

# **2006 National Water Quality Monitoring Conference San Jose, CA**

**“GIS and Remote Sensing Applications In The Hydropolitics of  
Sub-Saharan Africa: The Case of Multinational Management of  
River Niger Basin of West Africa”**

**By**

**Dr Edmund Merem\* and Dr Yaw Twumasi\*\***

**Jackson State University Mississippi\*  
Alabama A&M University \*\***

**07/05/06**

# Scope of the Presentation

- Purpose of the Research
- Background Information and Issues
- Multinational Water Sharing /Issues In West Africa
- Methodology and the Study Area
- The Regional Case Studies / Results
- Efforts
- Recommendations and Conclusions

# Objectives of the Research

- To update the literature on multinational sharing of water
- To analyze the current issues in transnational water management
- To apply the latest methods and advances in geospatial technologies in the study of hydropolitics
- To design geospatial decision support tools for the management of shared waters in West Africa

# Background Information/the Issues

- In West Africa, where no major rivers is contained in one nation transnational water sharing is essential for survival
- Even the globally stated goals of sustainability and environmental security are unattainable without bilaterally negotiated water agreements to improve access and quality
- Yet the systematic study of the nature, conduct of conflict, and cooperation between states over shared water resources in the Middle East continues to dominate the literature
- In the process, there has been limited coverage of the Sub-Saharan Africa experience and the role of GIS and remote sensing in monitoring the problem
- Considering the intense ecosystem stress inflicted on River Niger by human activities and natural forces emanating from upstream and downstream nations
- Researching the potentials for conflict and negotiated water sharing agreements among nations of the basin with spatial technology can help avert conflicts by bringing states much closer through cooperation and information exchange
- From a geopolitical standpoint, the nature of hydropolitics embodies the complex arenas of interactions between states that share river basins
- This is essential as the Niger Basin nations move towards a multi-national watershed management as a conduit for sustainability and equity

# Multinational Water Sharing and Issues In West Africa

## ■ International Basin Authorities

- Multinational water sharing can be manifested with the number of water basin authorities
- The water Basin agencies include Volta River Basin, the Senegal River and the Lake Chad basin

## ■ Essential Services and Functions

- Multinational water systems have been serving several nations in the region for over three decades.
- Through cooperation among the countries, the rivers provide life support to the inhabitants in the region

## ■ Unilateralism

- Despite mutual cooperation in the Niger basin, water projects designed without integrated management
- In some cases, hydro projects were pursued unilaterally without coordination and consent of neighbors

## ■ Multilateral Agencies

- As a remedy, the World Bank has been involved in a number of large-scale planning projects
- However, these efforts tended to concentrate on national scale planning without a multinational focus

## ■ Ecological Decline

- The Niger basin experiences over population /the flow of effluents from upstream to downstream states
- The ecological decline facing the region prompted African leaders to come up with an action plan
- Water quality issues leading to the search for a shared vision for the sustainable use of the river

# Methodology and the Study Area

■ The research stresses a four step approach involving a mix-scale connected to keyword literature search, descriptive statistics and spatial analysis with GIS and Remote Sensing

## ■ Step 1: Identification of The literature, Variables, Spatial data and Satellite Images

- Access to the relevant data bases containing the literature
- Procurement of 4 raw satellite images from NASA for the separate years between 1985-2000
- Four Landsat Thematic Mapper TM / Enhance Thematic Mapper Plus ETM P

## ■ Step 2: Preliminary Stages Leading to Design of Data Matrices, Maps and Images

- Tabular presentation and design of relevant information
- Image processing using ERDAS 8.7 Imagine, enhancement with equalization technique of histogram and classification

## ■ Step 3: Measure of Descriptive Statistics For the Percentages

- Display of the percentages, figures and ratios of selected variables

## ■ Step 4: Mapping and Analysis of The trends With Remote Sensing Technologies

- The remaining procedure involves spatial analysis and out put covering the study period with ARCHVIEW GIS

