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Sustainable agricultural management of drylands

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SUMMARY – In the first part of this paper, the Concept of "Sustainable Agriculture" is presented and discussed. Then a holistic view of drylands is given, starting with the aridity definition, then the location of drylands around the world. Drylands climate, soils and population are also characterized. The second part of the paper gives the principles and fundamentals of "Sustainable Agricultural Management of Drylands" at the regional level and the farm level. The role of education and extension is presented, the relation between natural resources exploitation and aridity is discussed.

Key words: Drylands, sustainable, agriculture, management.

RESUME – "Gestion agricole durable des zones arides". Dans la première partie de cet article, le concept d' "Agriculture Durable" est présenté et discuté. Ensuite une vision globale des terres arides est donnée, en commençant par la définition même de l'aridité à travers le monde. Le climat, les sols et la population des terres arides sont caractérisés. La deuxième partie de cet article présente les principes et les fondements du "Management de l'Agriculture Durable des Terres Arides" au niveau régional et au niveau de l'exploitation. Les rôles importants de l'éducation et de la vulgarisation sont soulignés, les relations entre les ressources naturelles et l'aridité sont discutées.

Mots-clés : Aride, durable, agriculture, management.

Introduction

Since the World War II, agriculture has changed dramatically. Food and fiber productivity soared due to new technologies (mechanization, irrigation, fertilizers, pesticides, etc.). In developed countries, fewer farmers produce the majority of food and fiber and export to less developed countries. These changes in agriculture have negative effects:

- (i) Top soil depletion.
- (ii) Ground water contamination (chemical pesticides and fertilizers).
- (iii) Decline of family farms.
- (iv) Rise of agricultural companies.
- (v) Disintegration of economic and social conditions in rural communities.

In this context, the concept of sustainable agriculture was born in developed countries. The concept of sustainable agriculture was born to address environmental, social and economic problems. The wide use of the phrase "sustainable agriculture" has led to an accelerated multiplication of definitions.

What is sustainable agriculture?

Sustainable agriculture is based on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainable agriculture aims to increase food productivity and build food security which is the access by all peoples at all times to adequate and appropriate food for healthy life.

Francis and Youngberg (1990) wrote (in Bonny, 1994): "Sustainable agriculture is a philosophy based on human goals and on understanding the long term impact of our activities on the environment and other species". Use of this philosophy guides our application of prior experience and the latest scientific advances to create integrated, resource conserving, equitable farming systems. These systems reduce environment degradation, maintain agricultural productivity, promote economic viability in both short and long term, and maintain stable rural communities and quality of life.

Sustainable agriculture was also defined as an agricultural system that is ecologically sound, economically viable and socially just.

Actually, there is a consensus that sustainable agriculture seeks to balance three long term goals:

- (i) Preserving environment and natural resources – soil, water, air, plant species, and diversity.
- (ii) Economics – sustainable agriculture should be a profitable activity for farmers.
- (iii) Quality of life – sustainable agriculture should satisfy personal, family and community needs for health, food, safety and happiness.

In any given situation, the most sustainable system is the one where the net effect comes closest to meeting all three goals: (i) quality of life; (ii) preserving environment and natural resources; and (iii) profitability.

Currently the concept of sustainable agriculture pervades all spheres of agriculture from production to research. The diffusion of "sustainable agriculture" has been facilitated by International Development Agencies and Organizations (World Bank, FAO, USAID, CGIAR...). These international organizations have used their funding power to integrate the sustainability dimension into existing agricultural and development programs.

Delineating drylands

Drylands definitions

FAO (1989) distinguishes arid and semi arid regions on the basis of their annual precipitation sums, they include:

- (i) Deserts with an annual precipitation sum < 50 mm, and devoid of vegetation.
- (ii) Arid regions with an annual precipitation sum of 50-250 mm, and sparse vegetation.
- (iii) Semi arid regions with an annual precipitation sum of 250-500 mm.

Based on the Aridity Index (P/ETP), where P is the precipitation and ETP represents potential evapotranspiration, we distinguish:

- (i) Hyperarid zone – $P/ETP < 0.03$.
- (ii) Arid zone – $0.03 < P/ETP < 0.20$.
- (iii) Semi arid zone – $0.20 < P/ETP < 0.50$.
- (iv) Subhumid zone – $0.50 < P/ETP < 0.75$.

Most deserts, arid and semi arid regions occur between 10° and 35° latitude in the interior parts of the continent and are dominated by continental influence (UNEP, 1992). Arid and semi arid regions

beyond 35° North and South latitudes exist because of topographical barriers of their distance from the source of marine air.

Where are drylands located?

Africa includes about one-third of the world's total semi arid land. Semi arid lands occur also in Eastern Europe, Middle East and Western Asia. In Eastern Asia, semi arid lands occur with summer precipitation (Russia, China, Mongolia, and India). About 75% of Australia is arid or semi arid. In South America, semi arid lands are mainly located in Argentina. Semi arid lands of North America extend from Mexico to Canada: Great Plains, Pacific Northwest region, Southwest Pacific region of California (UNEP, 1992).

