourrait avoir l'eau pour enjeu. Feu le roi Hussein de Jordanie, qui se distinguait par son habileté de négociateur, déclara à son tour qu'il ne pouvait imaginer que son pays puisse encore affronter militairement Israël, excepté pour l'eau.

Les Israéliens, de leur côté, brandissent la menace d'attaquer les pays en amont du lac de Tibériade si le moindre barrage réduisant le flux de ce lac était érigé.

L'ancien ministre de l'agriculture israélien, Eitan Rafael, déclare «qu'abandonner le contrôle de la Rive occidentale pourrait avoir un effet préjudiciable immédiat et significatif sur l'approvisionnement en eau d'Israël». Il ajoute que «rendre l'eau aux Palestiniens pourrait constituer un danger mortel pour Israël et pourrait de manière tangible menacer son existence» (CASA 1991).

Shimon Pérès (1993), ancien ministre des Affaires étrangères israéliennes, soutient qu'il est probable que la prochaine guerre dans la région sera déclenchée, non point à cause du problème des frontières, mais à cause de la lutte pour le partage des eaux régionales.

Les adversaires de ce scénario apocalyptique sont convaincus que la guerre de l'eau n'aura pas lieu si une vraie volonté de paix et de coopération se manifeste. Ils estiment que les partisans de ce scénario utilisent des données sélectives pour étayer leurs thèses. Ils ajoutent que la question de l'eau n'est pas une question de rareté, mais plutôt un problème de répartition et de gouvernance.

6. Les options techniques et politiques pour une gestion efficace de l'eau au Moyen-Orient

Les différentes solutions techniques, économiques et politiques proposées par les différents spécialistes pour faire face aux pénuries d'eau, ont toutes pour objectif l'augmentation de l'offre ou la réduction de la pression de la demande en eau (tab. 2).

Tableau 2
Les différentes options pour la gestion de l'eau

Options unilatérales
Réduire la demande
• Contrôle démographique
• Agriculture efficace
• Importation d'eau virtuelle
• Tarification de l'eau
• Programmes de sensibilisation de la population
Augmenter l'offre
• Traitement des eaux usées
• Construction de barrages, de lacs de retenue, de puits, de canaux, etc.
• Dessalement
• Exploitation des aquifères fossiles
• Transport d'eau par des aquatiers et de grands sacs plastiques
Option coopérative
• Transfert interbassin

7. La gestion de la demande

La gestion de la demande en eau peut prendre de nombreuses formes, depuis le contrôle de la croissance démographique, l'utilisation de techniques efficaces d'irrigation, l'importation d'eau virtuelle et la tarification de l'eau, jusqu'à des mesures d'incitations financières, des programmes de sensibilisation de la population.

L'accroissement maximum de la population s'est arrêté au cours de la décennie 1980 aux environs de 2,2 % par an et, actuellement, il est en recul inégal selon les pays grâce à l'alphabétisation de la population. Il est en moyenne de l'ordre de 1,8 à 2 % l'an.

Si les tendances actuelles de la baisse de la fécondité se confirment, cette évolution semble être réellement un maximum et sans doute ne sera-t-elle pas atteinte. Mais il faut s'attendre à une demande d'eau beaucoup plus importante que le simple accroissement démographique en raison des bouleversements économiques et sociaux qu'enregistre la société mondiale: la croissance urbaine et l'augmentation des superficies irriguées.

Pour faire face aux problèmes de la dépendance alimentaire, l'amélioration des performances dans le domaine agricole est devenue une priorité dans la majorité des pays en voie de développement.

La Banque mondiale estime que dans ces pays, on dépense beaucoup d'eau pour une faible production. Les pays en développement consacrent 88 % de leurs ressources en eau à l'irrigation, alors que la moyenne mondiale se situe à 70 %.

Beaucoup d'experts suggèrent des méthodes d'irrigation plus efficaces, le goutte-à-goutte par exemple, pour faire face à cette situation.

Le goutte-à-goutte n'est cependant pas une solution miracle. En effet, cette technique d'amélioration des rendements implique des investissements très élevés que les agriculteurs — surtout maliens, colombiens, palestiniens, jordaniens et syriens — ont rarement les moyens de réaliser. Par exemple, équiper un hectare de terre avec un système de goutte-à-goutte revient à environ deux mille dollars.

Dans les pays en voie de développement, les agriculteurs utilisent deux fois plus d'eau par hectare que ceux des pays du nord de la Méditerranée pour une production agricole deux fois et demi inférieure en valeur. Dans ces pays les gouvernements ne contrôlent pas le pompage des eaux souterraines, même lorsque les nappes sont surexploitées. De plus, les gouvernements n'utilisent pas d'incitants financiers pour encourager les agriculteurs à se tourner vers des modes d'irrigation qui consommeraient moins d'eau.

Toutefois, la recherche dans le domaine du génie génétique végétal pour la résistance contre la sécheresse et la salinité des sols (*genetic engineering for drought and salinity resistance*) représente un grand espoir pour les agriculteurs des pays en voie de développement. Un certain nombre de pays arabes utilisent, d'une manière discrète, les fruits des recherches génétiques israéliennes en achetant les graines de l'Etat hébreu. Dans un contexte de paix, cette pratique se généralisera et les agriculteurs des Etats arabes bénéficieront d'une économie d'échelle dans ce domaine.

Le concept d'eau virtuelle (ALLAN 2001) est une solution qui permettra de réduire la production des denrées agricoles là où elle induit de très fortes consommations d'eau, pour se tourner vers l'importation de ces mêmes denrées et consacrer cette eau ainsi économisée à des usages plus rentables.

Selon la *Food and Agriculture Organization* (FAO), 1 300 m^3 d'eau permettent de produire une tonne de blé, d'une valeur marchande d'environ 123 dollars en 2004, alors que la même quantité d'eau permet de dégager une valeur industrielle d'environ 14 000 dollars.

Cette réponse aux pénuries d'eau — si elle semble rationnelle — heurte les sensibilités politiques dans les pays en voie de développement, et plus particulièrement pour deux raisons.

Pour des raisons sociales tout d'abord: la population rurale qui travaille dans le secteur agricole est encore très importante dans ces pays. Supprimer leur activité économique signifie les pousser à l'exode vers les villes, dont les infrastructures ne suffisent déjà plus à la demande et où ils finiront par faire le lit des intégristes.

Pour des raisons politiques ensuite: l'autosuffisance alimentaire dans ces pays n'est pas seulement un slogan post-indépendantiste, mais aussi un axiome politique pour les peuples de la région, et plus particulièrement après l'embargo économique vécu par le peuple iraquien durant les années 1990.

La question du prix de l'eau, de sa tarification, est souvent posée en termes pressants par de nombreux experts, notamment les spécialistes de la Banque mondiale, dans la logique d'économie libérale du Fonds Monétaire International (FMI). Les partisans de cette thèse voient l'eau comme un bien économique, donc commercialisable, et par conséquent soumis aux règles de la rentabilité (CAMDESSUS *et al.* 2004).

Les adversaires de cette thèse considèrent l'eau comme un patrimoine mondial de l'humanité et l'accès à cette ressource comme un droit inaliénable (PETRELLA 1996).

Dans les pays en voie de développement, l'eau est administrée en termes de distribution et non de conservation et d'économie. L'eau, «don de Dieu», est considérée comme un bien naturel, inépuisable et gratuit.

La rareté de la ressource et les perspectives d'une réelle pénurie ont conduit quelques Etats du Tiers-Monde à encourager une meilleure gestion de la ressource et à modifier la politique de tarification. Les mentalités évoluent peu à peu chez les populations.

8. La gestion de l'offre

Des techniques pour accroître le volume d'eau disponible existent: la construction de barrages, de lacs de retenue, de puits, de pompes, de canaux, etc. Or, ces techniques ne sont pas nécessairement les plus simples, ni les moins coûteuses. De plus, elles soulèvent parfois de graves questions politiques.

En règle générale, ce sont les ressources de surface qui sont exploitées en premier. A mesure que les nouvelles sources d'approvisionnement en eau de surface deviennent moins accessibles et que les coûts d'exploitation deviennent plus élevés, d'autres sources d'alimentation, notamment les eaux souterraines, y compris les eaux fossiles, prennent de l'importance. A mesure que l'on se rapproche de la pleine exploitation des ressources en eau douce renouvelables, les méthodes non conventionnelles d'approvisionnement en

eau, telles que le traitement des eaux usées, le dessalement de l'eau de mer et les importations d'eau par transport ou par transfert interbassin, peuvent devenir les seules permettant d'obtenir de nouvelles ressources.

Les possibilités d'utilisation pour l'irrigation des eaux usées traitées ont été étudiées en détail dans un rapport publié en 1994 par la Banque mondiale. La conclusion de ce rapport est que le recyclage des eaux usées peut à la fois augmenter l'approvisionnement en eau et avoir d'importants effets écologiques dans la mesure où cette utilisation est soigneusement contrôlée. Le volume total des eaux usées augmente rapidement et, bien que dans la plupart des pays il reste faible par rapport à l'ensemble des ressources renouvelables, dans les pays de la péninsule arabique, où l'eau manque, les eaux usées peuvent représenter à long terme la principale source d'approvisionnement pour l'agriculture à fort coefficient d'irrigation.

De grandes superficies en bénéficient déjà dans plusieurs pays — Israël, Jordanie, Arabie saoudite — et d'autres projets-pilotes s'étendent largement dans toute la région.

Le coût de l'épuration des eaux usées, selon les indications fournies dans le rapport de la Banque mondiale, se situe entre 0,12 et 0,40 dollar par m^3 selon les techniques employées, un prix qui se compare favorablement à celui du dessalement.

Les techniques de dessalement consistent à extraire le sel dissous dans l'eau de mer ou saumâtre. Plusieurs procédés existent: les technologies thermiques classiques, la filtration membranaire et l'osmose inverse.

Aujourd'hui, 1 % de l'eau potable à travers le monde est produit par dessalement. La capacité totale de traitement dans le monde était de 23 millions de m^3 par jour en 2000.

Les coûts de dessalement de l'eau de mer ont baissé de plus de 84 % depuis 1978. Les gains de productivité dans la technologie permettent une rapide baisse du prix de revient du mètre cube.

Certes, de très nombreuses usines de dessalement sont construites au Moyen-Orient, à la fois parce qu'il y a peu d'alternatives et parce que le coût de l'énergie n'est pas un obstacle pour les pays producteurs de pétrole.

L'eau dessalée peut être distribuée aux consommateurs à des prix compris entre 0,8 et 4,6 dollars le m^3, selon la qualité d'eau à dessaler, le type de centrale de dessalement et les économies d'échelle que permet la production.

Les niveaux de prix de l'eau dessalée sont encore loin de la rendre propice à tous les usages: il s'agit vraiment d'une eau à usage domestique ou industriel. Elle ne peut convenir aux usages agricoles car, par exemple, les agriculteurs israéliens ne paient que de 0,12 à 0,16 dollar par m^3. De plus,

la transporter sur de grandes distances augmenterait son coût. L'eau dessalée convient pour des besoins locaux, dans des régions côtières.

Des navires-citernes modifiés, ou aquatiers, peuvent transporter de grandes quantités d'eau douce sur de longues distances. Cette pratique a déjà été utilisée entre la Turquie et Israël et entre Marseille et la Sardaigne.

Les coûts de transport par navire-citerne sur de longues distances rendent encore cette option peu avantageuse, si on la compare au dessalement.

Quant à la technologie des grands sacs plastiques, elle offre un prix de revient théorique plus avantageux que les aquatiers. Le coût de fabrication des sacs varie entre 125 000 et 275 000 dollars, soit nettement moins qu'un navire, et leur entretien est moins onéreux.

Une étude de faisabilité de l'importation de 50 millions de m^3 d'eau par remorquage de grands sacs plastiques entre la Turquie et Israël par mer, a permis d'évaluer les coûts à 0,22 dollar par m^3. Pour l'autre mode de transport — les aquatiers —, les coûts ont été évalués à plus de 1 dollar par m^3.

Mais les sacs d'eau présentent un inconvénient: outre le remorquage, ils ont besoin d'une infrastructure d'accueil, pour le remplissage, puis le pompage. Infrastructure d'autant plus spécifique que le volume est imposant. De plus, leur capacité à supporter les contraintes de traversées en haute mer reste à démontrer à long terme.

Malgré la nécessité des modèles de gestion de l'eau par la réduction de la demande ou l'augmentation de l'offre, leur mise en œuvre se heurte encore à des obstacles de nature économique, politique, sociologique et culturelle.

9. L'eau: un instrument de coopération

Sous le triple choc de la sécheresse, de la pollution, de la croissance démographique et urbaine, l'eau qu'on croyait inépuisable devient un bien rare dans pas mal de pays de la planète. Toutefois, cette situation n'est pas la conséquence d'une pénurie généralisée, mais plutôt une question de mauvaise répartition entre les pays les mieux dotés en eau et d'autres qui le sont moins.

Face aux faiblesses des différents modèles macroéconomiques, la mise en œuvre de chantiers hydrauliques permettant le transfert de l'eau des régions les plus dotées de cette ressource vers celles qui le sont moins, s'impose.

Les techniques permettant la mobilisation de très grands volumes d'eau des régions fortement dotées vers d'autres qui en manquent, existent.

Le projet espagnol de dérivation des eaux de l'Ebre prévoit le transport de 2,9 millions de m^3 par jour, essentiellement vers le sud de l'Espagne (82 %), le reste vers la Catalogne.

Les Russes et les Américains ont fait de cette technique un élément central de leur stratégie de mise en valeur des terres agricoles, avec les canaux issus des fleuves Syr et Amou en Asie pour les premiers, et les multiples canaux du Midwest et de la Côte Ouest pour les seconds.

Au Moyen-Orient, des projets qui préconisent la réduction des tensions autour de l'eau par son importation existent. Même si aucun accord n'est intervenu entre les Etats de la région, rien ne peut justifier leur abandon.

Durant ces trente dernières années, plusieurs projets de transfert interbassin ont vu le jour au Moyen-Orient. Nous n'avons retenu que ceux qui sont en conformité avec le droit international, à savoir: *pipeline* Euphrate-Jordanie, *pipeline* de la paix, mini *pipeline* de la paix, mini-mini *pipeline* de la paix et canal de la paix de Sadate.

Le manque de bonne volonté politique a laissé ces chantiers au stade de projet.

10. Conclusion

La situation actuelle de l'eau est lourde de menaces, source d'inquiétudes et obstacle à la coopération.

La rareté de cette ressource dans certains Etats est réelle, même si elle côtoie souvent le gaspillage et l'utilisation inconsidérée.

Dans un contexte où la mobilisation de ressources nouvelles est incertaine, cette rareté ne fera que s'aggraver avec l'accroissement démographique, l'urbanisation, la pollution.

Comme nous l'avons expliqué, la mauvaise répartition de l'eau ne débouchera pas sur un conflit armé.

Certes, la question de l'eau peut être un obstacle majeur à la paix et à la coopération régionale, comme dans le cas de la question du Jourdain, du Nil ou du Tigre-Euphrate.

Toutefois, même si le droit international est encore très balbutiant en matière de partage de l'eau, il ne faut pas négliger le chemin parcouru par un nombre important d'Etats grâce aux négociations de paix et à la coopération.

Seul le triomphe de la volonté de paix et de coopération autour d'une ressource rare peut faire face aux futures pénuries qui menacent les deux cents zones répertoriées comme conflictuelles.

L'accroissement de la quantité d'eau disponible est une condition nécessaire mais pas suffisante. Un potentiel pour une meilleure gestion de la ressource existante se trouve à la portée des gestionnaires et des décideurs politiques. Mais il faut mobiliser ce potentiel grâce à la négociation entre les différents Etats riverains et l'arbitrage politique de la communauté internationale. Ce qui nous fait dire que la question de l'eau est, avant tout, une question politique.

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International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 89-96.

Health Problems in Areas of Human Vulnerability: Field Experience of *Médecins Sans Frontières* (MSF) in the Sahel Region

by

Mit PHILIPS*

KEYWORDS. — Access to Care; Food Insecurity; Malnutrition; Sub-Saharan Africa; User Fees.

SUMMARY. — During the nutritional crisis of 2005, malnutrition rates reached very high levels in certain regions of Niger and neighbouring countries. In Niger, 40,000 severely malnourished (Weight/Height (W/H) below 70 %) children were treated in MSF's therapeutic feeding centres. In spite of the severe crisis, general free food distribution did not happen. As alternative, subsidized food was brought on the local market, but this remained out of reach of most of the already completely destitute families. This year, a similar crisis announces itself, with many months of continuing high levels of malnutrition. The question begs whether one can still speak about a temporary crisis situation or rather can label this an endemic state of malnutrition and associated child mortality.

In most Sahel countries, basic health care services are paid for by patients, also in public structures. Patient fees need to be paid before care can be obtained. MSF conducted epidemiological surveys in several of these low-income countries, to assess the impact of these patient fees in terms of exclusion of patients in need of care and in terms of further impoverishment of households. The results of the survey in Mali illustrate the degree of the problem. Thirty per cent of people did not seek any care during their last episode of illness, mainly because of lack of money to pay for care. Moreover, using the public health centre signified for an important proportion of patients the need to borrow money or sell goods to mobilize the cash. This led to delays in health care and carries risks of further impoverishment of the family. The median price paid for care was the equivalent of 6 $US, representing twenty days of an average income. Less than 2 % of the patients were exempted from payment, in spite of the national policy on protection of those unable to pay. Patient fees in a context of generalized poverty jeopardize access to essential health care and are counterproductive within the framework of the international commitment of poverty reduction and the Millennium Development Goals.

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1. Introduction

Médecins Sans Frontières, a medical humanitarian organization, is active in different countries of the Sahel belt, and in some of them for many years. The main focus of MSF's intervention is put on health problems in vulnerable population (groups). From our field experience of recent years, we would like to highlight two particular issues: 1. recurrent or continuously high levels of acute malnutrition on a large scale; 2. access barriers to paying health care in public health services among an impoverished population.

2. High Levels of Malnutrition: the Case of Niger

During the nutritional crisis of 2005, malnutrition rates reached very high levels in certain regions of Niger and neighbouring countries. Table 1 shows malnutrition rates measured during population-based surveys in selected contexts.

Table 1
Malnutrition rates as measured by MSF through population-based surveys in selected contexts during the year 2005

Acute malnutrition (Weight/Height)	**Total** (below –2SD)	**Moderate** (between –2 SD and –3 SD)	**Severe** (below –3 SD)
Mali, Goundam	17.0 %	15.5 %	1.9 %
Chad, Kanem	15.1 %	10.5 %	4.6 %
Niger, Maradi (April)	19.3 %	17.4 %	2.9 %
Niger, Maradi (Sept.)	19.2 %	15.1 %	4.1 %

We focus on the specific experience of MSF in Maradi in Niger (fig. 1). Maradi is a densely populated area (2.5 million inhabitants, with 65 inhabitants per sq. km on average). Twenty per cent of the population live on 3.3 % of the surface, concentrating in the south, where agriculture is most developed. In contrast with an overall relatively good agricultural production in the area, an important degree of food insecurity exists, mainly caused by extreme poverty. Food production per inhabitant is deficient and in particular during the lean period (May to October) there are problems.

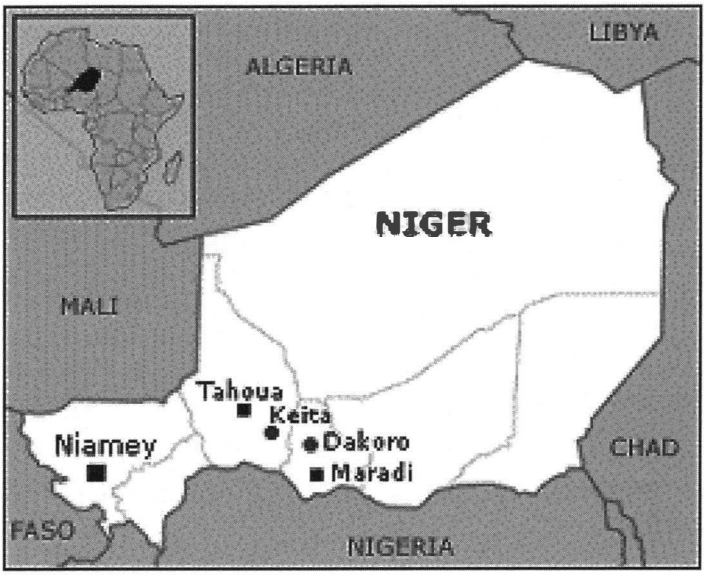

Fig. 1. — Map of Niger with location of Maradi.

Since 2001 MSF is present in the area and has provided nutritional care for severely malnourished (below –3 SD) children in therapeutic feeding centres and for moderately malnourished children (below –2 SD) in supplementary feeding centres. MSF teams have experienced a worsening of the situation, with increased numbers of malnourished children and an expansion of the lean period duration over longer periods of time.

