Module III. Vulnerability and adaptation
From theory to practice

Case Study 3

An evaluation of the vulnerability of agriculture and adaptive strategies aimed at achieving food security in the Sahel:

The example of the Niayes in Senegal.

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In collaboration with:

Content:

1. Introduction

2. The issues

3. Method and tools applied to the Niayes' situation

4. Lessons learned

5. Conclusions and prospects

1. Introduction

Agriculture in Senegal:

- **Employs 65 to 70% of the working population**
- **Over 95% of production systems are in rural areas**
- **Contributes only 20% to the national GDP**
- **Primarily rain-fed cultivation**
- **Exposed to climate hazards, such as cyclical drought**

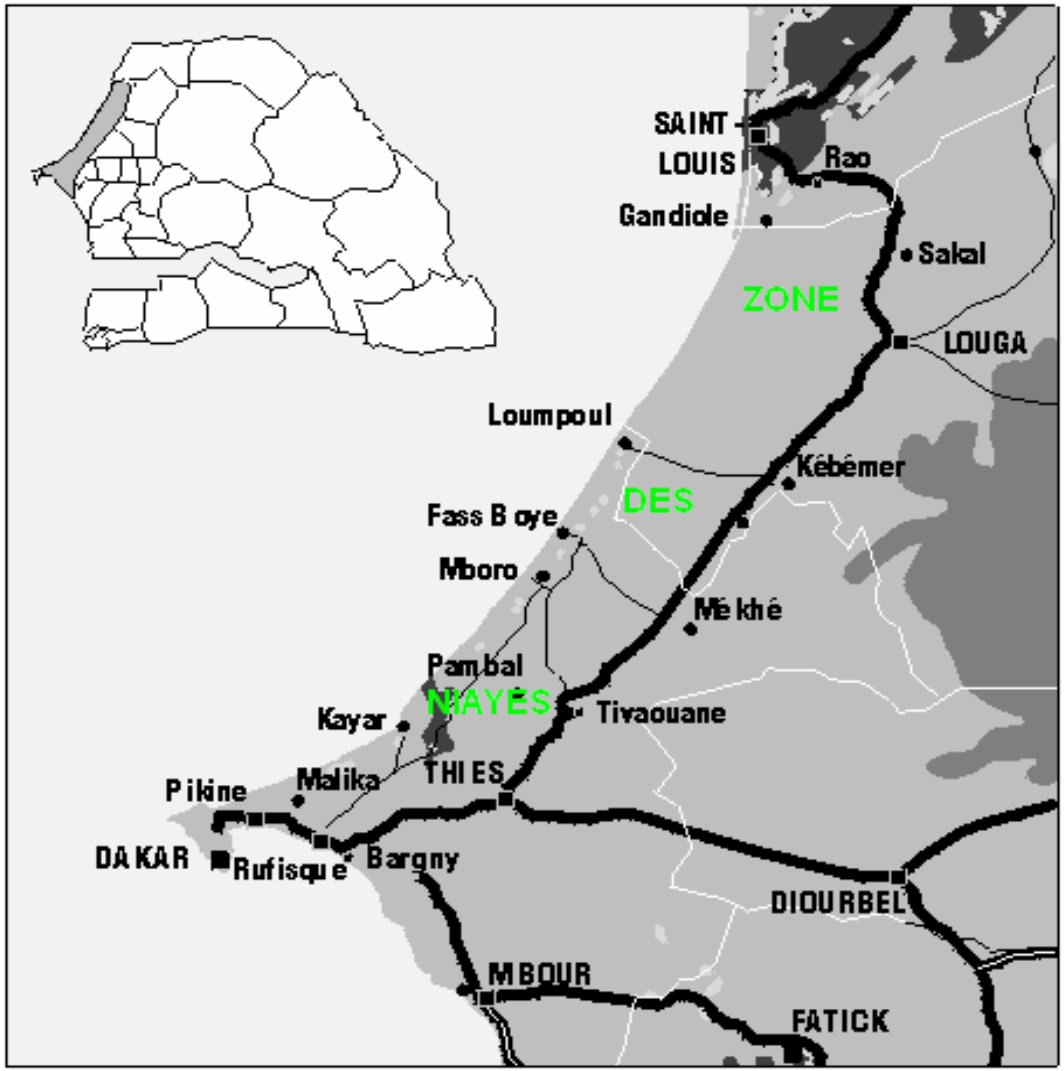
Source: www.gouv.sn/politicals/lpdia.html & M. SECK and M. M. NA ABOU, 2005.

Aims of the Niayes case study

- **To analyse the vulnerability and climatic risks that threaten agriculture and, partly, food security**

- **To propose adaptive alternatives that can be reproduced in other Sahelian countries**

The Niayes:
Location, towns and road infrastructure



Source: www.crdi.ca/fr/ev-27906-201-1-DO_TOPIC.html

2. The issues

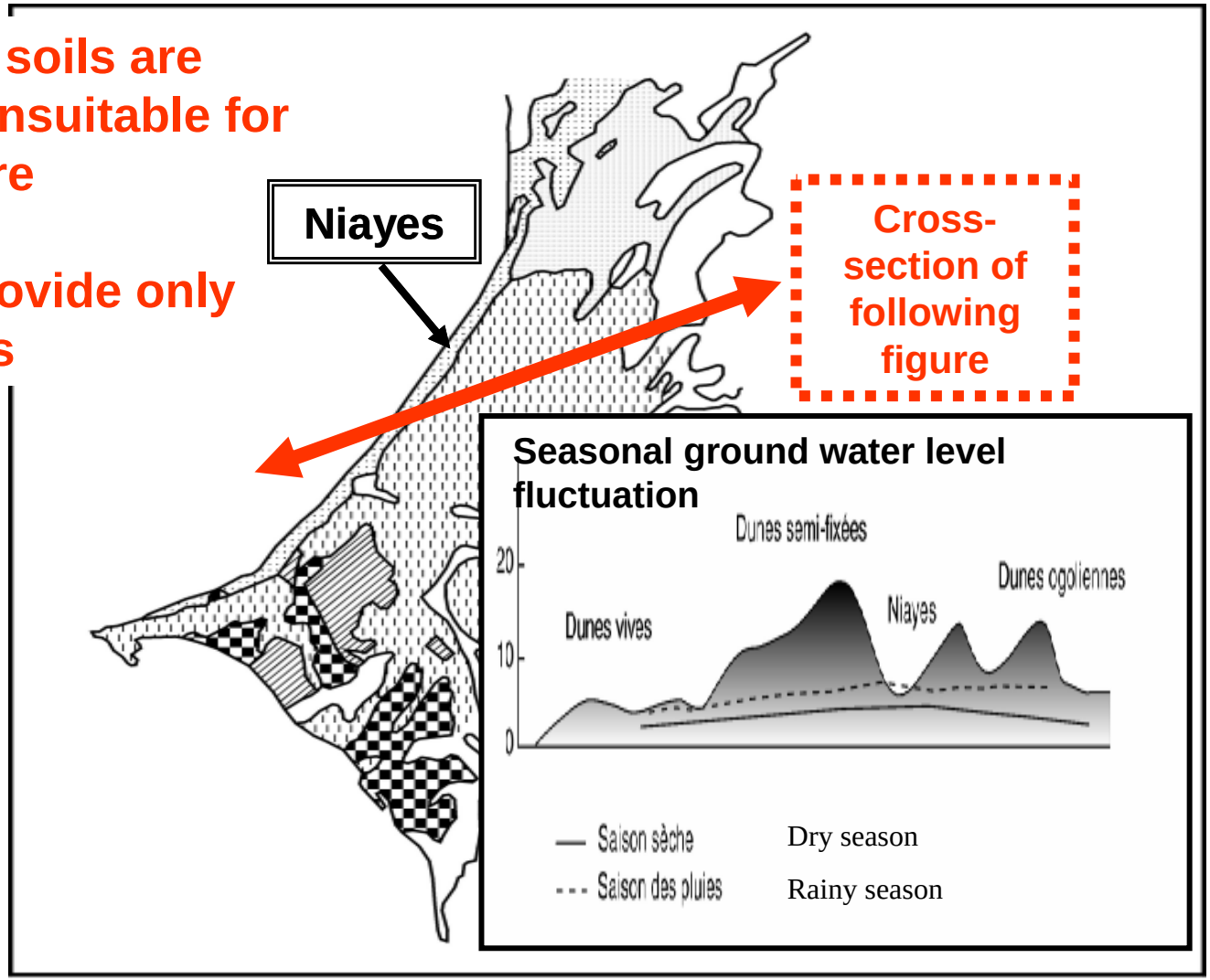
- **Environmental**
- **Socio-economic**
- **Legal, political and institutional**

Environmental issues

Soil composition and water resources in Senegal and in the Niayes

✓ 47% of soils are poor or unsuitable for agriculture

✓ 36% provide only low yields



Source: http://web.idrc.ca/en/ev-27906-201-1-DO_TOPIC.html

Soils in the Niayes

- **Raw mineral soils: low level or non-existence of humus-bearing horizons**

- **Unleached tropical ferrugineous soils occupy most of the Niayes region: poor in organic matter and subject to wind erosion and runoff**

- **Brown-red soils in the north-western part of Louga and south-east of Saint-Louis**

- **Vertisols located in the Sébikotane area (Bargny plateau) and the Somone - Tanma lake axis**

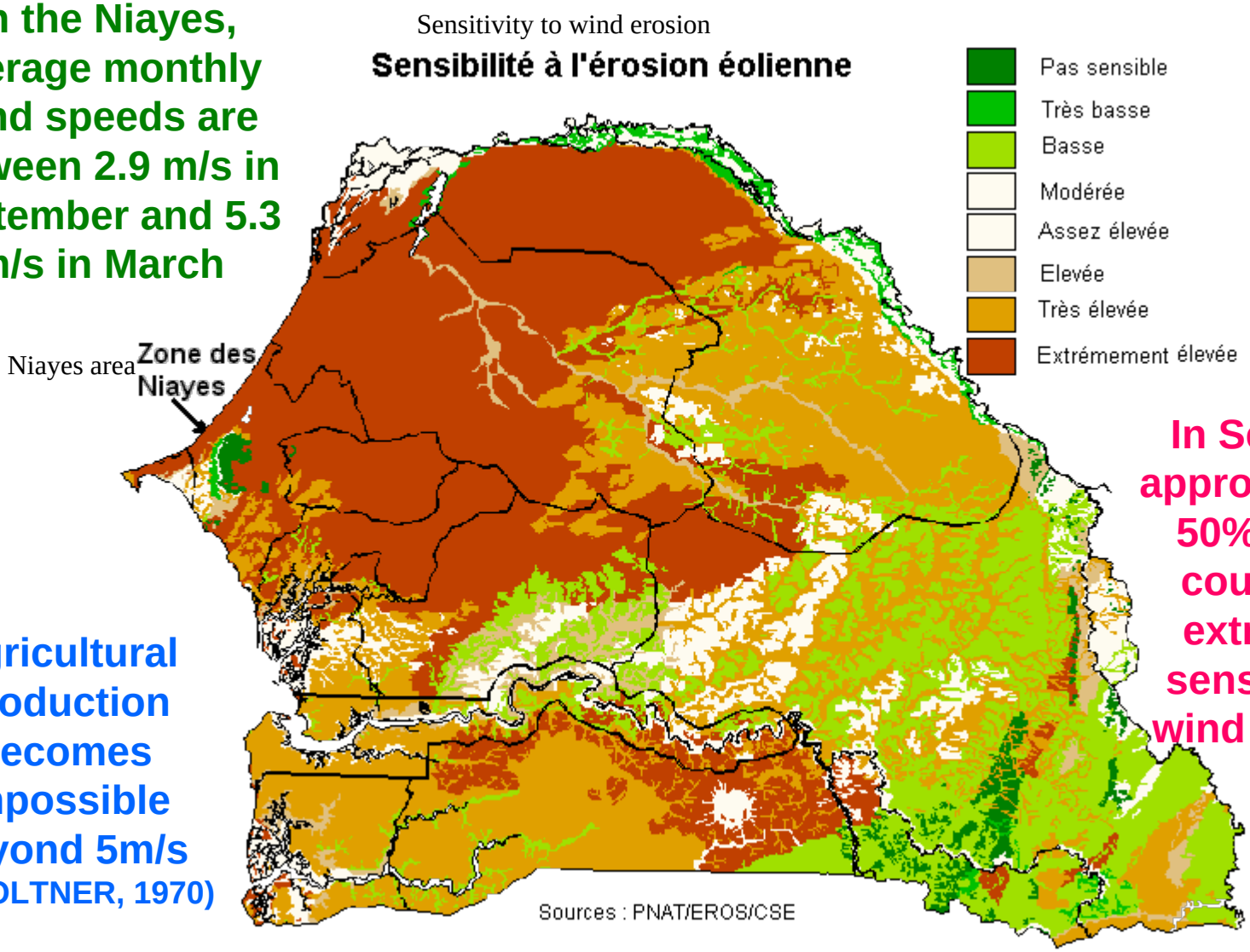
- **Halomorphic soils in the southern part of the Niayes (Dakar and Thiès regions) and in the Senegal River delta**

- **Pseudo gley mineral soils, very important to the Niayes, rich in organic matter such as vertisols: of high interest for agricultural production, especially market gardening**

Source: http://ns.cse.sn/fao/senegal.htm, 2000

Winds

In the Niayes, average monthly wind speeds are between 2.9 m/s in September and 5.3 m/s in March



Agricultural production becomes impossible beyond 5m/s (D. SOLTNER, 1970)

In Senegal, approximately 50% of the country is extremely sensitive to wind erosion

Source: http://ns.cse.sn/fao/senegal.htm, 2000 (UNEP – UNESCO, 2003).