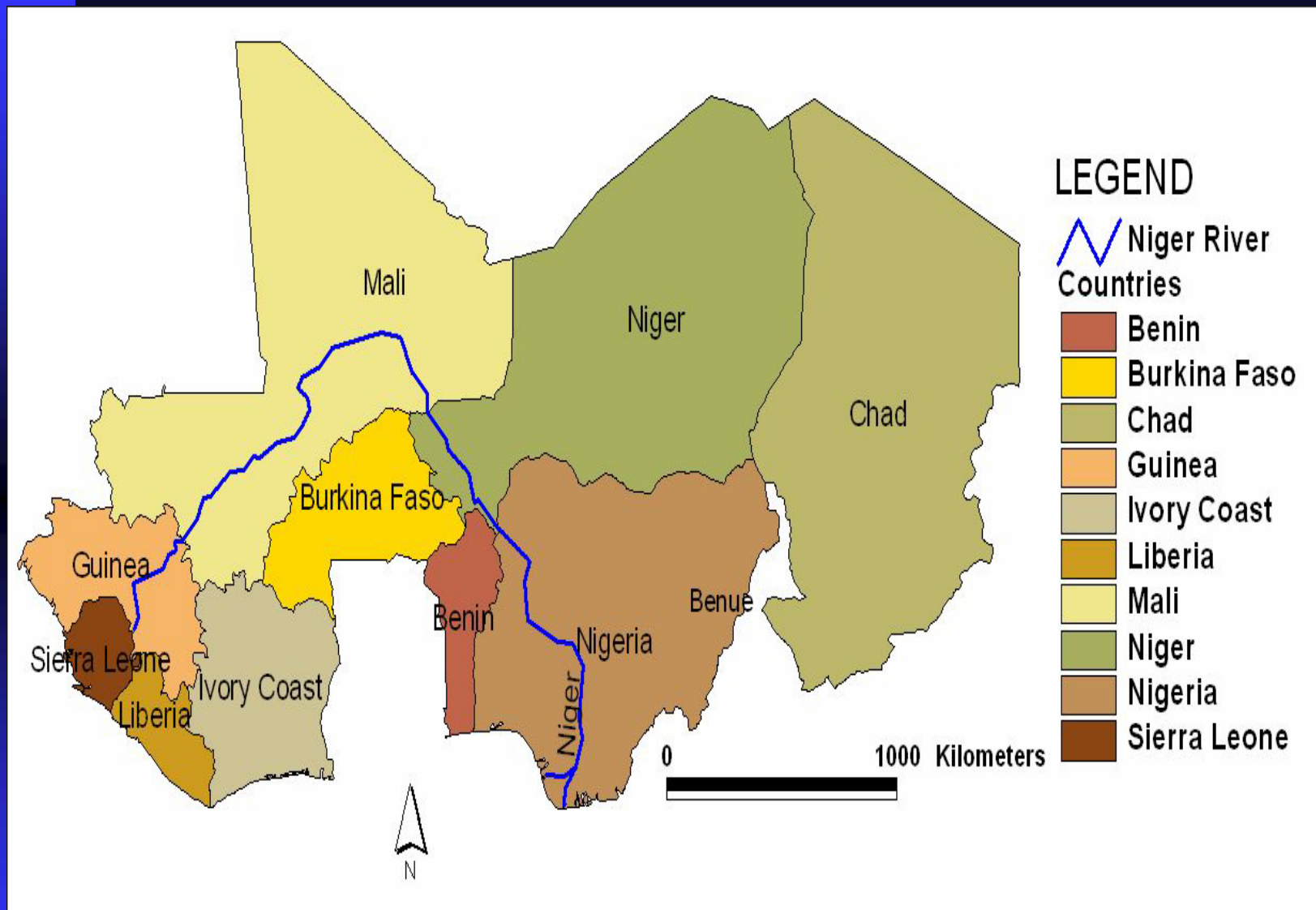


Figure 1.1: The Study Area- River Niger Basin





Figure 1.2 Images of The Niger River



# The Study area: River Niger Basin

- The River Niger as the principal river of West Africa extends over an area measuring 2500 miles (4000 km). It stretches across 9 West African nations from Senegal to Nigeria
- Ranked as the 3rd largest river in Africa, the basin's catchment area extends over a total surface area of nearly 1,471,000 km<sup>2</sup> shared by countries with a population of almost 100 million at an annual growth rate of 3.2%
- The extensive wetland ecosystems of the inland delta in Mali and the Atlantic coastal delta in Nigeria have been identified as important centers of biodiversity
- The region is susceptible to climatic hazards and had been by affected by serious droughts specifically those of 1963 -1991. In 1990, the river essentially stopped flowing in Niamey, the capital of Niger.
- Competing land use practice involving irrigation and cultivation of water thirsty crops often constitute a source of conflict among herdsman in the area
- Agriculture and oil industry development in the Atlantic delta region of Nigeria are increasing the pace of environmental change and the decline of water quality in the region
- Urban and industrial effluents drain into the river untreated from Mali, by the time the river water gets to Burkina Faso and downstream nations the water becomes highly polluted and certainly unsafe to drink.
- The affairs of the basin is administered by the Niger Basin Authority (NBA) created in 1964
- The nations often disagree over the requirements of equal financial contribution. Chad with 100,000 basin inhabitants thinks it should pay less than Nigeria with more than 60 million basin inhabitants
- The mandate of the NBA in securing a safe environment partly hindered by limited access to the state of the art geospatial information systems for tracking environmental change along the water basins