In 2005 an extreme crisis appeared. The number of severely malnourished children admitted to MSF feeding centres increased significantly. In response, extra facilities were opened, allowing to admit more children closer to their homes. Compared to the seasonal rise in previous years, the number of malnourished children skyrocketed, with up to 2,000 children per week admitted because of severe malnutrition (fig. 2).

In spite of the severe crisis, general free food distribution did not happen. As alternative, subsidised food was brought on the local market, but this remained out of reach of most of the already completely destitute families. Market prices did not diminish sufficiently to allow people to have access to it. Therefore, the measures injecting food subsidies may have increased the availability of food on the market, but did not tackle their unaffordability, thus blocking households to have access to the available food. In figure 3 the

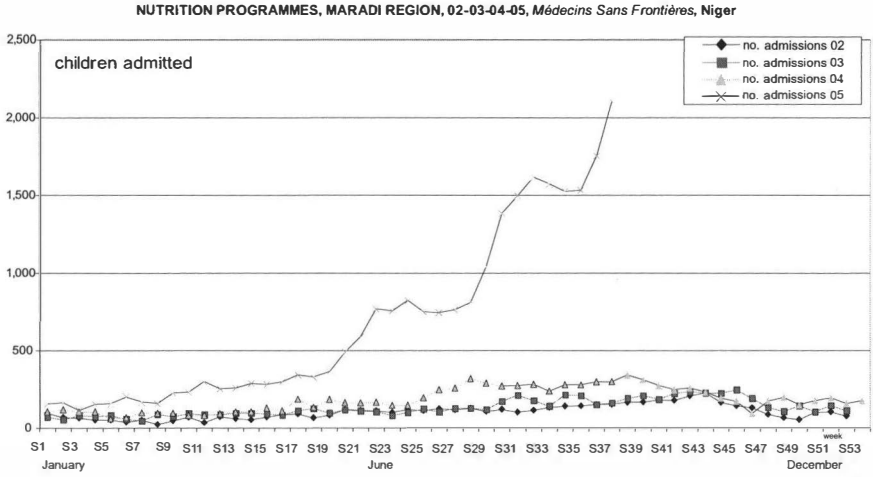

Fig. 2. — Evolution of the number of malnourished children admitted to MSF feeding centres from 2002 to 2005.

relation is shown between the price increase of millet — the main staple food — and the increase in malnourished children admitted. The two curves are strikingly similar, separated by an average period of five weeks.

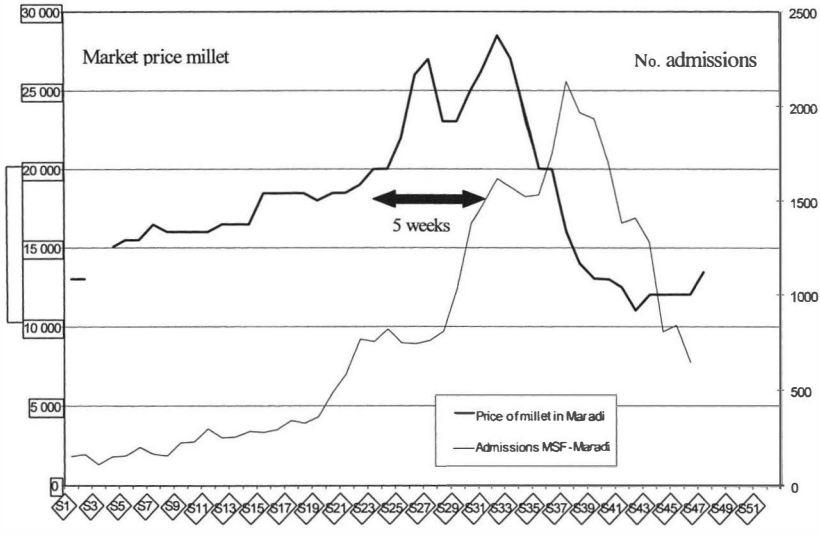

Fig. 3. — Comparison between market prices for millet and number of severely malnourished children admitted in Maradi region, Niger (2005).

The intensity, the recurrent nature of the nutritional crisis, and the extent of the population affected by the crisis, beg also the question if one can still speak about a temporary crisis situation or rather can label this an endemic state of malnutrition and associated child mortality. Are the usual development interventions still adapted to this type of situation?

The classic interventions based on food subsidies and market support seem to have failed in these circumstances (MSF 2006). Subsidised food remains inaccessible to households because they still must be paid for, whereas most households have no cash and have run out of assets to sell. "Food for work" is also questionable as measure, as the net caloric gain remains low and many households cannot provide the necessary labour force. There is clearly a need for free food distribution in order to guarantee access to food. Otherwise the most vulnerable households remain excluded.

The refusal by development actors to recognize the depth and extent of the nutritional crisis and their clinging to market support as sole measure are closely linked and raise the question when exceptional measures are considered justified. Overall, 40,000 severely malnourished (W/H below 70 % or below –3 SD) children were treated in the MSF's therapeutic feeding centres in 2005. Should we consider them as the acceptable side effect of failing development programmes?

3. Primary Health Care Unaffordable due to User Fees: the Case of Mali and Chad

As in most of the sub-Saharan African countries, basic and essential health care services are paid for by patients in most Sahel countries. Payment is generalized, including in public health structures. The introduction of user fees was considered justified as a response to the crisis in the health sector of low-income countries in the 1980s. This policy was endorsed by the World Bank within social adjustment reforms and — although from a different perspective — in 1987 promoted by the WHO and Unicef for Africa, through the 'Bamako Initiative'. Although raising hope at that time, experience has shown many negative effects on equity, effectiveness and efficacy of health services (ARHIN-TENKORANG 2000, GILSON 1997, RUSSELL & GILSON 1997). Moreover, health care expenses pose serious risks for further impoverishment for patients and their family (MEESSEN *et al.* 2003, XU *et al.* 2003). However, in the absence of an adequate state health budget and sufficient international funding for health, user fees remain the most important financing strategy for health care (WHITEHEAD *et al.* 2003).

With the objective to care for patients, where possible through public structures, MSF has documented the existing financial barriers to essential care and investigated the consequences of user fees for the population. MSF has conducted epidemiological surveys in several of these low-income countries to assess the impact of these patient fees in terms of exclusion of patients in need of care and in terms of further impoverishment of households. MSF has investigated access to care during the most recent illness episode among those households living at a reasonable distance of health centres applying user fees for primary health care. This suggests that exclusion is likely to be even higher in households living further away from a health centre, as geographical barriers become more stringent. We will discuss the results of surveys done in Bougouni (Mali) and in Bongor (Chad).

3.1. Bougouni, Mali

The results of the survey in Bougouni, Mali, illustrate the degree of the problem (MSF 2006). Overall, less then half of the ill persons consulted the nearest health centre (46 %). Thirty per cent of people did not seek any care during their last episode of illness, and two in three failed to do so for lack of money to pay for care. Some 17 % of ill people sought care from the informal sector, with one in three giving lack of money as main reason.

The median price paid for care obtained at the nearest health centre was the equivalent of 6 $US, representing twenty days of an average income. Less than 2 % of patients were exempted from payment, in spite of the national policy on protection of those unable to pay. Thirty-five per cent of patients had to borrow money or sell goods in order to mobilise cash to pay the required fees.

Moreover, using the public health centre signified for an important proportion the need to borrow money or sell goods to mobilise the cash. This led to delays in health care and carries risks of further impoverishment of the family. Ninety-eight per cent of households lived with less than 1 $US per person per day (the international threshold of extreme poverty), with rural households facing more cash problems. At the moment of the survey, 40 % of households declared a debt and one in six had a debt related to health care.

3.2. Bongor, Chad

In Chad, investigating episodes of malaria in Bongor revealed similar consequences of user fees (MSF 2006). Overall, only 56 % of all reported malaria

patients received complete treatment for malaria in the nearest health centre. Among the people who reported illness, 16.3 % did not consult anybody during the last episode of suspected malaria. Lack of money was reported as the major reason for not attending (76 %).

Instead, 21 % of people consulted the informal sector, mainly drug peddlers. For patients consulting the nearest health centre, the median fee paid was 1,500 FCFA (equivalent to $US 3.1), and 4,535 FCFA in hospital. In the informal sector, people paid less, a median fee of 700 FCFA. The price in the nearest health centre was the equivalent of a median twelve days of revenue; for the poorest quintile it was equivalent to one month's revenue. Fees were waived for only 1.7 %, and for only one in a hundred and three users in the poorest quintile.

Among those who used the nearest health centre, only 32 % had cash available to pay for care. Others obtained the money by selling goods or incurring a debt; for 48 % this risked (further) impoverishment. Ninety per cent of the study population were living on less than $US 1 per person/day; 50 % on less then $US 0.23; the poorest 20 % on less than $US 0.12. Given the widespread poverty of this population, these prices for essential health care are unaffordable for most; other costs, such as transport, and lost earnings reduce access even further. Our results highlight the general difficulties in ensuring accessible and affordable malaria treatment through health services that apply cost recovery, even when treatment is heavily subsidised. Donors, NGOs and health authorities need to ensure that the introduction of a new, more expensive treatment, such as ACT, goes hand in hand with measures to guarantee that this treatment is accessible and affordable. Table 2 and table 3 give an overview of these findings.

We conclude that patient fees in a context of generalized poverty, such as investigated in Mali and Chad, jeopardize access to essential health care and are counterproductive within the framework of the international commitment of poverty reduction and the Millennium Development Goals. The financial barriers caused by patient fees at primary health care levels have also negative consequences for the effectiveness of any medical intervention through these health structures, as they restrain coverage, limit effective use of resources and might place a financial burden on vulnerable patients.

Table 2
Overview of survey results on access to care in two contexts: Bougouni (Mali) and Bongor (Chad). Both surveys were conducted in 2005

	Bongor (Chad)	Bougouni (Mali)
Use of nearest health centre	57 %	46 %
Use of informal sector	21 %	17 %
Reason lack of money	*49 %*	*30 %*
No care beyond home	16 %	30 %
Reason lack of money	*76 %*	*65 %*

Table 3
Prices paid by patients and proportion of patients exempted among those attending public health centres in two contexts: Bougouni (Mali) and Bongor (Chad)

	Bongor (Chad)*	Bougouni (Mali)*
Total price paid by patient as equivalent $US	3,1 $US	6 $US
Total price paid by patient as equivalent to days of total expenditure	12 days	20 days
Proportion of patients exempted from payment	1,7 %	2 %

* Both surveys were conducted in 2005.

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Remediation and Local Governance

International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 99-107.

Building Livelihood, Saving Land: An Integrated Approach to Combat Desertification

by

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KEYWORDS. — Degradation; Desertification; Drylands.

SUMMARY. — Desertification threatens over 41 % of the Earth's land area, mostly in the dry regions, and has both environmental and economic (livelihood-related) impacts. Poverty leads to resource overexploitation and desertification, which in turn causes more poverty. Combating desertification will require, in addition to innovative technologies, enabling policies, appropriate institutions and regulatory frameworks utilizing an interdisciplinary multisectoral approach.

ICARDA and its partners have developed a range of research outputs that are contributing to global efforts to combat desertification. These include mapping of agroecological zones; decision-support software for characterization of climatic stresses; introduction of cereal-legume combinations to improve sustainability; low-cost water-harvesting methods; conservation-agriculture technologies; integrated pest-management methods; and technologies to improve livestock nutrition.

Degraded dryland areas are being rehabilitated using an integrated community-based approach. Crop diversification and value addition are substantially increasing farmers' options and incomes. Training programmes (including MSc/PhD research) are strengthening national scientific capacity and the adaptive capacity of land users. Multi-stakeholder workshops are bringing together land users and decision-makers who develop a common understanding and vision of the potentials of drylands.

1. Desertification: A Global Challenge

Our world is going through an ecological transition, which is affecting our planet — and our lives — in many ways. Desertification is one of the key challenges of this transition, a major threat to the global environment,

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and to the world's food security. According to the Millennium Ecosystem Assessment Report (MEA 2005), desertification threatens over 41 % of the Earth's land area, mostly in the dry regions. These regions are home to about 2.1 billion people, or one-third of the world population. Poverty levels are high, and women and children are the most vulnerable sectors of society.

Can we prevent or reverse desertification to improve the livelihood of the present and future generations of dryland inhabitants? The answer is "yes". Given the advances in science and technology, this challenge can be met, provided institutional and policy support is adequate.

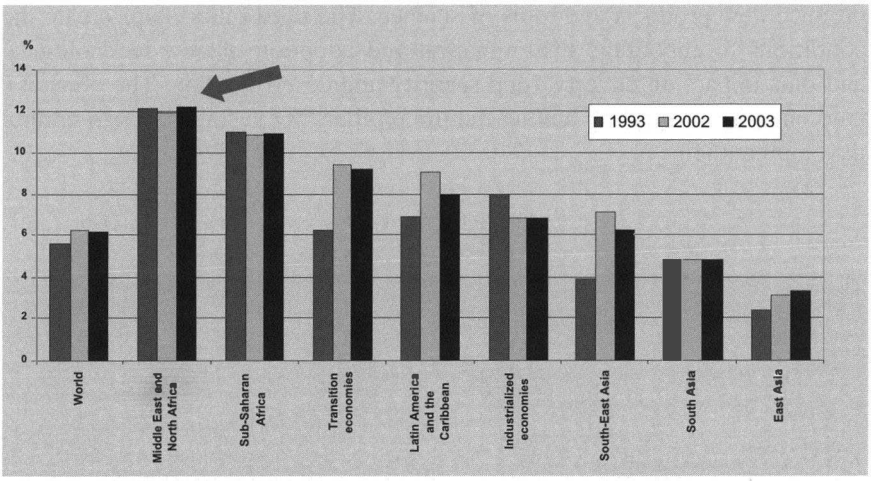
To combat desertification, we must first answer three questions: What are the causes of desertification? What are the impacts? How can science and technology make a difference in saving land and building livelihood?

Desertification is caused mainly by climate variations, natural disasters, and human activities. Desertification affects all aspects of life, with environmental as well as economic impacts, because environment and livelihoods are interlinked. Loss of good arable land (due to drought, salinity and other factors), loss of biodiversity, and the prevalence of both biotic and abiotic stresses lead to environmental poverty, which is most severe in the dry areas. Environmental poverty, in turn, leads to desertification, unless appropriate, sustainable solutions are implemented.

The world's drylands suffer from extreme environmental poverty. As a result, food deficits are endemic; the Central and West Asian and North African region (CWANA) for example, is the world's largest cereal importer. In addition, these regions face a number of converging trends that threaten the future livelihood of the poorest sector of society. These include: water scarcity, high population growth rates, climate change with dry regions becoming hotter with more erratic rainfall. When taken together with land degradation, these converging trends threaten the already fragile ecosystems, putting most of the world's dry areas at great risk.

About 132 million people in CWANA region live on less than one dollar a day, and 382 million live below the national poverty lines. Per capita income growth has stagnated since the 1990s. Unemployment, already among the highest in the world, is increasing further (fig. 1).

Poverty and desertification are interrelated in a vicious circle. Economic pressures can cause overexploitation of the land. Poverty causes desertification; desertification in turn causes more poverty. Poor households in the drylands are forced to extract as much as they can for food, energy, housing, and income. They are simultaneously the cause and the victims of desertification.



Source: World Employment Report 2004-05: Employment, productivity and poverty reduction — ILO (December 2004).

Fig. 1. — Unemployment rate in the world and world regions.

How can we combat desertification and build livelihood? What can make a difference? There are several approaches. Advances in science and technology are crucial. But the development and implementation of new technologies hinges on an enabling policy environment and strong political support. We need to support institutions and develop regulatory frameworks, community approaches, and a code of ethics for sustainable utilization of natural resources for economic growth. These efforts must go hand in hand with improved public awareness about the issues involved, the potential impacts, and the research/development approach being used to combat these problems.

The International Center for Agricultural Research in the Dry Areas (ICARDA) works with partners worldwide, helping to save land and improve livelihood. ICARDA is one of fifteen international agricultural research centres under the umbrella of the Consultative Group on International Agricultural Research (CGIAR), whose mission is to promote sustainable agriculture and protect the environment to alleviate poverty and hunger and achieve food security in developing countries.

The CGIAR's research approach rests on three pillars: natural resource management; crop genetic improvement; and socioeconomics and policy studies together with institutional capacity building. The first two pillars

produce new products and tools of science. The third pillar helps create the conditions to encourage dissemination and adoption of new technologies, and thus impact on poverty, food security and desertification. The objective is to enhance integration among the three pillars for sustainable agricultural development (fig. 2).

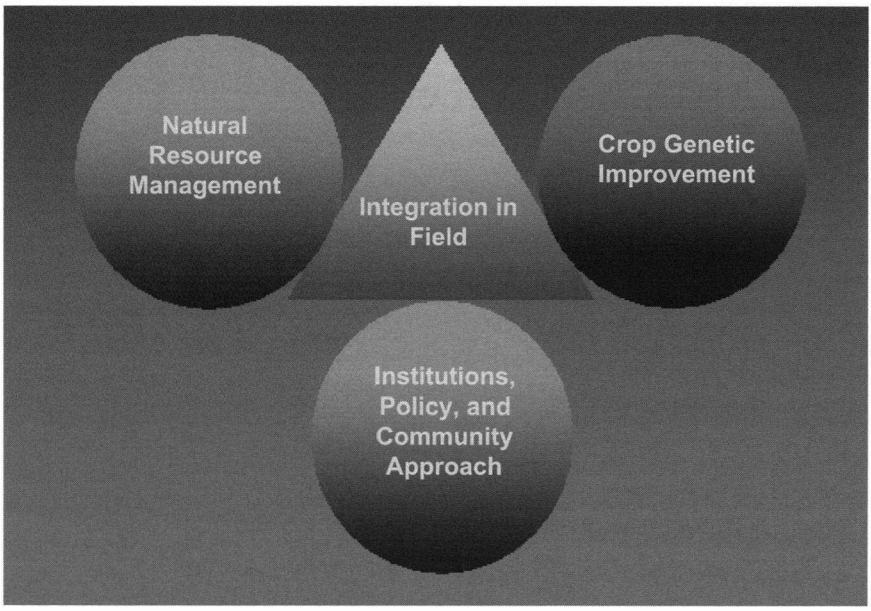


Fig. 2. — Three pillars to combat desertification.

2. Research Outputs to Combat Desertification

ICARDA and its partners have produced a number of research outputs to strengthen global efforts to combat desertification. A few of these are described below.

Agroecological zoning is an important prerequisite to efforts to remediate desertification. Using remote-sensing data and GIS tools, more than seven hundred agroecological zones in the CWANA region have been identified and mapped, based on differences in climatic conditions, topography, soils, and land use.

Particularly in the dry areas, where environments are highly diverse, it is important to understand the nature of climatic stresses. ICARDA and its partners have developed a decision-support software for the characterization of climatic stresses (cold, heat, drought). We are currently mapping drought severity using established drought indices (DE PAUW 2004).

To monitor the association between land use and land degradation, ICARDA has been conducting long-term trials. The use of legumes (medic and vetch) in a cereal-based rotation over a period of ten years has led to a significant increase in total nitrogen and organic matter content in the soil, compared to cereal monocropping or cereal-fallow rotations. Soil physical properties and fertility were improved, thus enhancing soil productivity and protecting farmland (EL BELTAGY *et al.* 2004).

The Food and Agricultural Organization (FAO) of the United Nations estimates that, in order to meet the goals of the Millennium Declaration and the World Food Summit, 80 % of the future increase in food production will have to come from agricultural intensification, *i.e.* increasing output per unit area. However, intensification, which is expected to increase in the coming two decades, is also a major threat to the environment and the sustainability of the natural resource base; it could potentially aggravate desertification.

Research and development agencies — and indeed all stakeholders — must help ensure that agricultural intensification is carried out in a sustainable manner, increasing output without causing degradation. One solution is the use of conservation agriculture, currently being practised mostly in South and North America. Its use is growing exponentially on small and large farms in South America, due to economic and environmental pressures. Conservation agriculture maintains the productivity of ecosystems, and can be particularly valuable in the fragile ecosystems in dry areas (FAO 2002, THOMAS *et al.* 2006). Various conservation-agriculture technologies (zero tillage, minimum tillage, raised-bed planting) have shown considerable promise in ICARDA's collaborative projects in Kazakhstan. Minimum tillage has proved to be more profitable and less damaging in cultivating the fragile soils found in dry areas (SULEIMENOV & THOMAS 2006).

Integrated Pest Management (IPM) is another important research area. IPM can substantially improve crop productivity. It is also cost-effective and reduces pollution resulting from excessive use of pesticides. The IPM strategy combines and balances the use of several options. ICARDA has introduced IPM methods to control Sunn pest, a major insect pest of wheat. Globally, farmers spend over US$ 150 million dollars per year on pesticides to control this pest. The use of IPM will increase their profit margins while protecting the environment from pesticide pollution.