Cyclical drought

In 20 years, Senegal has had 11 years of drought

Soil saturation and deterioration

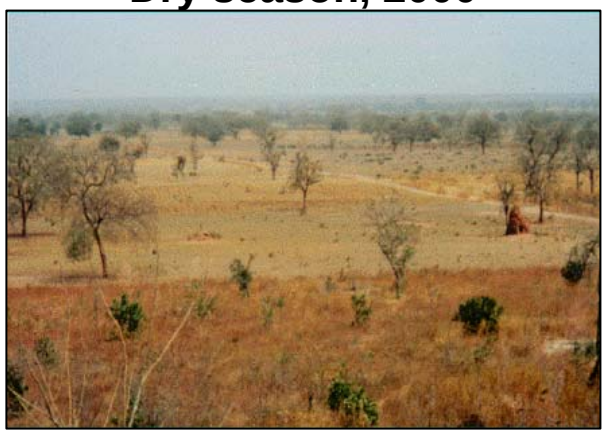
Nearly 50% of agricultural land has been damaged

Source: http://www.gouv.sn/politicals/lpdia.html

Climate variability:
Contrasting trends in Senegal and the Niayes

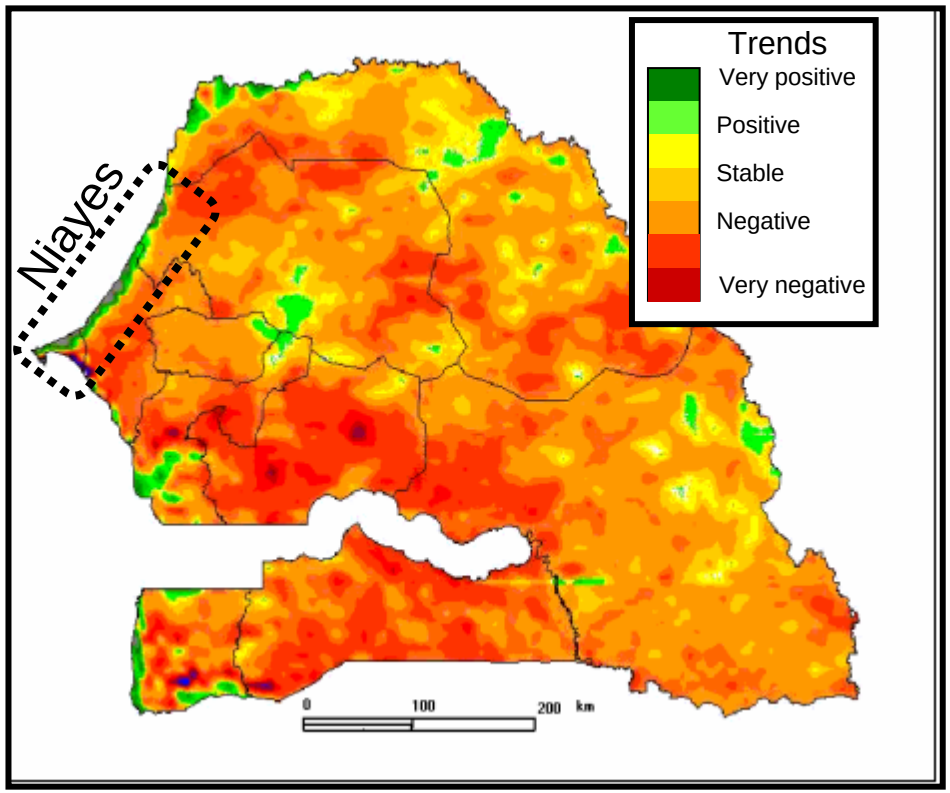
Vegetation
Wet season, 2000

Vegetation
Dry season, 2000



Map showing NDVI (Normalized Difference Vegetation Index) trends

1986-1999



Sources: http://www.diawara.org/senegal_vegetation.php
http://lada.virtualcentre.org/eims/download.asp?pub_id=92363

Socio-economic issues

Socio-economic profile of Senegal

Agriculture	**Agricultural land (2001) : *3,800,000 ha; 19%*** **Population in the primary sector: 70%** **Irrigated land (2001) : *76 000 ha; 2% of agricultural land*** **Use of fertilisers (% farms)** **Organic fertiliser : *19%*** **Chemical fertiliser : *16%*** **Organic/chemical fertiliser : *4%*** **No fertiliser : *61%***
Population and health	**Rural population : *51.1%*** **Urban population (2003) : *48.9%*** **Population (2025) : *16,900,000 inhabitants*** **Density (2000) : 48 inhabitants per km ^{2}** **Population below the poverty line** **1994 : *57.9 %*** **2001 : 53.9 %** **Babies born underweight (1998-2003) : 18 %** **Children under the age of 5 moderately or seriously underweight (1995-2003): 23 %** **Population with access to drinking water (2002) : 72 %** **Rural population with access to drinking water (2002) : 54 %**

Source: http://www.unicef.org/french/infobycountry/senegal_statistics.html

Socio-economic profile of the Niayes

Agricultural areas in the Dakar region: Louga, Thiès, Saint-Louis

- **Surface area:** approx. 3,090 $km^{2,}$ 13,000 ha of which are irrigated for a length of 180 km and a width of 5 to 30 km (agricultural part).

- **Arable land:** 1% of approx. 36,000 ha.

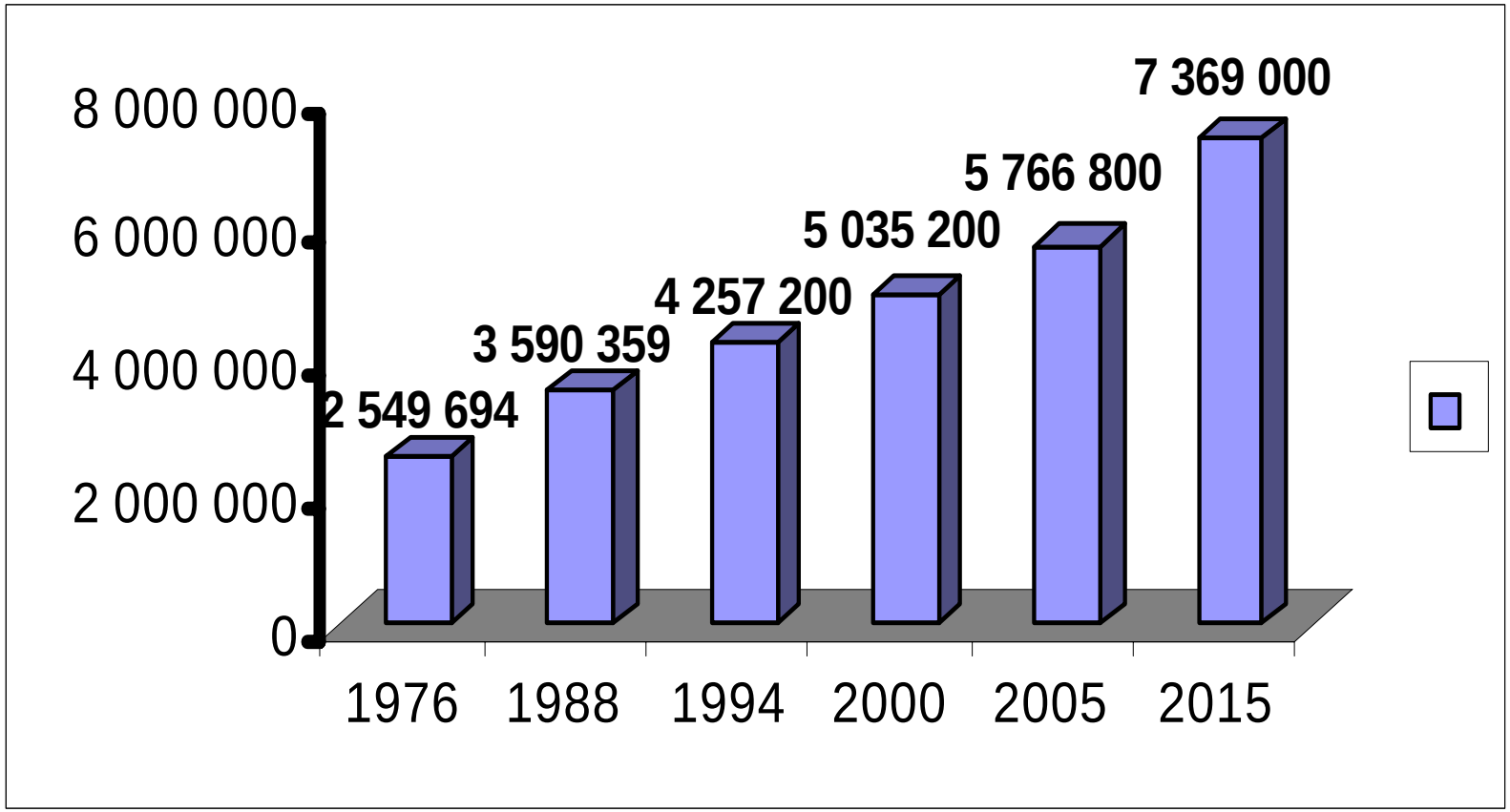
- **Agricultural production:** 80% of the fruit and vegetables produced in Senegal - 77.32% of the activities in Louga region and 80% in Saint-Louis and Thiès regions

- **Level of poverty** in 1995: 69.14%

- **Public investment in market gardening:** 2.2% for 1.0 % of cultivated land between 1988 and 1995.

Sources: http://ns.cse.sn/fao/utilisationterre.htm
http://www.univ-rouen.fr/droit-sceco-gestion/Recherche/CARE/Documents/PapierCabral27sept04.pdf
http://mfgfrenchstage.forumone.com/files/15243_3_enda.pdf
http://www.ch-hyeres.fr/chstlouis/article.php3?id_article=25

Population evolution in the Niayes



National growth rate: 2.55% in 2004

Growth rate in the Niayes: 3% in 2004

Source: http://www.indexmundi.com/g/*

Source: http://web.idrc.ca/en/ev-27906-201-1-DO_TOPIC.html

Legal, political and institutional issues

Senegal is characterised by:

- **A wide range of political tools and strategies for environmental management**
- **A wide range of institutions involved**
- **The embryonic aspect of climate change in environmental policy instruments**

Source: Senegalese environment regulations.

Land-use problems

- **Land ownership: the land is owned by the State (National Domain Law)**

- **Land-use change: to urban development in the best areas, or deforestation**

- **Land management: under the responsibility of rural communities and no longer favours the use of land for agriculture**

***Hence a feeling of land insecurity in the rural environment, which discourages long-term investment*.**

In the Niayes

1971-72 BUD Senegal the first major horticultural farm, was founded in the Niayes and was the result of a cooperation between the Senegalese Government and the BUD Dutch agro-industrial firm

Five years later, BUD Senegal, managed by expatriates, experienced its first crisis

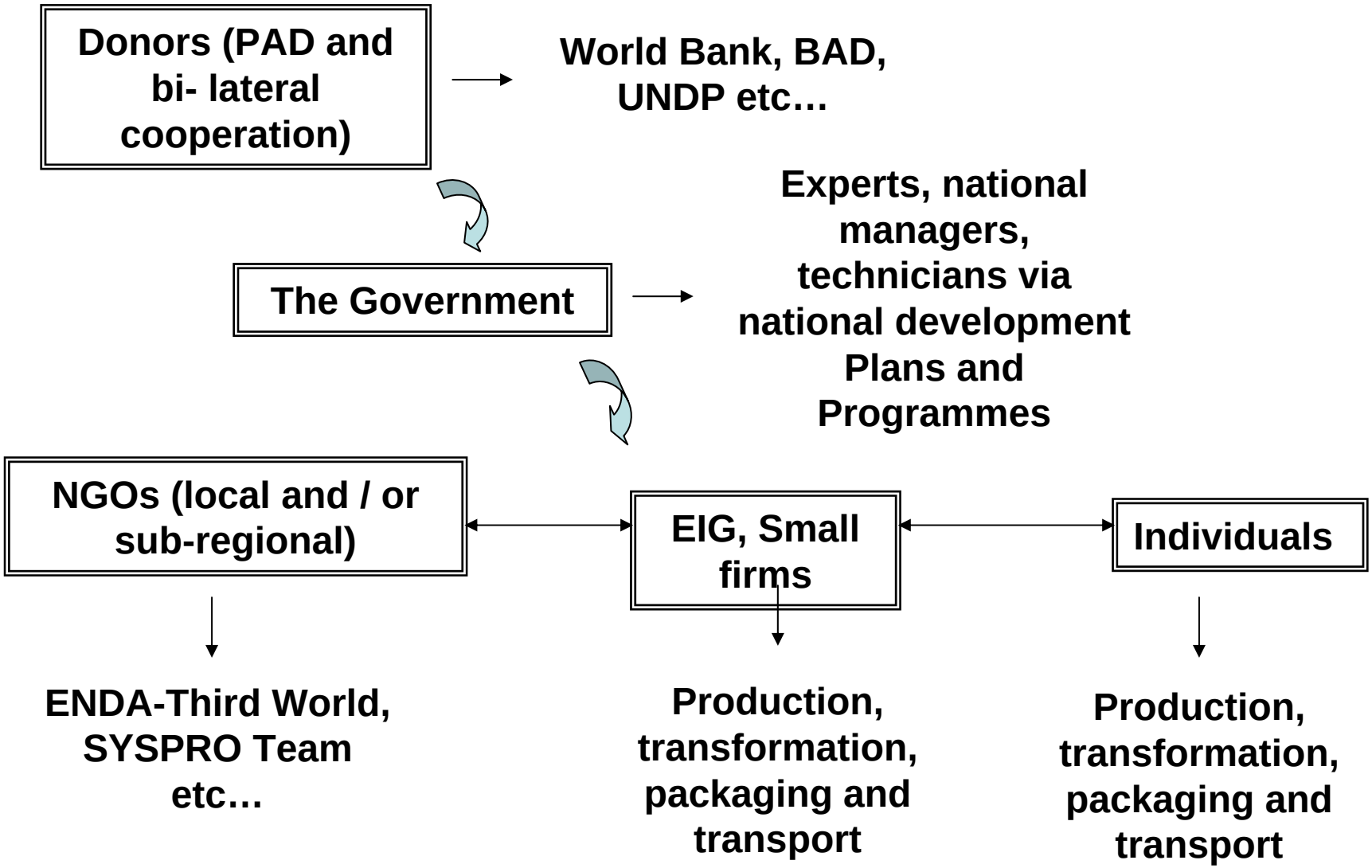
An administrative reorganisation set up a new structure on the same land, known as Sen-Prim and run by national managers for ten years before it went bankrupt, making way for Seproma

Seproma, run by former BUD Senegalese technicians, lasted for only one season

In 1990, a group of former BUD Senegalese workers, in cooperation with NGOs and local companies, took up the challenge and prospered.

Source: M. SECK and M. M. NA ABOU; 2005.

