AN ATTEMPT OF SUITABLE LAND SELECTION FOR REGIONAL AGRICULTURAL DEVELOPMENT USING REMOTE SENSING DATA AND GEOGRAPHICAL INFORMATION

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Introduction

Currently, the desertification in the Sahel region located along the south edge of the Sahara Desert is very serious, and it is believed that the desertification has tiggered the food crisis in the early 1970's. Desertification in the African Continent is spreading on the south and north sides of the Sahara Desert, in the African Horn and around the Karahari Desert in the south Africa. In the Sahel region, damages caused by the desertification on agriculture and stock-farming are serious, and it is said that the desertification has progressed seriously in the last 5 decades. (See Fig. 1 and 2).

Causes for desertification include mainly climatological changes, excessive cultivation, overgrazing, deforestation and improper irrigation. Prevention and control of desertification require prevention of overgrazing, protection of forests, proper management of water resources, soil erosion prevention, soil improvement, adequate land use policy and agricultural development. Of these measures, protection of forests and soil improvement take a long time before measures for these purposes are established and their effects become appearent. On the other hand, aggricultural development seems to be a short-term and realistic measure.

This report studied the Niger River Basin located in the south edge of the Sahara Desert, where lands suitable to agricultural development, which is expected as a short-term measure to prevent the desertification, were selected from a comprehensive viewpoint using LANDSAT MSS data and geographical information including soil, geological and geomorphological classifications. The analysis was made based on the overlay processing technique among images. This report describes a part of a big project being conducted in the last 5 years.