In areas that are already degraded (due to overgrazing, salinization and other factors), ICARDA uses an integrated approach, focusing on the communities and their production and livelihood strategies. One example of this approach is the Mashreq and Maghreb project in West Asia and North Africa (WANA), which has developed and promoted integrated crop-livestock production technologies for low-rainfall areas in the eight countries of the Mashreq and Maghreb region (THOMAS *et al.* 2003).

These technologies include improved barley production; on-farm feed production; use of feed blocks, cactus and fodder shrubs; improved small ruminant production; and pasture rehabilitation. All these technologies have had a direct impact on saving land and improving the livelihood of resource-poor communities.

ICARDA's research on developing microcatchments for supporting vegetative cover has been highly successful in the fragile environments of Syria, Jordan, Egypt, and Morocco. A mechanized system for constructing ridges, implemented in collaboration with the Syrian national programme in Mehasseh, has improved shrub survival rate from 10 to 90 % and saved the land from desertification. In spite of three consecutive drought years, plantations have survived and help arrest land degradation, while producing forage for livestock and generating income for resource-poor farmers (SOMME *et al.* 2004).

Rangeland management is an essential component of anti-desertification efforts. Our research has found that native forage shrub species are more suitable than exotic species for rehabilitating degraded rangelands. In a collaborative project, over 6,000 ha of rangeland have been rehabilitated with shrubs. Fodder shrubs provide the base vegetation cover, which protects the small annual plants and provides forage for livestock.

Another example of ICARDA's research on land and livelihood is in Syria's Khanasser Valley, where scientists and farmers have together established experiments in farmers' olive groves. The experiments are testing different tillage regimes, the use of cover crops, and the use of terraces to prevent soil erosion. These will help in slowing down or halting land degradation and increasing olive production, thus contributing directly to improving the livelihood of rural communities (THOMAS & TURKELBOOM 2006).

Diversification of agricultural systems and value-added products can significantly reduce risk and generate income, helping farmers to move from subsistence to sustainable livelihood. For example, indigenous fruits such as olives, date palm, almonds, figs and pomegranate, are an important source of vitamins, protein, and calories, especially during droughts (TUBEILEH *et al.* 2004). Identifying specific species and varieties of fruit trees and vegetable

crops, and targeting them to specific cropping systems, can lead to major improvements in health and livelihood.

Protected agriculture is now practised in the highlands of Yemen, to improve the productivity of traditional mountain terraces that were abandoned. Cucumber productivity in the terraces was seventeen times higher than in lowland fields; tomato productivity was twelve times higher. These initiatives have helped improve farm incomes, and also conserve soil and protect the highland environment.

ICARDA is also promoting village-level agro-industry in dry areas in several countries. For example, durum wheat is processed into many popular products, including *burghul,* pasta, *couscous*, and *freke.* These processed products fetch three to four times higher prices than wheat grain in the market. For example, *freke* accounts for one-third of the total household income of small and medium farmers in many dry-area countries. Value addition, by processing durum wheat into *freke*, can substantially improve profits and income. It also increases the productivity of female labour, as *freke* is mainly produced by women.

Similarly, dairy products from small ruminants are essential dietary components of pastoralists and urban populations. Women in the CWANA steppes milk and process dairy products, increasing the profitability of livestock production. Farmers are increasingly adopting technologies for improved yoghurt and cheese production, developed by ICARDA. This has improved income and household nutrition in poor rural communities.

At the institutional level, we have researched the value of a local microcredit financing scheme in a drought-prone region of Syria. The poor do not have access to formal credit sources, and are forced to rely on informal lenders, who charge high interest rates.

In addition to research, ICARDA places great emphasis on training young researchers from national programmes on issues relating to land degradation and desertification. More than fourteen thousand national scientists from over ninety countries have participated in ICARDA's training programmes since 1977, and over five hundred researchers have so far conducted their MSc and PhD work through collaborative training programmes with ICARDA.

Desertification is a complex problem and can only be addressed through global partnerships. Several multilateral agreements have been signed, such as the United Nations Convention to Combat Desertification (UNCCD), the United Nations Convention on Biological Diversity, and the United Nations Framework Convention on Climate Change. ICARDA has been actively participating in these global conventions. It has also participated in the Millennium

Ecosystem Assessment, and represents the CGIAR in the Facilitation Committee of the Global Mechanism of the UNCCD.

ICARDA is engaged with national research and extension agencies, regional and international organizations, and advanced research institutes, helping to build broad alliances to address the problems of dry areas and to provide a strong scientific basis for tackling desertification. For example, a consortium of scientists working on the problems of drylands developed a list of knowledge gaps and research themes that can be incorporated into a global research for development programmes (WINSLOW *et al.* 2004).

These alliances must work towards developing and implementing new technologies to save land and combat desertification, and increase the livelihood opportunities for poor communities in dry areas. These should include improved market opportunities (roads, markets, extension, inputs, credit); channelling off-farm income for sustainable development; technology development and transfer; improving institutional capacities; and enabling community action and governance. Simultaneously, pressure on drylands must be reduced through increased awareness, provision of incentives for long-term investment, provision of alternative livelihood (higher income per unit of land and water), payment for 'ecosystem services', and economic opportunities outside drylands. ICARDA strongly believes it is more cost-effective to prevent land degradation or desertification through better management and conservation technologies than to rehabilitate degraded and destroyed land. However, ICARDA is only one player in this process and it welcomes the opportunity to engage in dialogue and cooperation with national, regional, and international organizations.

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International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 109-115.

The Quantification of Vegetation Decline by Using Physiological Tools

by

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KEYWORDS. — Vegetation Decline; Abiotic Stress; Chlorophyll *a* Fluorescence.

SUMMARY. — Over the last decades the climate conditions have become more favourable to ecosystem disturbances. Cases of obvious vegetation decline related to modification of the growth environment were observed in both urban and natural areas exposed to severe abiotic stress, pollution or other anthropic activities. In the present study, the polyphasic rise in chlorophyll *a* fluorescence was evaluated as a rapid diagnostic test of the plants' physiological status. Different experiments revealed that the calculated performance index PIabs proved to be the most reliable physiological parameter to quantify the alterations on plants' vitality.

1. Introduction

Decline of coastal vegetation has been reported for the last fifty years, particularly on the tree species directly exposed to sea sprays and marine aerosols in the Mediterranean Basin Sea Coast, along the Ligurian and Tyrrhenian Sea Coast (GELLINI *et al.* 1981, 1983, 1985; BUSSOTTI *et al.* 1998, 2001; PAOLETTI *et al.* 2001), the Mediterranean coast of France and Spain (GARREC & SIGOILLOT 1992, BADOT & GARREC 1998, STAMMITI & GARREC 1998) and Cap Bon, Tunisia (EL AYEB *et al.* 2004).

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Symptoms like leaf chlorosis and necrosis patterns, up to defoliation or even dead trees, have been observed. Specific meteorological conditions, such as strong winds and sea storms, appeared to increase the intensity of these phenomena.

The coastal forest decline was related to the excessive salt uptake in plant species, which may come from the raised level of marine aerosols, hence the salt deposition on coastal vegetation, due to the global climate change (GUSTAFSSON 1997, AAMILD & HORNTVEDT 2002) or the presence of chemical contaminants in sea water, sea spray and aerosols (GELLINI *et al.* 1981, 1983, 1985; GARREC & SIGOILLOT 1992; BUSSOTTI *et al.* 1998; BADOT & GARREC 1998; STAMMITI & GARREC 1998; PAOLETTI *et al.* 2001; EL AYEB *et al.* 2004).

The most affected plant species are the conifers, such as *Pinus pinea, P. halepensis, P. sylvestris, Juniperus communis, Araucaria heterophylla, Abies sp.*, and the evergreens, such as *Quercus ilex, Erica arborea, Arbutus unedo* (GELLINI *et al.* 1981, 1983, 1985; GARREC & SIGOILLOT 1992; BUSSOTTI *et al.* 1998; BADOT & GARREC 1998; STAMMITI & GARREC 1998; PAOLETTI *et al.* 2001).

In order to study the health status of coastal vegetation and Chlorophyll *a* (Chl *a*) fluorescence, screening was used as a reliable non-invasive method to measure the quantum efficiency of the electron transport through Photosystem II (PSII) in leaves. Photosynthesis is a biological crossroad, occupying the central position within plant biosynthesis, and provides a link between the internal metabolism of a plant and the external environment. The measurement of primary photochemistry might provide very useful information for the risk assessment studies, and could be used as a tool for environmental predictions: early-warning system or indicator of the photosynthetic recovery on plants presenting a certain degree of damage.

The PSII operating efficiency is related to CO_2 assimilation and, consequently, to the ecophysiological performance of plants. Light energy absorbed by the chlorophyll molecules in a leaf can undergo one of three fates: it can be used to drive photosynthesis (photochemistry), excess energy can be dissipated as heat, or it can be re-emitted as light — chlorophyll fluorescence. These three processes occur in competition, such that any increase in the efficiency of one of them results in a decrease in the yield of the other two (MAXWELL & JOHNSON 2000, BACKER & ROSENQVIST 2004). Vegetation fluorescence is known to convey very specific information on the efficiency of light energy usage by plants, thereby relating to plant vitality and the potential for biomass production.

2. Material and Methods

2.1. Sampling Plot Location

The study areas have been established in Porquerolles Island (France) and San Rossore National Park (Italy). According to the literature data, serious vegetation damages have been recorded in those areas. The sampling plots were established on high-exposed (seashore) and low-exposed (inland) sites. The inland sites were considered under control. The size of the plots was established at 200 m × 200 m.

2.2. Physiological Measurements: Chl *a* Fluorescence

Chlorophyll *a* (Chl *a*) fluorescence measurements were performed using the Plant Efficiency Analyser (PEA) [Hansatech Ltd, UK].

The following species were investigated: *Quercus ilex*, *Pinus halepensis*, *Pinus pinea*, *Arbutus unedo* and *Pistacia lentiscus*. Those species presented a high degree of damage in the seashore sites.

In each plot, six trees were randomly chosen. Every tree was sampled by cutting young branches as much as possible to cover all crown canopy. Due to safety reasons and to lack of infrastructure, reaching the high canopy was not possible for *Quercus ilex* and *Pinus halepensis*. The samples were dark-adapted in black plastic bags for approximately one to two hours and then twenty-five random chlorophyll *a* fluorescence measurements per tree were performed.

The calculation of light energy fluxes and flux ratios, as well as the efficiency of electron transport of the PSII, were estimated from the polyphasic rise of the fluorescence transient using the JIP test (Strasser & Strasser 1995).

Among other JIP parameters, the performance index $PI_{(ABS)}$ provided the best preliminary overall assessment of the exposure types. This index combines the three main functional steps of photosynthetic activity of PSII, into a single multi-parametric expression, making it the most reliable parameter for the global estimation of the plants' stress response at the level of primary photochemistry (Strasser & Strasser 1995, Strasser 2000).

3. Results and Discussion

The performance index $PI_{(ABS)}$ calculated from the Chl *a* fluorescence measurements, revealed different degrees of vitality in the studied plant

species in Porquerolles site (fig. 1). In exposed plots, for *Arbutus unedo* and *Pistacia lentiscus* species the $PI_{(ABS)}$ showed significant lower values compared to the control site ($P<0.05$, Kruskall-Wallis test). In contrast, in *Quercus ilex* samples from the exposed plots, the value of $PI_{(ABS)}$ was higher compared to control. No significant difference was found between the *Pinus halepensis* trees from exposed and control areas.

In addition, the Chl *a* measurements are randomly taken, and the non-uniform distribution of the affected and healthy leaves in the tree canopy is reflected in variability of the $PI_{(ABS)}$ within species groups. In the case of *Quercus ilex*, the explanation for the lower vitality index $PI_{(ABS)}$ in the inland site compared to the seashore site, is that inland this species is found in compact forests where the access to sunlight is limited to more than 50 % of the crown. In addition, a high degree of infestation with lichens was observed in the inland forest.

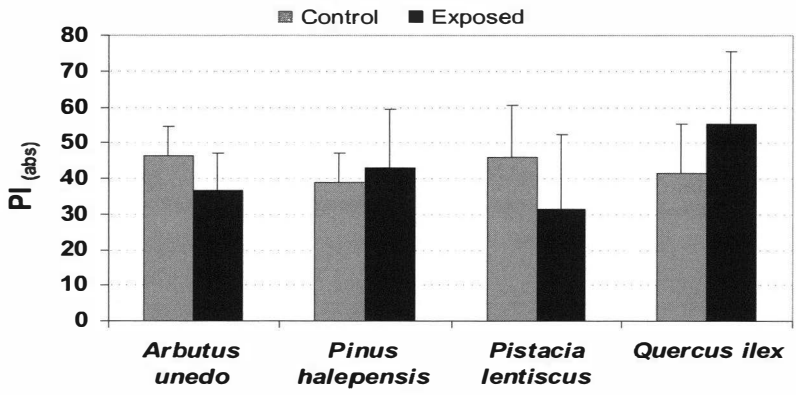

Fig. 1. — Performance Index $PI_{(ABS)}$ (mean + stdev, n = 25) in *Arbutus unedo, Quercus ilex, Pinus halepensis* and *Pistacia lentiscus* from control and sea-spray-exposed sites. The bars are clustered with respect to species given on *x* axis.

A general comparison of the physiological status of vegetation in the studied sites showed that the response of the plant species depends both on the species characteristics and the growth environment (fig. 2).

It could be observed that in San Rossore site, for *Pinus pinaster* species, the exposure to sea spray does not diminish the photochemical performance, and the presence of standing dead trees, skeletonised branches and brown needles suggests a past episode of strong damages.

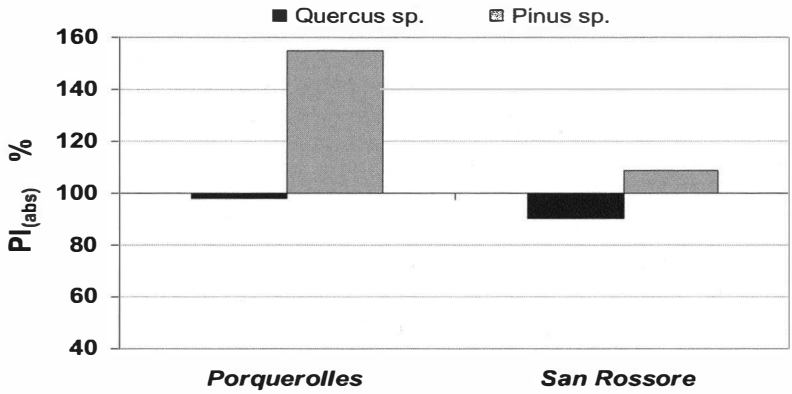

Fig. 2. — Comparative Performance Index PI $_{(ABS)}$ of *Quercus sp.* and *Pinus sp.* in San Rossore and Porquerolles exposed sampling sites. The data are represented as per cent with respect to control.

In Porquerolles site the performance index of *Quercus ilex* was not significantly different in exposed plots compared to the control, while in San Rossore the trees growing close to the seashore showed a significant lower $PI_{(ABS)}$. It is obvious that sea spray is not the only factor involved in vegetation decline, but also the sites appear to suffer transformations which can have both natural and anthropical causes. In San Rossore site we observed the erosion of the soil and the advance inland of sandy mobile soil, as well as the presence of halophyllous sand dune vegetation. In addition to this, Arno River, located in the south of the forest, may strongly contribute to sea water pollution.

In Porquerolles site, in some areas of the island, a strong competition for water resources seems to take place, due to the island geology. The potential contamination sources in this area could be the industry from Marseilles and Toulon, and the small harbours on the French coast.

4. Conclusions

The physiological measurements proved to be very useful in detecting the early effects of exposure to a stressor. The significant changes of some physiological parameters before any symptom at the visual level occurred, as well as their recovery after the exposure ceased, make them reliable for short-term prediction of the physiological state of the plants subjected to

stress. The JIP-test provided information consistent with results derived from total chlorophyll content measurements and visual symptoms, suggesting that the kinetics of Chl *a* fluorescence can substitute time-consuming methods and satisfy the requirements of a rapid and accurate screening method.

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International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 117-132.

Research Priorities to Promote Sustainable Development in Drylands: Tunis Declaration

by

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KEYWORDS. — Drylands; Desertification; Science; Knowledge; Education; Management; Water Resources; Degradation; Ecosystem.

SUMMARY. — An International Scientific Conference "The Future of Drylands" was organized in Tunis (Tunisia) from 19 to 21 June, 2006, in the context of the "2006 International Year of Deserts and Desertification" and celebrating fifty years of dryland research in the UN system.

Considering that the world's drylands are home to more than two billion people, and being concerned that many drylands are subject to desertification as a result of extended droughts, climate change and human activities that exacerbate poverty and food insecurity, and in spite of important knowledge gaps, new scientific challenges and opportunities have emerged that need to be addressed in order to promote sustainable development through action plans for combating desertification.

In an attempt to define future paths of dryland research for sustainable development, the following themes were identified as priority issues: (1) conservation of cultural and biological diversity; (2) integrated management of water resources; (3) assessing dryland ecosystem dynamics; (4) agriculture and pastoralism; (5) coping with natural and man-made disasters; (6) global change; (7) education and knowledge sharing; (8) reversing environmental degradation; (9) costs of 'inaction'; (10) renewable energies; (11) ecosystem services and their trade-offs; (12) viable dryland livelihood.

The scientific community was invited to increase the involvement of youth and women in research, innovation and education programmes.

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1. Introduction

According to the United Nations Convention to Combat Desertification (UNCCD), 'desertification' is defined as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities".

Dryland ecosystems are governed by the variability in climate parameters and the boundaries between the regions can be related to rainfall and temperature or to the amount of water available in the soil, commonly expressed as a water deficit for plant growth. An 'aridity index' classifies the type of climate in relation to water availability in the soil, defined as the ratio between mean annual precipitation (P) and mean annual potential evapotranspiration (ETP). Aridity is a critical environmental factor affecting the growth of natural vegetation by considering rainfall and air temperature as indicators.

Considering that the world's drylands are home to more than two billion people, and since many drylands are subject to desertification as a result of extended droughts, climate change and human activities that exacerbate poverty and food insecurity, new scientific challenges and opportunities have emerged that need to be addressed in order to promote sustainable development through action plans for combating desertification. Scientists were among the first to seriously consider drylands, either as ecosystems in their own right, or as areas with widespread poverty for which external agricultural and pastoral intervention schemes and new technologies could help to promote development.

In the early-mid 1950s, the first international and interdisciplinary research projects on arid lands were launched by UNESCO within the United Nations system.

While important knowledge gaps still exist, our scientific knowledge on drylands has vastly improved over the last fifty years and yet land degradation in drylands (desertification) continues to prevail in many parts of the world.

With this background, an International Scientific Conference "The Future of Drylands" was organized by UNESCO and other international and regional partners in Tunis (Tunisia) from 19 to 21 June 2006, in the context of the "2006 International Year of Deserts and Desertification". One of its objectives was to celebrate fifty years of dryland research in the UN system.

Another objective was to identify important knowledge gaps for defining future paths of research into drylands and desertification, in particular to promote application-oriented science for the sustainable development of dryland regions and to reach the Millennium Development Goals.

Eight working groups addressed priority issues which will be commented and illustrated hereafter with syntheses and conclusions and recommendations taken from the conference presentations of the eight session reports.

2. Conference Sessions

2.1. Session 1: Conservation of Biodiversity, Cultural and Natural Heritage in Drylands

(Ricardo Valentini, chair, Italy; Charles Hutchinson, rapporteur, USA)

A fifty years' study of traditional hydrotechnologies (*foggaras* in northern Africa and *quanats* in Asia) demonstrated their value as efficient water delivery systems. The spread of tube wells has destroyed many of these once viable traditional systems. In order to recognize and to promote the value of foggara technology, the following steps are suggested: (1) translate documents that describe foggara technology into appropriate languages to facilitate dissemination; (2) conduct a global inventory of foggara resources that identifies local expertise, and the cultural context in which the systems operate; (3) assemble kits that might be used for training; (4) prepare educational videos on foggara technology; and (5) support ongoing foggara research.

Livestock plays an important role in the agricultural economy of most world's drylands. Erosion of livestock genetic diversity in drylands and reduced mobility of herders are critical for diversity maintenance, which needs to be more seriously addressed in the future.

The focus of many efforts of biodiversity conservation is on areas of species richness, which tends to place drylands at a disadvantage. Hence alternative methods need to be identified in order to mobilize conservation efforts for the distinctive megafauna of drylands, in particular on keystone species that are critical to the maintenance of biodiversity (*e.g.*, oryx and gazelle in the Sahel). Linking archaeological/historical sites with natural sites of unique quality, through the theme of great mammals, is a particular promising approach to enhance the value of drylands.