Groups and / or institutions involved in the Niayes

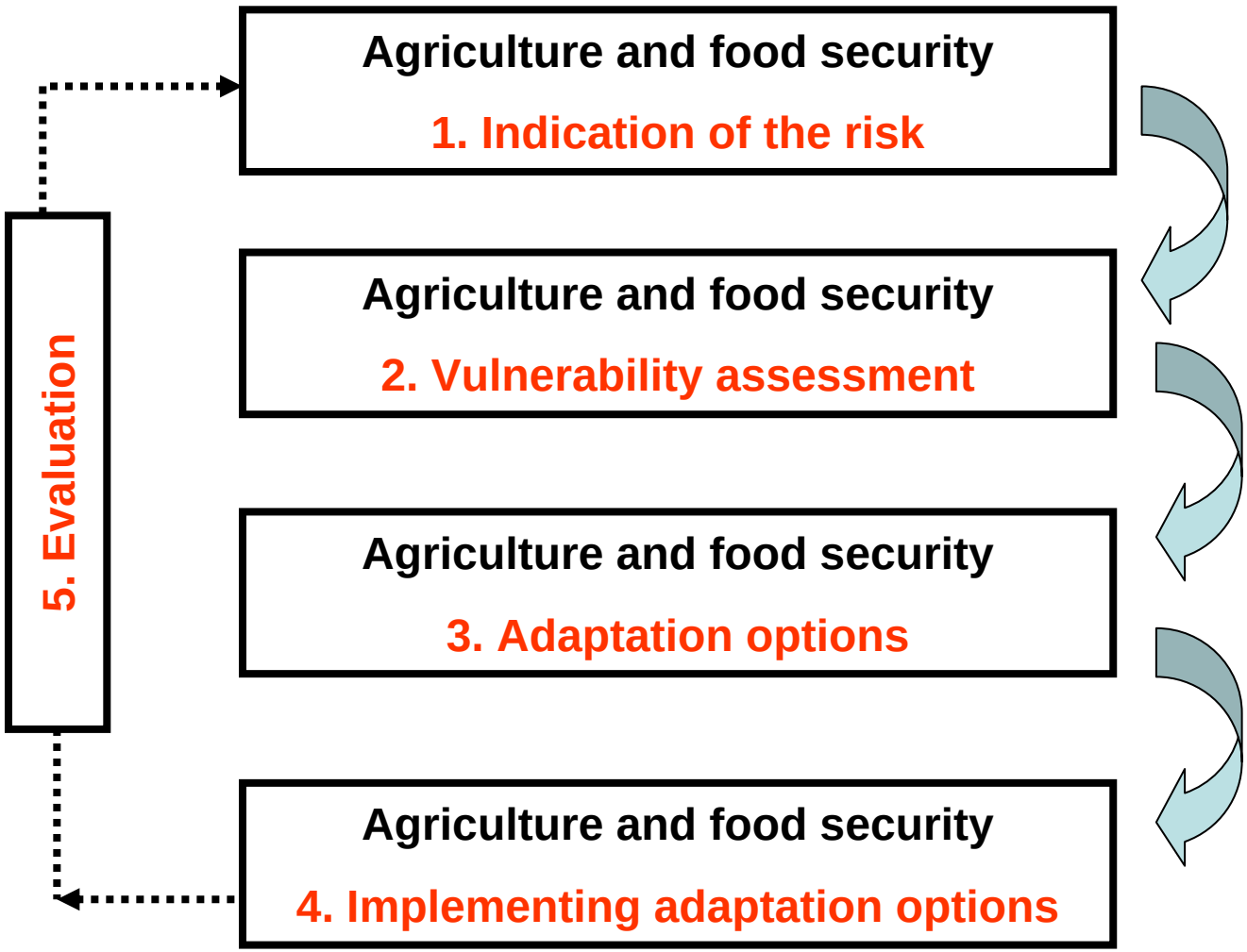


Source: M. SECK and M. M. NA ABOU; 2005.

3. Method and tools used to analyse vulnerability and adaptation applied to the case of The Niayes

- **The method**
- **The tools**
- **Applying the method with the appropriate tools**

3.1 The method



Source: Winograd, 2004 adapted by M. M. NA Abou, 2005.

3.2 The tools

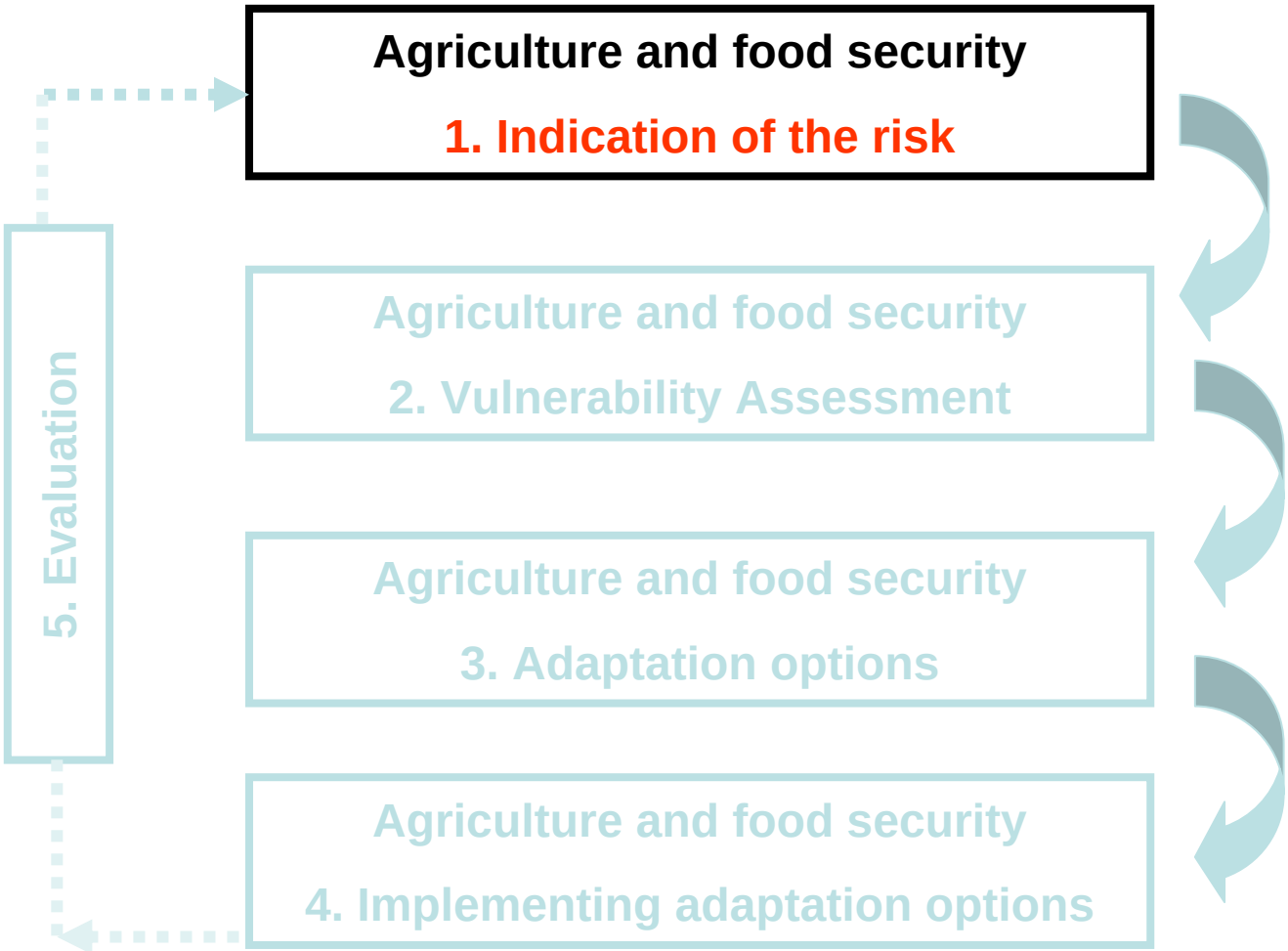
Evaluation Tools	Vulnerability	Adaptation	Description of the main applications
1. Institutional analysis	X		Identification of key groups and the interactions that determine how the institutions operate
2. Brainstorming	X	X	Construction of matrices and lists of ideas, knowledge and perceptions
3. Consultation of stakeholders	X	X	Consultation of individuals or groups affected by the decisions and the process
4. Oral histories	X		Use of the knowledge provided by the groups affected to construct analogies of strategies and future effects
5. Expert judgment		X	Technical evaluation of specific problems in the field
6. Vulnerability indicators	X		Compilation and mapping of data and knowledge to construct multi-scale/level indicators

The tools (cont.)

Evaluation Tool	Vulnerability	Adaptation	Description of the main applications
7. Macro-economic models and cost-benefit analyses	X	X	Economic and social valorisation of the impacts, options and responses
8. Vulnerability profiles	X	X	Mapping and analysis of indicators for different groups, regions, sectors
9. Cognitive mapping	X	X	Mapping the knowledge basis of stakeholders
10. Risk analysis	X	X	Introduction and analysis of uncertainty in decisions
11. Focus groups	X	X	Selected groups of stakeholders who analyse the options for dealing with certain issues

3.3 Applying the method with the appropriate tools

Step 1: Indication of the climatic risk



Aim: To analyse the risk of drought
Tools: Risk analysis (tool no. 10), oral histories (tool no. 4)

In Senegal:

- **Eight of the ten driest years for the period 1904 - 1994 occurred between 1970 and 1986**

- **A cycle of quasi-uninterrupted droughts hit the country: 1976, 1979, 1982, 1983, 1984 (record), 1985 and 1986**

Source: M. SECK and M. M. NA ABOU; 2005.

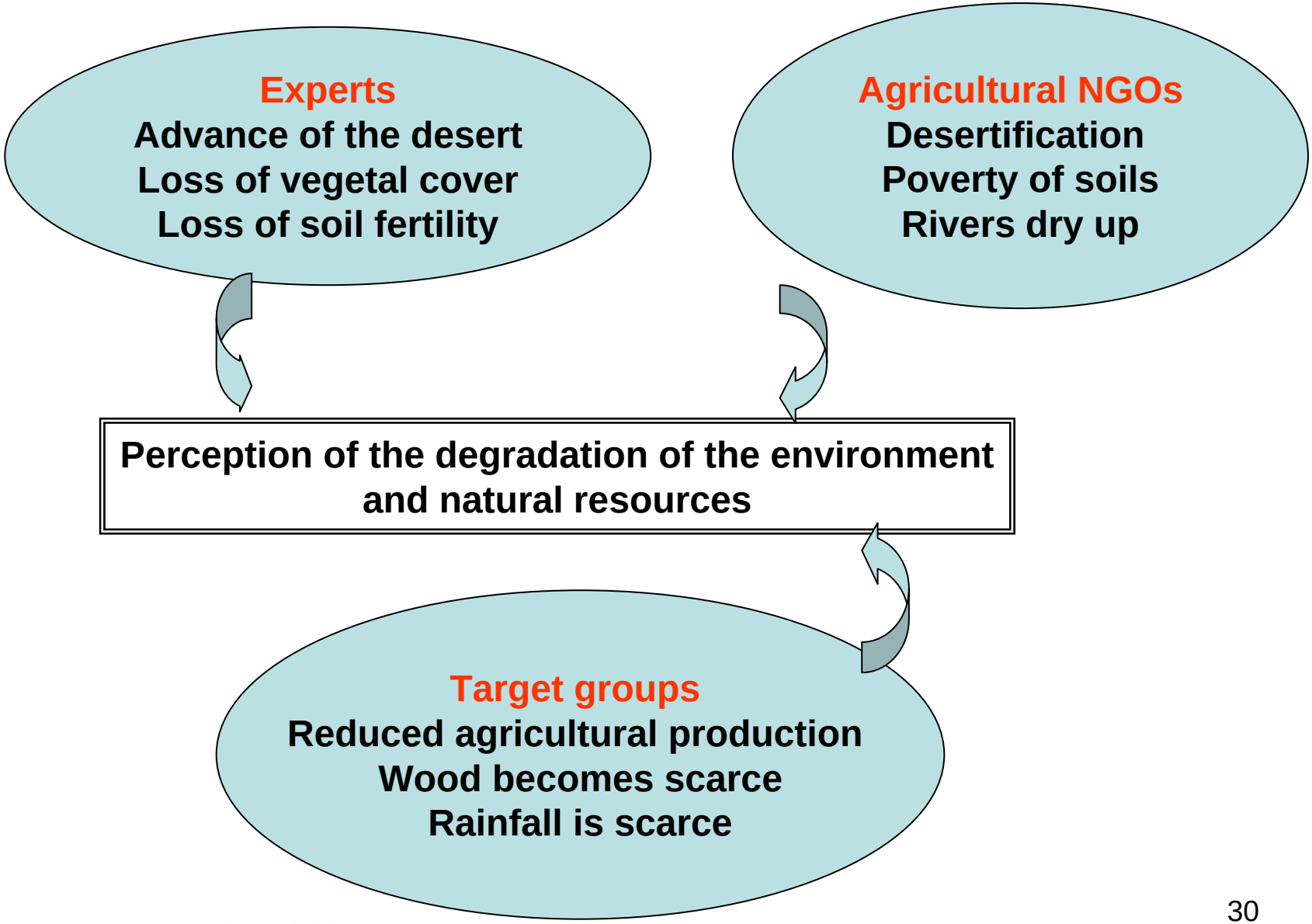
Aim: To analyse the risk of drought.
Tools: Expert judgment (tool no. 5), brainstorming (tool no. 2), focus group (tool no. 11)

This led to:

- **The almost complete disappearance of vegetal cover**
- **Increased wind erosion**
- **A drastic decrease in ground water levels**
- **Isohyets moving further south**

Source: M. SECK and M. M. NA ABOU; 2005.