1. Outline of the Niger River Basin

The Niger originates in the Guinea Highland 800 m above the sea level, joins with its tributaries of the Bani and the Benue and flows down into the Guinea Bay, as shown in Fig. 3. The Niger is the third longest river in Africa with 4130 km of total length, 209 millions km^2 of basin area, and 899 billions m^3 of annual volume of runoff. The Niger Basin consists of 9 countries of Guinea, Mali, Benin, Côte D'ivoire, Niger, Burkina Faso, Chad, Cameroon and Nigeria.
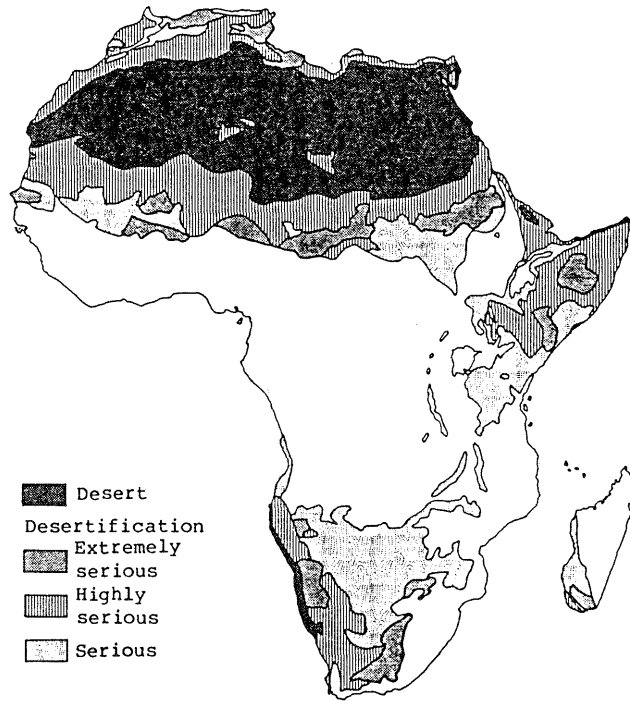
Fig. 1   The present situation of desertification
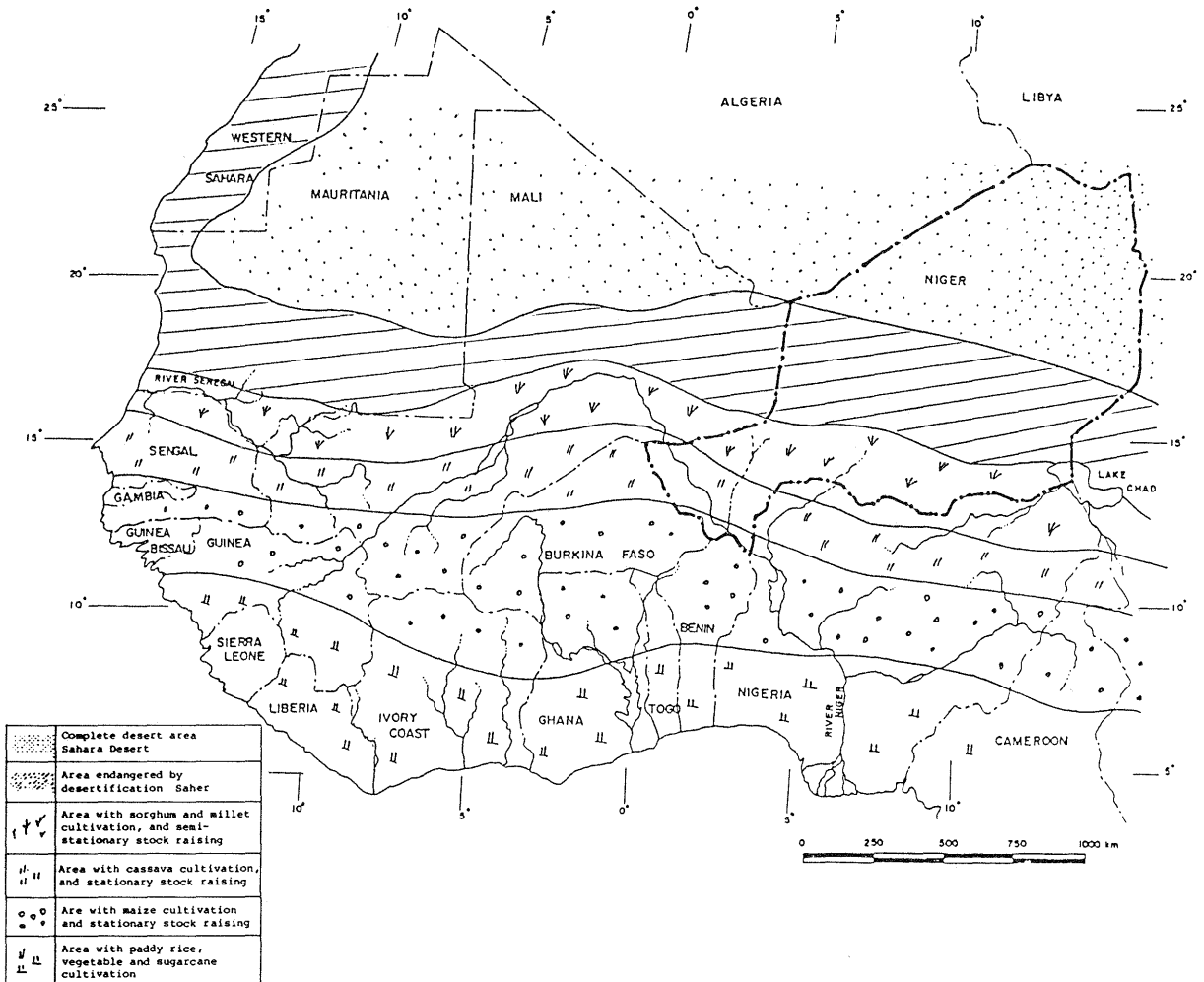in the African Continent

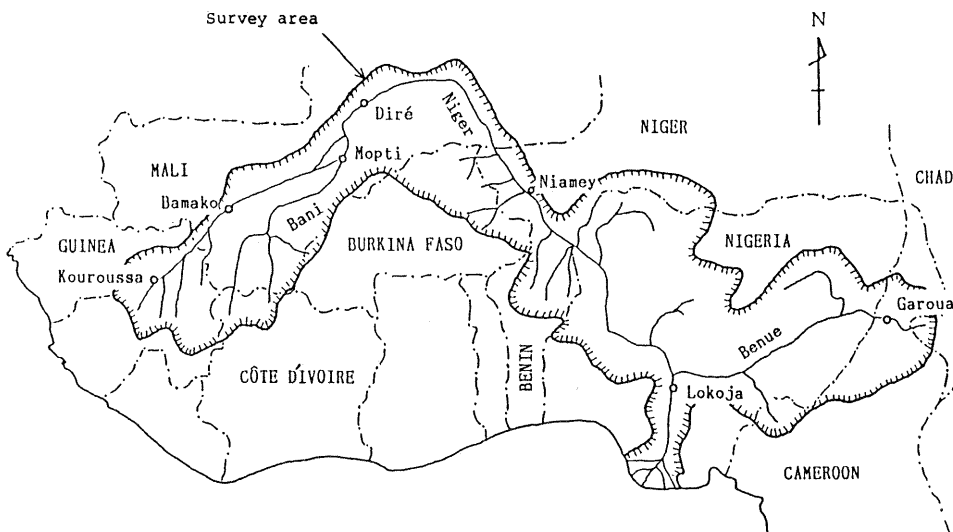Fig. 2   Agricultural forms in the west African area