The "biosphere reserve concept", which is based on understanding the nature of the (a) physical ecosystem, (b) the management organization, (c) the ecosystem users (*e.g.*, nomads), (d) the relationships among these components, (e) how they change seasonally and through time, and (f) how the players and their relationships evolve in the face of those changes, can be an appropriate model for sustainable dryland management.

Traditional knowledge for water and soil management, protection of natural areas, and architecture (urban and rural) have considerable value for drylands. They are technically and scientifically sound and offer a foundation on which to build modern technology. To capture, organize and disseminate traditional knowledge, an inventory of indigenous knowledge is being built in a georeferenced web-enabled database in order to share this technology and cultural heritage globally.

Development of craft industry, based on the use of local materials, is an opportunity to foster community development. Because there is a direct linkage between crafts and their relationship to the local environment, this approach may foster attitudes that are more conservative of local biodiversity in drylands.

The Bishnoi tribe (as an example of a unique dryland community in the Thar Desert, India) uses traditional knowledge to create sustainable production systems and conserve local biodiversity. Sacred groves of trees or protected forests — *orans* — are protected as a reserve for grazing animals and birds and the promotion of biodiversity. *Prosopis cineraria* is a "wonder tree" that provides food, fuel, fodder, medicinal products, and also serves as a windbreak and sand stabilizing plant. The Bishnoi have persisted and conserved their environment through "ecological sense and religious sensibility".

A case study from southern Tunisia revealed production of plants for their unique medicinal and aromatic values from a large regional flora. Many of these are "spontaneous" plants that have become part of rural pharmacopoeia. Studies and field trials are underway to understand the cultural requirements of plants and the quality of products that they yield under different cultural practices. The session also revolved around the use of traditional knowledge in general, and the rights to traditional pharmacopoeia specifically. Discussion focused on trying to find the answers to two related questions: (a) Who "owns" traditional technology? (b) How can local farmers benefit most and best from the production of crops and medicinal plants for sale, and/or from some form of licensing of intellectual property? As there was no resolution to neither of these very pressing issues, the session concluded that there must be further debate on these.

2.2. Session 2: Dryland Hydrology and Water Management

(Houcine Khatteli, chair, Tunisia; Donald Gabriels, rapporteur, Belgium)

It is made clear that "hydrological science and dryland management are key areas where knowledge is needed".

Dryland management, and in particular water resources management in drylands, has evolved from a focus on shared costs (1960s) to shared benefits (1990s) to, currently, the sharing of common risks and uncertainty. Management also requires monitoring, quantification and determining of indicators with this collected information shared and exchanged. "The water community might need the remote sensing community".

Changes in rainfall regimes put stresses on water resources in general, and on its use for agriculture in particular. More extreme rainfall events with subsequent inundations and damages are observed with negative consequences for the socioeconomic development of the region. Insufficient and unreliable rainfall, drought and low diversification of crops have resulted in natural resources degradation, low production and low water-use efficiency. Improving water-use efficiency through the implementation of appropriate technologies may lead to poverty mitigation.

In this session some interesting concepts of water-harvesting systems (figs. 1, 2, 3) were presented and the following statements were made:

— Floods in deserts are a blessing in disguise!
— Coarse-grained alluvium is worth more than oil!
— The cost of desertification prevention is much lower than the cost of remediation.
— Water is the most precious treasure in drylands.
— The available water capacity of soils is the most important direct driving characteristic.
— Harvested flood water is a land renovator and a soil builder.
— Large dams offer the most hydro-illogical technology in drylands where potential aquifers exist.

2.3. Session 3: Monitoring and Forecasting on Dryland Ecosystem Dynamics (Gisela Alonso Domínguez, chair, Cuba; Gertjan B. Beekman, rapporteur, Brazil)

This session was concerned with a vast spectrum of topics covering institutional, policy-relevant and conceptual models dealing with planning and development approaches with respect to desertification issues. Comprehensive views were outlined in respect to monitoring, assessment and definition of land degradation indicators. Forecasting and prediction models were discussed as well as integrated management practices, which were reported at village level and involved local stakeholders. Papers related in particular to

Fig. 1. — Roman water reservoir in Alexandria, Egypt, where (over)pumping resulted in complete drying-out of the reservoir.

Fig. 2. — Introduction of the 'diesel pump' led to excessive use of ground water with decreasing water use efficiency as a result.

Fig. 3. — Recharge well and gabion dam in southern Tunisia.

the following issues: monitoring for the assessment of desertification provided the data for a GIS — Local Environmental Information System in Tunisia that produces spatial ecological and agricultural balances. The final output of the model is to be made available to the various development agencies of Spatial Decision Support System in the planning and monitoring of combating desertification plans and natural resources management in dryland areas.

The coalition of national government institutions in Kenya was discussed as a need in subregional and eastern Africa to establish a long-term environmental observatory system in line with the ROSELT* premises.

The evaluation of the effects of soil protection, production of firewood and anthropogenic activities as components of climatic changes was also given due consideration in respect to the Sahelian region located in Mali.

FAO's Land Degradation Assessment in drylands (LADA) Project aims at developing assessment tools to collect up-to-date information on the status, impact and drivers of land degradation at local, national and global levels. In order to achieve this, it has developed a flexible methodological framework which relies on traditional and digital-assisted methods of data collection. The assessment tools represented invaluable input information for GIS and Decision Support System (DSS) modelling.

In order to assist production systems, a new toolkit was developed as an automated modelling package to assist mobile dry-rangeland livestock keepers in East Africa to cope with meteorological condition extremes. With such tools, decisions about current and future prevailing forage conditions will guide their mobility and decision-making patterns, which are thereby made more consistent.

The presentation of a Tunisian scientist proposed a conceptual model to evaluate the outcomes of institutional and structural changes that take place by considering a set of benchmarks as time references in modelling scenario changes.

Approaches towards forecasting dryland degradation and recovery processes based on remote sensing and geostatistical analysis to predict the future consequences for drylands were presented by an American scholar. The focus on the development of an interdisciplinary approach for dryland ecosystem forecasting that combines remote sensing, soil science and geostatistical analysis on limited territories such as islands was emphasized.

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* Réseau d'Observatoires de Surveillance Ecologique à Long Terme.

Application of Decision Support System for drylands watershed management at village community level was highlighted as a sustainable development approach in semi-arid regions of India. GIS and DSS modelling could provide methods to decision-makers and stakeholders in the decision-making processes for the integrated watershed management programme in drylands, specially concentrating on water resources management aspects.

Research on indicators of soil degradation is a necessity in communal-managed rangelands in order to assist land managers to develop strategies for conservation, restoration and sustainable use of soil resources in these rangeland ecosystems. The session concluded by stating that (a) there is an evident need for further scientific assessment of desertification and land degradation processes, taking into account their negative social, economic and environmental impacts; and (b) mismanagement of soil water and other natural resources as well as human impacts have been aggravating factors contributing to poverty, food insecurity and human suffering.

2.4. Session 4: Sustainable Land Use and Agriculture

(Mekhlis Suleimenov, chair, Uzbekistan; Sayyed Ahang Kowsar, rapporteur, I. R. Iran)

Note: Each small letter corresponds to the research priorities of the presentation preceded by its capital equivalent.

a. Identification of other plants, which may be propagated using the same method; finding the best time(s) of the year when the success of the treatment is more assured; application of growth hormones for initiation of root growth in difficult cases.
b. As some of the C4 grasses, such as *Panicum antidotale* Retz, are potential N-fixers, and they tolerate heat and drought, their identification and improvement is suggested; alfalfa with its very long roots (10 m) is a valuable fodder that may be planted with spate irrigation in very deep soils; fodder trees, such as *Acacia salicina* Lindl., offer a potential stock for drylands facing recurrent droughts. This tree provides pollen and nectar for honeybees in fall and winter, too.
c. Introducing soil and plant parameters in the model is necessary to predict the yield more accurately. As most of the soils in northeastern Brazil are underlain with rock — and water remains in the rooting zone —, the

improved model may be used to estimate the area of spate-irrigated farm fields based on the amount of flood-producing rainfalls, thus "riding the variability curve".

d. Participation of the locals in genetic resource conservation and biodiversity protection; rangeland productivity determination, and effect of management in yield enhancement; domestic and export marketing information; collection of traditional knowledge in weed control, rangeland yield assessment, and range plant evaluation; finding the not-so-obvious causes of land degradation and possible ways for their prevention and remediation; water harvesting for spate irrigation and the artificial recharge of ground water.
e. Identification and/or breeding of drought and salt-resistant small-grained cereals; developing wheat and barley with exceptionally long roots; spate irrigation of cereals in rotation with annual and perennial fodder legumes; soil building through spate irrigation along with the artificial recharge of ground water.
f. Reinstitution of nomadism for herders, along with the provision of water and fuel wood on their treks through water conservation methods, particularly spate irrigation and the artificial recharge of ground water.
g. Species and variety trials with fish and shrimp, with waters of different salinity levels, are recommended. Salt-tolerant plants, such as date palm, may be irrigated with the fish pond water.
h. Variety and provenance trials, pruning and thinning studies, fertility experiments, and advanced forest management research project may contribute to an increase in yield and enhancement of gum arabic.
i. Spate irrigation of fodder shrubs, along with the species trial of fodder trees in water spreaders will bring more forage and better protection of the fragile soil.

2.4.1. *Human Development Index, a Practical Tool for Well-Being Assessment*

Assessment of the Human Development Index (HDI) at certain intervals (*e.g.*, five years) is a more accurate method of measuring the impact of reclamation activities.

As the main aim of all desertification control activities is the provision of a better living condition for desert-dwellers, even for the entire human population, inclusion of HDI assessment in the entire reported project is strongly recommended.

Conflicts should be considered between pastoralists who want to graze their herds and conservationists who prefer the protection of wildlife habitat (fig. 4). Rangeland degradation because of drought causes bush encroachment (fig. 5) on grasslands and improvement in livestock marketing and animal feeding can be a direct approach for increasing the income of graziers.

Fig. 4. — Conflicts between pastoralists and conservationists.

Priority should be given to breeding of drought- and salt-resistant small-grained cereals; developing wheat and barley with exceptionally long roots; spate irrigation of cereals in rotation with annual and perennial fodder legumes; soil building through spate irrigation along with the artificial recharge of ground water.

Nomadism for herders should be reinstituted, along with the provision of water and fuel wood on their treks through water conservation methods, particularly spate irrigation and the artificial recharge of ground water. Spate irrigation of fodders shrubs, along with fodder trees in water spreaders, will bring more forage and better protection of the fragile soil.

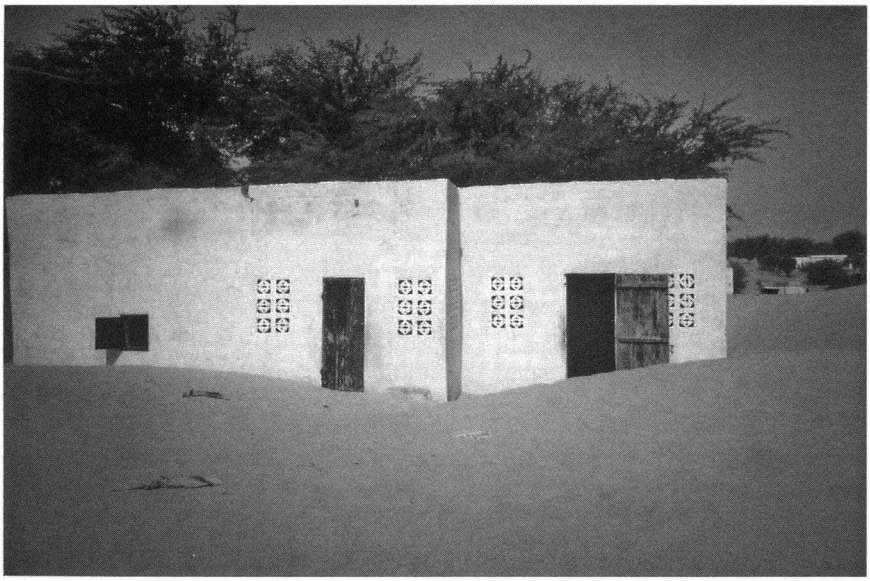

Fig. 5. — Sand encroachment blocking houses and roads in Mauritania and Tunesia.

2.5. Session 5:
Disaster and Risk Management in Drylands
(Gertjan B. Beekman, chair, Brazil; Mary Seely, rapporteur, Namibia)

Drought, representing the exceptional periods when conditions are considerably drier than usual, is a known and accepted risk of drylands that affects both crops and livestock.

Severe droughts and extreme flooding events with flash floods have irreversible and damaging effects on crop and livestock production, and on the environment.

Adaptive strategies are essential for addressing aridity, which is a natural phenomenon accompanied by naturally high climate variability, and the increasing dryness in drylands. This represents risk assessment.

Coping strategies are necessary for application during the exceptional periods when drought prevails or other disasters occur. This represents disaster management.

What is needed in drylands is proactive prevention based on a reliable system of information and coordination to support proactive management at all levels.

A key issue related to both risk management and drought and other disaster response is education of decision-makers so that they can focus on and support maximising adaptive strategies and actions and minimising vulnerability, essential components of living in drylands.

2.6. Session 6:
Policy, Governance and Socioeconomic Dynamics in Changing Drylands
(Boshra Salem, chair, Egypt; Mekhlis Suleimenov, rapporteur, Uzbekistan)

It is demonstrated that drylands are suffering from severe desertification: the land frontier for pasture expansion into marginal land areas has been exhausted; crop land is encroaching on the most productive land while protected areas are also increasingly expanding into rangelands. The economic, institutional, social, and legal contexts in which traditional pastoral systems operate are rapidly changing following the worst scenario of increased pressure on resources because of population growth.

It is recommended to encourage more empirical studies on the links between desertification and migration, and to consider not only the social and economic costs but also the benefits of migration, taking into account the gender issues.

2.7. Session 7: Viable Dryland Livelihood and Policy Options (Dali Najeh, chair, Tunisia; Marc Bied-Charretpn, rapporteur, France)

The multifunctionality of drylands and the valorisation of their comparative advantages are recognized.

As diversification can improve the well-being of pastoralists affected by drought, the following activities can be foreseen for the benefits of dryland dwellers: apiculture, palm leaves processing, fish farming, ecotourism, and handicraft, establishment of saving and credit groups, and increasing social services.

Craft industry, based on the use of local materials, is an opportunity to foster community development. This can take two paths. One is focused on developing the national and international craft market for art objects. A second is focused on developing crafts for local and regional markets for functional, aesthetic and symbolic objects. Because there is a direct linkage between crafts and their relationship to the local environment, this approach may foster attitudes that are more conservative of local biodiversity.

Also "spontaneous" plants can be basic parts in the production of medicinal and aromatic products.

An analysis of the priorities of project beneficiaries should be made: farmers, herders, civil society, researchers, community, and state.

2.8. Session 8: Education and Knowledge Sharing in Drylands (Mary Seely, chair, Namibia; Boshra Salem, rapporteur, Egypt)

A scientific baseline is needed to assess land degradation and to make scientifically-informed decisions about dryland development.

Information exchange requires platforms for people to interact so that information and needs for information from all levels can be exchanged amongst communities, service providers, researchers and decision-makers.

Learning to learn from lessons of the past is still an issue after fifty years. "Traditional technology should go hand in hand with modern knowledge and modern technology with traditional knowledge".

Evolution of research, education and knowledge sharing has shifted from a focus on the biophysical to the social and cultural, and now incorporates information exchange. In the future, even more emphasis must be placed breaking down communication barriers between different land-user groups,

and between land users and researchers from different disciplines, to better facilitate training, education and outreach.

UNESCO's work related to drylands is based on: (1) environmental conservation using international normative instruments such as the World Heritage Convention and the World Network of Biosphere Reserves; (2) scientific studies on ecosystem structure, functioning and dynamics to better understand human-environment interaction in drylands.

While earlier projects focused primarily on natural ecosystem dynamics and natural resource use, later projects have taken more fully on board socio-economic and sociocultural parameters and dimensions to promote sustainable development in drylands. Today, information sharing among scientists and outreach of scientific results for the benefit of local communities and decision-makers, even cross international boundaries, is seen as key issue in putting dryland sciences at the service of sustainable dryland development.

3. Priority Research Issues

Held within the context of the "2006 International Year of Deserts and Desertification", the conference participants adopted the "Tunis Declaration", which identifies the twelve themes as priority research issues in an attempt at defining future paths of dryland research for sustainable development:

1. Interdependence and conservation of cultural and biological diversity;
2. Integrated management of water resources in the context of a looming water crisis;
3. Assessing and forecasting dryland ecosystem dynamics in order to formulate adaptation strategies in the context of global change and to alleviate poverty so as to achieve the Millennium Development Goals;
4. Agriculture and pastoralism as opportunities for sustainable land use;
5. Coping with and management of natural and man-made disasters;
6. Formulating and implementing scenarios and policy options for good governance in the context of global change;
7. Identifying viable dryland livelihood and policy options for the benefit of dryland dwellers (such as ecotourism);
8. Educating for sustainable development and knowledge sharing;
9. Reversing environmental degradation and promoting rehabilitation;
10. Costs related to 'inaction' in the field of land degradation;
11. Renewable energies suitable for dryland development;
12. Evaluation of dryland ecosystem services and their trade-offs.

Fig. 6. — Reforestation on Cape Verde Islands.

4. Conclusions, Recommendations and a Declaration

In order to address these priority issues, an enabling environment is essential. This will entail that governments and multilateral environment agencies step up their efforts to use sound scientific knowledge to formulate and implement policies, laws, regulations and action programmes vis-à-vis the environmental issues stressing integrated management of natural resources and conservation practices. At the same time, the scientific community is requested to ensure its findings are made available and understandable to decision-makers and local dryland communities so that research can help shape sound policies and good governance as well as education on an interactive basis for sustainable dryland management and improved livelihood.

Conference participants also reminded national decision-making bodies and the scientific community to increase their efforts in implementing research for development projects in close collaboration with and for the benefit of local dryland communities. Integrating modern technologies with traditional knowledge to achieve sustainable development in drylands was seen as one promising way along which local communities, scientists and government officials could collaborate.

International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 133-141.

Itinéraire d'un agent de l'administration du développement local: expériences et enseignements d'une carrière

par

Samba BA*

RESUME. — Cet itinéraire retrace quelques étapes significatives du parcours d'un jeune banlieusard qui, pour se remettre d'un échec scolaire, réussit à un concours et embrasse une carrière 'd'agent technique d'agriculture'.

Ce parcours démarre au début des années 1970 au nord du Sénégal dans la région du fleuve, dans une structure administrative d'encadrement du développement rural: le Centre d'Expansion Rurale Polyvalent (CERP), ultime ramification de l'appareil d'Etat de planification du développement.

Au bout de deux ans d'oisiveté dans le CERP, je change de cap en réussissant à un concours de recrutement de la Société de Développement et de Vulgarisation Agricole (SODEVA). Il me revenait de prêcher les mérites de 'thèmes' techniques productivistes et dévastateurs des ressources naturelles à de vieux paysans rompus à des pratiques séculaires mais ignorées. Ensuite, je fais une carrière de commerçant gestionnaire, responsable d'un réseau de magasins d'approvisionnement en intrants.

Par la suite, je quitte la SODEVA pour retourner à l'école. Au bout de trois ans d'une formation alternant les sessions théoriques et les stages pratiques dans les villages, je deviens formateur à la Direction de l'Alphabétisation et de l'Education de Base. Ce retour à l'école m'a permis de disposer d'outils de relecture de ma petite expérience et de mieux appréhender les enjeux du développement rural à la lumière des principes de la planification participative (participation populaire) et de la pédagogie des opprimés (*cf.* Pablo Freire). Cette étape vécue à Dakar me replonge dans ma vie de banlieusard et sert de déclic. Elle marque le début de prises d'initiatives en matière de pratiques sociales en marge et/ou souvent en complément de mes activités professionnelles.

Au bout de quatre ans à Dakar, je décide de retourner en brousse pour accompagner le processus de décentralisation et développer le plus grand nombre d'initiatives d'autopromotion paysanne et d'appui au développement local. Durant cette période, j'adhère au RITA (Réseau d'Information des Terres Arides) et entre en contact avec le RIOD (Réseau International des ONG pour la lutte contre la Désertification), qui m'invite au Forum national de vulgarisation de la Convention

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de lutte contre la Désertification à Dakar. Avec l'appui du RITA et d'autres membres du RIOD, j'organise, un an plus tard (en mars 1996), le forum paysan regroupant pendant cinq jours des leaders des organisations communautaires de base, des élus locaux, des techniciens et des autorités administratives.

Un événement qui va en engendrer d'autres, parmi lesquels: le projet Réseau Paysan et Radio rurale de Thiès, la publication d'un manuel de vulgarisation du code forestier, etc.