Aim: To assess the damage to the environment & natural resources
Tools: Expert judgment (tool no. 5), consultation of stakeholders (tool no. 3)



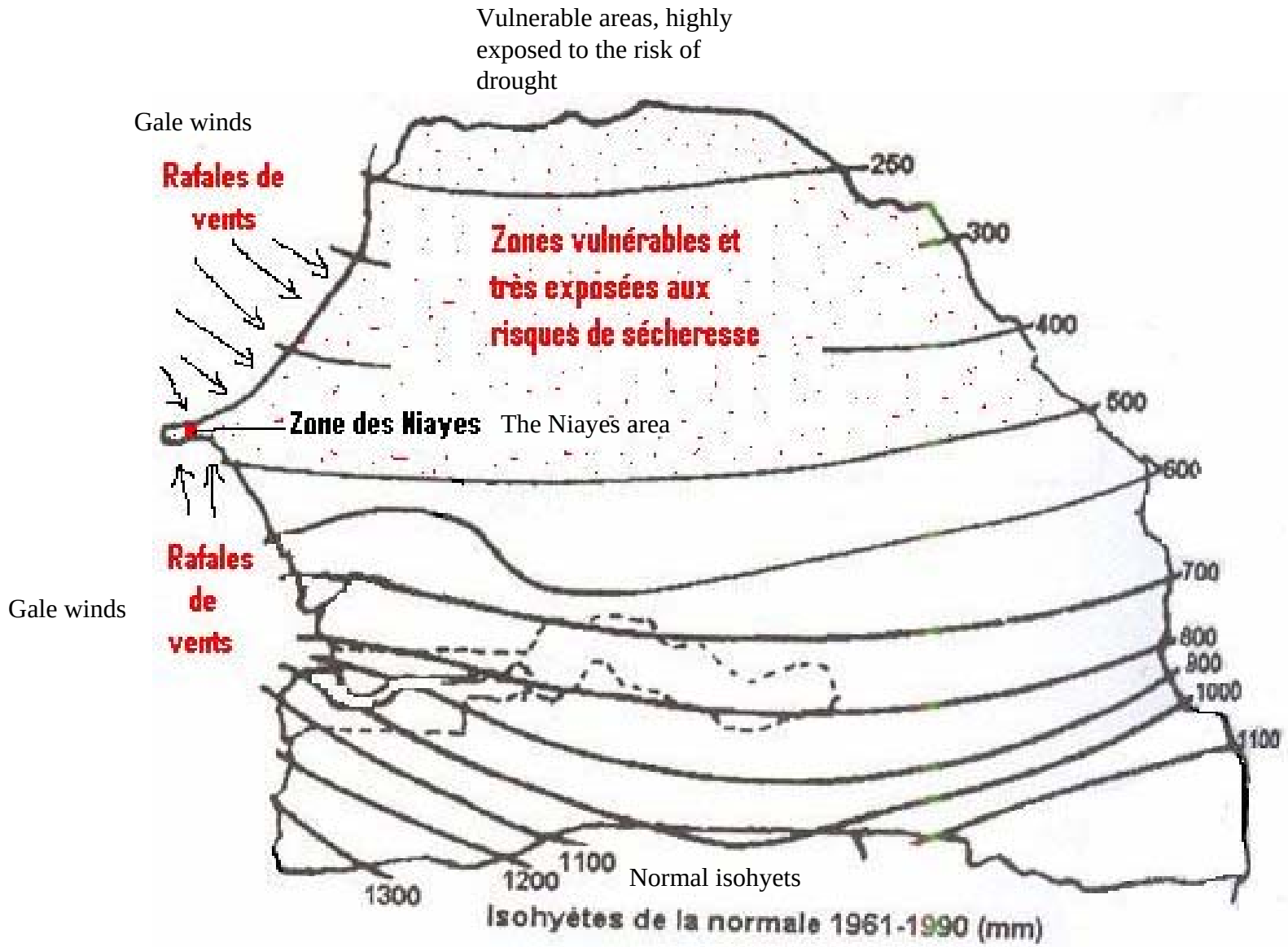
Source: M. M. NA ABOU, 2005.

Aim: To evaluate the presence of wind gales in the Niayes
Tools: Expert judgment (tool no. 5)

- **Trade winds: Winds from the sea, blowing in a North-West to South-East direction during 7 to 8 months of the year**
- **The « harmattan »: A continental, hot and dry South-East wind from the Sahara**

Source: M. SECK and M. M. NA ABOU; 2005.

Aim: To identify areas at high risk (drought and wind impacts)
Tools: Vulnerability profile (tool no. 8), Expert judgment (tool no. 5)



Source: M. M. NA Abou, 2005 –Senegalese National Communication.

Aim: To show evidence of deforestation
Tools: Photographs , Expert judgment (tool no. 5)

Deforestation

Charcoal production

- **Average national wood production : 3.5 million m^3, with a 33% progression in the last ten years**

- **Deforestation rate: approx. 30,000 ha per year**

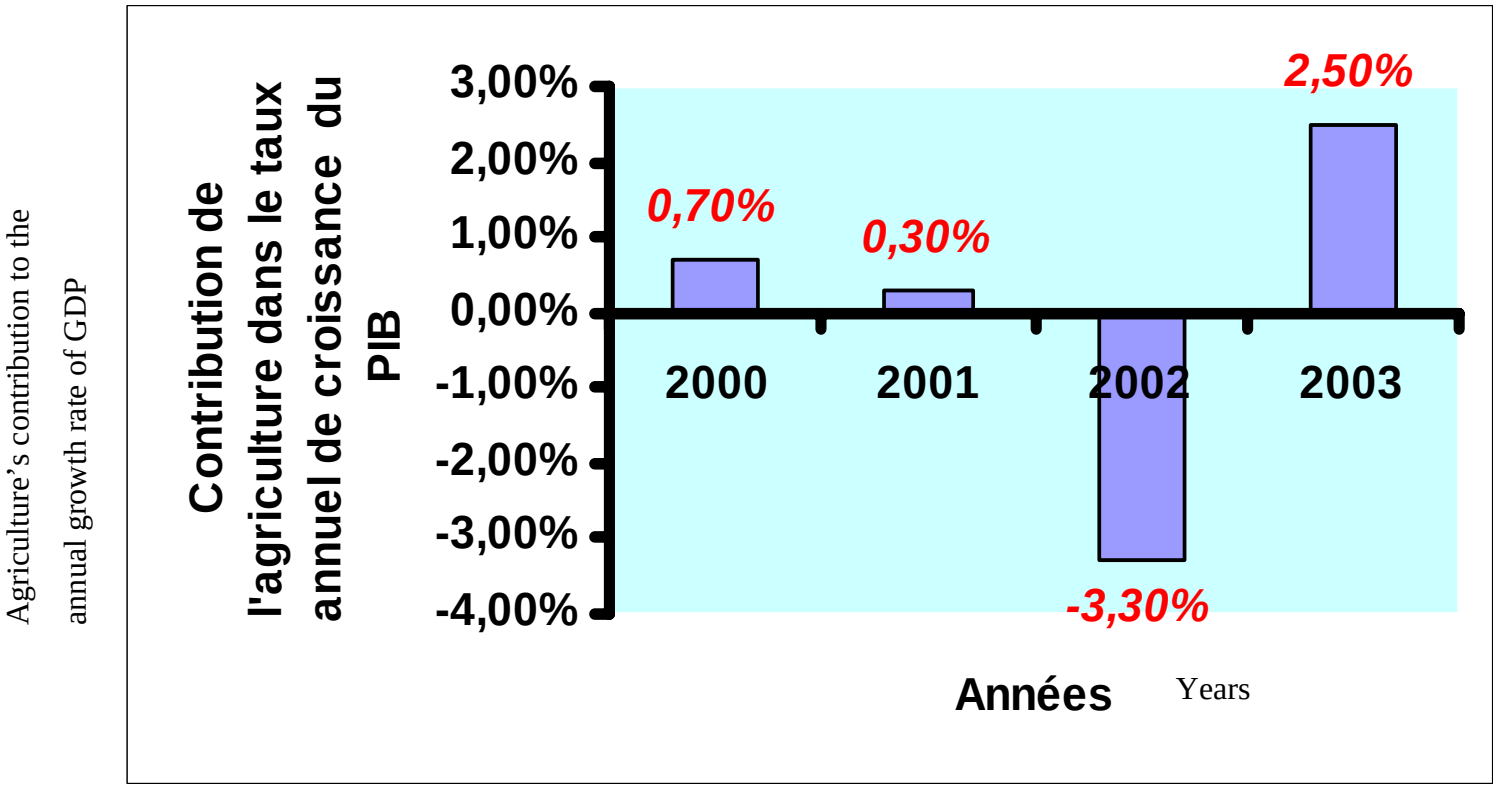
Source: http://www.un.org/esa/forests/pdf/national_reports/unff5/senegal.pdf

Aim: To evaluate the risk of food insecurity in the Niayes
Tools: Stakeholder consultations (tool no. 3), Focus groups (tool no. 11), Expert judgment (tool no. 5)

- **Continuous drop in agricultural yields**
- **Gradual destruction of vegetal cover**
- **Soil deterioration due to wind and water erosion**
- **Increasingly harsh impacts of drought**
- **Farmers become poorer**

Source: M. SECK and M. M. NA ABOU; 2005.

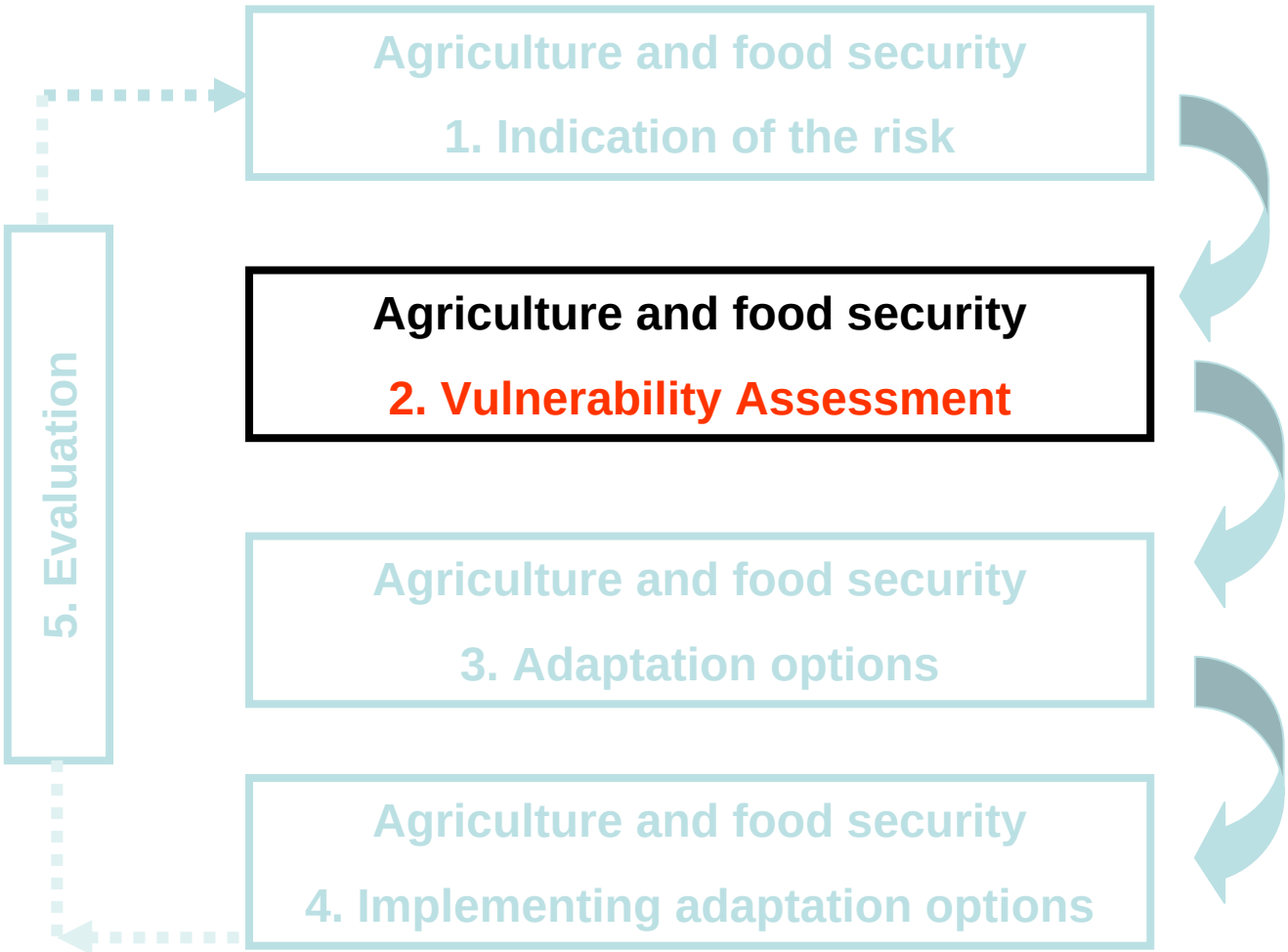
Aim: To show the impact of climate variability on the country ’s GDP
Tools: Modeling/simulation (tool no. 7)



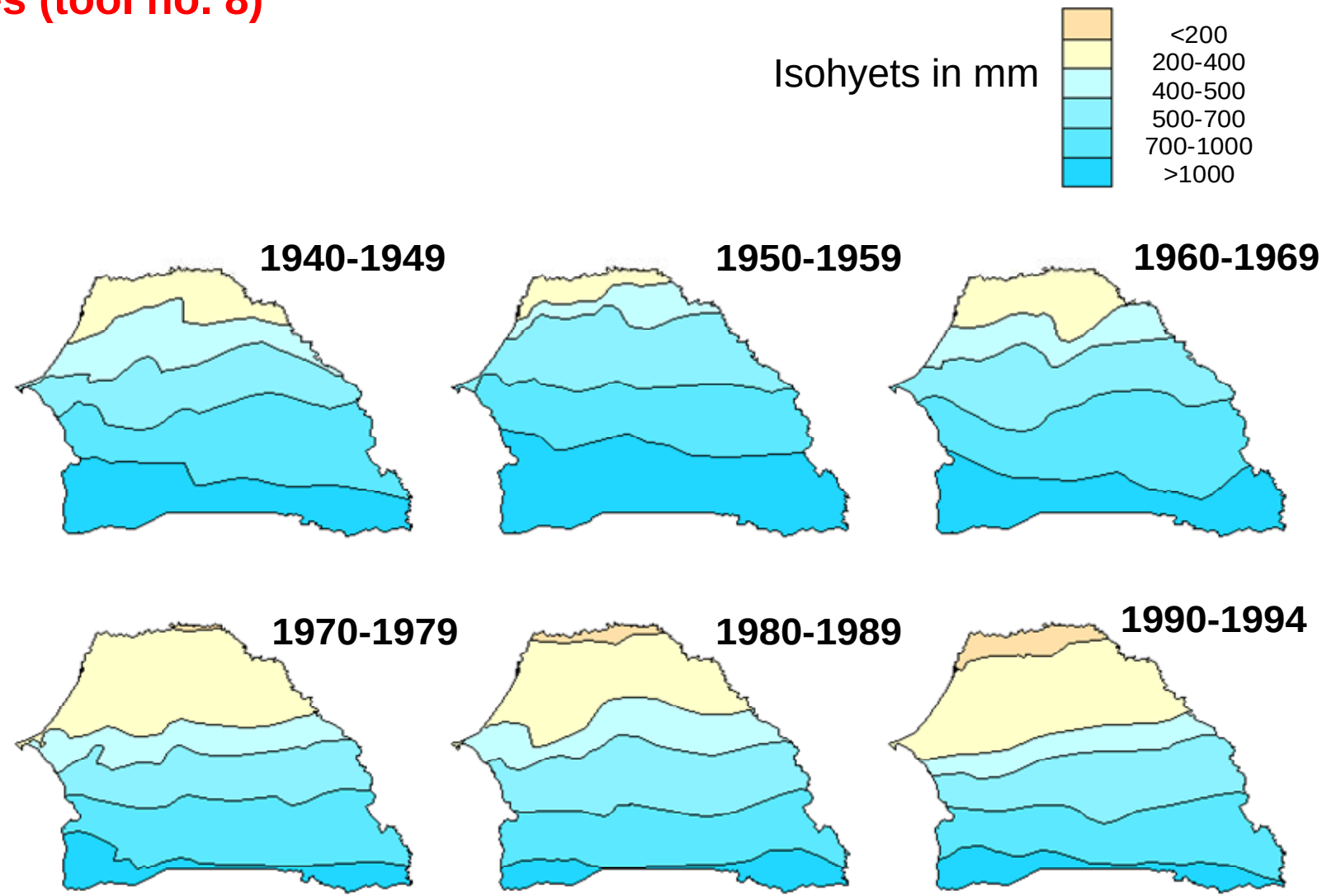
The bad climate conditions in 2002 led to a 3.3% fall in agriculture’s share of the national GDP

Source: Ministry of the Economy and Finance, 2004.