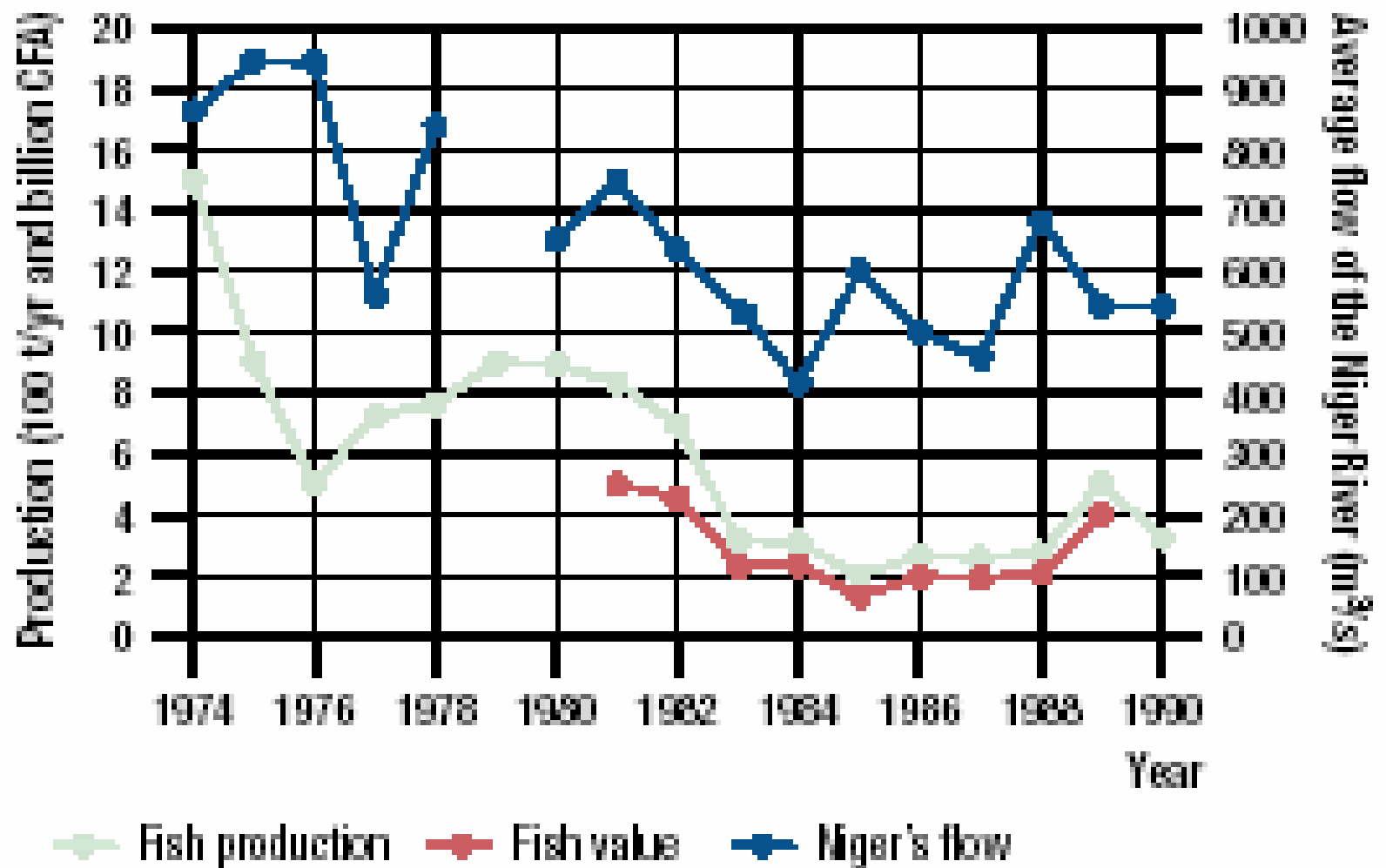


Figure 1.3 Environmental Change



Figure 1.4 Biodiversity

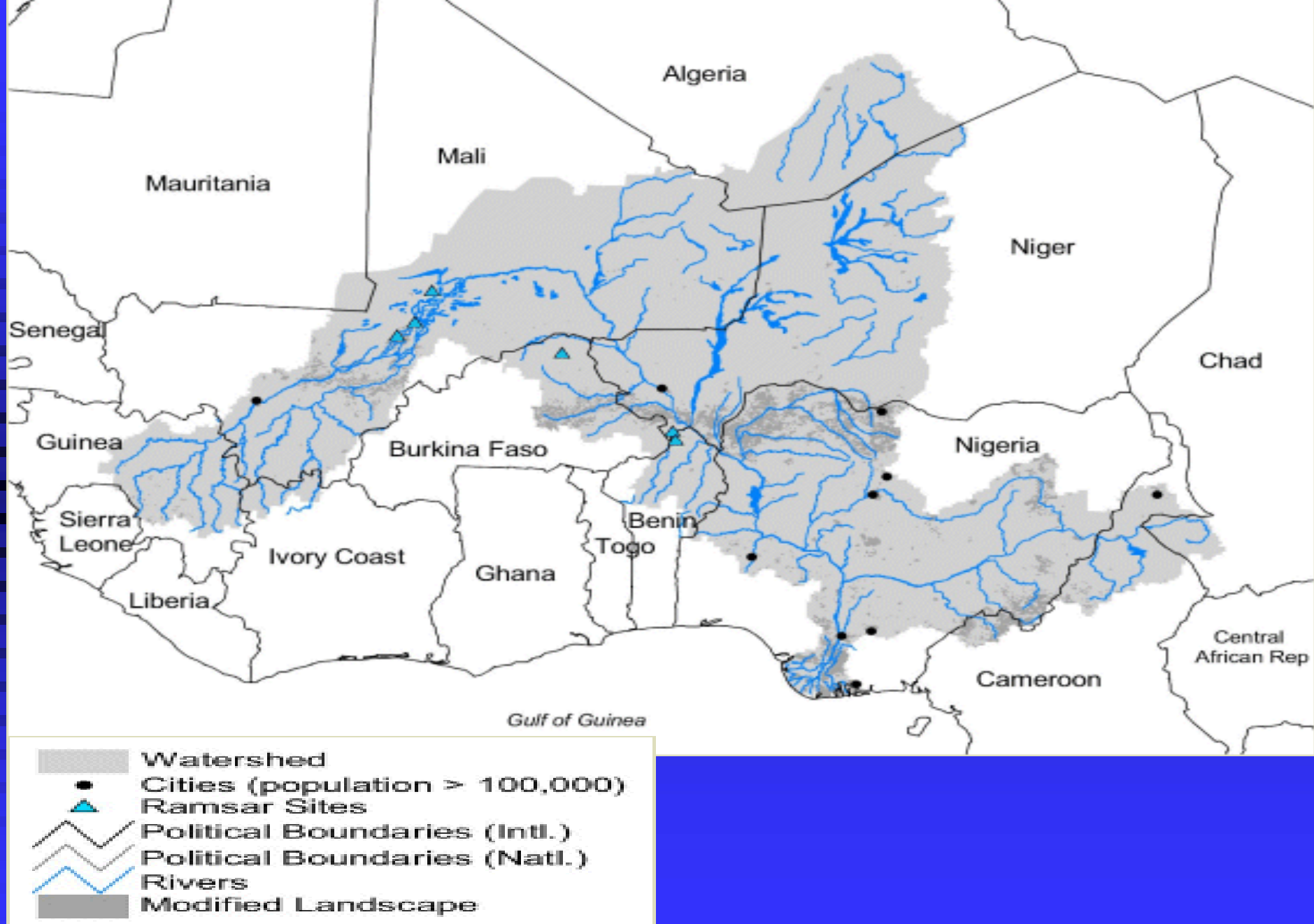


Figure 1.5 Complete Ecological Map of the Niger River Basin

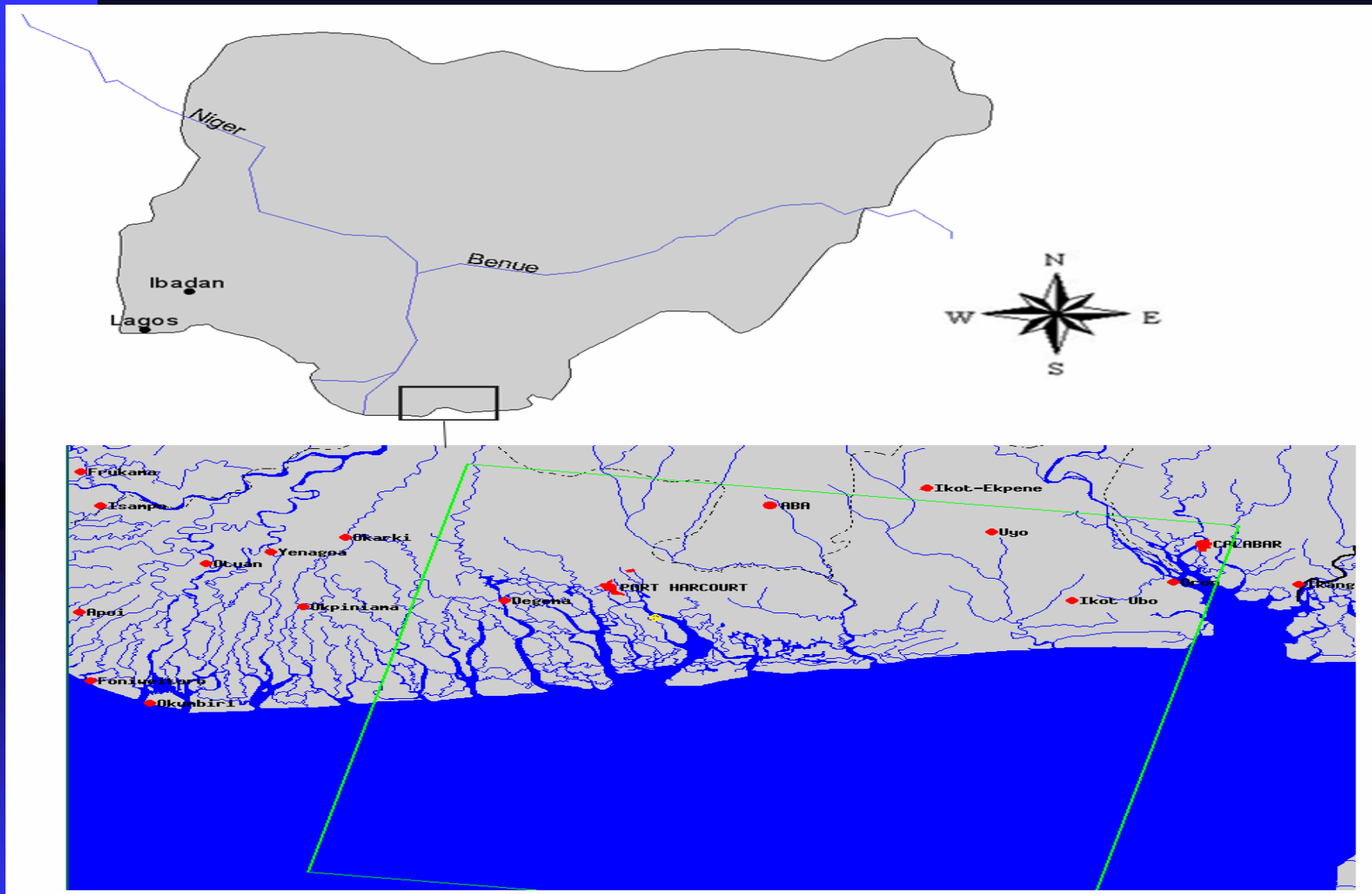


Figure 1.6: Map of Niger Delta In Southern Nigeria

**Table 1.1 Water Distribution Rate****The Distribution of Surface Catchments Area****Nations****The Percentage of Surface Catchments**

Benin

2.5

Burkina Faso

3.9

Cameroun

4.4

Chad

1.0

Guinea

4.6

Ivory Coast

1.2

Mali

30

Niger

23.8

Nigeria

28.3



**Table 1.2 Population of Nations Along The Basin**

**The Population Distribution of The River Niger Basin**

<b>Nations</b>	<b>Population</b>
Benin	1,950, 000
Burkina Faso	2, 400,000
Cameroun	2,100,000
Chad	80,000
Guinea	2,500,000
Ivory Coast	800,000
Mali	4,000,000
Niger	2,700,000
Nigeria	67,000,000

	Table 1.3 The Size of Irrigated Area				
Nations	Irrigated Crop Areas In West Africa (thousand hectares)				