Autres expériences majeures parmi celles qui m'ont valu d'être décoré par son Excellence Monsieur le Président Abdou Diouf: deux projets de recherche-développement et, plus tard, le projet «Centre Mampuya pour le Développement durable». Par ailleurs, j'ai eu le privilège de participer à un processus de décentralisation d'une ONG du Nord vers le Sud.

Ce tour d'horizon des quelques expériences significatives résume une carrière faite de mobilité dans l'espace et une diversité dans les fonctions au service du développement local.

Au bout du compte, j'ai fait beaucoup de découvertes et des rencontres enrichissantes qui m'ont appris l'humilité et l'importance de l'écoute du vis-à-vis. Je me suis aussi rapproché du mouvement paysan sénégalais dont les péripéties méritent d'être capitalisées et partagées: ce sera là un nouveau chantier à explorer.

1. Introduction

Cet itinéraire retrace quelques étapes significatives du parcours d'un jeune banlieusard qui, pour se remettre d'un échec scolaire, réussit à un concours et embrasse une carrière 'd'agent technique d'agriculture'.

Dans cette contribution, il s'agit de passer en revue certaines expériences et tirer les enseignements d'une carrière d'un agent du développement à la base qui deviendra, trente-cinq ans plus tard, cadre de l'administration du développement local, militant actif du mouvement associatif et adepte inconditionnel de méthodes participatives.

2. De l'oisiveté dans un service administratif...

Ce parcours démarre au début des années 1970 au nord du Sénégal dans la région du fleuve. Nouvellement diplômé, je suis affecté dans une structure administrative d'encadrement du développement rural, ironiquement dénommée par les populations «centre d'élégance et de repos permanent» (CERP). En fait, c'est le Centre d'Expansion Rurale Polyvalent, un service administratif, ultime ramification de l'appareil d'Etat de planification du développement qui m'accueille comme agent d'agriculture.

Membre d'une équipe polyvalente qui se réduit à deux éléments (le chef du CERP et l'agent d'agriculture), je vis le désœuvrement dans un environnement semi-désertique. De temps en temps, j'accompagne le sous-préfet dans ses tournées de recouvrement des impôts ou de distribution de vivres de soudure dans tout l'arrondissement. Le cycle des sécheresses venait de s'installer. Cependant, l'impératif d'accroissement des productions agricoles d'exportation, surtout l'arachide, demeurait constant. Donc, il fallait intensifier les systèmes de production au mépris des incidences écologiques. Des sociétés de développement des filières agricoles (arachide, riz et, plus tard, coton) sont créées à cet effet.

3. ...à l'activisme dans une société de développement

Au bout de deux ans d'oisiveté dans le CERP, je change de cap en réussissant à un concours de recrutement de la Société de Développement et de Vulgarisation Agricole (SODEVA), héritière d'une société française, la SATEC, dans le bassin arachidier. Après une formation de six mois sur le machinisme agricole et les techniques de vulgarisation, je suis affecté au Ferlo, dans la zone sylvo-pastorale, comme assistant technique de vulgarisation de l'arrondissement de Barkèdji. Disposant d'une équipe d'encadreurs de base et de vulgarisateurs, il me revenait de parcourir, au volant d'une 2 cv, les villages pour y prêcher les mérites de «thèmes» techniques productivistes et dévastateurs des ressources naturelles. Nous étions pour la plupart des jeunes urbains s'adressant à de vieux paysans rompus à des pratiques séculaires mais ignorées. Ces derniers sont classifiés suivant des critères d'équipement et de niveau d'intensification en TL (Thèmes Légers), TB (Traction Bovine) et TBFF (Traction Bovine Fumure Forte). Sur nos conseils, ils devaient s'endetter pour s'équiper, disposer d'intrants, mais aussi dessoucher leurs champs pour faciliter le passage des charrues, houes et autres semoirs et instruments attelés (avec des primes de dessouchage). Ils étaient incités à adopter de nouvelles techniques de production dont l'incidence économique seule est mise en exergue au détriment des conséquences écologiques.

Cette étape de vulgarisateur agricole durera quatre ans. Toujours en quête d'une promotion, je réussis à un concours de recrutement interne d'intendant de la SODEVA. J'entame une carrière de commerçant gestionnaire, responsable d'un réseau de magasins d'approvisionnement en intrants agricoles dans un département. Au bout de trois ans d'intendance, je quitte la SODEVA pour retourner à l'école.

4. L'école de la praxis

En effet, je réussis au concours professionnel de recrutement de l'Ecole Nationale d'Economie Appliquée (ENEA), creuset de formation des cadres du développement à la base. Ce retour à l'école sera déterminant dans l'évolution future de mon itinéraire en ce qu'il m'a permis de disposer d'outils de relecture de ma petite expérience et de mieux appréhender les enjeux du développement rural à la lumière des principes de la planification participative (participation populaire) et de la pédagogie des opprimés (*cf.* Pablo Freire).

Au bout de trois ans d'une formation alternant les sessions théoriques entre quatre murs à Dakar et les stages pratiques sur le terrain d'application dans les villages, je retourne dans la production comme formateur à la Direction de l'Alphabétisation et de l'Education de Base. Cette étape vécue à Dakar me replonge dans ma vie de banlieusard et sert de déclic. Elle marque l'entame de prises d'initiatives en matière de pratiques sociales en marge et/ou souvent en complément de mes activités professionnelles.

C'est d'abord la création d'une association sportive et culturelle de mon quartier et la prise de responsabilité dans le mouvement de jeunesse appelé NAVETANES, deux organismes qui gèrent les activités de vacances. Je suis président de zone à l'ODCAV (Organisme Départemental de Coordination des Activités de Vacances) de Pikine, dans la banlieue de Dakar.

5. Accompagner la décentralisation et la participation

Au bout de quatre ans à Dakar, je demande à retourner en brousse pour des raisons sociales et professionnelles. D'une part, je me préoccupe de sortir de la banlieue et d'éviter à mes enfants (six filles) une éducation de la rue. D'autre part, je me sens plus utile en milieu rural, d'autant plus que durant ma formation j'ai acquis la conviction que:

— La décentralisation est incontournable pour promouvoir le développement à la base;
— Le CERP est l'outil d'encadrement le plus pertinent du point de vue conceptuel pour accompagner ce processus de responsabilisation et de participation des populations dans la gestion de leur quotidien;
— Les associations villageoises de développement sont les leviers de la participation des populations.

En effet, le Sénégal, depuis son accession à l'indépendance, a choisi une politique de *décentralisation* progressive, prudente mais irréversible. La décentralisation est un choix politique par lequel l'Etat attribue des pouvoirs et confie des compétences à des collectivités locales. Le pouvoir de décision exercé par l'Etat dans la conduite de certaines activités au niveau local est maintenant confié à des personnes publiques élues par les populations au sein de collectivités déterminées: les collectivités locales (région, communes et communauté rurale). La décentralisation vise essentiellement à promouvoir une administration de proximité et de développement exercée par (1) des autorités décentralisées (élus locaux) proches des citoyens et (2) des représentants de l'Etat sur le terrain dotés de pouvoirs déconcentrés, qui assurent un contrôle de légalité adapté et rapproché.

Les objectifs de la décentralisation sont de trois ordres: (1) l'accélération du processus de développement local; (2) le rapprochement des décisions à la base; (3) la responsabilisation des populations dans la gestion de leurs affaires.

Dans cette volonté de retour en milieu rural, je serais confronté aux lenteurs administratives. Au bout d'un an de démarches, je suis affecté comme chef du CERP dans l'arrondissement de Toubacouta, à la frontière avec la Gambie. Deux événements majeurs vont marquer mon passage dans cette localité: (1) l'élaboration participative, avec les élus locaux et les techniciens, de plans locaux de développement pour les quatre communautés rurales et (2) l'organisation d'un tournoi de football entre deux villages gambiens et deux villages sénégalais pour la commémoration de la fête de la Sénégambie. Ainsi démarre effectivement mon compagnonnage avec les collectivités locales et les jeunes ruraux.

Après un bref séjour, je suis affecté au CERP de Fissel, dans la région de Thiès. C'est dans cet arrondissement de 700 km^2, composé de deux communautés rurales, soixante-cinq villages pour une population de trente-sept mille habitants, que je vais développer le plus grand nombre d'initiatives d'autopromotion paysanne et d'appui au développement local. Dès mon arrivée, je suis frappé par trois constats: (1) la forte dégradation des ressources naturelles, notamment de la strate arborée composée essentiellement d'acacia «albida», qui fait l'objet d'un émondage abusif étant le seul fourrage disponible; (2) la faible implication des femmes dans le processus de développement local (trois groupements existent dans un arrondissement de soixante-cinq villages); et (3) le mouvement associatif est en pleine expansion mais suscite des rivalités de leadership porteuses de crise.

En plus de ces constats, je trouve des conditions favorables qui me permettront de faire du CERP un outil efficace de promotion du développement

à la base. En effet, en plus d'une équipe de jeunes techniciens qui en veulent, je noue d'excellentes relations avec des partenaires non gouvernementaux et saisis l'opportunité de la coopération décentralisée. C'est ainsi que le CERP pourra conduire des expériences novatrices en matière de:

— Structuration et autofinancement du mouvement féminin avec les caisses de solidarité et les unions communautaires;
— Gestion participative des ressources naturelles avec les auxiliaires forestiers;
— Formation des élus locaux avec des sessions régulières de renforcement de capacités;
— Assainissement de la gestion du comité de jumelage des collectivités locales de Ndiaganiao au Sénégal, Saint Herblain en France, et Sant Ingbert en Allemagne, qui m'a valu mon premier voyage en Europe (la conduite de projets de développement: construction d'un château d'eau, école, case de santé);
— Elaboration et suivi de deux programmes de développement local au profit de deux unions de groupements villageois (Koulouck et Jig Jam).

6. Lutter contre la désertification

C'est aussi durant cette période que j'adhère au RITA (Réseau d'Information des Terres Arides), une ONG anglaise d'information et de formation au service des expériences et agents de développement du Sud. RITA (ou ALIN, *Arid Lands Information Network*, en anglais) édite et publie plusieurs supports dont un organe de liaison, «Le Baobab». Je l'évoque parce que c'est en qualité de membre du RITA que je vais entrer en contact avec le RIOD (Réseau International des ONG pour la lutte contre la Désertification), qui m'invite au Forum National de vulgarisation de la Convention de lutte contre la Désertification à Dakar.

Mon sentiment en écoutant les différents intervenants à cette rencontre était qu'enfin la communauté internationale s'intéresse aux préoccupations des populations menacées par la dégradation des terres. Des populations qui ont toujours lutté contre la désertification, dont des exemples existent, que j'ai envie de montrer à la communauté des acteurs non gouvernementaux. Je pris le pari d'organiser un forum paysan de vulgarisation de la convention contre la désertification et du code forestier avec visite d'expériences locales.

Avec l'appui du RITA et d'autres membres du RIOD, le forum paysan se tient un an plus tard (en mars 1996) regroupant pendant cinq jours des leaders des organisations communautaires de base, des élus locaux, des techniciens et autorités administratives. Un événement qui va en engendrer d'autres.

Je suis invité à participer au Forum euro-méditerranéen de mise en œuvre de la CCD, co-organisé à Montpellier en octobre 1996 par SAHEL DEFIS et le CIEPAD (Carrefour International d'Echanges et de Pratiques Appliquées au Développement).

Avec l'appui du *British Council* et du RITA, un manuel de vulgarisation du code forestier du Sénégal est réalisé et publié sous forme de bande dessinée.

D'autres partenaires, comme OXFAM/GB et OXFAM/NOVIB (*Nederlandse Organisatie Voor Internationale Bijstand*), appuient le processus de mise en place d'un réseau paysan de protection de l'environnement et d'une radio rurale. D'ailleurs, le projet Réseau paysan et Radio rurale de Thiès sera le prétexte d'un partenariat entre SAHEL DEFIS France et le Service régional du Développement à la Base de Thiès, que je dirige depuis deux ans. Cette action est appuyée par un financement du Ministère français de l'Environnement et de l'Aménagement du Territoire. Entre-temps, j'ai été nommé chef du Service régional du Développement à la Base de Thiès.

Dans ce cadre, plusieurs activités de communication, d'appui à des initiatives locales et de formation seront menées en marge de la deuxième conférence des parties de la CCD tenue à Dakar en décembre 1998.

Autres expériences majeures parmi celles qui m'ont valu d'être décoré par Son Excellence Monsieur le Président Abdou Diouf, Chevalier de l'Ordre du Mérite et, un an plus tard, Chevalier de l'Ordre National du Lion: deux projets de recherche-développement sur le genre et la gestion des ressources naturelles et sur l'institutionnalisation de la participation dans un contexte de gestion des terroirs villageois. Ces projets, initiés par le Service régional du Développement à la Base de Thiès, sont appuyés par le programme Sahel de l'Institut International pour l'Environnement et le Développement (IIED). Le premier prend l'échelon d'un groupement féminin villageois et le second concerne toute la région et s'appuie sur une typologie d'expériences diversifiées.

Au moment où je m'y attendais le moins, survient une autre affectation. Je suis nommé chef du Service régional à Louga, ville au nord du Sénégal. Ce déplacement imprévu m'incite à une nouvelle réorientation de ma carrière: je décide de stabiliser ma famille qui m'a toujours suivi dans mes pérégrinations et de m'investir plus dans le mouvement associatif.

Avec des collègues et des responsables des groupements bénéficiaires, nous constituons SAHEL DEFIS Sénégal pour pérenniser les acquis du projet Réseau paysan et Radio rurale de Thiès. Ma famille rejoint mon domicile à Mbour, sur la Petite Côte, et je sollicite une affectation en complément d'effectif à la Direction d'Appui au Développement Local à Dakar. Ce sera un court séjour mis à profit par la Direction pour me confier la conception et l'édition d'un bulletin de liaison *Echo des CERP*.

7. Partenariat pour le développement durable

Au bout d'un an de recherches, je trouve des partenaires privés pour lancer une nouvelle expérience de création d'un centre écologique, touristique, culturel et social. Je demande une disponibilité de deux ans pour me lancer dans une nouvelle expérience. Ce projet est la fusion de deux idées: la création d'un centre d'accueil et la mise en place d'un programme communautaire de communication rurale et de développement durable.

Il participe d'une volonté de création d'activités de reconversion après ma retraite de l'administration.

Le projet est intitulé «Centre Mampuya partenariat pour le développement durable». Un «point vert du Sahel» est implanté pour la réhabilitation des collines dégradées du plateau de Diass, dans la région de Thiès, et des activités d'appui aux initiatives locales mises en branle.

C'est ainsi qu'une mutuelle d'épargne et de crédit est implantée, regroupant les femmes de douze villages, un projet de lutte contre la pauvreté lancé de même qu'un projet de recherche-développement sur «Tourisme durable et développement local, quelles stratégies?» ainsi qu'un projet de «Protection des ressources naturelles et promotion des produits locaux». Ces expériences sont portées par une nouvelle association dénommée Actions Concertées pour l'Entraide et la Solidarité (ACCES).

Par ailleurs, j'ai eu le privilège de participer à un processus de décentralisation d'une ONG du Nord vers le Sud. Quand les responsables d'Agrécol EV, une organisation suisse qui s'investit dans l'agriculture biologique et écologique, décidèrent, en 1996, de se «délocaliser» et transférer la direction à des cadres africains, je fus coopté comme membre du comité consultatif qui sera érigé plus tard en conseil d'administration d'Agrécol Afrique. Au bout de trois ans de démarches et d'actions sur le terrain, Agrécol Afrique est reconnue comme ONG au Sénégal, et j'en assume la présidence.

Ce tour d'horizon des quelques expériences significatives résume une carrière faite de mobilité dans l'espace et une diversité dans les fonctions au service du développement local.

Quelles enseignements tirer de ce parcours d'une trentaine d'années dans le monde rural?

D'abord, des découvertes et des rencontres enrichissantes qui m'ont appris l'humilité et l'importance de l'écoute du vis-à-vis qui, souvent, est dépositaire d'un savoir utile.

J'ai découvert la complexité du processus de développement rural qui se veut global et multisectoriel et acquis la conviction qu'un agent de développement doit se comporter plus en médiateur social et pédagogique plutôt que d'être un transmetteur de savoirs livresques.

Au bout de l'itinéraire, je me suis beaucoup rapproché du mouvement paysan sénégalais, dont les péripéties méritent d'être capitalisées et partagées; ce sera là un nouveau chantier à explorer.

International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 143-151.

Désertification et société civile

par

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MOTS-CLES. — Développement durable; Enjeux; Gouvernance locale; Société civile; Genre.

RESUME. — Le 'développement' est un long processus qui vise le bien-être de l'Homme, son évolution harmonieuse avec son environnement naturel; il s'inscrit dans la 'durabilité' et dans la recherche de la qualité de vie. La désertification est également un processus, mais qui va à l'encontre d'un développement humain durable. Ces deux processus sont antagoniques.

L'Homme a certes une durée de vie limitée, mais il a l'avantage de la pensée, de la science et de la technique, dans son combat contre un adversaire d'autant plus redoutable que la désertification est un phénomène sans état d'âme et qui avance inexorablement.

Les 'enjeux' de la lutte titanesque que l'Homme mène au quotidien contre la désertification, pour un développement durable, sont mis en exergue, sous l'angle de la 'gouvernance locale', c'est-à-dire la prise en charge à la base, par les populations, de leur vie dans un contexte climatique et géographique difficile.

Les inévitables mutations culturelles et socioéconomiques, caractérisées notamment par la perte des repères identitaires, et quelques effets pervers de la décentralisation sont relatés, par le biais de notre expérience de terrain. Notre témoignage, restreint, est celui d'un membre de la société civile, à la fois trésorière du Comité de Pilotage des Radios de Proximité (CPRP) au Niger et vice-présidente de SAHEL DEFIS (Développement, Environnement, Insertion Sociale) Burkina.

Notre vision de ce thème s'appréhende à travers le prisme du 'genre' car nous avons l'avantage d'être femme et, à ce titre, nous sommes solidaire du noble combat de nos sœurs.

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Mon engagement en tant que militante du développement depuis plus de trente ans m'a permis de vivre quelques modestes expériences. Ayant eu la

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chance, dans mon jeune âge, de passer un séjour chez un ami de mon père, le Président Kwame Nkrumah du Ghana, pendant les commémorations de l'indépendance de ce pays en 1957, et d'y côtoyer l'Américain W. E. Burghardt Dubois, j'entendais, sans en assimiler réellement leur portée, leurs discussions sur le conscientisme, l'autonomie de l'Afrique, le panafricanisme. Auparavant, j'étais déjà imprégnée des échanges de télégrammes entre mon père, depuis la Haute-Volta, et son ami Patrice Lumumba, au Congo. Mon père, qui était à l'époque un des administrateurs de l'Afrique-Occidentale française, lui proposait de réfléchir sur la possibilité d'adapter le communautarisme africain à la non-violence de Gandhi en Inde, pour forger un modèle de développement spécifique à l'Afrique.

Très tôt, j'ai voulu comprendre comment cette Afrique, qui avait eu de grands empires, subissait aujourd'hui un incroyable recul. Mon continent était classé dernier et le terme de «pays sous-développés», qui sonnait comme une condamnation sans appel, parce que sans connotation de la moindre progression, me hérissait d'autant plus que les Africains avaient largement contribué à développer l'Europe, l'Asie, le Proche-Orient, et surtout à faire de l'Amérique la première puissance mondiale. Cette situation m'interpellait particulièrement et j'estimais que les Africains devaient faire un bilan sans complaisance de cette catastrophe pour mieux organiser le développement du continent. Mais, en dehors de mon vénéré Professeur Cheikh Anta Diop, je ne parvenais pas à rallier mon entourage à ma cause.

Lorsque je plaidais pour que les Africains parviennent à se hisser, en s'acceptant mieux et en analysant au moins correctement les conséquences sur leur développement de phénomènes tels que l'esclavage — le sujet de ma thèse —, la colonisation et décolonisation, la contribution à deux guerres mondiales, les travaux forcés, la démocratisation, la chute du pouvoir d'achat suite aux prêts d'ajustement structurels et, plus tard, la dévaluation du franc CFA, etc., mon auditoire le plus poli m'opposait des contre-arguments irréfutables. J'ai appris à mes dépens que mes élucubrations sur les torts de l'esclavage n'étaient pas scientifiquement démontrables et que, de toute façon, les esclaves avaient été vendus d'un côté et achetés de l'autre. Mon directeur de thèse de troisième cycle me fit même modifier mes recherches sur ce sujet «pour ne pas me faire massacrer». Pour tous, j'aurais mieux fait de me tourner résolument vers l'avenir, sans situer les responsabilités de part et d'autre, et me battre à mon humble petit niveau pour contribuer au développement de l'Afrique actuelle. En conséquence, il n'y avait plus lieu de se laisser aller à des lamentations — stériles — sur le passé et encore moins de faire des revendications pour une quelconque réparation.

