International Journal of Scientific Engineering and Science
Volume 8, Issue 7, pp. 12-22, 2024. ISSN (Online): 2456-7361

To Empower Geomatics Processes for Sudan Boundary Making

Kamal Abdellatif Abdalla Sami[1], Mohammed Faisal Hassan Mansour[2]
[1, 2]Department of Surveying Engineering, Faculty of Engineering, University of Khartoum
Email address: Kamal.sami@uofk.edu[1], mohfaisal1990@gmail.com[2]

***Abstract*—** *The process of demarcating and defining international and State borders helps prevent international and internal conflicts and wars and enables smooth economic exchanges, traffic, and movement between neighboring countries. Many of the world's conflicts now stem from disputes over borders and the right to own land. The paper presents the terms and methods of border demarcation and its legal status, and processes, as well as how the international delimitation model is implemented with its five principal stages, which are allocation, demarcation, identification, installation, and documentation, and border maintenance with the implementation of modern geomatics techniques and processes. The methodology for demarcating the Sudanese border was discussed and the demarcation of the border between Sudan and Chad in 1994 was presented as a case study.*

***Keywords*—** *Boundary, geodetic network, Borders, Boundary Commission, Delimitation/Demarcation, Treaties and Technical Committees, ICJ: International Court of Justice, ITLOS: International Tribunal for the Law of the Sea.*

I. INTRODUCTION

The purpose of the presentation is to promote the sharing of methodological knowledge and experience related to the determination of the borders of Sudan. It is well known that, the process of boundary-making begins with preparations for a boundary agreement and continues with boundary delimitation, boundary demarcation, boundary documentation, boundary maintenance, and administration. So, the main objective of the paper is to produce clear geomatics/surveying methodologies to demarcate the borders of Sudan, using the latest technologies, hardware, and software to facilitate the process of making international and national internal administrative boundaries.

Treaties and charters are among the main data sources that are used when conducting the boundary demarcation processes, as well as the maps that can be used for delimitation between Sudan's neighboring countries (Example Sudan Chad border processes in 1994). The geomatics processes have been used for other Sudan borders with the neighboring countries to demarcate and define the border on the ground. In Sudan, the administrative boundaries between Sudan's federal states or regions are considered, because, sometimes leads to conflicts and tribal problems.

The basics of the modern theory of practical boundary-making were established [1, 2, 3] by Lord Curzon (1907), and Sir Henry McMahon (1935). Most of the important borders were related to borders, because there was a conflict of interest between indigenous peoples living on both sides of the border. The magnificence of geomatics started to appear at the end of the last millennium with the technological evolution of space satellites and computer science which provided new prospects for dealing with challenges that might be faced. Surveying for boundaries is of a high-level specialist nature and the surveyors' role demands a wide portfolio of surveying expertise. These range from boundary documentary research, geodetic surveying, digital imagery and mapping, reconnaissance, monumentation, and positioning. The paper intended to promote the sharing of methodological knowledge and experience related to the delimitation of Sudan's boundaries and the promotion of peace throughout the country. The process of boundary-making begins with the preparatory work for a boundary agreement and continues with boundary delimitation, boundary demarcation, boundary documentation, boundary maintenance, and administration. Here it is stressed to differentiate the terminologies of the stages of boundary-making: especially between the term's delimitation and demarcation. As a result of technological development enabling sub-sea drilling to depths of kilometers, geomatics processes of maritime boundaries are also being highlighted.

Sudan's boundary conflicts necessitate the implementation of the internal border-making process for Sudan's federal States, localities, and community units by demarcation of boundaries for administrative purposes and to resolve States/Localities and tribal conflicts.

II. HISTORICAL BACKGROUND ON LEGAL AND DEFINITION OF TERMS

Territorial boundaries are essential for managing the property rights of countries, states, communities, individuals, and organizations. Territorial boundaries are required for proper administration and management of international and national boundaries. In the past prominent natural physical obstacles were used to define the boundaries, such as mountain crests, seas, rivers, and wadis. The definition of detailed internal boundaries was mainly used for the delimitation of land property rights at the tribal and family levels and for assessing land taxation [5]. In the last century, the trend of establishing new states has gained popularity, in which, the international boundaries define the territorial limits and sovereignty of the country, and the area where its laws are applicable [3]. In Sudan, also, there are also local laws that define the legal, administrative, social, and economic regulations that the inhabitants of the federal states are obliged to follow.

In the boundary-making process, the two dominant words used are delimitation and demarcation, in which, the delimitation represents the preparatory work and defines the boundary in the

http://ijses.com/
All rights reserved

treaty either by words or on maps, whereas, the demarcation represents the laying down of the boundary on the ground after the treaty has been signed [3].

2.1 Legal environment for both international and national borders

The issue of territorial boundaries is important all over the world in the past, today, and in the future, so the Montevideo Convention on the Rights and Duties of States, signed in 1933 at the Seventh Pan-American Congress, is one of the few international documents that identify an immerge of a new country/state from the point of view of the international law [5]. According to the Convention, a country/state must have the following four characteristics to be a subject of international law: (1) Permanent indigenous populations (2) A particular area (3) A private organization, and (4) The ability to establish civilized relations with other countries. The Countries/State's standards and characteristics are regularly updated and improved as a subject of international law. The claimant states are required to provide guarantees for compliance with the conditions of (a) Respect for the Constitution of the United Nations (b) The commitments were made following the Helsinki Final Act and the Paris Act, in particular regarding the rule of law, democracy, and human rights (c) Providing guarantees for respecting the rights of ethnic and national groups and minorities following the commitments made under the Organization for Security and Cooperation in Europe (OSCE) [1, 5]; (d) Respect for the sanctity of all boundaries that can only be changed peacefully by agreement of the parties (e) Commitment to disarmament, nuclear non-proliferation, and regional security and stability and (f) Obligation to resolve all issues related to state succession and territorial disputes, and to conclude agreements, including the necessity of submitting to international arbitration.