Fig. 3   The Niger River Basin

The annual rainfall in the Niger River Basin increases from the north to the equator, and the most north end of the main Niger is a less rainy area with approximately 200 mm annual rainfall.   On the other hand, the area along the Gunia Bay is a very rainy area with 1300 - 1500 mm annual rainfall.   (See Fig. 4)   As to monthly rainfall, in many cities the rainy season is between June and September with a peak in August.   The area north from the capital city of Niger, Niamey, has almost no precipitation between October and May.
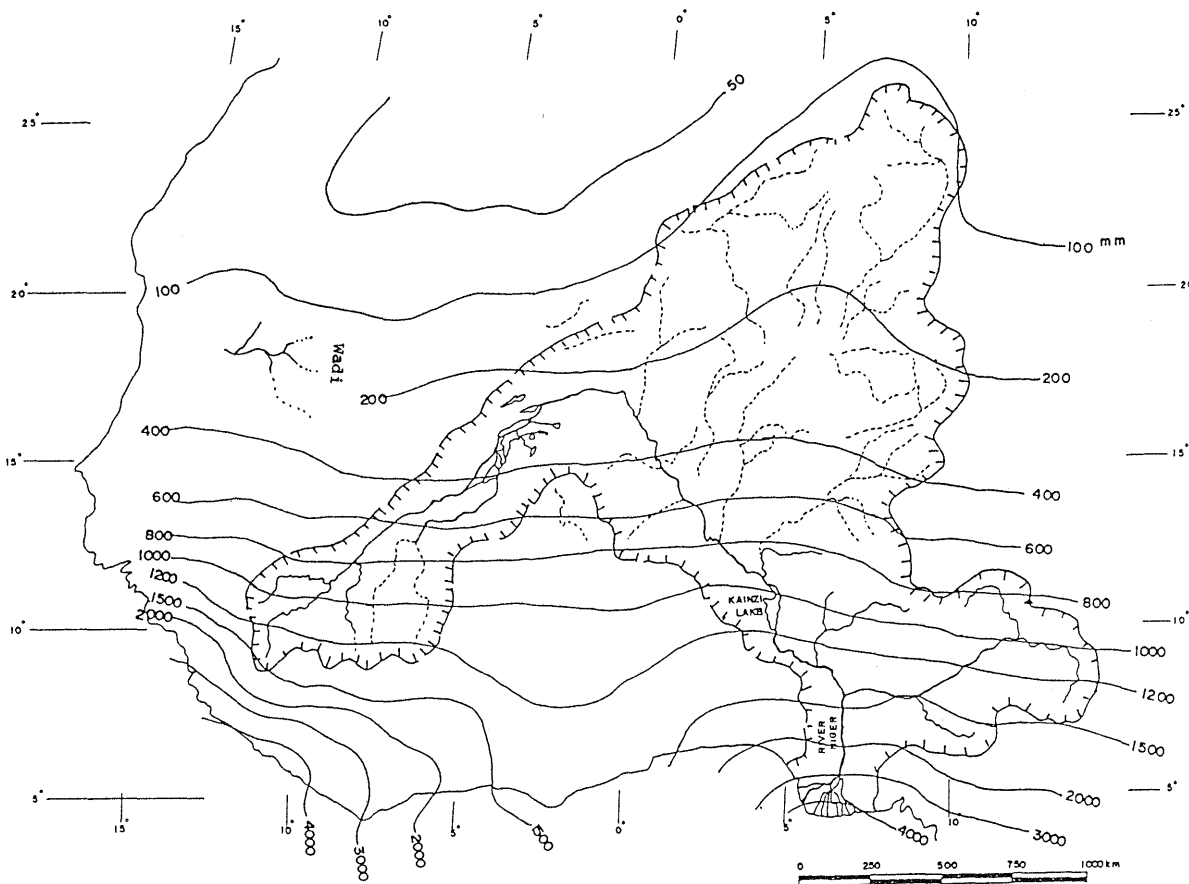

