

Fundamental Study of Topographic Map in Sub-Sahara Africa

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Topographic Map is fundamental information for infrastructure development in the view point of understanding geographical and social feature. Recently, the needs to develop topographic map increased in conjunction with the increase of infrastructure development.

In this paper, as the fundamental study of topographic mapping, firstly we review the existing mapping projects conducted by Japan International cooperation Agency (JICA). Sorting out the situation that the map development needs increase, we propose indicators for quantification of the topographic mapping needs. Moreover we estimate the topographic mapping needs in Sub-Sahara Africa applying the quantification indicators. This is the summary of “the Basic Study of Topographic Map in Sub-Sahara Africa¹⁾” conducted by JICA.

Key Words: *topographic map, Sub-Sahara Africa, quantification, international technical cooperation*

1. INTRODUCTION

As basic materials of land development and land planning, topographic mapping (hereinafter referred to as “the Mapping”) has been kept importance. Mapping cooperation has been conducted prior and has been utilized for technical cooperation related to land infrastructure. These cooperation include aspects of technical transfer and capacity development as well as aspects of planning and implementation of infrastructure development. The cooperation varies to development study, technical cooperation project, dispatch of Japanese experts, and acceptance of trainees in Japan.

In recent years because of the background of rapid economical growth, requests for technical cooperation in the field of the Mapping are increasing. Especially there are strong needs of development of national basic map and maps in metropolitan areas. Those requests submitted to the government of Japan by the African countries are noteworthy in terms of those numbers and need degree.

From the above background, JICA conducted the study “Basic Study of Topographic Map in Sab-Sahara Africa”. The study aimed to quantify the

Map development needs (hereinafter referred to as “the Needs”), and to sort out cooperation priority.

In this paper, as the summary of the JICA’s study, firstly we review the existing JICA conducted mapping projects in Chapter 1. Secondly, we sort out the situation that the Needs increase in Chapter 2. Thirdly, in Chapter 3, we propose indicators for quantification of the Needs. In the final Chapter, Chapter 4, we estimate the Needs in Sub-Sahara Africa using the proposed indicators.

2. REVIEW OF MAPPING PROJECTS

JICA started the technical cooperation for Mapping in 1971 with the project “Topographic Mapping Project of the Barito River Basin” in Indonesia. JICA has conducted 70 of development studies until 2012. These projects have a variety in terms of the region, scale, and purposes.

(1) Regional characteristics

In terms of the number of the mapping project, Africa and Asia are the popular regions; three quarters of the projects out of 70 are conducted in either African or Asian countries (Fig.1). In Asia, 1990s and 2000s were the peak in number; In Africa, the

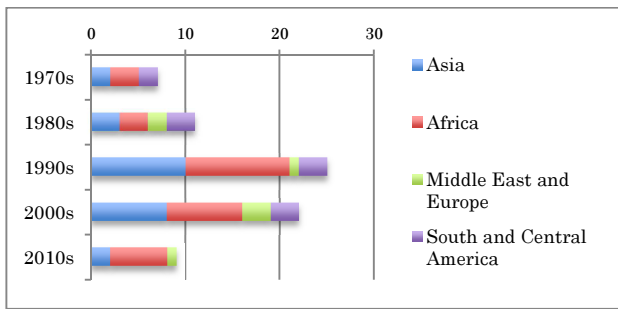


Fig.1 Regional Feature of Mapping Projects

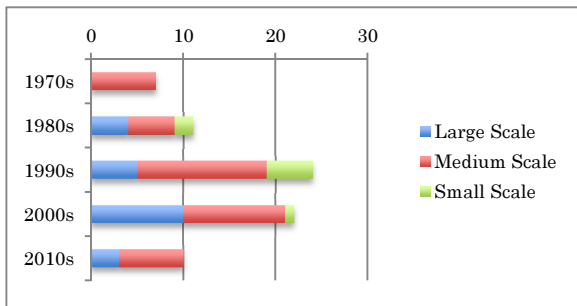


Fig.2 Scale of Mapping Projects

First peak came 1990s and 2000s; after the decreasing period of late 2000s, the second peak has come in the early 2011.

(2) Scale

Maps play different roles depending on each scale. Firstly the large scale more than 1/10,000 is utilized for detail planning of urban area as describing each building and road without any omission. The second one is medium scale between 1/10,000 to 1/50,000. This scale is utilized for regional planning for specific region, or nation wide as describing main roads and urban areas. Thirdly, small scale less than 1/50,000 is utilized for land planning for nation wide.