C'est ainsi que mon engagement dans la société civile eut un véritable effet de levier sur ma pénible réorientation. J'ai pleinement adhéré à SAHEL DEFIS Burkina et SAHEL DEFIS Niger. J'y suis par conviction.

Ma seconde expérience la plus parlante est celle que j'ai vécue avec le Comité de Pilotage des Radios de Proximité (CPRP) au Niger, lorsqu'il nous fallait œuvrer à désenclaver, notamment en matière de communication, des zones désertiques totalement isolées et non couvertes par les médias nationaux.

Mon témoignage, plutôt restreint, est celui d'un membre de la société civile au sens large, comprenant donc les ONG, les associations et les groupements, les collectifs, etc.

Ma présentation a trait à ma perception, en tant que membre de la société civile, de la gouvernance, par elles-mêmes, des zones désertiques d'Afrique subsaharienne, dans un contexte d'avancement de la désertification, par rapport à un développement durable. Lutter contre la désertification dans ces zones arides est, en soi, un énorme combat. Vouloir y relever le défi d'un développement durable est un pari majeur.

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Au préalable, je dirai que l'une des avancées significatives du moment est la consécration de l'année 2006 comme Année internationale des déserts et de la désertification par les Nations Unies.

Au niveau du terrain et de mon engagement personnel, je dois avouer que je me suis aventurée dans le nord du Burkina et dans le désert nigérien la tête pleine d'idées préconçues sur la promotion du développement à la base nécessitant des actions cohérentes, structurantes et pérennes, pour combattre la désertification.

Le premier choc que j'ai eu, a été le constat qu'il fallait vivre avec la désertification, ce qui n'était pas pour remonter le moral d'une combattante très motivée, convaincue d'être née pour faire du développement. J'ai dû me résoudre à reconnaître que le désert avait ses propres lois. Que de contrastes entre mes croyances initiales et mon vécu!

Je me rendais compte qu'au lieu d'un développement durable pour l'Afrique, mon continent sombrait plutôt dans des guerres durables, plus visibles et plus sensationnelles que la lutte contre la désertification et pour la protection de l'environnement. Et pourtant, les démocraties de type occidental avortaient successivement. Les méfaits de la désertification étaient occultés. Pour moi, la réalité de terrain était que famines et sécheresses alternaient

avec inondations dans le désert. Le cycle de ces sécheresses, l'érosion, la dégradation du couvert végétal, le dépeuplement dû à la migration et à l'exode rural, entravaient un développement durable. Le pire, c'était la fatalité — ou peut-être était-ce là une forme de sagesse — avec laquelle les cataclysmes étaient acceptés. Les besoins sont tellement énormes qu'aides et subventions semblent insignifiantes. Le combat contre la désertification exige d'énormes ressources humaines, matérielles et surtout financières, sur une longue durée.

Le sentiment d'impuissance qui me gagnait au début, face aux aléas de la désertification, semblait en revanche n'avoir jamais entamé ni le courage ni la détermination des populations du désert dans leur lutte quotidienne pour la survie. Mais l'une des premières choses avec lesquelles j'ai dû composer, c'est que leur hospitalité légendaire pouvait aisément devenir une barrière vis-à-vis de tout intrus voulant cultiver des relations durables. Ces habitants, en raison d'un environnement difficile ayant forgé leur mode de vie, sont méfiants et pragmatiques. Ils ne finissent de se livrer à un tiers que graduellement, par paliers, et jusqu'à un certain point. Ils prennent un long temps pour jauger la fiabilité de l'autre et sont enclins à jouer aux idiots pour endormir sa curiosité.

L'un des problèmes de la profane que j'étais, c'était l'initiation à la vie dans le désert. J'ai appris le rôle premier du bâton du berger, les conséquences de malformations aux pieds, l'aberration de la préférence de la bougie à l'électricité, etc.

C'est que la société civile dont je me réclame, est engagée dans de nombreuses activités de formation, microfinance, gestion autonome, promotion de l'artisanat local, banques de céréales, petit commerce, agriculture, maraîchage, embouche bovine, hygiène, assainissement, reboisement, etc. J'ai vu nombre de projets, de réformes se succéder alors que l'insatisfaction persistait tant au niveau des populations que des intervenants. Après chaque échec, il s'ensuivait des évaluations, des formations complémentaires... Les résultats étaient souvent mitigés. En même temps, je réalisais que je pouvais difficilement imputer certains échecs aux représentations erronées faites sur les populations.

Sans être afro-pessimiste, je découvrais une réalité pire que prévu, masquée par d'incroyables jeux d'intérêts, selon les acteurs concernés. Auparavant, je voyais cet univers à travers le prisme des médias, des politiciens, etc. J'ai compris que les dysfonctionnements récurrents devraient faire l'objet d'études socio-anthropologiques approfondies, mais leurs résultats ne devraient pas pourrir dans des tiroirs.

Le combat entre désertification et développement durable pouvait, pour ma part, être livré et gagné grâce au savoir et au savoir-faire d'une société

civile de qualité et un soutien conséquent de partenaires sérieux et motivés. Or, les financements étaient faibles, ponctuels et ne permettaient pas de mener à leur terme les actions soutenues exigées par un développement durable. Le drame, c'est l'interruption de ces financements aléatoires pour cause de mauvaise gestion et le coup d'arrêt porté, à mi-parcours, à des actions prometteuses.

Les réalités du terrain et le tarissement des financements ont conduit les populations à apprendre à s'organiser elles-mêmes, à nos côtés. Exemple, lorsqu'il fallait faire occuper par le cheptel, de façon rotative, les directions pour permettre la régénération naturelle du parcours des animaux, les populations ont dû assimiler les ficelles de la gestion rationnelle des pâturages et la concertation. Les partenaires financiers exigent la transparence, alors qu'au village, il n'est pas dans les habitudes de dénoncer, surtout auprès d'un étranger, certains actes posés par un chef. En effet, quand le chef n'est plus bon et que, chaque matin, ses notables ne viennent plus le saluer, il déduit de lui-même qu'il doit s'en aller.

A nos côtés, les populations tranchaient elles-mêmes lorsqu'il fallait enrichir les parcelles avec de la fumure animale ou par des semis de semences importées, faire l'enrichissement avant ou après la mise en jachère, choisir à qui incombait cette tâche entre le propriétaire du troupeau et l'éleveur, déterminer la classe d'âge de ceux qui devaient le faire, sachant que les animaux pâturent en général dans un rayon de 25 km autour d'un puits. Cette gestion rationnelle des espaces nécessite un suivi permanent et, bien qu'épuisante, est incontournable.

La sonnette d'alarme a été tirée plusieurs fois par SAHEL DEFIS. Cette association représente un réseau d'ONG sahéliennes actives dans la lutte contre la désertification et la pauvreté. Elle est notamment accréditée auprès du Secrétariat de la Convention des Nations Unies sur la lutte contre la désertification. L'objectif de SAHEL DEFIS est de «soutenir financièrement et techniquement les initiatives locales porteuses, en vue d'en faire un tremplin pour des actions de développement durable à travers la formation, la génération d'emplois et de revenus, ainsi qu'une saine gestion des ressources naturelles et la réhabilitation des sites environnementaux menacés».

SAHEL DEFIS a initié de nombreux programmes d'appui aux initiatives locales, parmi lesquels le «programme femmes et jeunes du Sahel», le «projet d'appui aux plateformes multifonctionnelles», les «points verts du Sahel», dont le lancement officiel a été réalisé avec l'opération Djomga 2001, *Global Green Burkina* en partenariat avec le Japon, les actions d'appui au Sénégal, au Mali. Une antenne a été créée au Niger. Les activités de représentation de SAHEL DEFIS au plan international sont nombreuses. En

particulier, elle s'est attachée à la mobilisation des ONG pour la mise en œuvre de la Convention des Nations Unies sur la lutte contre la désertification (CCD).

Le succès de SAHEL DEFIS a consisté à proposer «des réponses locales pour des questions globales». Ainsi énoncées, les choses semblent simples, alors que SAHEL DEFIS livre un véritable combat de titan. Et malgré les nombreux obstacles que l'association a rencontrés, la lutte continue, partant d'un autre constat: celui que l'Homme a certes une durée de vie limitée, mais qu'il a l'avantage de la pensée, de la science et de la technique, dans son combat contre un adversaire d'autant plus redoutable que la désertification est un phénomène sans état d'âme et qui avance inexorablement.

Au Niger, avec le CPRP, j'ai davantage parcouru le désert du Ténéré, l'Aïr. Souvent, les paysans assistent impuissants au recouvrement des cuvettes dans les localités assiégées par le sable qu'ils surnomment «l'envahisseur». La désertification s'y traduit par la perte de grandes superficies, la disparition de la faune sauvage. Les opérations conduites, avec la participation physique des populations locales, pour la stabilisation, puis la fixation mécanique et biologique des dunes, ont dans certains cas réussi, avec la plantation d'arbres en blocs, la multiplication des pépinières villageoises. Mais les sites récupérés par des populations qui ont travaillé avec acharnement, sont menacés par les mêmes populations et, quelquefois, il est difficile de comprendre certaines formes de négligence. La conquête effrénée de terres cultivables et le surpâturage aggravent dangereusement le processus de désertification. La sensibilisation pour y remédier est quotidienne. Le taux de croissance de 3 % de la population augmente le besoin en terres de culture.

L'une des stratégies de lutte est le système de contrats de culture établi avec les populations riveraines des forêts afin de les faire participer à la gestion de la forêt. L'autopromotion paysanne en période de soudure, de juin à octobre, se fait par les banques céréalières par l'offre d'un service de vente et d'achat de proximité de céréales, à des prix modérés, en jouant un rôle modérateur sur la fluctuation des prix, en période de pénurie.

Les inévitables mutations culturelles et socioéconomiques nées de la désertification se caractérisent notamment par la perte des repères identitaires et quelques effets pervers de la décentralisation. Certaines populations migrent vers les pays dits de qualité et peuvent devenir des clandestins, au péril de leur vie. La mendicité urbaine est un recours de survie humiliant. Les nomades de la ville, désorientés, sans ressource, vivent une agonie permanente et se retrouvent immigrés chez eux. Ceux qui restent sur place voient leur habitat détruit par les inondations et subissent une inversion de

leurs activités. On voit aujourd'hui des agriculteurs se transformer en mauvais éleveurs. Les conflits qui en résultent sont souvent dramatiques.

SAHEL DEFIS n'a jamais oublié les lourdes charges qui pèsent sur les épaules de la femme des sables. L'élimination des déchets incombe à ces femmes, les exposant à des maladies graves inhérentes à la pollution de l'environnement, la contamination de l'eau par des pesticides et produits chimiques toxiques et à une mort par empoisonnement. Sans compter que la recherche de l'eau sur de longues distances provoque des maux de dos chroniques et surtout de nombreuses fausses couches, s'accompagne de risques d'abus sexuels à la tombée de la nuit lorsqu'elles recherchent le bois.

Une des solutions serait d'appliquer effectivement une politique cohérente de gestion des ordures publiques à tous les stades, avec la construction de dépotoirs, des actions de salubrité et de réhabilitation des puits mieux ciblées, un appui renforcé aux agents de sécurité pour les patrouilles.

On évalue le nombre de groupements féminins au Niger à 2 000 dans la capitale Niamey, 1 792 à Maradi, 1 400 à Zinder et 667 à Agadez. C'est dire l'engouement des femmes pour participer au plan communautaire au développement durable. Ces groupements jouent un rôle moteur de réflexion, de liberté d'expression, de formation et d'information permettant aux femmes de contribuer au développement durable. L'octroi d'une pirogue peut transformer la vie des femmes du Fleuve. A cet effet, une meilleure exploitation du fleuve Niger serait une solution de développement durable. L'industrialisation, des courges notamment, serait une option porteuse. L'embouche bovine, les cultures de contre-saison illustrent la rentabilité des activités des femmes des groupements. Le principal frein, c'est l'insuffisance ou le manque de financement; ensuite, la gestion rationnelle de ces financements est à suivre de très près. Une meilleure exploitation du fleuve Niger serait une solution durable.

Concernant la jeunesse, la scolarisation des enfants nomades se heurte à des difficultés inhérentes au déplacement incessant des familles, avec leurs animaux au gré des saisons et des lieux, à la recherche de pâturages abondants et de points d'eau. Le défi que la société civile contribue à relever est d'aider à la formation des enfants des «écoles nomades». Ces écoles sont implantées dans des localités reconnues zones nomades et sont montées sous forme de tentes ou de paillotes qu'on déplace en suivant les éleveurs. C'est un véritable parcours du combattant. Les enfants, soumis à des tâches pénibles de corvée d'eau et de conduite des animaux pour le pâturage et l'abreuvement, n'ont pas le temps de fréquenter correctement les écoles. Celles-ci sont dotées de cantines, mais cela ne résout pas toujours le problème, compte tenu de la forte mobilité des populations. Aujourd'hui, grâce

à la sensibilisation faite par la société civile, il y a des cas exceptionnels où les parents consentent à laisser volontairement leurs enfants poursuivre leurs études toute l'année scolaire dans la même localité. Pendant les vacances scolaires, un membre de la famille vient rechercher les enfants, dans la poursuite des périples quotidiens. Je puis témoigner que les enfants internés sont généralement intéressés par l'école, surtout avec la présence des cantines.

Cependant, la leçon magistrale a été pour moi qu'à bien considérer les choses, l'avenir du Sahel nigérien est plus dans les zones désertiques. J'en étais consternée.

L'Afrique est d'essence matriarcale et les vestiges y sont. Les formes d'organisation matriarcale sporadique demeurent. Le pouvoir réel de la femme est énorme, mais ne se manifeste pas au quotidien pour un œil non averti. La femme est la source de l'héritage, le pouvoir lui appartient et l'homme agit souvent par délégation. Des protocoles culturels peuvent être passés avec elle.

Ne nous trompons plus de combat, la victoire dans la lutte contre la désertification et le développement durable passe par la femme.

REMERCIEMENTS

Au nom de SAHEL DEFIS international, de SAHEL DEFIS Burkina, du Président fondateur, Monsieur Tahirou Diao, et en notre nom propre, nous remercions l'Académie Royale des Sciences d'Outre-Mer, et en particulier le Professeur Danielle Swinne, Secrétaire perpétuelle, et son équipe, pour nous avoir fait l'honneur de nous inviter à cette conférence internationale de haut niveau sur la désertification. Cette attention, à laquelle nous sommes sensible, nous permet d'apporter le témoignage de la société civile au Burkina et au Niger et de partager, en notre qualité de vice-présidente de SAHEL DEFIS Burkina, notre modeste expérience de terrain en matière de lutte contre la désertification, dans une optique de développement durable.

C'est le lieu de remercier la CCD pour tous les efforts consentis en faveur de l'Afrique, et du Sahel en particulier.

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International Conference
Desertification:
Migration, Health, Remediation and Local Governance
Royal Academy for Overseas Sciences
United Nations
Brussels, 22 September, 2006
pp. 153-154.

Note d'introduction du film «Quand le désert avance»

par

Jean-Marie Karimou AMBOUTA*

MOTS-CLES. — Niger; Gouré; Cuvettes; Ensablement; Fixation des dunes.

RESUME. — Le tournage de ce film a été réalisé en janvier 2006 par M. Daniel Bay lors d'une mission des partenaires belges du Projet Interuniversitaire Ciblé de Recherche sur l'Etablissement des Cuvettes à Gouré (PIC-REC Gouré).

Il s'agit d'un projet d'initiatives émanant d'institutions universitaires en matière de coopération au développement. Il est né de la volonté de certaines institutions universitaires du Nord (Université de Liège, Faculté Universitaire des Sciences Agronomiques de Gembloux, Université Catholique de Louvain) et du Sud (Université Abdou Moumouni de Niamey) de travailler ensemble sur la thématique de la désertification, plus particulièrement sur les processus de l'ensablement.

Le projet vise les objectifs suivants:

— La compréhension des processus éoliens de mobilisation des particules de sable;
— Les impacts de ces processus éoliens sur la fertilité des sols;
— L'amélioration des méthodes de lutte (fixations mécanique et biologique) et leur impact.

Les atouts du Niger et de la région de Gouré (sud-est du Niger) pour accueillir un tel programme de recherche sont principalement:

— L'environnement nigérien fragile et vulnérable;
— L'existence de compétences pour traiter de façon interdisciplinaire la problématique de l'ensablement;
— Gouré est une des régions du Niger parmi les plus sensibles au phénomène de l'ensablement des cuvettes, terrains privilégiés pour une production agricole moins sensible aux fluctuations climatiques.

Les acteurs en présence dans le projet sont:

— Les populations des villages de Tchago et Worro;
— Les universitaires belges et nigériens intervenant en partenariat;
— Les étudiants thésards et mémorants belges et nigériens;
— Le Service de l'Environnement de Gouré.

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Le film présente:

— Le milieu physique constitué de dunes plus ou moins vives ponctuées de cuvettes;
— Les activités d'exploitation et de production;
— Les menaces de l'ensablement;
— Les interventions du projet sur les dunes et les cuvettes;
— Les attentes des principaux acteurs;
— Les perspectives pour l'après-projet.

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Conclusions

by

Jean MARCHAL

Cette conférence a été très riche en présentant différentes facettes de la problématique de la désertification.

Nous avons d'abord visionné un remarquable film réalisé en janvier 2006 par M. Daniel Bay lors d'une mission des partenaires belges du Projet Interuniversitaire Ciblé de Recherche sur l'Ensablement des Cuvettes à Gouré (PIC-REC Gouré).

Nous avons pu ensuite rêver en suivant l'itinéraire qui a retracé quelques étapes significatives du parcours d'un jeune banlieusard qui, pour se remettre d'un échec scolaire, réussit à un concours et embrasse une carrière «d'agent technique d'agriculture». Il lui est revenu de prêcher les mérites de «thèmes» techniques productivistes et dévastateurs des ressources naturelles à de vieux paysans rompus à des pratiques séculaires mais ignorées.

Il a été démontré dans une autre présentation que la relation développement-désertification-migration est certainement complexe mais suffisamment apparente pour remplacer progressivement la logique migration-sécurité.

New in the UNCCD is the integrated manner in which desertification and land degradation are addressed. It has been shown that it is necessary to create a dynamic, coordinated process that links the environmental dimension of desertification with a broader socioeconomic framework, and results in conditions that support self-sustained livelihood in dryland areas.

Une chose est certaine, a-t-il été dit par un orateur: il est temps de commencer à agir pour gérer une rareté croissante de l'eau; il ne reste que peu d'années avant que cette rareté ne devienne un frein majeur au développement et un catalyseur de tensions.

Il a été démontré ensuite que des paramètres physiologiques précoces permettent de quantifier le dépérissement de la végétation de manière à enclencher les interventions thérapeutiques et éviter les effets physiologiques irréversibles menant à la mort de la plante.

In one of the lectures, the following themes were identified as priority issues, in an attempt to define future paths of dryland research for sustainable development: (1) conservation of cultural and biological diversity; (2) integrated management of water resources; (3) assessing dryland ecosystem dynamics; (4) agriculture and pastoralism; (5) coping with natural and man-made disasters; (6) global change; (7) education and knowledge sharing; (8) reversing environmental degradation; (9) costs of 'inaction'; (10) renewable energies; (11) ecosystem services and their trade-offs; (12) viable dryland livelihood. The scientific community is invited to increase the involvement of youth and women in research, innovation and education programmes.

Un orateur a bien mis en évidence deux processus antagonistes, à savoir que, d'une part, le développement est un long processus qui vise le bien-être de l'Homme, son évolution harmonieuse avec son environnement naturel; il s'inscrit dans la durabilité et dans la recherche de la qualité de vie alors que, d'autre part, la désertification est également un processus, mais qui va à l'encontre d'un développement humain durable.

It has also been pointed out that the monitoring of desertification is an increasingly important advance in the management of dryland areas. The establishment of long-term and rigorous monitoring programmes is an effective way to assess the status of natural resources and the evolution of desertification processes.

Desertification is due to population pressure, socioeconomic and policy factors that lead to overgrazing, deforestation and poor agricultural practices. In addition, rainfall shortages increase degradation in the fragile dryland ecosystems. In this presentation, new longer datasets have been explored at different locations of West Africa. Results confirm previous estimations, *i.e.* very high concentrations of fine particles during the dry season. The human health threat of mineral dust is therefore very likely, despite current statistical evidence from West-African studies because adequate particulate air pollution and health data are inexistent at present.

From the field experience of MSF in recent years, two particular issues have been highlighted: recurrent or continuously high levels of acute malnutrition on a large scale; access barriers to paying health care in public health services among an impoverished population.

Improving livelihood in conjunction with research on combating desertification and drought, crop diversification with horticultural crops, and promoting village-level agro-industry through value-added products are among the options with great potential for increasing the income and nutritional level, and generating employment, for rural communities in CWANA.