Fig. 4   Annual rainfall distribution

The southward advance of the Sahara Desert reaches the Niger River Basin,
resulting in coverage of 60 - 70% of national land with the desert in
Mali, Niger and Chad located north of the basin. An important factor for
the progress of desertification is meteorological drought. Meteorological
drought is said to be caused by natural factors such as the fluctuation in
the orbital motion of the earth and the rise in sea surface temperature
taking place in a cycle of less than 10 years. The trend in precipitation
in the last 5 decades in Niger (see Fig. 5) suggests the occurence of a
drought every 10 years. The rainfall in recent years has recorded the
least of 200 - 350 mm in the last 5 decades.
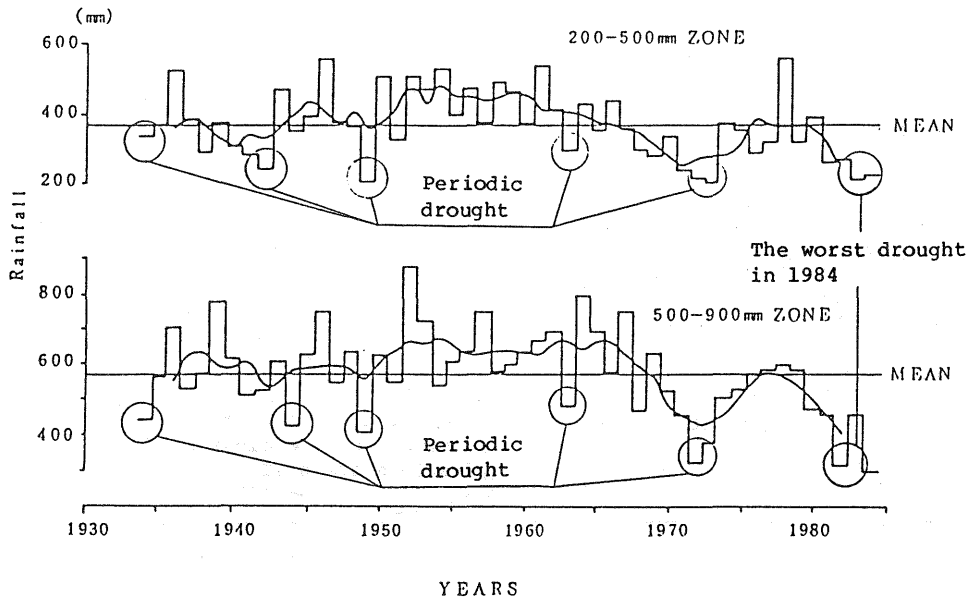

YEARS

Fig. 5 Trend in annual precipitation in Niger in the last 5 decades

2. Analytical Method

This study was conducted to select suitable land for agricultural
development as a part of a short-term desertification control measure in
the Niger. Fig. 4 illustrates a flowchart of the analysis. The whole
study was divided into 3 steps for higher efficiency because of the wide
coverage of the Niger River Basin.

(1)   In the first step, the present conditions of the whole basin
      including the natural environment was studied for provisional
      designation of a study area in order to conduct an efficient study
      over the whole Niger River Basin. For this purpose, LANDSAT data
      were actively used to understand the land cover condition in the wide
      area.

(2)   In the second step, mid- and long-term measures for desertification
      prevention will be emphasized, and land suitable for agricultural
      development and a basic idea for the development will be concluded.