The most popular scale throughout the ages is medium scale. Large-scale projects are started in 1985 and reach to the same level with medium scale in 2000s. Although five of small-scale projects were conducted in the 1990s, there is little after then.

(3) Background and Purpose

Looking at the background of the Mapping projects, world's political, economical, and social situation at the moment have been reflected to the purpose and feature of the projects.

a) Variation according to times

At the early age (1970s to 1990s), while lots of developing countries in Asia and Africa were independent and worked for the national formation, "Creating topographic map as the basic data for cre-

ating and implementing national development plan" was the mainstream as the purpose for the projects.

After 1980, urbanization, occurred concurrently with economical development and centralization, had arrived at capital cities in developing countries. In this phase, new tendency for developing large-scale map had reached for the purpose of tackling urban problems.

On the late 1990s, the background and purpose of the project diversified by political and social issues such as environmental issues, reconstruction assistance after the civil war, the collapse of the Soviet Union and division of Yugoslavia. From the late 1990s the technological advances such as satellite, Internet and information sharing are inserted to the projects.

b) Creating a topographic map as basic database

Firstly, in order to make plans and its implementation such as agricultural development plan, natural resource development plan, and regional development plan, it is necessary to understand the geographical and social state of the target area. Maps incorporating to the latest topography and geography became essential information. However, lots of developing countries have no maps reflecting the current situation; some country have topographic map itself, which were created more than half century ago. Moreover, in many cases, the development of topographic maps by themselves is difficult from financial and technical problems and constrains. As the feature of the project, we point out the developing maps is emphasized rather than technical transfer required in the process.

Secondly, due to the deterioration of urban situation in developing countries, such as urban congestion by concentration of the population into urban areas, over slums, traffic congestion, waste, environmental degradation, the large-scale mapping projects started with the first case in metropolitan Manila, Philippines in 1985. Since large-scale map is detailed and accurate representation of the actual city, maps are utilized for planning and implementing various plans and comprehensive development of the city. In many cases thematic maps, such as land-use map, were simultaneously created.

c) Clarification of the purpose and diversification of background and purposes which reflect the political, economic and social situation (From the early 1990s)

First, maps correspond to environmental issues have been highlighted since the early 1990s). The Earth Summit held in 1992 has disseminated the concept of sustainable development, raising people's awareness of global environmental protection. Since the global environmental problems contain lots of issues related to developing countries such as the

desertification and decrease in tropical rainforest, the mapping projects at this period also tend to be conducted with the background of environmental issues: mapping project to develop and conserve tropical rain forest, and to prevent desertification. One of the typical examples is the project conducted in Kazakhstan, 1997 with the purpose to make plan and measures of the Aral Sea environmental issues. Since the issues cover the wider area, the scale of the map is small (such as 1/100,000) using satellite imagery.

Second, it is noted that maps have contributed to the reconstruction of civil war (since the late 1990s) Many of the war, occurred after the termination of the cold war, are civil war (which occurred by domestic conflict); and devastate countries. For the reconstruction of the devastation in particular developing countries, technical and financial assistance form international organizations and developed countries are required. With the background above, mapping projects are conducted to create basic information for formulation and implementation national and urban reconstruction development plan in post conflict countries. In the initial stage, small-scale maps covering wide area were developed in Cambodia and Angola. In recent years, the trend shift to large-scale maps in Afghanistan (Kabul), Sudan (Juba), Liberia (Monrovia) and Sri Lanka. In addition, topographic mapping are often created in a short period of one to two years by its purpose.

A significant case of maps for national independence is also introduced. That is related to the division of Yugoslavia and the collapse of the Soviet Union (From the late 1990s). On the process of the independence of many nations due to the division of Yugoslavia and the collapse of the Soviet Union, the confusion have happened in mapping field such as the lost of original versions of topographic maps, and the dispersion of technicians. Moreover these countries were for behind world wide progress in digital mapping technology. Technical assistance of rebuilding the organization, with an emphasis on technology transfer to develop digital topographic mapping have been made. Since these mapping projects are required in the confusion of national independence, middle-scale maps are created as national base map. Also, the capacity building for mapping agencies are focused on in the mapping project.