	Crop Types				
	Wheat	Rice	Sugarcane	Vegetable	
Benin	-	10	1	-	
Burkina Faso	-	21	4	6	
Cameroun		12	-	15	
Chad	2	10	3	3	
Guinea	-	65	-	2	
Ivory Coast	-	14	20	4	
Mali	4	213	4	3	
Niger	2	30	6	12	
Nigeria	50	10	26	152	

Table 1.4 The Use of Water For Certain Agricultural Crops In the Region								
Water Consumption By the Thirstiest Crops in the Niger Basin River								
Nations	Rice		Vegetable		Sugarcane		Wheat	
	Ha	Million m3	Ha	Million m3	Ha	Million m3	Ha	Million m3
Mali	2,8000	631	3,000	59	4,000	200	4,000	112
Niger	30,000	1,050	12,000	278	6,000	493	3,000	72
Nigeria	374,000	10,800	100,000	1,777	26,000	1,296	50,000	1,000
Total	406,800	12,481	115,000	2,114	36,000	1,989	57,000	1,184

**Table 1.5 Projected Water Demand**  
**Water Demand Forecasts For Four West African Countries**

Selected Nations	Irrigated Cereal Area	Primary Water Supply	Rain Fed Cereal Area	Potential Utilizable Water
	Million ha	Km3	Million ha	Resource km3
<b>Chad</b>				
1995	0.12	1.18	2.75	76.5
2025	0.16	1.56	4.32	
Increase ( % )	33	35	57	
<b>Mali</b>				
1995	0.03	0.7	6.49	28.2
2025	0.05	1.3	10.83	
Increase ( % )	66	90	67	
<b>Niger</b>				
1995	1.06	5.0	16.75	158.3
2025	1.43	7.6	26.41	
Increase ( % )	35	53	58	
<b>Nigeria</b>				
1995	0.00	0.17	1.51	25
2025	0.00	0.32	2.37	
Increase ( % )	0	54	36	

# Lower Niger: Nigeria's Niger Delta Case Study

- Water bodies declined from 399,346 to 305,207 hectares at the rate of -24%
- Mangrove area also posted an overall decline of 11 %
- While mangrove, water bodies and closed forest were decreasing, settlement, agricultural and economic activities were increasing as well
- Agricultural and economic activities increased from 17,810 hectares to 116,092 hectares representing a change of 552 %
- Settlements also showed an overall change of 190 percent from 10,968 hectares in 1986 to 31,839 hectares in 2000
- The incidence of change attributed to demography and a rise in economic indicators