(3)   In the third step, land suitable for agricultural development where
      short-term effects can be expected and a basic idea for the
      development will be concluded on the basis of examination of measures
      for desertification prevention. In addition, data collected in the
      first and second steps and study results will be analyzed to examine
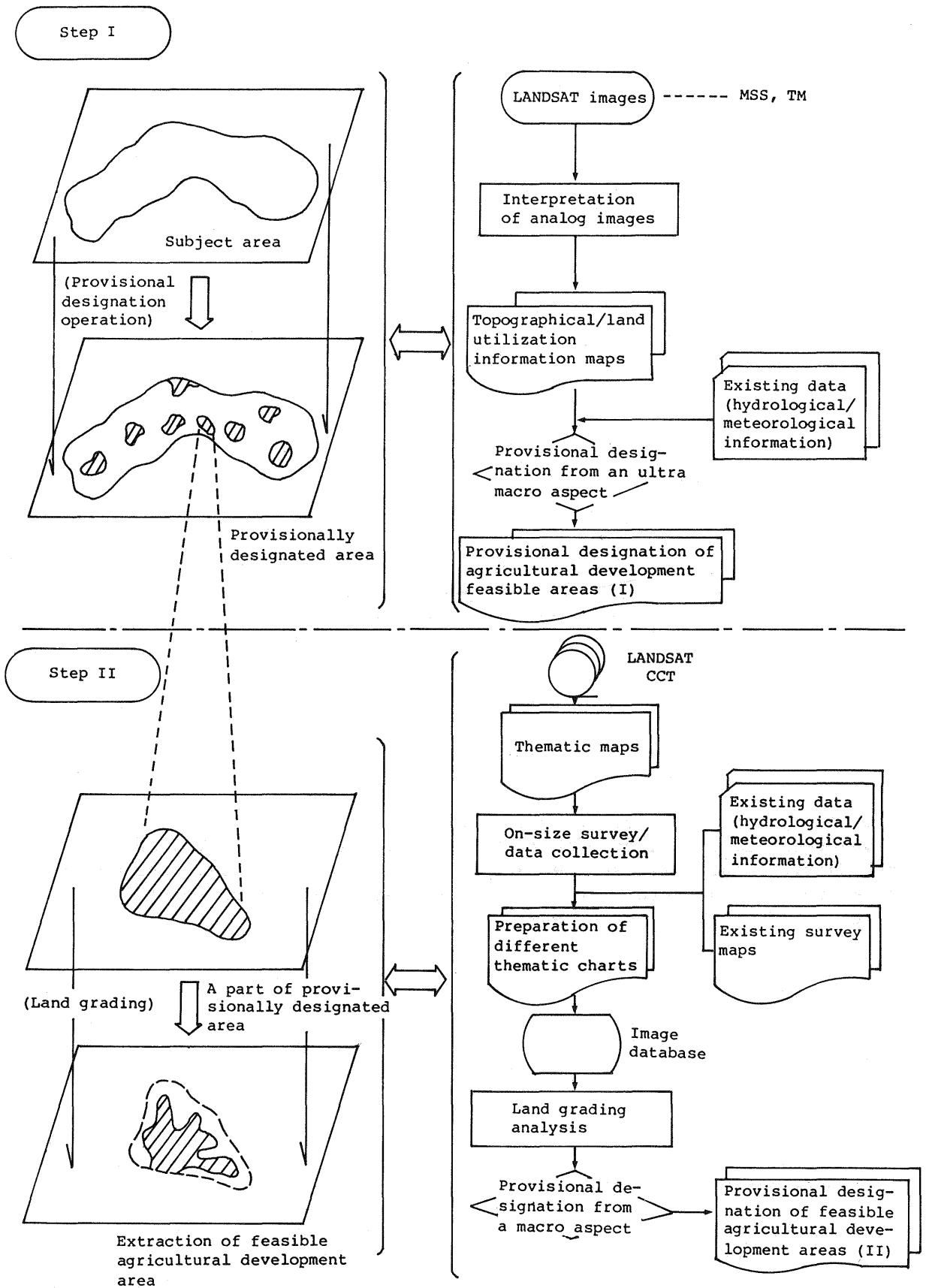   measures for desertification prevention from long-term viewpoints.