Drylands climate

Drylands climate is characterized by low and highly variable rainfall. The rainfall variability occurs within crops growing cycle and across years. Under such climate the potential evapotranspiration is quite high (ETP) up to 12 mm/day and we have frequent occurrence of drought.

Drylands soils

Drylands soils throughout the world have similar characteristics even though they have differences that place them in different classifications. Soils of drylands have undergone the process of soil development, but they are not as well developed as soils of humid regions. As a consequence, most drylands soils are shallow and poor in organic matter. This is a serious constraint to soil water storage and soil fertility, which are directly correlated to productivity.

Drylands population

Home to over two billion peoples living in some 100 countries, drylands (deserts not included) cover almost 40% of the world's area. It is estimated that one billion people depend on rural drylands for their livelihoods. Overall, most drylands are characterized by: (i) rapid population growth; (ii) poverty; (iii) malnutrition; and (iv) imbalance between natural resources, human population and basic human needs.

Principles of sustainable agricultural management of drylands

Producing sufficient food for drylands populations from sustainable agriculture is a challenge. It depends on a careful study of the potentials of those areas, an inventory of natural resources and needs of people (Ibrahim, 2004). Planning sustainable agricultural management of drylands, should be done through three levels of measures: (i) regional level; (ii) farm level; and (iii) education and communication.

Regional level

At the regional level, successful sustainable agricultural management should be done through the following steps:

- (i) An inventory of the population needs for livelihoods.
- (ii) A good knowledge of the local climate characteristics (rainfall, temperatures, ETP, drought occurrence, drought severity, etc.).
- (iii) Assessment of land capability (NRCS, 1997) for the concerned area. Land capability is a systematic arrangement of land into various categories according to its capability to sustain particular

land uses without land degradation. Land capability assessment provides three sorts of information that are necessary for sustainable and adequate land management: (i) erosion risk based on existing conditions; (ii) erosion hazard factors that increase erosion risk; and (iii) management constraints imposed by natural conditions.

(iv) Assessment of land suitability FAO (1993), which is a more refined classification and apply to the land resources to sustain particular forms of land use such as arable farming, rain fed agriculture, irrigated cropping, forestry, pastures, etc.

(v) Assessment of available water for agriculture – quantity and distribution of rainfall, surface water and ground water.

(vi) Design of viable systems to support human and livestock populations and meet their needs.

(vii) The designed systems should take into account the major risk factor, which is drought, and set a drought mitigation strategy.

(viii) The designed systems should be economically profitable to farmers.

Farm level

At the farm level, successful sustainable agricultural management of drylands should be done through the following steps:

(i) Efficient management of the most limiting factors, usually available water and soils.

(ii) Maximize biodiversity on the farm by integrating crops and livestock productions, combining annual and perennial crops, diversification of adapted plant species and varieties and by the abandon of monocropping in favor of rotations, intercropping and companion planting.

(iii) Adopt integrated weed and pest management and biological pest control, minimum use of chemical pesticides.

(iv) Build soil structure and fertility (green manure, compost, conservation tillage, etc.).

Role of extension and education

Successful setting of sustainable agricultural systems requires:

(i) Education of farmers and extension agents on principles and tools used to achieve the objectives of sustainable agriculture. Education is aimed to make farmers aware of the potential and constraints of their physical environment and practice farming within the limits of their constraints.

(ii) Farmer's involvement in the process at the county level and through farmers organizations.

(iii) Establishing links and relations between researchers, extension agents and farmers for the adequate transfer of sustainable agriculture practices and technology.

Natural resources degradation

The low productivity of agriculture in drylands, especially of poor developing countries, and the intensive population growth puts much pressure on natural resources. These natural resources are seriously threatened by over-exploitation beyond their renewable limits (Benderradji *et al.*, 2006). In this context, we usually have conversion of grasslands to croplands, expansion of cropland into less and less favorable areas, use of saline water for irrigation.

Expansion into new areas is especially attractive following a year or sequence of years of above average precipitation. When precipitation amounts return to average or below, crop production systems on such lands cannot be sustained.

Irrigation of drylands with saline water will induce, after a few years, salt accumulation in the soil to a level that will not permit any crop growth. These fragile areas will then become extremely vulnerable and exposed to erosion and other forms of soil degradation.

Consequently, the area that was previously grassland, sustainable for livestock production, become unsuitable for either crop production or livestock and cannot be restored as grassland. This is how the desertification process starts.

In such fragile environments, when sufficient food for drylands populations cannot be produced from sustainable agriculture, the local government should promote other activities as a source of income for farmers to divert them from over-exploitation of natural resources beyond their renewable limits.

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