Step 2: Evaluation of the vulnerability



Aim: To show evidence of the rainfall reduction over the years
Tools: Vulnerability indicators and mapping (tool no. 6), Vulnerability profiles (tool no. 8)



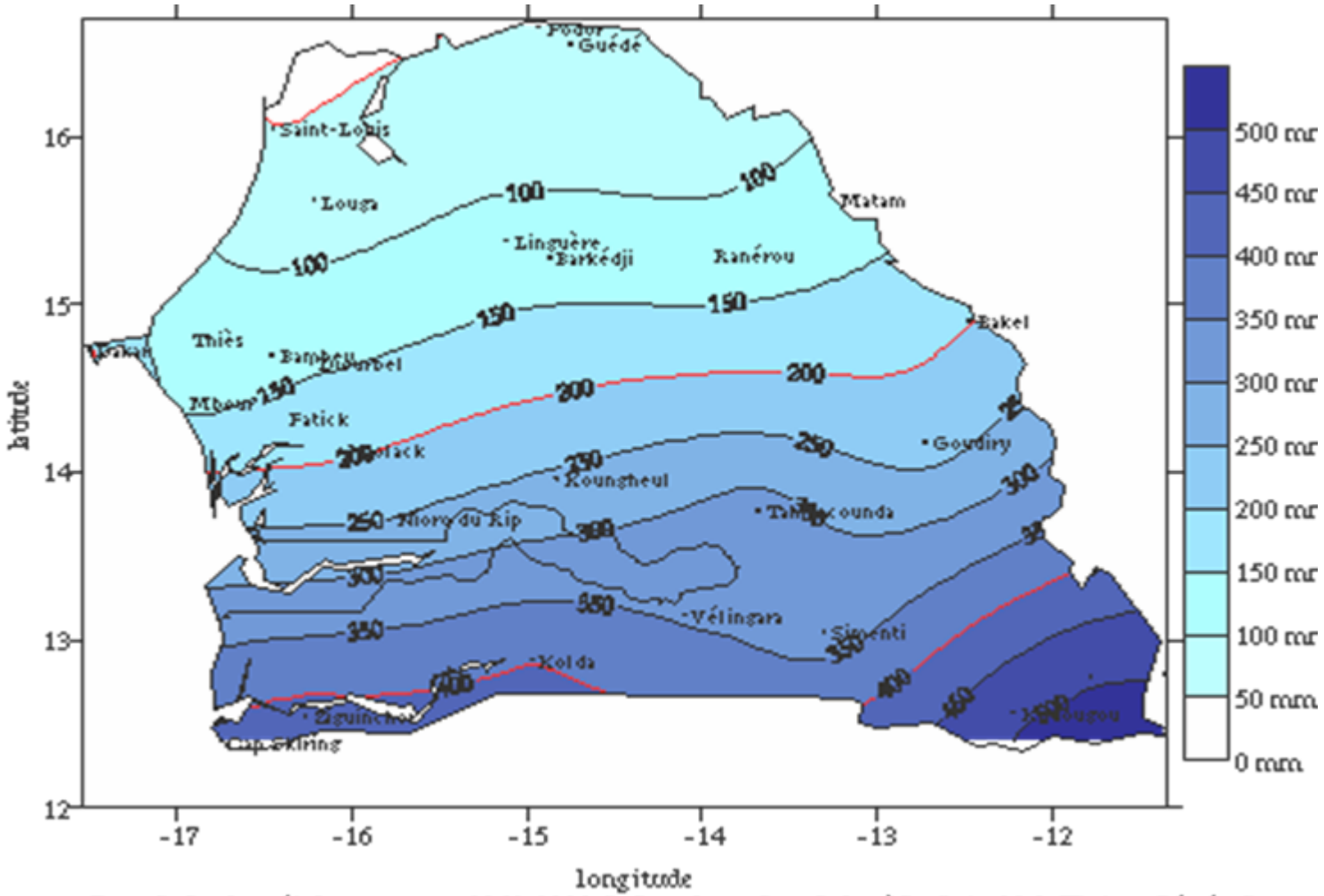
Source: National Meteorological Office.

Aim: To show evidence of the vulnerability of agriculture
Tools: Vulnerability indicators (tool no. 6), Expert judgment (tool no. 5)

- **North of the country is totally affected by drought**
- **1990 – 1994: agriculture highly vulnerable across nearly 40% of the country**
- **In 50 years, average annual rainfall in the Niayes has fallen from 500-700 mm to 200-400 mm**

Source: M. M. NA Abou, 2005.

Aim: To show evidence of the reduction and delay in rainfall over the years
Tools: Vulnerability indicators and mapping (tool no. 6), Vulnerability profiles (tool no. 8)

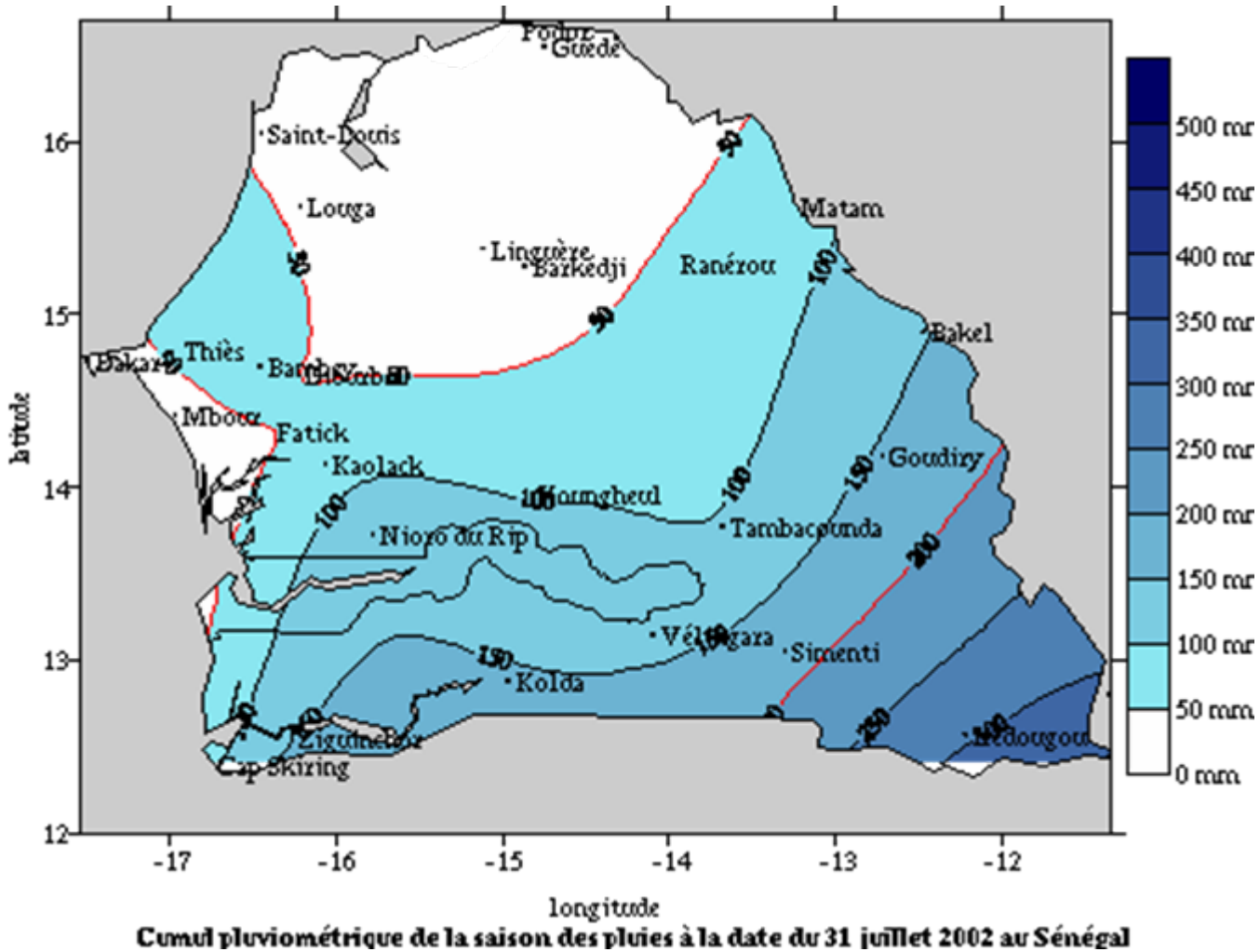


Cumul pluviométrique moyen 1961-1990 de la saison des pluies à la date 31 juillet au Sénégal

Average cumulated rainfall (1961-1990) for the rainy season on 31 July in Senegal

Source: http://medias.obs-mip.fr/emercase/Emercase/precipsen310702.html

Aim: To show evidence of the reduction and delay in rainfall over the years
Tools: Vulnerability indicators and mapping (tool no. 6), Vulnerability profiles (tool no. 8)



Average cumulated rainfall (2002) for the rainy season on 31 July in Senegal

Source: http://medias.obs-mip.fr/emercase/Emercase/precipsen310702.html

Aim: To show evidence of the vulnerability of agriculture to drought
Tools: Vulnerability indicators (tool no. 6), Expert judgment (tool no. 5)

- **Water: a limiting factor in all agricultural zones (the 31 July 2002 a rainfall cumulus was less than 300 mm)**
- **Over 90% of the country was in the same situation on 31 July 2001**
- **The Niayes 31 July 2002 rainfall cumulus was 0 to 50 mm compared to the average of 50 to 150 mm during the 1961-1990 period**

Source: M. M. NA Abou, 2005.

Aim: To show evidence of the vulnerability of agriculture to drought
Tools: Vulnerability indicators (tool no. 6), Expert judgment (tool no. 5)

VULNERABILITY INDICES

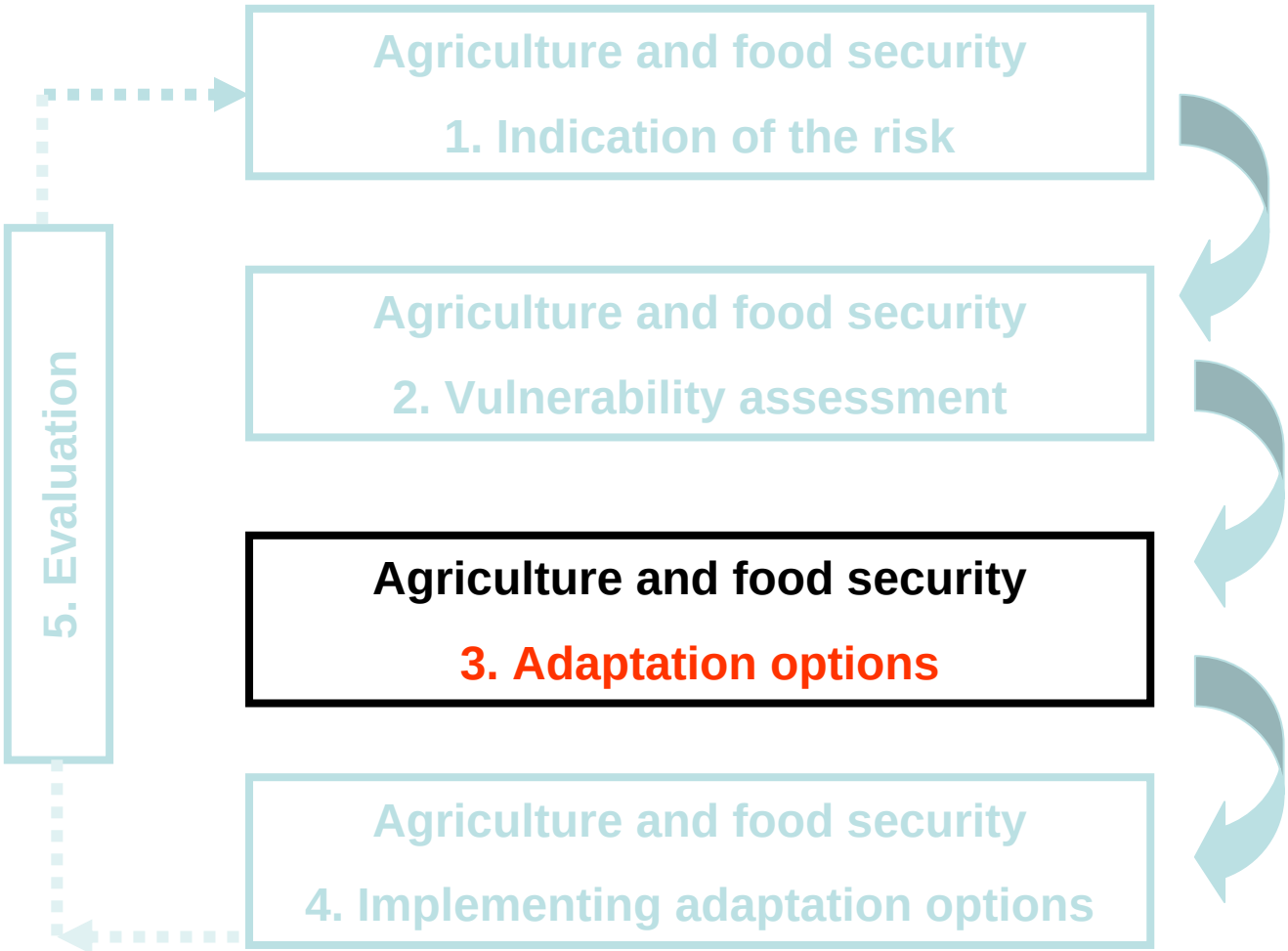
BIOPHYSICAL VULNERABILITY

- Diminution of the rainfall height (Isohyets moving southwards)
- Rainy season starts later
- Deterioration of natural resources (soils, vegetation, etc.)
- Droughts