Step I

Subject area

(Provisional designation operation)

Provisionally designated area

LANDSAT images ------ MSS, TM

Interpretation of analog images

Topographical/land utilization information maps

Existing data (hydrological/ meteorological information)

Provisional designation from an ultra macro aspect

Provisional designation of agricultural development feasible areas (I)

Step II

(Land grading)

A part of provisionally designated area

Extraction of feasible agricultural development area

LANDSAT CCT

Thematic maps

On-size survey/ data collection

Existing data (hydrological/ meteorological information)

Preparation of different thematic charts

Existing survey maps

Image database

Land grading analysis

Provisional designation from a macro aspect

Provisional designation of feasible agricultural development areas (II)

Fig. 6 Flow of the provisional designation of extensive agricultural development feasible areas

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2.1 Provisional Designation of a Study Area

Provisional designation of a study area was carried out as the first step, where LANDSAT MSS data were used to prepare 1/1,000,000 geographical information maps based on 1/1,000,000 color mozaic maps and available materials, and then to designate provisionally potential land for agricultural development. In the provisional designation, geomorphological conditions, water utilization conditions, collunity location conditions, and the presence or absence of major roads were fully taken into consideration.

2.2 Classification of Potential Land for Agricultural Development

For the provisionally designated area, potentiality of land for agricultural development was classified in the second step, and land suitable for agricultural development was selected on 1/200,000 topographical maps. This analysis consists of (1) macroscopic image analysis of LANDSAT data, (2) preparation of surmise maps, (3) a field survey, (4) preparation of thematic maps, (5) examination of land classification standards, (6) classification of potentiality for agricultural development, and (7) examination of results of the classification.

(1) Analysis of LANDSAT MSS data

LANDSAT MSS data covering the study area were rectified based on a digital image analysis to prepare false color images.

(2) Preparation of surmise maps

The LANDSAT MSS data and topographic maps were used to prepare land cover classification images, which were then used as surmise maps for a field survey.

(3) Field survey

This field survey was made to confirm the premise maps and collect materials.

(4) Preparation of thematic maps

The materials collected in the field survey were used to prepare various thematic maps required for land classification and understanding of local characteristics. These maps were processed to image data base for convenience in digital image analysis.

(5) Examination of land classification standards

Land classification standards for selection of land suitable for agricultural development was examined based on results of the field survey.

(6) Classification of potentiality for agricultural development

Based on the classification standards examined in (5), classification was made from three viewpoints; 1. land productivity based on soil conditions, 2. water resources potential, and 3. land safety. The result was used for classification of potentiality for agricultural development. The land classification analysis was made to

classify/evaluate potentiality for agricultural development by overlaying image information from the various thematic maps.

(7) Examination of classification result

The classification/evaluation result was examined for its appropriateness using the result of the field survey and others.

3. Preparation of Thematic Maps (See Photos 1 through 3)

Prepared thematic maps include, (1) vegetation/land use map, (2) geomorphological classification map, (3) soil map, (4) geological map, (5) alltitude division map, (6) drainage system map, (7) community map, (8) road map, and (9) population map, and these scale was 1/200,000. Of these maps, the vegetation/land use map in (1) was made by checking the land cover classification from LANDSAT MSS data prepared as surmise map for re-classification. Items for classification are paddy field (based on irrigation), paddy field and water front grasses (rain water fed paddy field and grasses along rivers), cultivated land (cultivated land for millet, sorghum, maize and others), grasses (grassy plain distributing spot-like on a plateau), bushes, bare land, bare land with exposed red soil, water (river/lake) and others.

4. Classification and Evaluation

When potentiality for agricultural development is classified, from what viewpoints the classification is conducted and what classification standards have to be questioned. The land classification requires analysis based on not only natural conditions but also social conditions. However, only a little amount of information concerning social conditions which precise enough for the analysis are available for this study area. Therefore, this study conducted classification based on only natural conditions. Fig. 7 shows a flowchart of this classification.

Since land productivity is greatly depending upon soil conditions, the soil maps were used for land productivity classification. On the other hand, water resources are a key factor for agricultural development, and so the altitude division map, geomorphological map and drainage system map were used for general classification of water resources potential. From a standpoint of land safety, the flood plains along the Niger are fertile and favourable as land for agricultural development, but subjected to high risks of flooding. Furthermore, slopes in the inland part are exposed to serious soil erosion. The land safety classification was made from these aspects. Final classification was made by integrating the above mentioned classifications.