Environmental disruptions are generally recognised as an increasingly important factor of migration. It has been shown that these environmental disruptions can be extremely diverse, brutal or slow-induced, natural or man-made, that they often have in common to affect the most vulnerable populations and cannot adapt to a changing environment. Among these environmental migrations, the aim of this paper is to study those triggered by desertification.

Un projet a également été présenté qui vise à déterminer des propositions en vue de garantir l'adoption locale de solutions de lutte contre la désertification et le succès de l'implication des acteurs dans ce processus. La réduction du risque de désertification réside dans une meilleure compréhension des problématiques environnementales et sociales rencontrées, dans l'échange autour des solutions et techniques de lutte contre la désertification à mettre en place et dans une meilleure implication des associations et acteurs dans ce processus.

This International Conference has been organized on the initiative of our colleague André Ozer and the "Environment and Development" Commission chaired by our colleague Morgan De Dapper.

My warmest thanks to the United Nations for chairing this conference with us, to all the speakers and participants, to the staff of our Academy for their hard work preparing this event, and also to all the sponsors for supporting this Conference.

POSTERS

Reviving Deserts: Dryland Natural and Cultural Heritage Restoration and Conservation

by

Roseline BEUDELS*

KEYWORDS. — Saharan Biodiversity; Megafauna Restoration; Extinction; Emblematic Species; Linking Natural and Cultural Heritage.

SUMMARY. — Eurasia and North Africa are crossed by the largest and most complex continuous belt of arid lands on earth, comprising an entirely interconnected set of deserts.

Such arid lands tend to have a negative image in dominant socio-economic models, even among organizations concerned with environment and sustainable development.

Yet, these extraordinary biomes and their associated rivers and mountains were the scene of the earliest expression of many endeavours of mankind, the birth of several great civilizations, of urban life, of writing, of alphabets. They harbour a fauna and flora of prodigious beauty and fascinating adaptations. They are the cradle of most major animal and plant domestication events. They harbour an invaluable cultural and natural heritage, unique cultural landscapes, prestigious architectural and artistic legacies of civilizations going back over ten millennia.

Deserts, more than any other ecosystem, have, by the very nature of the challenges they provide, generated extraordinarily elaborate responses both through the process of biological evolution and through that of human technological and cultural development. The achievements of these processes can still be admired today in animal and plant species of unique emblematic value and in expressions of traditional cultural know-how.

The exceptional heritage is seriously threatened, in part by ignorance of its significance, and not in the least by the schemes of those who, with a stupefying blindness to history, see the desert only as a general nuisance, waiting to be transformed into a productive wasteland amenable to the rules of the market.

Identifying conservation processes is urgent. The megafauna may be a determinant factor of these efforts.

Many archaeological sites, with their potent emotional and intellectual contents, are scattered over areas of great natural beauty, in unique habitats where the megafauna once roamed, and are very rarely visited.

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Protected areas holding large mammals are a major source of revenue for East and southern African countries; they are a magnet that can be combined with historical, cultural and indigenous people's values to constitute packages of much higher attractive potential.

Linking its main archaeological and historical sites with natural sites of unique quality, through the theme of the great mammals, is a particularly promising approach to the revalorization of resources of drylands, first through quality tourism and its immediate by-products, then by the longer-term notoriety effects it generates. Desirable development, beyond subsistence, can only rest on access to and promotion of resources that enhance the local quality of life or whose benefits can be traded with other people.

The conservation and restoration of the megafauna of arid lands has been a major and ambitious endeavour of the United Nations Convention on Migratory Species since 1991, translated into two major Concerted Actions, the Sahelo-Saharan Antelope Concerted Action and the Central EurAsian Aridland Concerted Action.

The Convention's approach is based on admiration, praise, respect, passion for a heritage painted, carved, sculpted, used, hunted, worshiped by millennia of brilliant civilizations, a desire not to change the nature of the arid zones but to conserve and enhance their value, and a will to considerably raise the world's awareness of their significance. The Actions aim at federating the many initiatives already operating in the area and at constructing a coherent network of protected areas and migration corridors closely linked to the major anchor points of the cultural heritage.

Etude de l'ensablement dans la région de Gouré (sud-est du Niger): processus et apports de la télédétection

par

Catherine BODART*, Amina TIDJANI ALOU** & André OZER*

MOTS-CLES. — Niger; Ensablement; Télédétection.

RESUME. — L'étude consiste en une approche de la problématique de la remise en mouvement du sable dunaire et de la dégradation du milieu dans la région de Gouré (sud-est du Niger) au moyen, notamment, de l'analyse diachronique de la zone d'étude par télédétection. Son originalité est l'utilisation complémentaire de différentes sources de données (photographies aériennes, images satellitaires optiques et radar, données climatiques, voyages de vérité-terrain) dans l'analyse du processus d'ensablement.

Pour combattre efficacement l'ensablement des terres et assurer une fixation durable du sable dunaire, une bonne compréhension du processus et du secteur dans lequel il prend place est nécessaire. Dans cette optique, une discussion sur le modelé dunaire de la région de Gouré a d'abord été entreprise pour passer ensuite à l'analyse diachronique par télédétection du milieu et du processus d'ensablement sur une période d'un peu moins de cinquante ans.

Il ressort de cette analyse qu'un problème de grande ampleur sévit dans la région de Gouré. Les péjorations climatiques des années 1970-90 et la pression anthropique croissante sont majoritairement responsables de la réduction de la couverture végétale et de la diversité des espèces ainsi que de nombreux processus de remaniement du sable dunaire. Les dunes réactivées menacent actuellement l'existence de certaines cuvettes interdunaires, de certains villages et de nombreuses terres de culture de la région de Gouré. Cependant, la reprise d'une pluviométrie plus normale observée durant les dix dernières années, ainsi qu'une meilleure gestion des territoires, devraient permettre une régénération future du couvert végétal, telle qu'elle est déjà amorcée dans certaines zones non affectées par l'activité de l'Homme.

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Apport de la télédétection à l'étude du changement de couverture du sol à l'aide de l'indice PVI. Cas de la partie amont du bassin versant de l'Oued Isser, Algérie

par

Mohamed DAOUDI*, André OZER**,
Marc SALMON*** & Abdelkader ABDELLAOUI****

MOTS-CLES. — Erosion; Ravinement; Télédétection; PVI.

RESUME. — L'érosion ravinante est un phénomène complexe très répandu au nord de l'Algérie qui menace gravement les potentialités en eau et en sol.

Pour faire face à cette problématique, une étude de changement de couverture du sol à partir de données multisources et multidates de télédétection sur la partie amont du bassin versant de l'Oued Isser, a été réalisée. Trois images ont été utilisées (TM 1987, ETM+ 2001 et Aster 2005) pour calculer l'Indice Perpendiculaire de Végétation (PVI) afin de classifier et quantifier les modifications de couverture du sol durant la période considérée.

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Root Characteristics of Representative Mediterranean Plant Species and their Potential to Increase Topsoil Resistance against Concentrated Flow Erosion

by

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KEYWORDS. — Erosion Resistance; Gully Erosion; Mediterranean; Root Density.

SUMMARY. — In Mediterranean environments, water erosion is one of the main desertification processes. Several studies indicate that in such environments gully erosion may be responsible for more than 80 % of total soil losses due to water erosion, whereas this process often only operates on less than 5 % of the land area. Re-vegetation of concentrated flow zones is considered as one of the most effective ways to reduce sediment production and to decrease sediment connectivity. Many studies describe the effect of vegetation on runoff hydraulics, sediment detachment rate and transport capacity of the flow, but most studies attribute the effect of vegetation on reducing soil erosion to the effects of the above ground biomass. Research on the effects of root characteristics on topsoil resistance to concentrated flow erosion is rather limited. However, in a Mediterranean context, the above ground biomass can temporarily disappear because of fire or overgrazing and when concentrated flow erosion occurs, roots can play an important role in controlling soil erosion rates. Despite the recent knowledge on the effects of roots on the topsoil resistance to concentrated flow erosion, information on root characteristics of Mediterranean plants, growing on semi-natural lands, and their effects on the topsoil resistance is lacking. A framework to evaluate plant root systems for this purpose is absent as well. Therefore, typical Mediterranean plant root systems were examined according to their potential to increase the soil erosion resistance of the topsoil against concentrated flow. Root density (RD), root length density (RLD), root diameters and root to shoot ratio were assessed for twenty-six typical Mediterranean plant species. RD in the 10 cm thick topsoil ranged between 0.13 kg m^{-3} for *Bromus rubens* and 19.77 kg m^{-3} for *Lygeum spartum*, whereas RLD ranged between 0.01 km m^{-3} for *Nerium Oleander* and 120.43 km m^{-3} for *Avenula bromoides*. Root density values and root diameter distribution were then transformed into relative soil detachment rates using recently published empirical relationships in order to predict the erosion-reducing effect of roots. Comparison of erosion-reducing effects for each plant species allows one to rank the different plant species according to

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their effectiveness to prevent soil erosion by concentrated flow. The results show that grasses like *Helictotrichon filifolium, Piptatherum miliaceum, Juncus acutus, Avenula bromoides, Lygeum spartum* and *Brachypodium retusum*, have the highest potential to reduce soil erosion by concentrated flow. But also shrubs like *Anthyllis cytisoides, Retama sphaerocarpa* and *Taùarox canariencis*, having high root densities in the topsoil, can reduce erosion rates drastically. Among the species growing in channels *Lygeum spartum* has the highest erosion-reducing potential, whereas *Phragmites australis* was the least effective. On abandoned fields, *Avenula bromoides* and *Plantaga albicans* were the most effective species in reducing soil erosion rates, while *Thymelea hirsuta* and *Bromus rubens* were the worst. On steep badland slopes, *Helictotrichon filifolium* and *Stipa tenacissima* performed the best in the analysis of erosion-reducing potential, while *Ononis tridentata* was the least effective species.

Quantifying Water Savings by Supplemental Irrigation Using Remote Sensing and Spatial Modelling. A Case Study in Syria

by

Eddy DE PAUW*, Theib OWEIS, Bashar NSEIR & Jawaad YOUSSEF*

This study describes a modelling methodology for using Geographic Information System (GIS) tools to identify potential areas for the introduction of supplemental irrigation. Supplemental irrigation, in contrast to full irrigation, makes optimal use of natural precipitation, resulting in substantial water savings in the irrigated areas, which can then be used to irrigate previously rainfed areas and reduce vulnerability to drought.

The method is based on the combination of a simple model to calculate possible water savings, made by the shift from spring/summer fully-irrigated crops to supplemental-irrigated winter/spring crops, with a water allocation procedure for the surrounding rainfed areas based on suitability criteria.

In order to model the complex relationships between irrigated and rainfed areas, a Spatial Water Allocation Algorithm was developed as a stand-alone Visual Basic programme operating on data layers consisting of climate surfaces, classified Landsat imagery and the SRTM digital elevation model. Landsat imagery was the basis for identifying areas irrigated in summer, forest areas and arable land by supervised classification methods. Forest areas were considered a prohibitive constraint, whereas the land-use category 'arable land' was, in the absence of good soil maps, a proxy for 'suitable soils'.

From this modelling exercise it appears that there is in Syria a large potential for supplemental irrigation by shifting from a fully irrigated summer crop to a partially irrigated winter-spring crop. This potential amounts roughly to a more than doubling of the area under irrigation at any particular time.

The methodology can be applied in other dryland areas without major modifications. The factors, decision rules and thresholds that determine suitability and water allocation priorities can be adjusted to local conditions. The data requirements include data layers related to precipitation and evapotranspiration, a digital elevation model, land use/land cover and soil maps, or, in their absence, these factors derived from satellite imagery.

Future work includes the testing of this methodology as well as its incorporation into a decision-support system that allows user control in developing relevant scenarios for change, which may differ from place to place.

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Lutte contre l'ensablement à Nouakchott grâce au projet «ceinture verte»

par

Elise DION* & André OZER**

MOTS-CLES. — Mauritanie; Pression anthropique; Dégradation environnementale; Lutte contre l'ensablement; Télédétection.

RESUME. — Nouakchott, capitale de la Mauritanie, se situe le long de l'océan Atlantique, en milieu sahélien, zone en équilibre écologique fragile. Depuis les années 1970, cet équilibre est perturbé par une chute sensible des précipitations, premier facteur responsable du processus de désertification. Nouakchott connaît une situation plus critique encore par la croissance effrénée de sa population suite à la sédentarisation massive des populations traditionnellement nomades entraînant une importante pression démographique sur le milieu. La population de cette ville s'est multipliée par deux cents depuis sa création en 1958 (elle comptait en 1950: 500 habitants, en 1970: 37 500 habitants, en 1990: 400 000 habitants et en 2006: 1 000 000 d'habitants). Cette augmentation accentue le phénomène de désertification par la destruction du couvert végétal (avec le déboisement, le surpâturage, le piétinement, ...).

Un effet néfaste important de la désertification est la remise en mouvement du sable d'anciens cordons dunaires qui étaient fixés par la végétation. L'érosion éolienne a pour conséquence d'ensabler les quartiers nord et nord-est de Nouakchott, posant d'énormes problèmes d'aménagement car le sable menace toutes les infrastructures socio-économiques. La lutte contre l'ensablement est donc devenue une priorité.

Un projet de plantation d'une ceinture verte autour de la ville a été lancé en 2000 dans le but de reboiser, en amont de la direction des vents transportant les sables, pour protéger les zones urbaines critiques. Ces plantations sont implantées en vue de stopper l'avancée des sables des dunes vives mais également pour favoriser la régénération naturelle de la végétation locale. Ce projet, « Appui à la réhabilitation et à l'extension de la ceinture verte de Nouakchott », est géré par la FAO et financé par l'IRGT (Institut Royal pour la Gestion durable des ressources naturelles et la promotion des technologies propres), organisation présidée par S.A.R. le Prince Laurent de Belgique.

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Kosteletzkya virginica (Malvaceae): A Halophyte Species of Interest for Agricultural Production on Salt-affected Soils

by

Michel GHANEM*, Laila SAAD**, C. J. RUAN***, J. JIN***,
Charlotte LENOIR*, P. QIN****, Y. Q. GUO****,
Grégory MAHY** & Stanley LUTTS*

SUMMARY. — Each year, an important portion of agricultural areas is lost as a consequence of salinization problems. Several halophyte plant species with potential interest for agriculture and environmental management have already been identified but their rational use is greatly hampered by our insufficient knowledge about the specificity of physiological and biochemical mechanisms which allow halophyte species to cope with environmental constraints and by the important intra-specific biodiversity. *Kosteletzkya virginica* is a perennial halophyte species well adapted to saline areas of the Liaoning, Tianjing, Shandong and Jiangsu Province, China. The aim of our work is to quantify the putative interest of this species for alternative agricultural production and re-vegetation of salt-affected degraded lands. Populations of *K. virginica* were identified at the Ecological Experiment Center (Nanjing University) and at the Jinhai Agricultural Experimental Farm of Jiangsu province. Plants obtained from seeds were tested for salt resistance in controlled conditions. The plant water content remained hardly affected by salt stress, thus confirming that this plant is able to absorb water, even when the external osmotic potential of the solution remains at a low value and may compromise water absorption. The plant appears to be able to regulate its internal osmotic potential which decreased by more than 200 % in the leaves of the plants exposed to the highest dose of salt (100 mM NaCl). The presence of a moderate salt concentration enhanced the growth of the plants. Under salt stress conditions, sodium concentration strongly increased in roots, but only to a moderate level in leaves while K concentration decreased in all organs. Mechanisms of self-pollination and impact of selfing on fitness were determined after various pollination treatments. We confirmed the possibility of autonomous self-pollination and the high level of self-compatibility in *K. virginica*. However, our results were different from previous studies as we found

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a significant lower seeds' set following selfing than following cross pollinations. The fact that a species exhibits self-compatibility does not mean that selfing is its predominant mode of reproduction in the field. Difference in pollen tube growth following self- and cross-pollination may favour cross-fertilization. In such a case, selfing would be considered as a mechanism of reproductive insurance. One of the putative interests of *Kosteletzkya virginica* is its use as a source of biofuel. Seeds contain a high concentration of oil which could be added to Diesel. According to our first data, this oil may be suitable for this purpose. Both roots and leaves contain high amounts of mucilage which has a commercial value for emollient and demulcent actions. Experiments are still in progress to determine the chemical and structural properties of mucilage as well as the impact of salt on mucilage content. The determination of the genetic structure of selected populations of *K. virginica* using RAPD and ISSR markers is also in progress and should allow us to suggest the best strategy for further improvements of this species through breeding programmes.

Determination of Copper, Lead, Zinc and Nickel in Blood's Workers of Copper-Plates Manufacturing in Karbala City (Iraq) and Finding Statistical Models for Connecting Them

by

Ala'a K. HASHIM*, Dakhil N. TAHA* & Ali L. ALI**

KEYWORDS. — Copper; Lead; Zinc; Nickel; Pollution.

SUMMARY. — We have been charged of determining the pollution level for some heavy elements that are copper, lead, zinc, nickel in samples of blood's thirty workers (25-68 years) of manufacturing of housing copper plates in Karbala City during the summer 2004.

The obtained rate of the recorded values for Cu, Pb, Zn, Ni, is high, *i.e.*, the level of pollution is high in the samples of blood studied as compared to the rates and natural values known and printed for WHO on a world scale and for the Iraqi Ministry of Health on a local scale.

The analysis of the results is made statistically when the highest correlation coefficient between Zn and Ni is (R = 0.764), between Pb and Cu is (R = 0.662), and between Zn and Cu is (R = 0.217). The mathematical model was achieved to this end.

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Upgrading and Expanding Existing Water

by

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KEYWORDS. — Upgrading; Expansion; Treatment; Alum; Turbidity.

SUMMARY. — The main objectives of the present work are to study and to evaluate the possibility of upgrading and rehabilitating the performance of existing Al-Wathba water treatment plants, both qualitatively and quantitatively by:

— Improving the performance of rapid mixing units by using optimum velocity gradient (G_{mix}) and the best range of detention time in rapid mixing tanks also, and by using only alum produced locally as coagulant for water purification.
— Studying effective velocity gradient on performance and flocculation process by using different values of G_{floc}. in this experimental work in order to get the optimum range of G_{floc}. which yields the best TRE % in the effluent settling basin at different values of flow rates for raw water with low turbidity levels ranging between 20-100 NTU.
— Studying the improvement of the performance of sedimentation process (both in the capacity of the settler and in the quality of effluent) by using the technique of inclined plate settler in the secondary sedimentation basin, and also by studying the influencing inclination angle on the performance of these plates by testing different values of the inclination angles, to find the optimum calculated value of the inclination angle for different values of flow rates and for raw water turbidity range between 20-100 NTU.
— Improving necessarily the filtration units in the plant and upgrading their performance which is in their design capacity, or better complying with the improved requirements of the rehabilitated pre-filtration unit processes, through changing or improving their working media, and by using the results of recent studies.

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Desertification Process in the Sahelian Belt of West Africa: What's the State of Play?

by

Yvon-Carmen HOUNTOUNDJI*, **, Nestor SOKPON**,
Jacques NICOLAS* & Pierre OZER*

KEYWORDS. — Integrated NDVI; Rainfall; Rain Use Efficiency; Trend Analysis; Desertification; Sahel.

SUMMARY. — The implementation of the UNCCD needs the identification of areas that record declining productivity of the vegetation over long-time periods. In this scope, we analyse the state of the vegetation productivity using 1982-1999 time series of NOAA-AVHRR NDVI data and compare it to rainfall data. For this, 354 rain gauges data distributed from yearly average isohyets 100 to 900 mm in five countries of West Africa are analysed. We use for trend analysis, the ratio between integrated vegetation index (INDVI) during the growing period (June to October) and the May to October sum of rainfall (RR). This ratio is a proxy of the Rain Use Efficiency which is widely accepted. Overall, 91 and 94 % of RR and INDVI data recorded positive trends over the 1982-1999 periods. Most stations in the Sahel were stable for the INDVI/RR (49.5 %). However, 37.8 % showed strong to very strong negative change in the INDVI/RR ratio, while only 1.3 % showed positive trends. The strong negative trends recorded in more than 1/3 of the analysed stations may reflect ongoing desertification processes in the Sahel and could be a starting point for the identification of hot-spot areas to determine where to take action to combat desertification.

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Solutions locales pour limiter la désertification dans les espaces agricoles fragiles au Maroc

par

Abdellah LAOUINA*

MOTS-CLES. — Maroc; Espaces agricoles fragiles; Conservation des sols et des eaux; Approches de recherche sociale; Terroirs villageois.

RESUME. — L'analyse des conditions de vulnérabilité, la mesure et le suivi des phénomènes de dégradation sont opérés, dans la région de Rabat, par une équipe de chercheurs marocains, dans le cadre du projet européen de recherche sur la désertification «DESIRE», coordonné par l'Institut Alterra (Wageningen, Pays-Bas) et réalisé en partenariat avec différentes équipes. Le projet vise aussi à déterminer des propositions en vue de garantir l'adoption locale de solutions de lutte contre la désertification et le succès de l'implication des acteurs dans ce processus.