In addition, the importance of maps for disaster prevention measures has been increased since the late 1900s to the early 2000s). After the wide-scale damage by Hurricane Mitch in 1998, several projects were implemented to develop maps for disaster prevention measures especially in the Central American region which have a lot of natural disasters such as earthquakes and volcanic eruption. In addi-

tion to topographic map, mapping project often develop hazard maps for earthquakes, volcanoes, and floods etc.

3. QUANTIFICATION OF THE NEEDS

In this section of the paper, firstly we sort out the situation that the Needs increase, proposing the hypothetical factors that create the situation. Secondly, we propose quantification methods stating indicators related to the Needs.

(1) Needs analysis

Analyzing background and features mentioned above, here we categorized six types of situation that the Needs increase hypothetically. In addition, we mention the hypothetical factors and social and economic information related to the situation.

(a) For smooth formulation and implementation of regional planning.

In the case that the regional development such as agricultural, natural resources and regional development are to be scheduled, the needs to develop map become high for formulation and smooth implementation of the plan. Moreover the needs become higher if there is no map or the map is too old to utilize. Major scale with this purpose is medium.

Hypothetically analyzing the situation that requires the regional planning, the population increase and the GDP increase shall be the factors to accelerate the regional development. In addition, there are several factors to encourage regional development. They are the high of the Gini's coefficient which explains the regional disparity and the value index of foreign trade which explains economic growth. Next, the low of infrastructure index such as road length, railway length and channel length can not be neglected.

(b) For tackling urban problems scientifically

Urbanization and urban problems, which are accelerated by the economic grows, raise the needs to develop maps for tackling urban problems scientifically through formulating and implementing urban plan. Mostly the large scale is adapted on this purpose.

Hypothetically analyzing the situation in which urban problems occurred, the population increase should be one of the factors to accelerate the urbanization. In addition, the location of the urban area, whether the city locates economical development area or not; and the amount of cargo handled in the nearest ports which explains economical attractiveness of the city also be the factors.

(c) For the re-construction of post-conflict

For the smooth implementation of re-construction, maps are to be developed promptly. The scale is

varied depending on the targeted areas for reconstruction. The countries and the regions that initiated reconstruction process after the termination of civil war, require reconstruction. The reconstruction situation often is explained as domestic stability and security situation. In addition, the economical and social situation described (a) and (b) shall be the factors to require reconstruction of post-conflict.

(d) For the birth of a new nation

A map is originally a tool to clarify the range of the state power and to understand current situation for governing. In other words, a map is a tool to establish the identity of the nation. For this purpose, when the new nation is born, the needs to develop map become high. Since the target area often stretches to wide area, the scale of the map become small to middle in general.

Since the birth of the nation has strong relation with civil war or independence from colonial power, the situation here is interpreted as the same described in (c).

(e) For environmental conservation and disaster prevention measures

For environmental conservation and disaster prevention, maps provide as basic and useful material to promote understandings of geo-spatial characteristics of target area. Countries and regions, which contain environmental conservation area or areas vulnerable to natural disaster, have necessity to tackle these issues. In addition, from the aspects of negative factors against mitigation of environmental pollution and disaster, the situation here is interpreted as the same described in (a) and (b).

(f) For Industrial development and administrative efficiency

Integrated various public data promotes not only administrative efficiency but also science and technology which leading industrial development. Geographical Information System (GIS) and Internet accelerate the integration of various database; maps serve as fundamental database in GIS.

In developing countries, under the concept of National Spatial Data Infrastructure (NSDI) construction, the use of Internet and GIS digitization are promoted. The countries and regions, which are on the process of economical development, require industrial development as well as improvement of administrative efficiency.

As factors coursing economic development are described above, situation described in (a) and (b) is interrupted simultaneously. In addition, the situation of IT infrastructure such as Internet penetration rate, PC ownerships shall be factors.

(2) Quantification of the Needs

Under the assumption that the mapping development needs are explained social, economical and

political factors mentioned above, we examine quantification of the Needs. As a beginning, we explain the three things as prerequisite and policy for this quantification.

The first one is, as it was described, the purpose to development map is different from scale to scale; the quantification is divided into two types: medium scale (1/25,000 to 1/50,000) and the large scale. Another is, considering to the feature of scales, the Needs for medium scale are quantified using national data. The quantification for large scale is implemented using city data. As the other thing, it is necessary for quantification to be simple and be used easy. We propose to combine simple indicators, so that it is possible for anyone to calculate and verify easily, and also be applied in any countries or cities in world.