In this classification/evaluation, model areas selected in the study area were subjected to the classification/evaluation to examine the classification standards, which were then applied to other areas. Consequently, lands suitable for irrigation based cultivation were selected mainly along the Niger. Photos 4 and 5 show classification results.
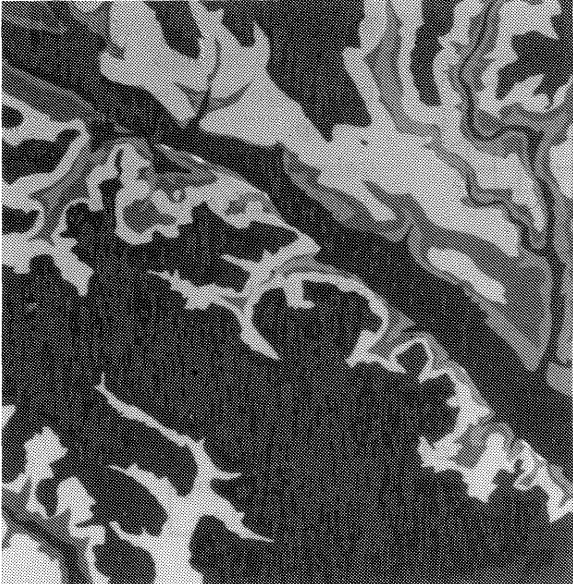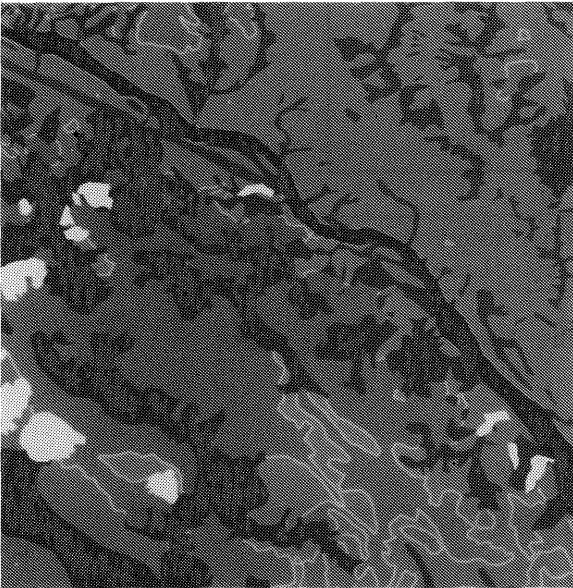
Photo 1. Alltitude division map
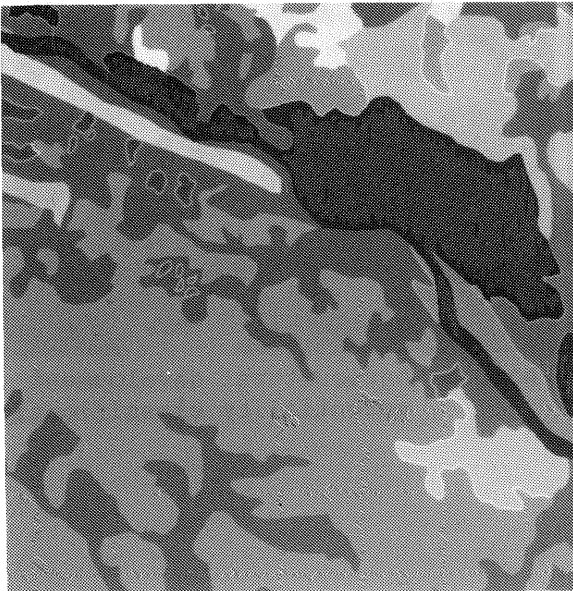

Photo 2. Geomorphological map

Photo 3. Soil map

(Thematic maps)

Altitude
    division map
Drainage system
    map
Geomorphological
    classification map
Land use map
Soil map