La réduction du risque de désertification réside dans une meilleure compréhension des problématiques environnementales et sociales rencontrées, dans l'échange autour des solutions et techniques de lutte contre la désertification à mettre en place et dans une meilleure implication des associations et acteurs dans ce processus.

Au Maroc, la désertification peut potentiellement toucher tous les écosystèmes, mais plus particulièrement les terres agricoles fragiles, caractérisées par une pression excessive sur les écosystèmes et par l'adoption de techniques non conservatoires des sols et des eaux. Or, l'agriculture durable exige une utilisation rationnelle des ressources en vue de satisfaire les besoins des populations locales et repose sur la valorisation de ces ressources par des techniques d'utilisation adaptées et maîtrisées par les agriculteurs.

Les mesures de conservation des sols et des eaux sont fonction des spécificités de chaque terroir. Dans les zones à tradition conservatrice, l'action visera principalement le maintien et la pérennité des pratiques, mais aussi l'amélioration du savoir-faire en vue de les rendre plus faciles à étendre et à répliquer. Dans les régions fragiles, sans tradition agricole, soumises à des phénomènes de dégradation liés à la pression humaine comme au manque de savoir-faire, la méthode de transfert et d'adoption de ces techniques se basera sur des essais de démonstration et de suivi d'itinéraires techniques *in situ* chez les agriculteurs, renforcés par des sessions de formation.

L'organisation des agriculteurs en associations est un préalable capital; l'approche privilégie l'entité d'action «terroir villageois», dont les comités agiront comme une interface entre l'association et les agriculteurs bénéficiaires. Ces comités seront

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encadrés par l'ONG et participeront aux différentes phases de planification, de réalisation et d'évaluation des actions à entreprendre dans le cadre du projet.

L'implication des ONG nécessite leur accompagnement par des mesures de renforcement leur permettant une mise à niveau et une amélioration de leur opérationnalité et de leur fonctionnement sur le terrain. Le secteur associatif marocain de l'environnement est encore jeune, ce qui constitue un handicap majeur à l'épanouissement de l'action associative. On observe par ailleurs un manque de spécialisation et de disponibilité de ressources humaines compétentes pour le montage de projets et un déficit en ressources financières pour la réalisation des actions. Le travail patient d'accompagnement, dans le cadre d'approches de recherche sociale, au sein du projet «DESIRE», aura pour but de proposer des méthodes d'approche afin de garantir plus de succès aux actions de lutte contre la désertification proposées.

Adoption of Cover Crops and Farmer's Perception in Rainfed Orchards in Southeast Spain

by

André MEERKERK* & B. VAN WESEMAEL*

KEYWORDS. — Remediation; Cover Crops; Rainfed Tree Crops; Soil Protection; Mediterranean.

SUMMARY. — After Spain joined the EU in 1986, the area of tree crops showed a pronounced increase whereas the total agricultural area declined. This increase has been related to the Common Agricultural Policy (CAP) by several authors. The orchards became larger, production intensified and the use of terraces and retention banks decreased. Recently, investigations have been conducted on the use of cover crops as an alternative means of erosion control. Field trials have shown that the use of cover crops combined with chemical weeding increases olive yields by 20 % (n = 73) in Andalucía. Rainfall simulation tests in Córdoba showed a decrease in erosion from 12 t/ha under conventional tillage to near-zero values for the cover crop treatment during intensive rainfall. The application of cover crops in rainfed orchards seems economically viable since the yield increase can cover extra costs. However, farmers may not be inclined to switch to cover crops quickly for several reasons. Erosion is often not regarded as an important issue, whereas the eroded topsoil is low in organic matter and prior to planting the bedrock is simply ripped open to provide a substrate for trees. On stony soils, soil depth and tillage erosion have no effect on total evapotranspiration and water availability, as shown by a calibrated water balance model. Hence, soil erosion does not result in a serious decline in productivity. Another obstacle is the tradition of frequent tillage and the fear that any other practice will negatively affect water availability and yield. The frequent tillage aims to prevent weeds to compete for water and to increase infiltration. However, various studies have shown that proper no-tillage and cover crop treatments lead to an increase in productivity. This is partly because the tillage itself can result in important evaporation losses and prevents the tree roots from accessing the upper 20 cm of the soil. In addition, we studied under which conditions cover crops can be used without a reduction in tree growth by examining the role of climate at the Mediterranean scale. The results show a clear climatic threshold and indicate locations in the Mediterranean where cover crops can be grown without any negative effect on production. It appears that agricultural policy forms the key to bring producers to adapt SWC measures like cover crops and no-tillage, given the strong historic response to the CAP. Good practices like cover crops and no-tillage could form a prerequisite for producers to be eligible for (a part of) the general and additional support payments.

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Integrated SWC-Management to Stop Desertification in Tigray, Ethiopia

by

Jan MOEYERSONS*, Jan NYSSEN**, Haile MITIKU**,
Jean POESEN** & Jozef DECKERS**

KEYWORDS. — Desertification; Ethiopia; Exclosure; Sustainable Agriculture; Soil and Water Conservation.

SUMMARY. — The role man has played in land degradation and desertification in Tigray, Ethiopia, since 5,000 BP is well established. Since last century, gullying has been worsening the hydrological situation.

This poster shows the imperfections but also the remediational effects of environmental rehabilitation techniques and their contribution to sustainable agriculture.

Study area: Hagere Selam, 50 km to the west of Mekele, Tigray.

Methods applied: mapping, experimental plots and "AGERTIM", a combination of gully characteristics' definition with interviews to reconstruct past gully development.

Stoniness: plot experiments show an optimal production of cereals with a stone fragment (> 2 cm) mulch covering 5 to 10 % of the soil surface.

Dagets and stone bunds: stone bunds and integrated dagets lead at the start to a reduction of 68 % in soil loss and a 10 % increase in crop production yield. The storage capacity of stone bunds is reached after some ten years. They have to be highered.

Tillage erosion: experiments with oxen-pulled maresha ard-type plough show erosion of 68 to 272 kg/m on slopes of 0.03 to 0.48 m/m.

Check dams: observations and interviews reveal the high vulnerability of these stone dams and their implementation with biological means is strongly advised. Nevertheless, field work also reveals that gully development has been halted since the massive installation of check dams in the gully bottoms and stone bunds along the divide contours.

Exclosures: exclosures enjoy a rapid development of arborescent vegetation. They further show a high retention capacity for sediments, eroded upslope and transiting the exclosure.

The role of microdam reservoirs in SWC: these 10^6 m^3 order retention lakes, mainly constructed for irrigation purposes, are often not considered as successful, because of technical shortcomings, rapid silting-up and important leakage. Nevertheless, they contribute to water-table replenishment and to gully stabilization downstream.

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Contour stone bunds on the slopes, checkdams in gully bottoms, the exclosure of marginal land, the construction of ponds and small lakes are a number of technical SWC-techniques showing the possibility for land rehabilitation. But the actual investment will lose its effect if not continued at the current zeal. Stone bunds and checkdams need continuous maintenance and their storage capacity has to be highered. The possible role of forest as buffer against reservoir siltation has to be investigated. Finally, small ponds and lakes, even if they do not fulfil the initial objectives, play an important hydrological role when it comes to water-table replenishment and river hydrographic regularization. They are crucial to the development of the water sector in the perspective of the millennium goals.

De 1954 à 2003, le sud-ouest de la Mauritanie: un territoire profondément affecté par la désertification

par

Abdoul Jelil NIANG*, André OZER** & Pierre OZER***

MOTS-CLES. — Mauritanie; Fleuve Sénégal; Dégradation environnementale; Télédétection.

RESUME. — Le sud-ouest de la Mauritanie, qui englobe le secteur que nous étudions, est à cheval sur le Sahara et le Sahel dont la limite varie en fonction des fluctuations climatiques. Ce qui en fait une zone de choix pour l'analyse des phénomènes de désertification.

Au cours du Quaternaire, ce secteur a connu une longue évolution morphodynamique sous des paléoclimats très différents. Il est caractérisé par l'importance du recouvrement dunaire appartenant au Quaternaire récent, notamment à la dernière grande phase aride dite ogolienne (entre 18 000 et 12 000 BP).

Le déficit pluviométrique cumulé depuis le début des années 1970 et l'intervention de l'homme ont largement contribué à la dégradation généralisée de l'environnement. C'est ainsi que d'intenses modifications morphodynamiques et des bouleversements socio-économiques ont accompagné l'extension des conditions de désertification (exacerbation des phénomènes éoliens, réalisation d'aménagements hydro-agricoles). La sécheresse a également affecté les activités socio-économiques essentiellement rurales dominées par l'agriculture au sud et l'élevage au nord.

Malgré le retour à des précipitations plus abondantes observées ces dernières années, le milieu naturel reste encore traumatisé, l'érosion mécanique (éolienne surtout, mais aussi hydrique) est devenue l'élément primordial de sa dynamique morphogénique. La recrudescence des lithométéores demeure une caractéristique de la zone étudiée.

C'est dans ce contexte que nous nous sommes intéressés à l'évolution morphodynamique consécutive à la désertification qui constitue un défi au développement durable en ce sens qu'à long terme elle entrave la conservation des ressources naturelles.

La méthodologie utilisée se base sur l'analyse multisources. Etant donné le caractère progressif des phénomènes de dégradation, la télédétection par l'étude diachronique qu'elle autorise par le traitement de l'imagerie satellitale et aéroportée (optiques, radar et photographies aériennes), constitue un outil de choix pour

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leur suivi et leur compréhension en vue de l'élaboration de stratégies de lutte contre la désertification. Il s'agit d'images optiques (Landsat). L'interprétation des données climatiques et de terrain vient compléter l'étude par télédétection.

Les différents traitements auxquels ces données ont été soumises donnent des résultats sur l'évolution de la zone depuis les années 1954 jusqu'à présent. La comparaison et la superposition des photographies aériennes de 1954, 1972, 1992 et 2003 montrent l'ampleur de la dégradation de la couverture végétale. Sur une superficie de 12 000 ha, le taux d'occupation de la végétation dense est passé de 17 à 2 %. La confrontation des indices de végétation sur les images prises à des dates différentes montre également la déplétion de la couverture végétale. La remise en mouvement et le remaniement des dunes sont révélés par l'apparition des crêtes dunaires vives sur les photographies les plus récentes. Sur les images radar ERS, cela se manifeste par une perte de cohérence à plusieurs endroits entre deux passages du satellite en 24 h. L'emprise de l'homme sur le milieu apparaît également à travers la prolifération des rizières et les auréoles de dénudation visibles autour des villages.

Les signes de dégradation environnementale demeurent prépondérants, même si, à certains endroits, on peut noter une amélioration sensible de la couverture végétale. Ce qui suppose que le retour des écosystèmes à des conditions normales nécessite des mesures de protection des ressources naturelles.

Le développement urbain de la ville de Nouakchott et le risque d'inondation, conséquence de la désertification

par

Mohamed Ahmed OULD SIDI CHEIKH*

MOTS-CLES. — Nouakchott; Expansion urbaine; Vulnérabilité; Inondation; Télédétection.

RESUME. — La ville de Nouakchott, capitale de la Mauritanie créée officiellement en 1958, a connu un développement urbain et démographique considérable. La sécheresse des années 1970 et 1980 a engendré un exode rural très important et a accéléré le processus de sédentarisation des populations nomades dans les centres urbains des principales villes du pays, et particulièrement dans la capitale qui a vu son nombre d'habitants passer de 140 000 en 1977 à plus de 700 000 en 1997 et à près d'un million en 2005. Cette urbanisation était caractérisée par l'abondance d'habitats spontanés et illégaux et par une grande densité des îlots urbanisés et leur grande hétérogénéité. L'environnement urbain connaît depuis lors des difficultés liées à la gestion des déchets, à la qualité et la quantité de l'eau de consommation et à l'assainissement qui posent d'énormes problèmes de santé publique aujourd'hui à Nouakchott. Ces changements ont entraîné un bouleversement des modes de vie: travail, alimentation, hygiène, habitat, habitudes sociales, ...

La ville n'était pas préparée à abriter ce grand nombre d'habitants et ne satisfait guère à leurs besoins de base. La pression démographique est à l'origine de grands bouleversements dans la vie de la population urbaine à cause de l'ensablement chronique de la zone urbaine et de ses artères ainsi que de la dégradation du sol. Cette pression est aussi à l'origine d'un nouveau risque comme l'inondation dans le milieu urbain pendant les pluies d'hivernage. Risque d'autant plus réel quand on sait que la ville s'est étendue vers des zones dépressionnaires et salines où la nappe d'eau subaffleurante remonte à la surface lors de pluies intenses, créant ainsi une situation très grave pour l'hygiène et la santé publique.

Tout récemment, pendant l'été 2005, plusieurs quartiers de la ville ont été submergés l'espace de quelques jours mettant ainsi l'économie et la santé de la population en danger à cause de conditions favorables à la propagation des épidémies, notamment celles liées à l'eau comme le choléra dont plusieurs cas ont été recensés dans les zones inondées.

La ville de Nouakchott subit un autre risque potentiel: l'inondation en cas de rupture de l'étroit cordon dunaire qui protège la ville contre la mer. La forte demande en matière de logements, consécutive au développement urbain observé

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depuis 1970, a entraîné une exploitation sauvage de la dune côtière (carrières de sable), seule protection de la ville contre les inondations par l'océan.

Les résultats des simulations numériques préliminaires montrent que, si aucune mesure de protection n'est prise, la ville de Nouakchott sera soumise à un risque d'inondation marine à la suite de l'érosion de la plage située au sud du port dont la jetée a bloqué l'apport sédimentaire, et du fait qu'en plus une grande partie de ces zones se trouve à un niveau topographique inférieur à celui de la mer.

Ces risques multiples témoignent encore une fois de la vulnérabilité des villes des pays en développement où souvent les structures de gestion de risque n'existent pas ou font défaut en plus de la mauvaise qualité des infrastructures urbaines d'assainissement et d'évacuation des eaux comme c'est le cas de Nouakchott.

L'affiche proposée met en lumière ce problème de risque d'inondation dans le milieu urbain de Nouakchott, conséquence indirecte de la désertification, et ses impacts actuels et futurs sur la population et sur l'avenir de la ville. Des images satellitaires comme SPOT, Landsat et Radar ERS sont utilisées et couplées avec d'autres données socio-économiques pour délimiter les zones à risque afin de proposer des mesures concrètes pour minimiser ou réduire l'impact négatif de ce phénomène.

Une véritable politique urbaine, maîtrisant les ressources en eau, le contrôle de la population urbaine et le choix des secteurs susceptibles d'être urbanisés, est vivement recommandée pour améliorer notablement la situation actuelle et pour juguler l'expansion future de la ville. Il faut notamment penser à un système fiable de protection de la ville et à un dispositif d'évacuation des eaux de pluie.

Understanding social constraints in sahelian Niger communities as a decision-support tool for development operators

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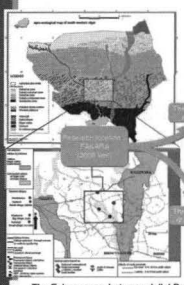
Context

Sahelian rural villagers has shown little reaction to actions development agencies have achieved in the Sahel over the past decades. Dissonances between agencies conceptions and village social organizations are a strong factor for the failure. Understanding the way families are organized regarding the management of assets could suitably support decision-making for development agencies in the country.

Research hypotheses

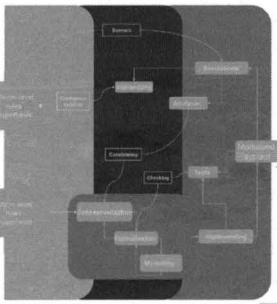
- Multi activity is crucial for families in rural rainfed Niger. Focusing on millet farming productivity is too risky (Milleville, 1989)
- Families are not unified under one strategy : each adult has its own, according on the assets he/she has socially access to. Therefore, social constraints analysis is the key to understand the management of activities in a sahelian village (Gastellu, 1980).

Field methodology

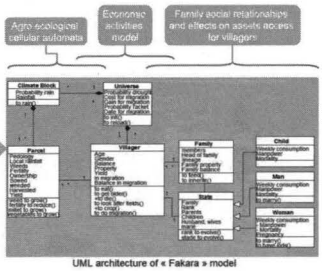


The Fakara area, between dallol Bosso & Niger river [AGRHYMET-FMA] & mental map (2005)

Modelling methodology



The agent based Model



UML architecture of « Fakara » model

Two family organization structures are tested, defined by Sen (1977):

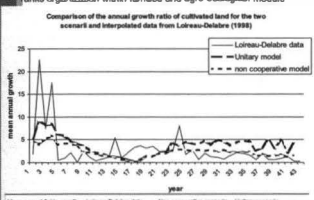
- A unitary family structure, ruled by by the head of the family through the control of assets and the management of products.
- A collective non cooperative family structure, where members access to assets are linked to their ranks in the family.

	Unitary family structure hypothesis	Collective non cooperative family structure hypothesis
Sharing food	All incomes are given to the head of the family, who shares them within members	A « family granary » : as a waypoint to share to fulfill family non-here demands
Fields and families extension	Families do not explode and fields extend based on family needs	The direct heir has all the inheritance, others have to settle somewhere else
Availability for seasonal migration	Manpower needs defined the head of the family. Only him can allow a young male family member to leave family for migration	A young male family member can leave during cropping season only if a higher rank elder stay at home
Wedding access conditions	The dowry should be payed by the head of the family, using the granary	The dowry should be payed by the father alone

Results

A. Model confidence building

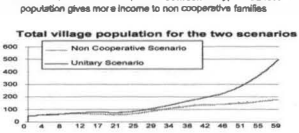
- The Fakara Model gives good confidence regarding adequation with available data (fields extension and demographic growth (National census 1988))
- Fair performance of the Fakara Model regarding activities and ranks organization within families and agro-ecological module

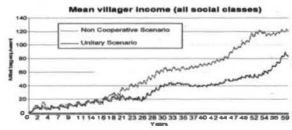


Mean annual fields growth	Loireau-Delabre data	Non cooperative scenario	Unitary scenario
All years	2.22% per annum	2.32% per annum	3.68 % per annum
First period (1950-1972)	3.91% per annum	2.45 % per annum	3.35 % per annum
Second period (1973-1993)	1.65% per annum	2.18% per annum	4.03 % per annum

B. Activities and social groups

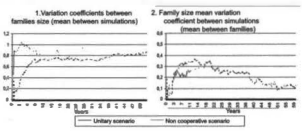
- Thanks to family support, access to weddings and production assets are reduced for new members in unitary family structures. Population grow faster than in the non cooperative structure.
- However, a better adequation between cropped surface and population gives more income to non cooperative families





C. Family organization risks

- Unitary organization crystallizes families in big clans : after 60 years, 7.7 families remains in average vs. 17.2 families in the Non Cooperative Family Structure (1).
- Concentrating assets and products management into family head hands, when family size are bigger, increases the risk of a collapse due to climatic risks (2).



1. As seen in (A), family structure dominancy seems to have shifted from a unitary structure to a non cooperative one. Luxereau & Roussel (1996), Raynaut et al. (1977), Reardon (1994) Gastellu & Dubois (1997), Yamba (2005) have described such changes in more densely populated areas.
2. (B) suggests a higher fragility of the Unitary structure.
3. (C) outputs indicate that drought crises, as in 1973 and 1983, are strong collapse factors of this structure.

Perspectives

- Demographic growth is transforming sahelian societies, forcing them to intensify their farming systems, in competition with aridity and alternative income-generating activities in more southern places. The model will be developed further to include social and farming system changes in a sahelian village.
- For a development operator, activities to promote and the way to promote them are crucial factors, as well as the already existing social connexions between villagers. The model should include the reputation network between villagers and the development scheme impacts to better simulate the real interactions between villages and a project.

Project financed through the Direction Générale pour la Coopération au Développement- DGCD

A New One-line Semi-automated Environment Method for Determination of Chlorate Using ($ClO_3^- + I^- + H_3O^+$) System through Merging Zone Technique

by

Dakhil N. TAHA*, Issam M. A. SHAKIR** & Rana S. KHALAF*

KEYWORDS. — Flow-injection; System; Chlorate; Iodine; Absorbance.

SUMMARY. — Flow-injection system for rapid, sensitive and selective determination of chlorate ion is based on the release of iodine from ($I^- + ClO_3^- + H_3O^+$) reaction and measures its absorbance at 350 nm. Physical and chemical parameters were completely optimized. A sample size of 127 microl. was used with a flow rate of 1.95 ml/min. The reproductibility for the determination of all the concentrations studied was close to zero. Linear regression of the plot concentration (M) versus absorbance (peak height Mv) gives a correlation coefficient of 0.9999 in the range ($5*10^{-2}$ $5*10^{-7}$ M), detection limit was ($5*10^{-10}$ M). Applying this method to the analysis of chlorate in standard samples was successfully carried out.

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