1) Outline of quantification

The social, economic and political information associated with topographic mapping needs are used as indicators in the model. Considering to the availability of information, the indicators that are used are shown in Fig. 3 and Fig.4.

We assume that the Needs for medium scale can be explained by five items shown in Fig.3: 1) mapping status, 2) population situation, 3) infrastructure needs, 4) economical situation, and 5) political situation. Each items are consist of several indicators highlighted. Here are the interpretations for each indicator:

- (a) Map condition; the Needs become high when no map exists or existing map is too old to use. The existing mapping conditions in African countries were reviewed in the JICA mapping study²⁾.
- (b) Population density; the Needs become high when the population density high, considering the population density represent the scale of beneficiaries. The United Nation reports the population density³⁾.
- (c) Population growth rate; the Needs become high when the population growth rate become high, considering the population growth rate represent both social and economical changes to be handled, and the scale of beneficiaries. The United Nation reports the population growth rate³⁾.
- (d) Paved road ratio; the Needs become high when the large infrastructure needs are counted high. Considering the unpaved road represents infrastructure needs; when paved road ratio is low, large infrastructure needs high; and simultaneously the Needs become high. The paved road ratio is reported by AfDB⁴⁾.
- (e) Length of Road / land area; the Needs become high when the large infrastructure needs are counted high. Considering the road length per unit area represent the infrastructure needs; when

the road length per unit area is low, large infrastructure needs are counted high; and simultaneously the map development needs becomes high. The length of road and land area is reported by CIA library⁵.

- (f) Length of Railway/ land area; the needs become high when the large infrastructure needs counted high. Considering the railway length per unit area represent the infrastructure needs; when the railway length per unit area is low, large infrastructure needs are counted high; and simultaneously the map development needs become high. The length of railway and area is reported on the website⁶.
- (g) Accessibility to drinking water; the needs become high when the infrastructure needs counted high. Considering to the access rate to drinking water; when the rate is low, infrastructure related to water access needs counted high; and simultaneously the map development needs become high. The country level data is reported by the United Nation⁷.
- (h) GDP and GDP increase; technical assistance for developing maps is required for low GDP and lower growth rate of GDP. The GDP database is reported in the World Economic Outlook Database in IMF⁸.
- (i) Domestic stability; the needs become high when the country become stable after the confusion in the domestic affairs such as civil war. This indicator is applied equally to countries, which do not have any confusion or civil war. Assuming domestic stability has strong correlation with security situation, we adopt security information reported as an indicator reported by the ministry of foreign affairs, Japan instead⁹.

We also assume that the Needs for large scale can be explained by three items shown in Fig.4: 1) population situation, 2) development potential, and 3) political situation. Each item consists of several indicators highlighted. Here is the interpretation for each indicator:

- (j) Population density; the Needs Map development needs become high when the population density high; considering the population density represent the scale of beneficiaries. The population density in African countries is reported by Thomas Brinkhoff¹⁰.
- (k) Population growth rate; the Needs become high when the population growth rate become high, considering the population growth rate represent both social and economical changes to be handled, and the scale of beneficiaries. The population growth rate in African countries is reported by Thomas Brinkhoff¹⁰.



Fig.3 Indicators for medium scale mapping needs

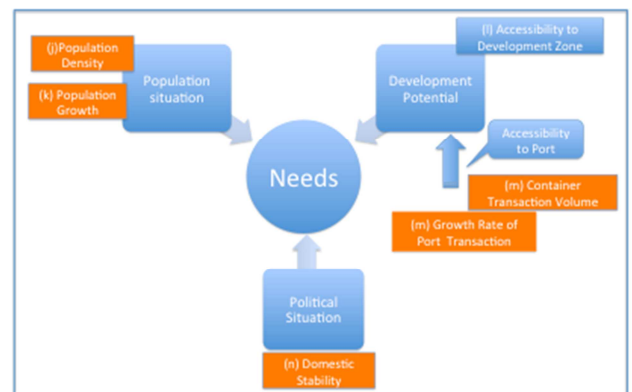


Fig.4 Indicators for large scale mapping needs

-dled, and the scale of beneficiaries. The population growth rate in African countries is reported by Thomas Brinkhoff¹⁰.