SOCIO-ECONOMIC VULNERABILITY

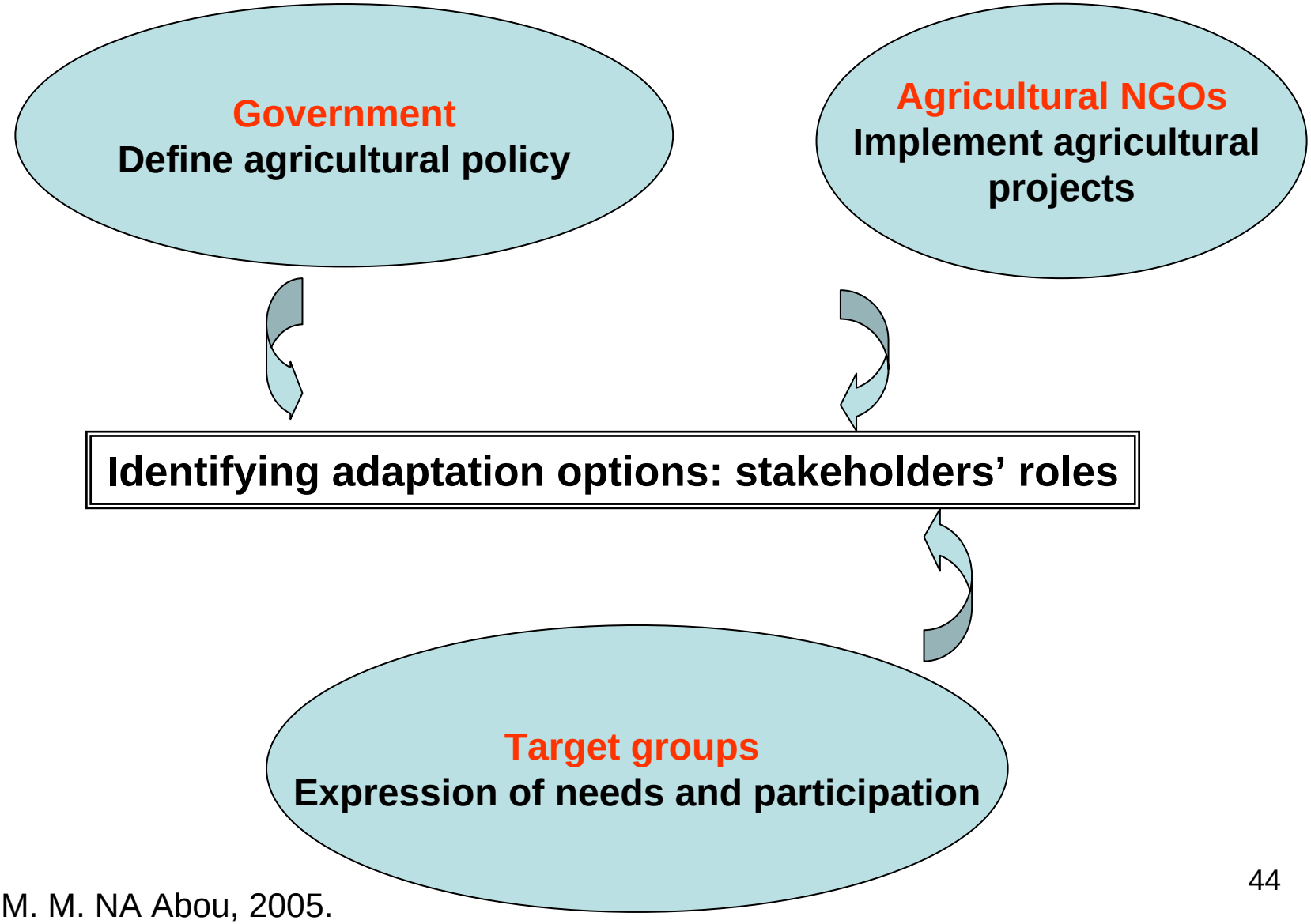
- Decrease of the agricultural GDP
- Continuous decrease in yields
- Farmers becoming poorer

Step 3: Adaptation options



Aim: Defining the roles of the main stakeholders involved in identifying adaptation options

Tools: Stakeholder consultation (tool no. 3), Expert judgment (tool no. 5)



Source: M. M. NA Abou, 2005.

Aim: Review of previously implemented adaptation options
Tool: Expert judgment (tool no. 5)

PRODUCTION SYSTEMS PREVIOUSLY IMPLEMENTED

- **TRADITIONAL or "FIRST GENERATION" PRODUCTION SYSTEM**
  - **Rain-fed system**
  - **Use of tools such as hoes, "hilaires", "dabas", etc.**
- **"SECOND GENERATION" AGRICULTURAL PRODUCTION SYSTEMS SUPPORTED BY THE GOVERNMENT**
  - **Irrigation**
  - **Mechanisation**
  - **Seed selection**
- **LIMITATIONS**
  - **Lack of quickset hedges**
  - **Agricultural production inversely proportional to carbon sequestration**
  - **The environment is not considered as a "factor of production"**

Source: M. SECK and M. M. NA ABOU, 2005.

Aim: To analyse the perception of stakeholders concerning the failure of previously implemented options

Tools: Brainstorming (tool no. 2), Focus groups (tool no. 11), Institutional analysis (tool no. 1)

Government (national managers, technicians, workers)

Poor management

Laxity

Lack of qualified staff

Experts

Lack of modernisation

Poor management

Lack of monitoring

Failure to convey message

NGOs

Initiatives not participative

Compartmentalised decisions

Approach not systemic

Cyclical droughts

Winds

Deforestation

Farmers

Initiatives not participative

Compartmentalised decisions

Difficulty in gaining access to land

Lack of loans

Cyclical droughts

Deforestation

Source: M. SECK and M. M. NA Abou, 2005.

Aim: To identify adaptation options

Tools: Brainstorming (tool no. 2), Stakeholder consultation (tool no. 3)

Government (national managers, technicians, workers)

- Decentralisation
- Privatisation
- Food aid
- Training of agronomists
- Modernisation of the sector

Experts

- Modernise the agricultural sector
- Better management of allocated funds
- Provide rigorous monitoring
- Raise awareness

NGOs

- Participative approaches
- Systemic approach
- Promote irrigation
- Install wind-breaks

Farmers

- Participative approaches
- Facilitate access to lands
- Grant loans
- Food aids
- Find a substitute for rain-fed agriculture

Source: M. M. NA Abou, 2005.

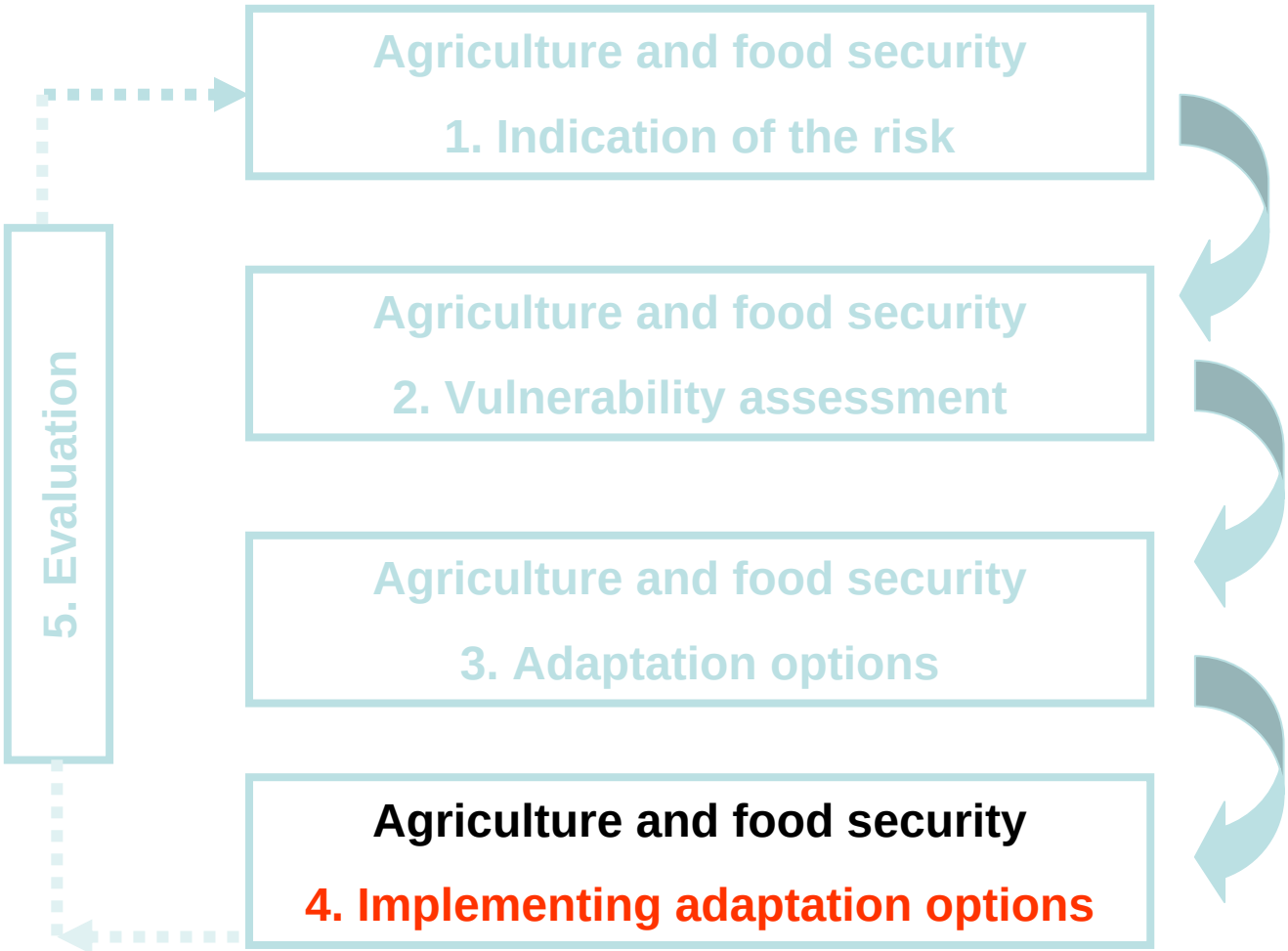
Aim: Adaptation options in the Niayes: "Third-generation" production systems

Tool: Expert judgment (tool no. 5), Stakeholder consultation (tool no. 3)

- **Supplement rain-fed agriculture with irrigation**
- **Stop the gale wind damage to agricultural production**
- **Produce environment instead of consuming it**
- **Promote 4 fundamental parameters: Technical; Environmental; Economic and Social**