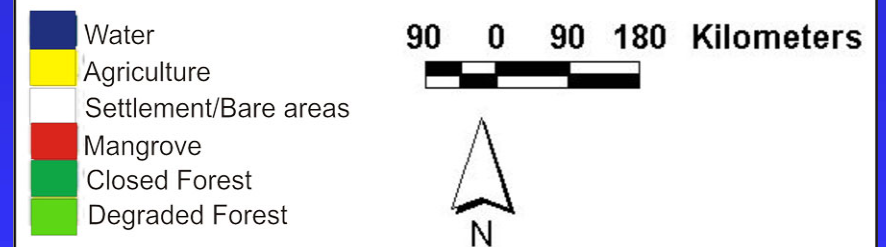
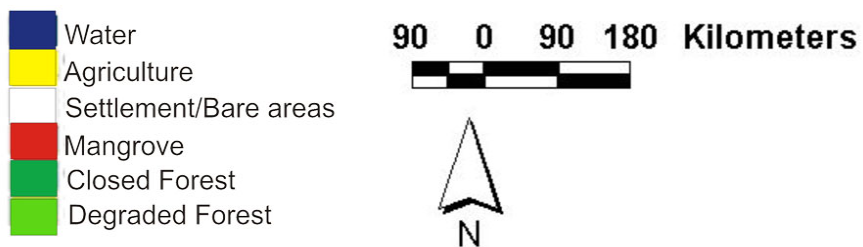


Figure 2.1: Classified Image of Landsat TM, May 20, 1986

Figure 2.2: Classified Image of Landsat TM, June 19 2000





Figures 2.3 Images of Burnt River From Oil Spill

**Table 2.1: Results of The Classified Images For 1986 and 2000**

Classes	Area (ha)	Area (ha)	% change
	1986	2000	1986-2000)
Water	399,346	305,207	-24
Agriculture/economic activities	17,810	16,092	552
Settlement / bare areas	10,968	31,839	190
Mangrove	114,266	101,326	-11
Closed forest	357,657	108,759	-70
Degraded forest	73,097	309,921	324

# Upper Niger: Mali and Niger Case Study

- Profound decrease in the area of water bodies from 158,702 to 138,010 hectares and spreading of that trend among the area units
- Shrubs and plateau surface also posted a decline from an initial estimate of 620,042 hectares in 1987 to 471,026
- Between 1987 and 2000, agricultural activities increased from 107,996 hectares to 223,988 hectares representing a change of 107.40%
- GIS mappings show an increase in settlements /bare surface. For example, from the initial estimate of 53,290 hectares in 1987, it doubled to 127,859 hectares in 2000 an increase of 140 %
- The decline of water bodies, development of bare areas and decline of the prime vegetation in the area might be attributed to the seasonal changes in the rainfall patterns and increase in population from the 1970s to 2000