- (l) Accessibility to economic development zone; the Needs become high when the target cities and areas locate near the economic development when the population growth rate become high, considering the population growth rate represent both social and economical changes to be handled, and the scale of beneficiaries. The population growth rate in African countries is reported by Thomas Brinkhoff¹⁰.
- (m) Accessibility to major port, Container transaction volume and growth rate of the port transaction; the Needs become high when ports locate near the targeted cities and areas. Moreover, the higher transaction volume of the port, the higher development potential of the city which represents high map development needs. In addition the growth rate is considered as development potential simultaneously. The database is reported in the containerization international year-book¹².
- (n) Domestic stability; Map development needs become high when the country become stable after the confusion in the domestic affairs such as civil war. This indicator is applied equally to coun-

tries, which do not have any confusion or civil war. Assuming domestic stability has strong correlation with security situation; we adopt security information as indicator reported by ministry of foreign affairs, Japan instead⁹⁾.

2) Needs Estimation method

Setting threshold, score of each indicators is set. The scores are summing up to describe the map development needs.

4. Quantification of the needs in Sub-Sahara Africa

We analyze the Needs in sub-Sahara Africa through the quantification devised by the JICA's study. In addition, through interviews to the National Survey Departments of Sub-Saharan region, we also review and evaluate the result of the quantification.

(1) The qualification method

Targeting 48 countries in sub-Sahara Africa, we quantified the Need. We set threshold value into five categories, considering the equal distribution of each index value. Moreover each value is scored. Only the transaction volume of the port which is used for index to calculate large scale mapping needs, were weighted by the distance between port and the targeted cities. (This quantification has been implemented before the independence of South Sudan.)

(2) Results of the qualification

1) Development Need for medium scale map (national level)

The Needs were calculated high in Eritrea and Samaria in eastern area, and Niger in western area. Moreover the needs tend to be higher in landlocked countries such as Central Africa, Chad and Ethiopia. The results of some countries such as Botswana, Namibia, and Mauritania are different from general perception. The reason is consider that to be the length of railway and the paved road ratio influenced strongly. (Appendix.1)

2) Development Needs for large scale map city level)

The map development needs were calculates high in Brazzaville, Accra, Conakry and Dakar which locate costal area. The cities such as Nairobi, Kinshasa, Bujumbura, and Monrovia, in which JICA conducted mapping project, get high score; the validity of the technical cooperation has been confirmed. Because of data availability, in some cities, the Needs are calculated lower than actual needs. Beira and Nacala in Mozambique are the examples that could not reflect the transaction volume to quantification, even both cities have ports. (Appendix.2)

(3) Review and evaluation the result of the quantification

We conducted interviews to the Survey Department of Ethiopia, Ghana, Cameroon, Guinea, the republic of Congo, Nigeria, and Benin on May 2011 on the occasion of CODIST (Committee on Development Information, Science and Technology) II at the UN Economic commission for Africa located in Addis Ababa to evaluate the result of the quantification.

1) Medium Scale maps (National Level)

It was confirmed that some country such as Ethiopia, the republic of Congo, Benin have strong needs to develop as same as the result of the analysis.

2) Large Scale maps (City Level)

It was confirmed that some cities such in Ghana and Guinea have strong needs to develop maps as same as the result of the analysis. On the other hand, despite of the analysis result, the needs of Brazzaville in the republic of Congo is recognized lower because the large scale map covering the city has already developed. Due to the data limitation, the needs quantification for large-scale map does not include mapping status of large-scale maps; it can be one of the factor, which the gaps between the analyses result, and the interview.

5. Conclusion and Remaining Issues

In this paper we analyzed circumstances that increase the Needs to develop map reviewing existing mapping projects conducted by JICA. Based on the analysis, we examined future needs to develop map in Sub-Sahara Africa through quantification of the needs. We conducted interviews to review and evaluate the result of the quantification; we conclude the remaining issues of the quantification here.

For needs analysis of mapping, scoring method using social and economical indicators is usable in general. To further elaboration, it is necessary to analyze the degree of influence to the needs of each index, and consider weight to the index. In addition, Existing map status is one of the most important indicators for the realizing the Needs. Consequently, it is necessary to include the map status information into the quantification.