Land productivity classification based on soil conditions

Water resource potentiality classification

Land safety classification based on flooding and soil erosion

Integrated classification of land productivity and water resource potentiality

Agricultural development potentiality classification
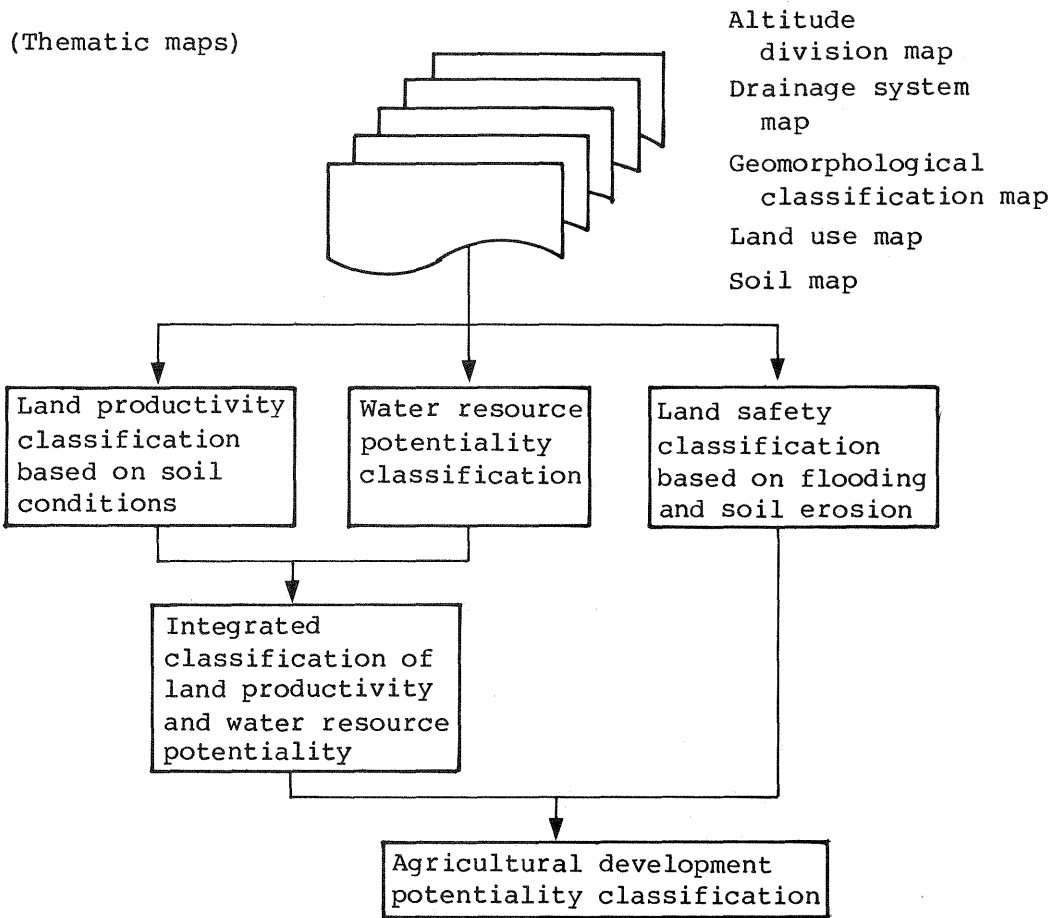
Fig. 7   Flowchart of the land classification

Photo 4   Land productivity
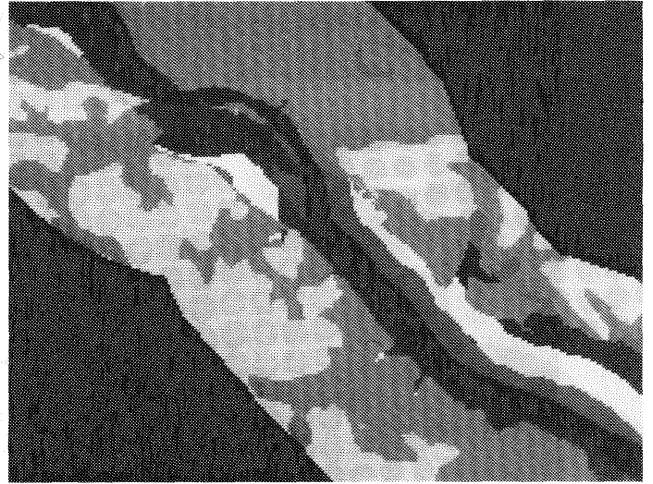   classification

Photo 5   Agricultural development
          potentiality classification

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Afterword

In this analysis, potentiality for agricultural development was examined with special reference to irrigation based agriculture and rain water fed agriculture which are expected as an effective short term measure to prevent desertification. In future, measures for desertification prevention from general viewpoints have to be examined in consideration of water resources development including potential utilization of ground water, rain water and the Wadi, and promotion of planting.