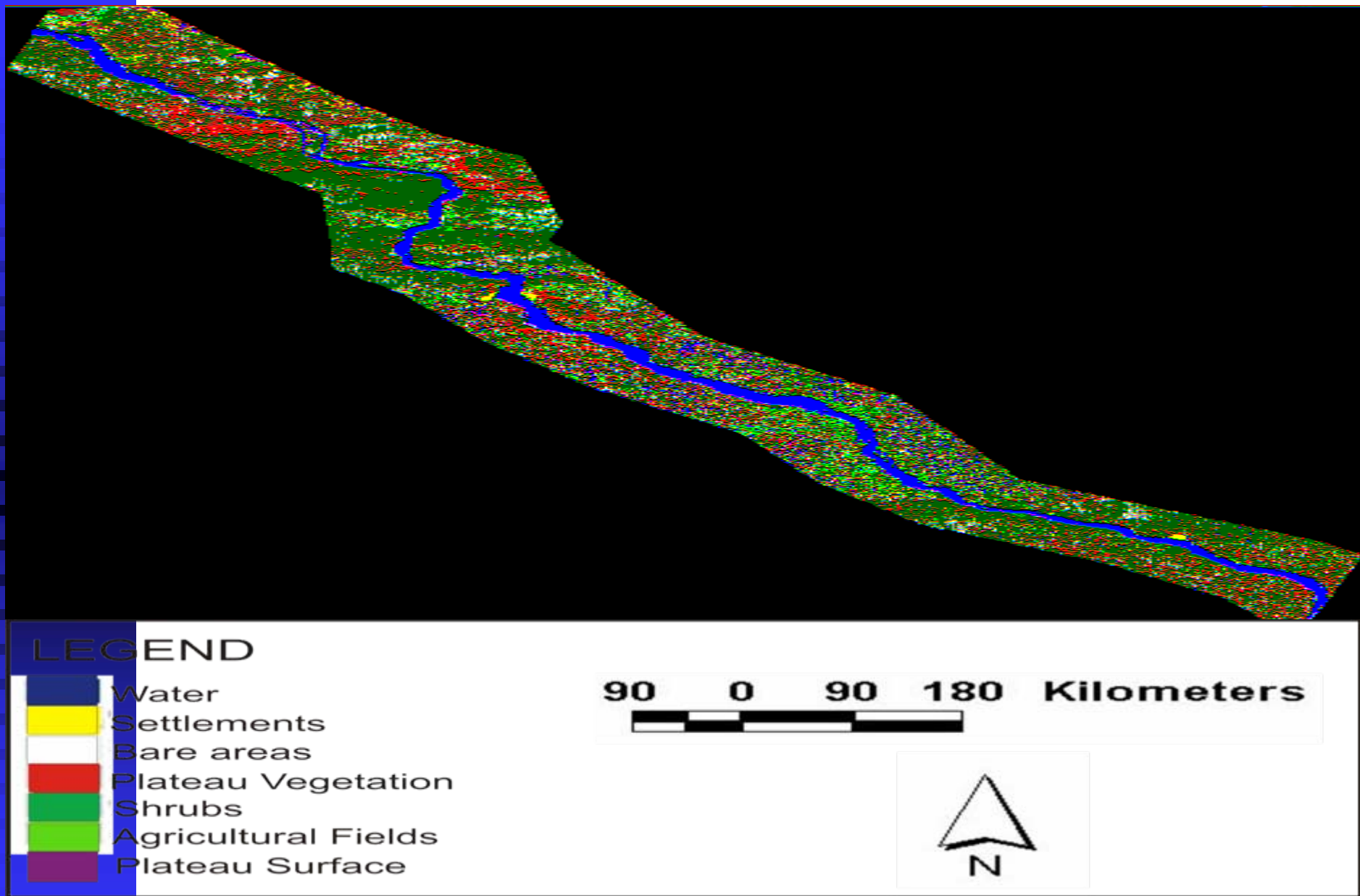


Figure 3.1: Classified Image of Landsat TM, 13 October 1987

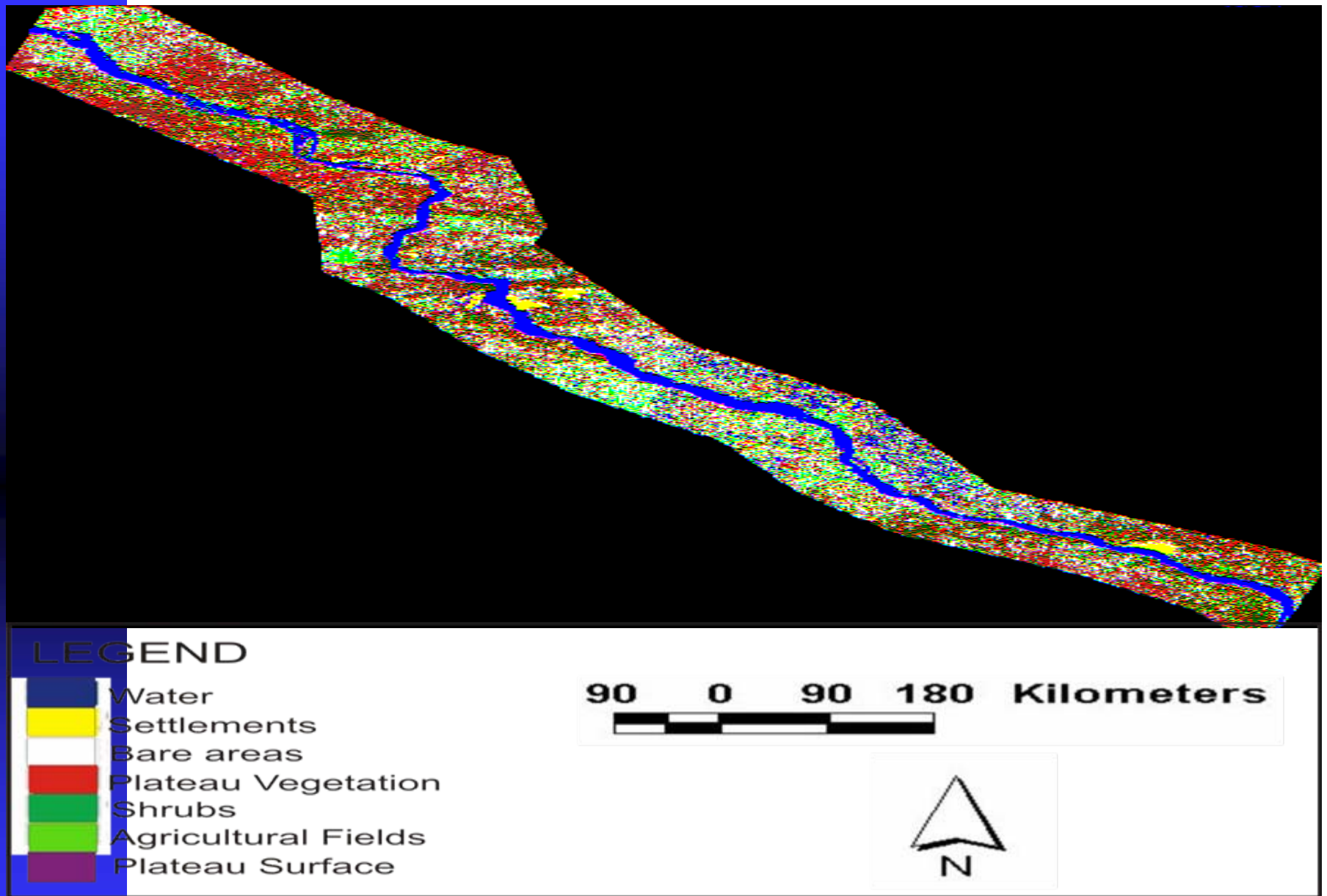


Figure 3.2: Classified Image of Landsat TM, 20 October 2000

# Table 3.1: Results of The Classified Images For 1987 and 2000

Classes	Area (ha)	Area (ha)	% change
	1987	2000	(1987- 2000)
Water	158,702	138,010	-13.04
Shrubs	620,042	471,026	-24.03
Settlement	53,290	127,859	140.00
Plateau Surface	406,552	220,240	-46.00
Plateau Vegetation	233,175	255,065	9.39
Agricultural Fields	107,996	223,988	107.40
Bare Areas	200,110	343,679	72.00