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APPENDIX 1: Development Need for medium scale map (national level)

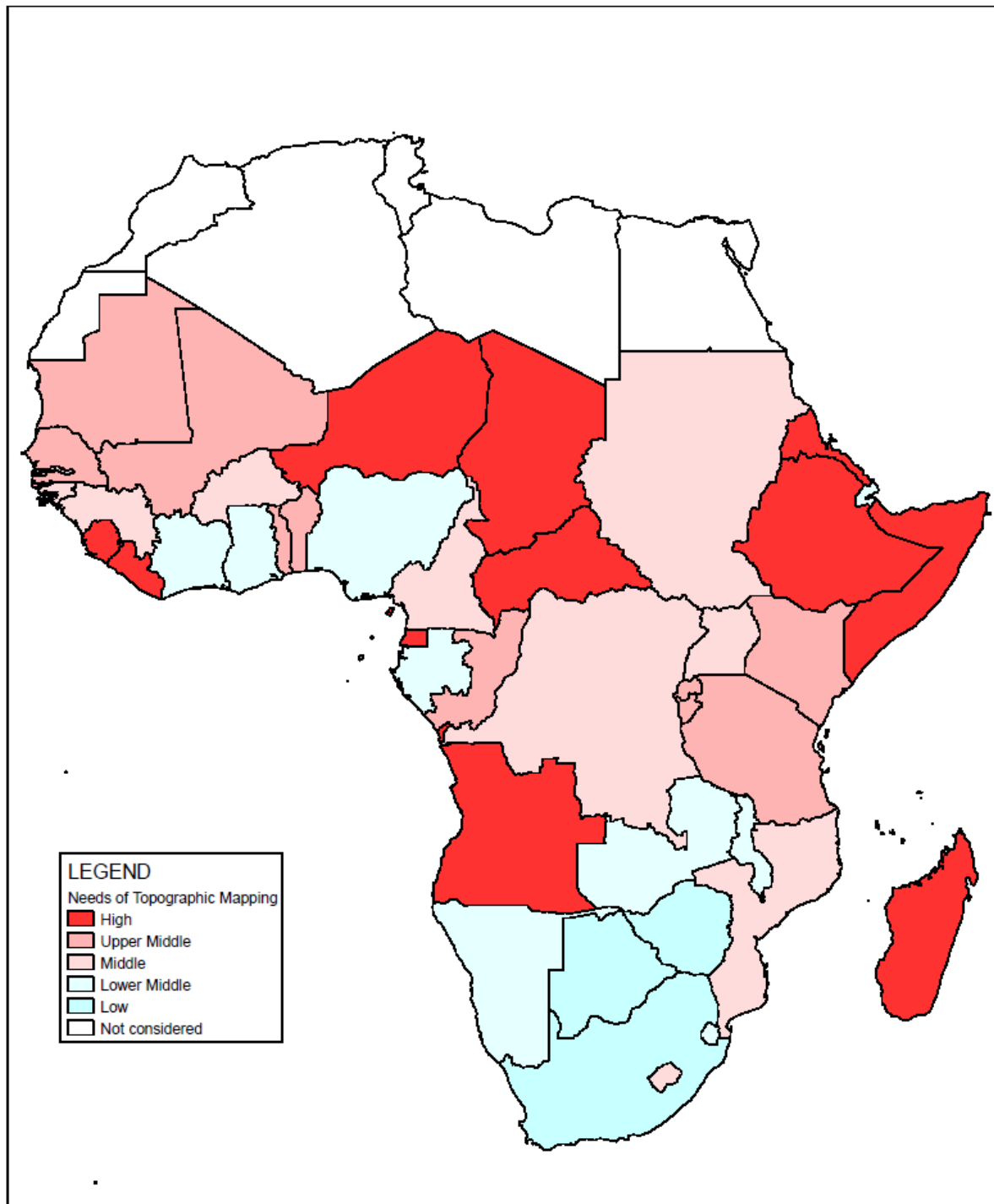
APPENDIX 2: Development Needs for large-scale map (city level)

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NEEDS OF DEVELOPING MEDIUM SCALE TOPOGRAPHIC MAP IN SUB SAHARA COUNTRIES