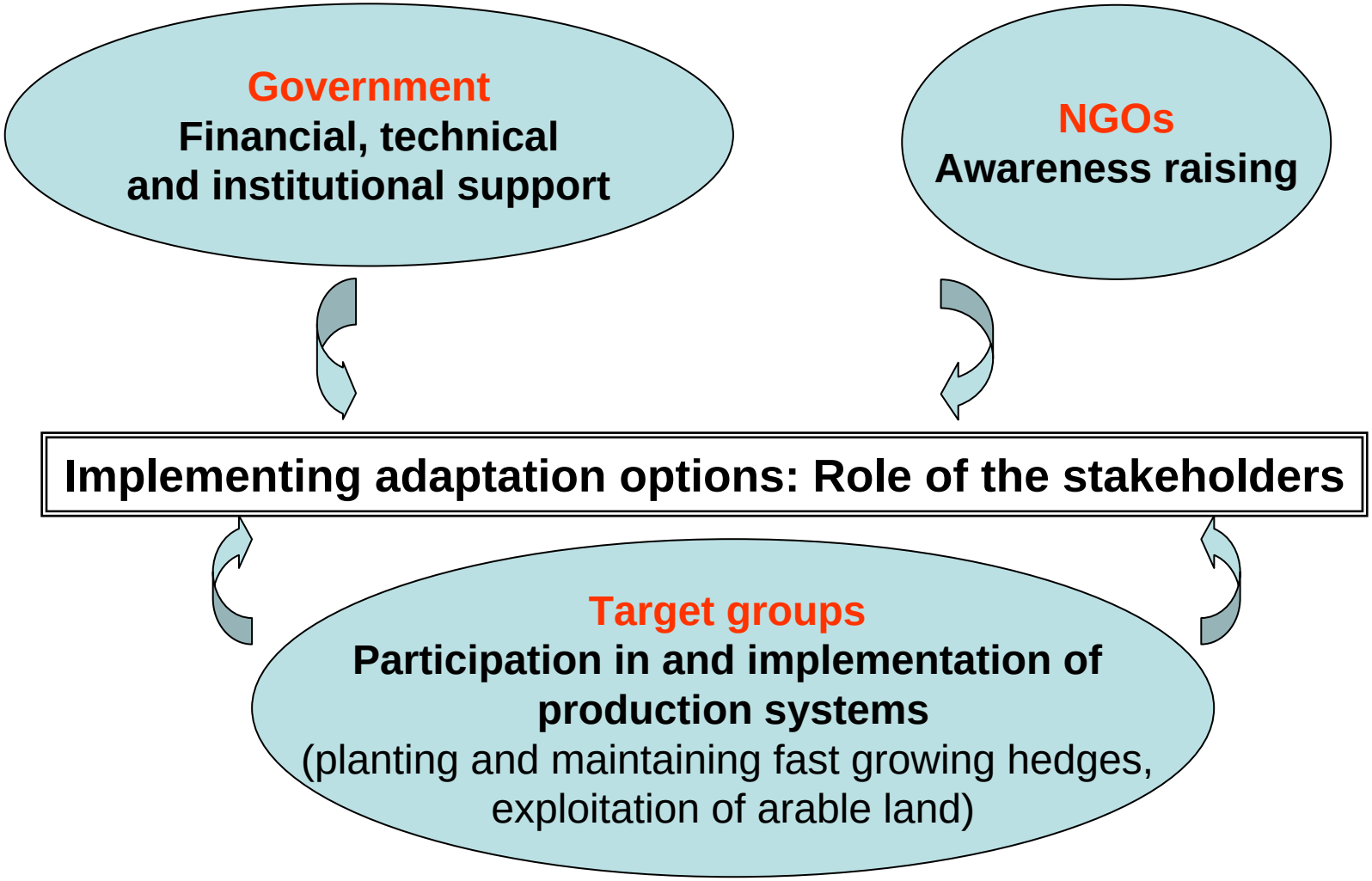
Source: M. SECK and M. M. NA ABOU, 2005

Step 4: Implementing adaptation options



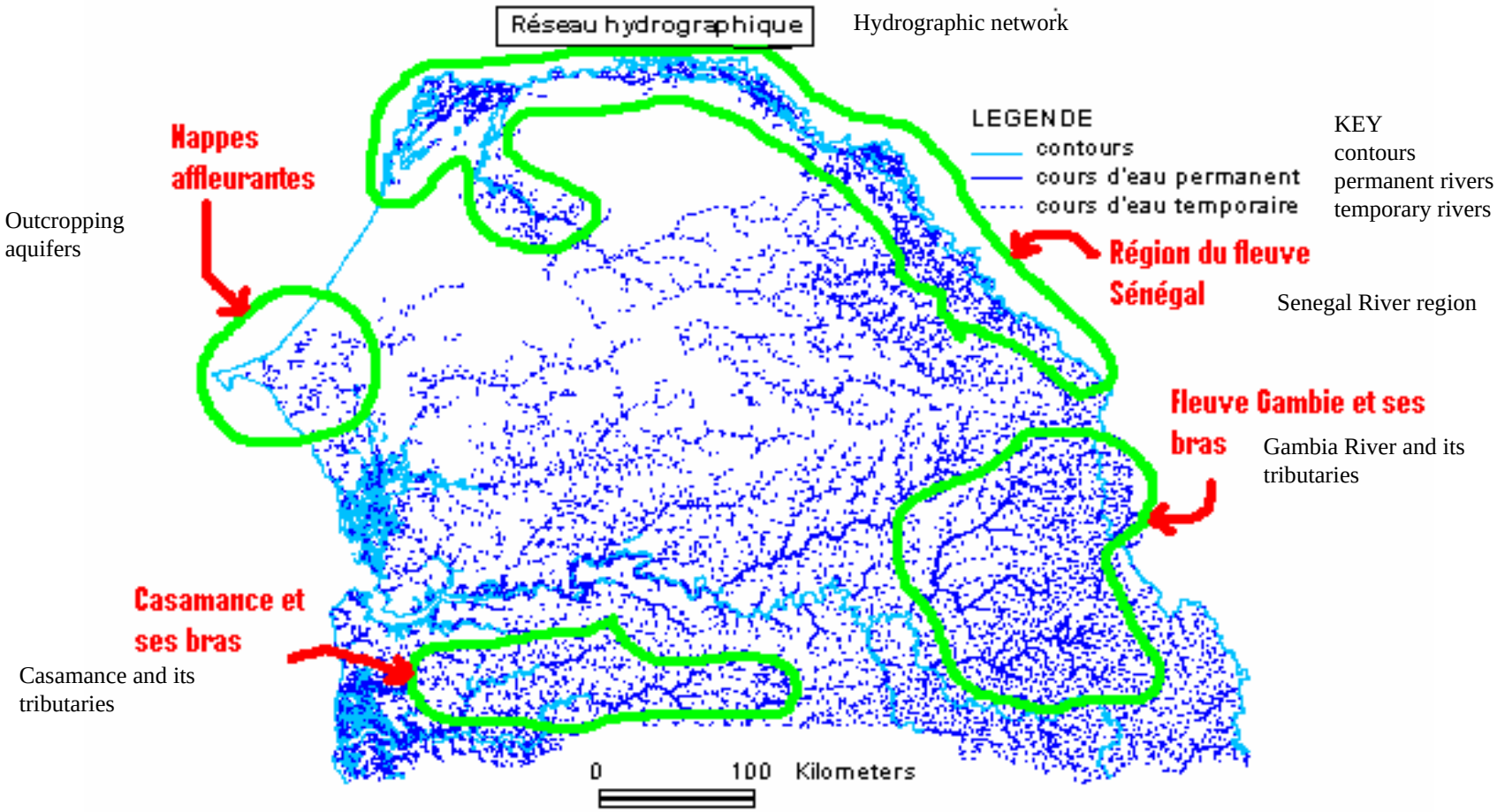
Aim: To implement adaptation options in Senegal, roles of the various stakeholders

Tools: Focus groups (tool no. 11), Stakeholder consultation (tool no. 3), Expert judgment (tool no. 5)



Source: M. M. NA ABOU, 2005.

Aim: To implement adaptation options in Senegal, potential for irrigation in Senegal
Tools: Cognitive mapping (tool no. 9), Vulnerability profiles (tool no. 8), Expert judgment (tool no. 5)



Source: M. M. NA Abou, 2005 and http://ns.cse.sn/fao/utilisationterre.htm

Aim: To block gale winds
Tools: Expert judgment (tool no. 5), Stakeholder consultation (tool no. 3)

National managers and technicians
Combat deforestation
Reforestation

NGOs
Install wind-breaks
Install fast growing hedges

How to block gale winds?

Target groups
Plant trees
Plant hedges around plots

Fast growing hedges

Source: M. SECK and M. M. NA ABOU, 2005.

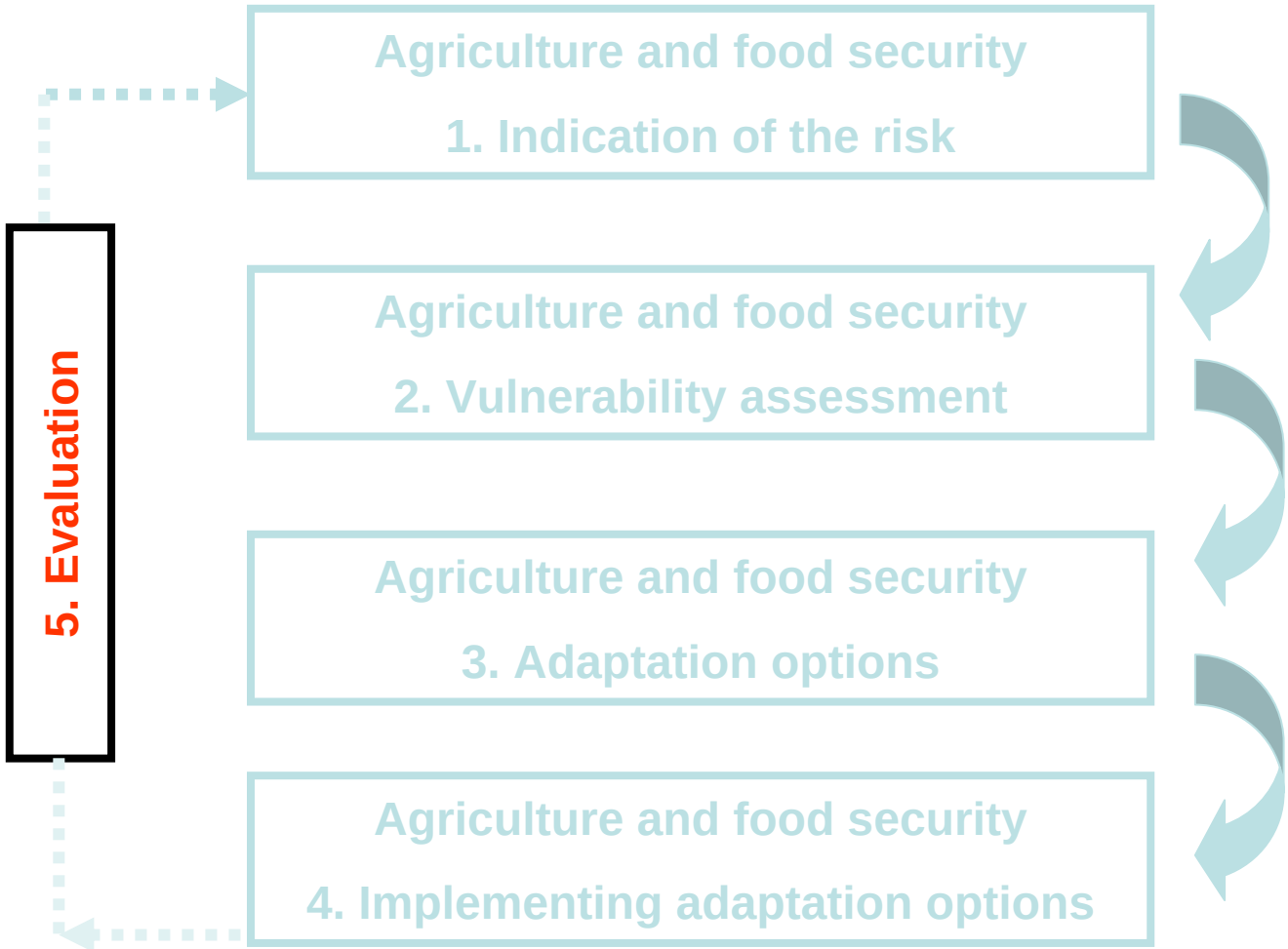
Aim: To enhance the environment
Tool: Expert judgment (tool no. 5)

Functional configuration, wind-break: the nature and species of wind-break help to reduce evapo-transpiration of plants and fix larger quantities of carbon and organic matter in the soils.

Fast growing hedges around cultivated plots

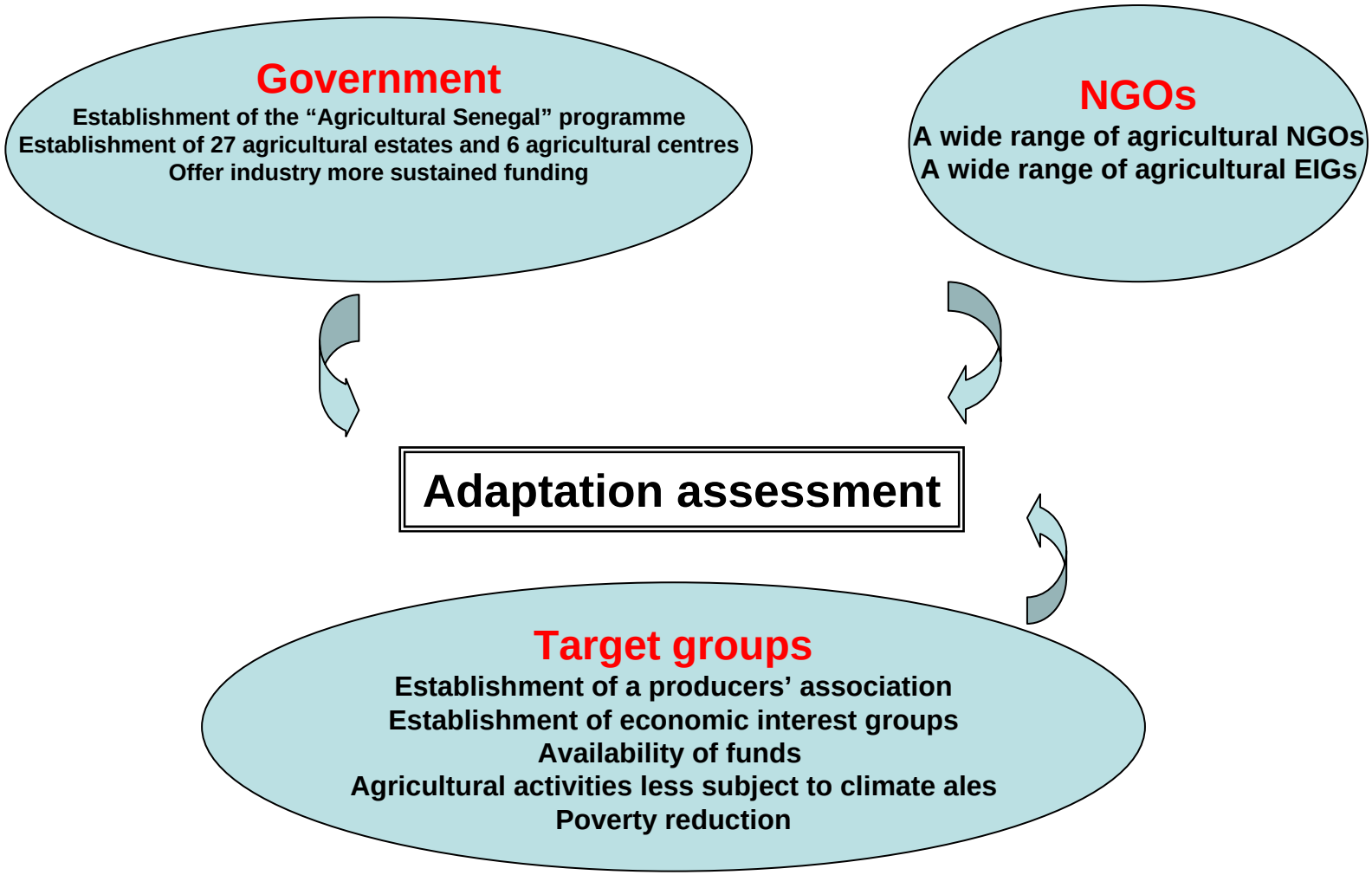
Source: M. SECK and M. M. NA ABOU, 2005.

Step 5: Evaluation



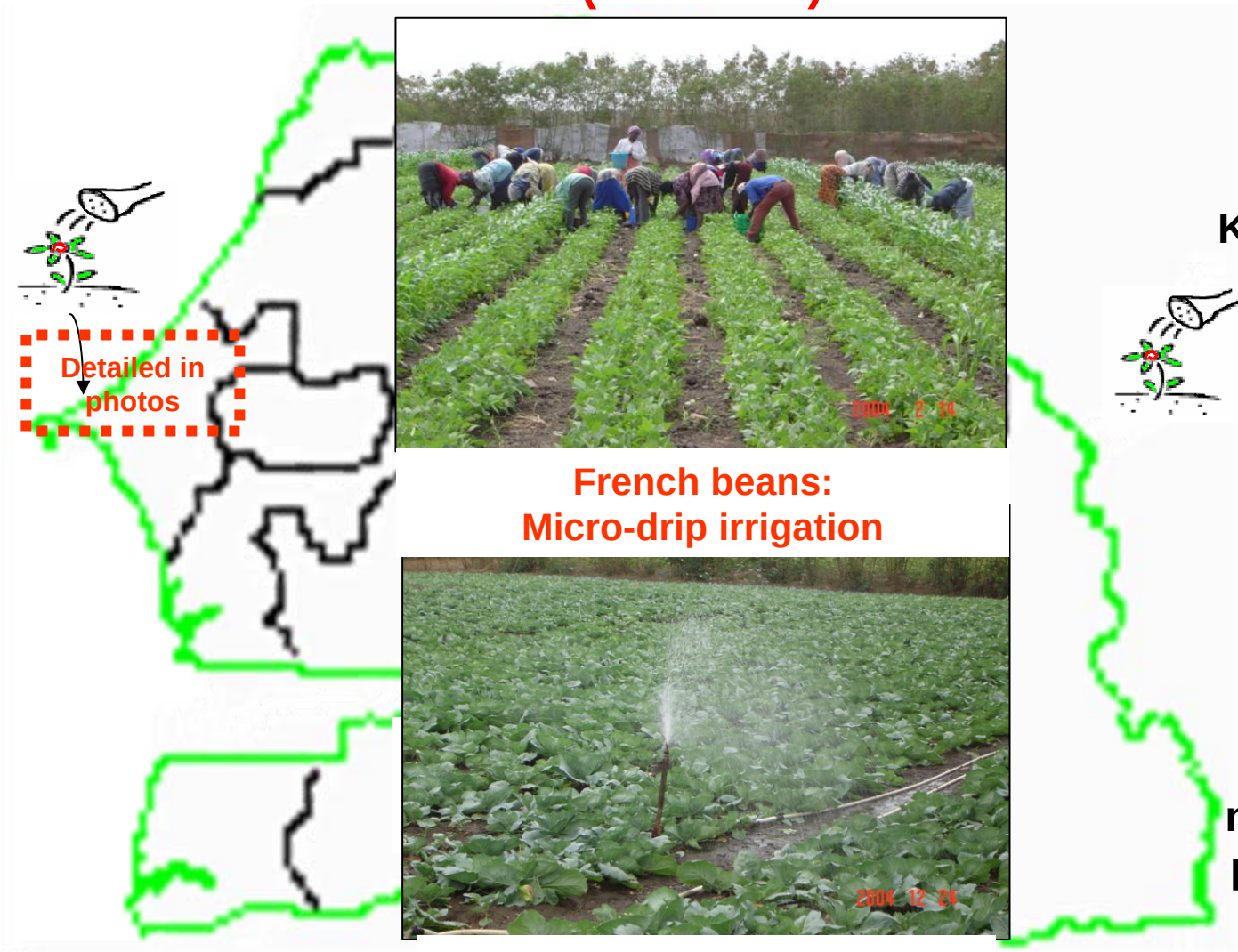
Aim: To assess adaptation

Tools: Focus groups (tool no. 11), Stakeholder consultation (tool no. 3), Expert judgment (tool no. 5)



Source: M. SECK and M. NA ABOU; 2005.