**Table 4.1: The Complexities and Factors Responsible For Crisis Along Shared Watersheds**

<b>Factors Driving Water Conflicts</b>	<b>Regions</b>
Water security	MENA
The Need For Improved Income	MENA/Ni ger
Uncoordinated Development	MENA/Ni ger
Population Expansion	MENA/Ni ger
The unpredictability of inter state relations	MENA
Geographical and topographic factors (upstream vs downstream)	MENA/Ni ger
Domestic policies confronting States with complex issues in conducting hydropolitics with neighbors	MENA
Colonial era legacies of contested borders divided ethnic spaces, national integration and techno-capital	MENA/Ni ger
Desperation and fear among some nations of becoming dependent on others for an essential resource	MENA
The others are national self interest and the reluctance of emergent states to accept any dilution of their sovereignty	MENA
The uncertainties inherent in estimating future water supplies and demands in each riparian state in a basin	MENA/Ni ger

# Regional Efforts: River Niger Basin

## ■ Design of Development Plan /International Cooperation

- NBA has adopted a potential development planning agenda on water quality programs/ desertification
- This is under the framework of economic and technical cooperation between Japan and southern nations

## ■ Acquisition of Technological Infrastructure To Boost Water Rights

- Uses technology in disseminating relevant hydrological information among the nations of the basin
- Adopted a system made of satellites from which the transfer of hydro data occur every 60-200 seconds

## ■ Formation of New Administrative Structure

- Poor finances in the 1980s resulted in administrative restructuring that redefined the objectives for NBA
- Focused on making NBA a regional organ economically in tune with capacities of the member states

## ■ Technical Support Through Monitoring and Evaluation

- Strategic action plans for assessing shared water needs through cooperation agreements
- Joint agreement to foster the development of human and institutional capacities for the collection and dissemination of agro hydrological data

# Findings of the Research

- Transboundary water resource use based on hydropolitics tie up states sharing a river basin into a web of interdependencies
- In spite of the efforts to address trans-boundary watershed problems, the Niger Basin faces daunting task in reversing water pollution
- Overall the Niger Basin nations of Niger, Mali and Nigeria experienced some significant changes in their respective environments
- The results point to a decline in waterbodies, mangrove forests, and increase in human settlement, mixed forests, cropland and agricultural intensification that requires the use of agrochemicals
- This means that natural systems such as wetlands essential for water purification are not only degraded but they are lost in the process
- While the Niger Basin nations operate under the principles of cooperation, the financial contribution formula works in favor of nations with more population along the basin. Such unequal funding formula breeds dissent
- The projected population growth will create more problems in terms of access to quality water
- This will not only threaten the carrying capacity of an already fragile ecosystem, but it poses enormous challenges for both environmental and natural resource managers and policy makers

# Recommendations

- To address some of the concerns that were identified in the research, six recommendations are presented as part of the remedies

- **Support Cooperation and Negotiation On Water Issues**

- Negotiated settlements among the Niger River nations on any perceived threats of water conflicts in accordance with the tenets of international law

- **Involve Local Communities In Multinational Water Management Decisions**

- The involvement of locals has the potentials to minimize the current level of water stress

- **Reform Current Policy Regarding Financial Contribution**

- The imbalances inherent in the agency's water sharing and financial contribution formula should be addressed in order to ease the burdens on smaller nations

- **Adopt Sustainable Water Management Strategies**

- Education of stakeholders will help curb practices leading to discharge of pollutants into the basin

- **Encourage More Research**

- Current gaps in knowledge can be dealt with by drawing on the experiences of West African nations in dealing with shared water

- **Regular update of Environmental Trends With Geospatial Information**

- The NBA should continue to support the dissemination of hydrological data using GIS /Remote Sensing

# Conclusions

- Five vital conclusions can be drawn from this study
- 1)-The complexities of hydropolitics and web of interdependencies often associated with MENA nations not new in the River Niger basin region
- 2)- GIS and RS applications revealed a change in water bodies and increase in stress factors threatening access to good quality water in the Niger Basin
- 3)-With data becoming available in electronic format, the capability of spatial analysis in promoting cooperation in watershed management will be enhanced
- 4) -Geo-information is capable of providing a road map for conservation that will enable the design of effective mitigation measures
- 5)-GIS and RS applications stand as viable decision support tools for managers in tracking the problems of shared rivers in developing countries

# **2006 National Water Quality Monitoring Conference, San Jose CA**

**“GIS and Remote Sensing Applications In The Hydropolitics of  
Sub-Saharan Africa: The Case of Multinational Management of  
River Niger Basin of West Africa”**

**By**

**Dr Edmund Merem\* and Dr Yaw Twumasi\*\***

**Jackson State University Mississippi\*  
Alabama A&M University \*\***

**07/05/06**