* Medium scale: 1:25.000 - 1:50.000

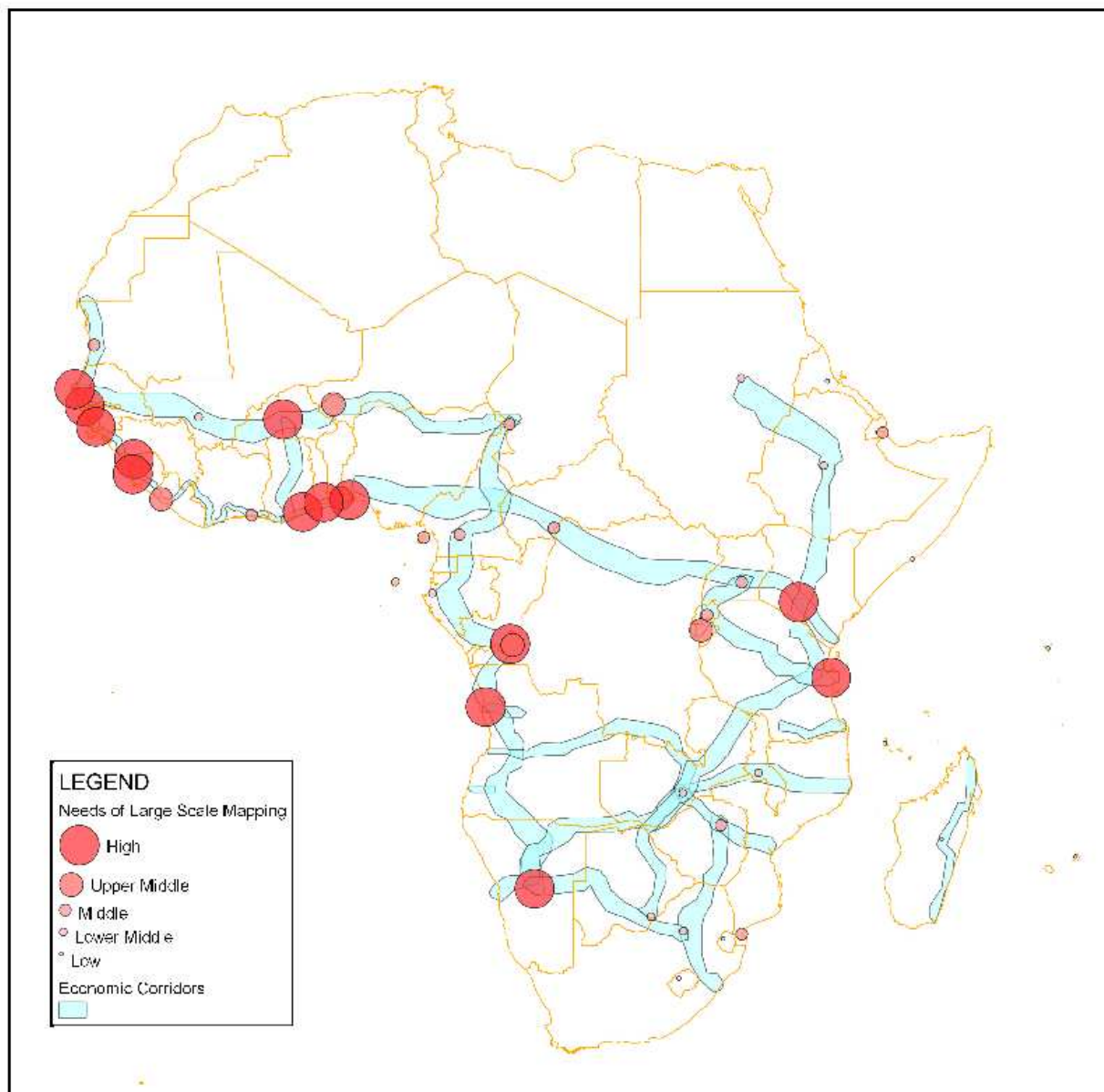


* This mapping need is calculated using various indicators made from the following statistics and other information: Status of medium scale topographic mapping+, population density, population increase rate, paved road ratio+, road length per unit area+, railroad length per unit area+, access to improved drinking water sources+, GDP per capita+, GDP increase rate+, political stability

* Please note that the smaller data with + mark are, the more needs are assumed to exist.

* National Boundaries of this map shows just outline, and is not official and authorized by any organization.

NEEDS OF DEVELOPING LARGE SCALE TOPOGRAPHIC MAP IN CAPITAL CITIES OF SUB SAHARA COUNTRIES



* This mapping need is calculated using various indicators made from the following statistics and other information:
Population density, population increase rate, location of economic corridors, container traffic in main ports, political stability

* Please note that population density and population increase rate data for some cities are not used in the calculation due to the lack of information. Container traffic data in some main ports as well.

* National Boundaries of this map shows just outline, and is not official and authorized by any organization.