Aim: To introduce adaptation options in Senegal
Tools: Cognitive mapping (tool no. 9), Vulnerability profiles (tool no. 8), Stakeholder consultation (tool no. 3)



French beans:
Micro-drip irrigation

Cabbage:
Sprinkler irrigation

Key

Sites set aside for the introduction of adaptation options

The Government aims to implement these adaptation strategies in 33 departments through a vast national agricultural programme entitled "Agricultural Senegal"

Source: M. SECK and M. NA ABOU; 2005.

Aim: To show evidence of the impacts of adaptation
Tools: Expert judgment (tool no. 5)

- **Cultivated areas: 300,000 ha (projections)**
- **Yields: Cherry tomatoes grown in the field: 120t per ha; Carrots, cabbages, potatoes: over 30t per ha**
- **Production of fresh products (fruits and vegetables, meat, milk, …): 6 million tonnes (projections), i.e. double the current food production in Senegal**
- **Potential direct and indirect jobs: 2 million (men and women)**

Source: M. SECK and M. NA ABOU; 2005.

Aims: To show evidence of the impacts of adaptation
Tool: Photographs, Expert judgment (tool no. 5)

French beans and maize

Sweet corn

Wind-break and farmland

Cherry tomatoes irrigated by micro-drip

Aim: To evaluate the adaptation options
Tool: Expert judgment (tool no. 5)

Advantages/disadvantages of irrigation

- ✓ **Irrigation helps:**
  - **To significantly raise production**
  - **To diversify production**
  - **To improve farmers' incomes**

- ✓ **But:**
  - **Water resources (underground and surface) have considerably decreased as a result of over-exploitation**
  - **Soils are becoming increasingly saline.**

Source: CSE, 2003 and http://are.berkeley.edu/~zilber/water.ppt

Aim: To assess the economic costs/benefits of the adaptation options
Tool: Stakeholder consultation (tool no. 3)

Production factors	Soil preparation, Seeds, Fertilisers, Phytosanitary products, Labour (maintenance), Labour (harvest), Energy (Electricity and Diesel), Maintenance and repairs, Nursery (peat, containers, canvas), Planting wind-breaks							
Type of crop	**French beans**	**Pepper**	**Sweet corn**	**Chili pepper**	**Melon**	**Cherry tomatoe**	**Straw-berries**	**Gombo**
Costs per ha (in thousands of CFAF)	***2,300***	***2,080***	***910***	***2,630***	***2,180***	***7,100***	***2,100***	***2,080***
Value in CFAF on the European market in 2003	***1,000 to 2,600***	***700 to 2,500***	***1,100 to 3,500***	***1,200 to 3,500***	***700 to 2,500***	***1,000 to 1,800***	***2,000 to 3,000***	***1,400 to 2,500***

NB: Farmers are organised into EIGs for production, packaging and export

Source: M. SECK and M. NA ABOU; 2005.

Aim: To evaluate the options for their ability to enhance the environment

Tool: Expert judgment (Tool no. 5)

Advantages of reforestation via fast growing hedges

- ✓ The **production of firewood** (19 T of wood per ha) can significantly help to reduce deforestation and reduce energy dependence.
- ✓ Increased **soil productivity** with organic matter levels reaching as high as 6%.
- ✓ Mobile dunes threaten **market gardening pools** despite the planting of a green belt 180 km long, made up of filaos, to prevent wind erosion.
- ✓ **Carbon sequestration** may go as high as 15 T of C per ha (root and above-ground biomass in a 5-years old plot).
- ✓ The relatively low financial costs of sequestrating carbon (10 USD per T of carbon).

Source: CSE, 2003; M. SECK and M. M. NA ABOU, 2005; http://www2.essex.ac.uk/ces/Research Programmes/CESOccasionalPapers/CSEQ PaperFINAL.pdf

4. Lessons learned

Agriculture and natural resource management

- **Adapting the agricultural sector to climate variability means, in part, that rain-fed agriculture has to be "supplemented" by irrigated agriculture.**

- **The 'produced' environment could/should be considered as a 'production factor' in the same way as seeds, inputs or production techniques.**

Target groups:
Populations in Sébikotane

- **The reticence of local populations to agricultural innovation is explained by the failure of previously implemented adaptation strategies**

- **The reproduction of a successful experiment should be accompanied by the strengthening of the population's capacity to implement and manage these new agricultural production systems**

5. Conclusions and prospects

Conclusions

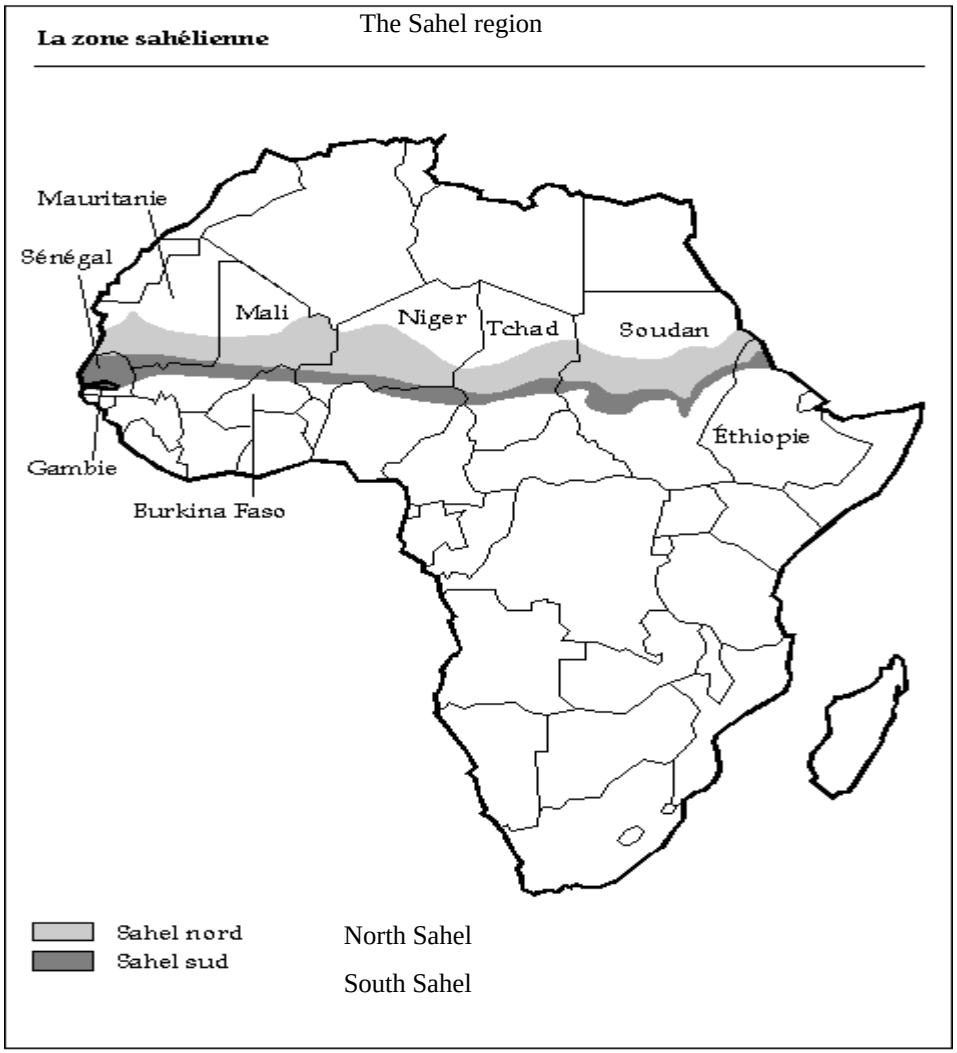
If food security in Senegal partly requires agriculture to adapt to climate variability and change, the following is required:

- **Irrigation should be promoted**
- **Environment must be taken into account as a 'production factor'**
- **Agricultural sector needs to be modernised**
- **Traditional knowledge in agricultural production needs to be adapted**

Prospects

Diagramme 1 Diagram 1

The Sahel region

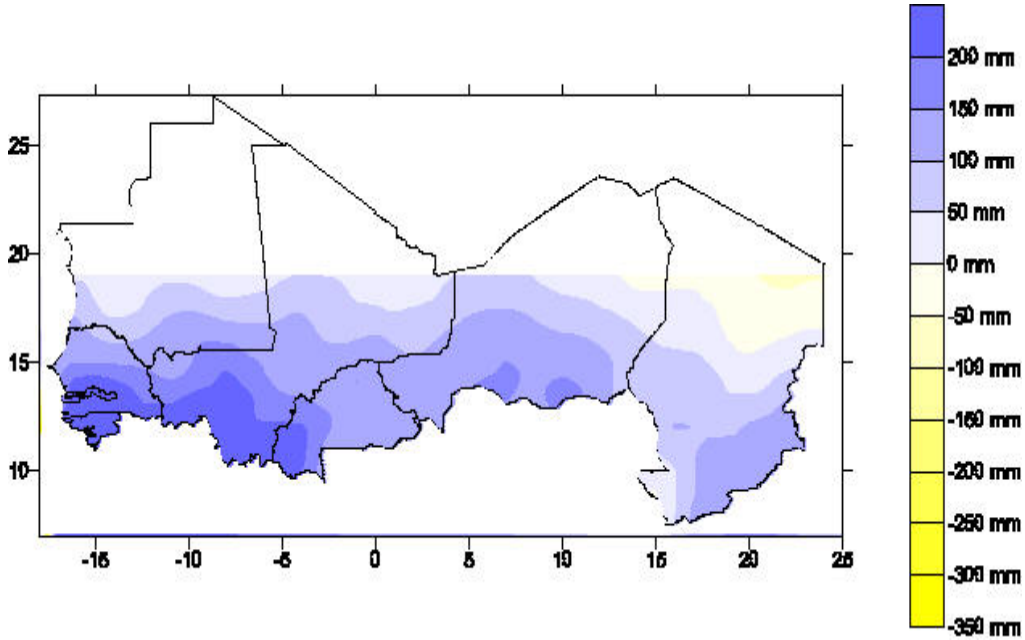


Source : H.G. Mensching, *Desertifikation*. Darmstadt, 1990. p. 55

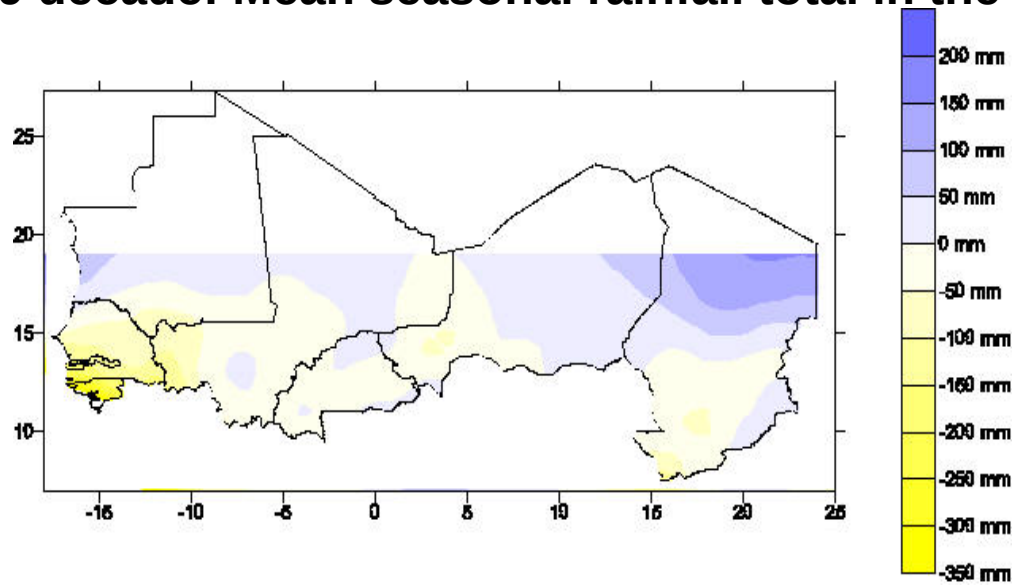
Senegal forms part of the Sub-saharan band known as the Sahel, and presents the same geo-climatic problems as the other countries in the region:

- **Low rainfall**
- **Climate change/ variability**
- **Food insecurity**

1950 – 1959 decade: Mean seasonal rainfall total in the Sahel



1990-1999 decade: Mean seasonal rainfall total in the Sahel



http://amma.mediasfrance.org/france/formation/enseignements/amma2e1/doc/08sept03/266,9,Slide 9

Towards a change of scale…

✓**Drought situation due to climate variability that has hit Senegal concerns the whole Sub-saharan region: the Sahel**

✓ **Can adaptation alternatives implemented in Senegal be applied to:**

Mauritania, Mali, Burkina Faso, Niger, Chad, Sudan and Ethiopia, with a view to helping them move towards food security?