As said, the state border is a mandatory property (character) of a sovereign state. To address this issue in international practice, the principle of "current possession" is often used such as that identified in Roman law [9]. For Africa, in 1964 the Organization of African Unity, OAU (now African Unity, AU) adopted a resolution stating that the borders of the colony that existed at the date of its formation as an independent state are a reality and that all OAU member states undertake to respect them [8, 7].

The 1986 United Nations International Court of Justice in settling the conflict between Burkina Faso and Mali noted that the essence of the principle of current tenure “is its main objective - to ensure respect for territorial boundaries at the time of state independence [9]. The countries/States commonly send diplomatic protest notes, when they object to the behavior of other States, particularly their neighbors in a boundary dispute. The United States keeps a ‘global watch’ on maritime claims made by other States and issues notes of protest when it considers those claims excessive. A protest note is a means of placing on public record the fact that one State does not accept the action taken by another State.

2.2 State Border Creation

The system of activity of separate links of state administration when creating state borders for newly formed states, still occupies, as a rule, only the former lands in a different legal status. Among other tasks, one of the primary tasks of the new state is the establishment of borders. At the same time, extensive work is underway to draw up basic laws, some of which are directly or indirectly related to boundaries. Only with a certain set of legislative acts, one can proceed to the preparatory stage of the formation of a system that ensures synchronization between the activities of individual units of the government for the establishment of state borders.

For national legislation, the government establishes a working group or committee (Boundary Commission, in the case of Sudan) and instructs it to prepare a report on the legal, political, economic, and technical status of the border, and recommendations on the future establishment of the border for political approval. Usually, ministries, departments, academia, and the production community delegate senior specialists and managers to the working group. In Sudan, the Sudan Survey Authority leads the border commission technical committee.

2.3 Chambers

When taking cases to the ICJ or the ITLOS, it is sometimes possible for state parties to stipulate that they do not want the entire tribunal to adjudicate their case [1, 7]. The Tribunal itself, or sometimes the State Parties, may select a limited number of judges to constitute a ‘Chamber’ of the Court. Chambers decided on two of the most important boundary cases of recent times, the El Salvador/Honduras case, the Canada/United States Gulf of Maine case, and the Abye area treaty for Sudan and South Sudan.

2.4 Cairo Resolution

The African Assembly of Heads of States and Governments meeting in its first ordinary session in Cairo in July 1964 adopted Resolution AHG/Res. 16(I), which stated that it is fundamental to all modern African boundary-making, as it recognizes that ‘the borders of African States, on the day of their independence, constitute a tangible reality,’ whereby the Member States pledged to respect their colonially defined boundaries on achieving independence. All African countries accepted the resolution except Morocco and Somalia. The intention behind the resolution was to avoid potential future conflicts [2, 8].

III. International Boundary-Making Model

The international model of boundary delimitation in a peace agreement enables a successful process of boundary-making. This may reduce boundary problems at the demarcation stage, preventing future disputes, and supporting reliable future boundary restoration (if needed). The model covers all the stages of boundary-making processes, the components and activities to be included in each process, and the recommended technologies and technical means. The model does not always reflect a linear process of succeeding steps, though the linear option is more common nowadays [2]. The linear process includes the stages of allocation, delimitation, boundary agreement, demarcation, documentation, and boundary line (Figure 1).

http://ijses.com/
All rights reserved

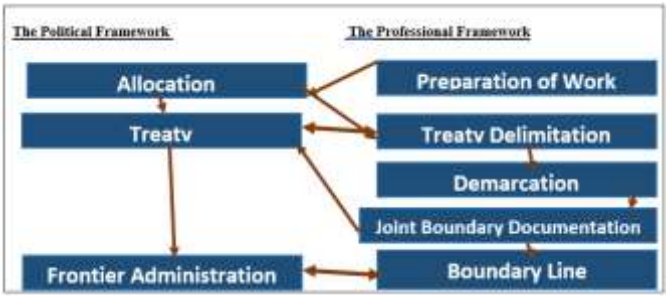

Fig. 1. The Boundary-Making Framework

The model can make use of orthophoto or ortho-images, GNSS measurements, established joint boundary datum, joint production of coordinates, etc. The suggested model is unique and was first successfully implemented in the October 26, 1994 peace agreement between Israel and the Hashemite Kingdom of Jordan [7]. The fact that the implementation of the process was carried out smoothly and that during the last thirty years, since the signing of the treaty, no serious problem arose, , reflects the reliability of the model. The implementation of the recommended model has the potential to stabilize the boundary-making process and reduce unnecessary friction and disputes between the parties.

The basic stages of the boundary-making process begin with the preparation of documents and supporting materials to achieve a peaceful agreement and finish with the maintenance of the boundary. The basic stages include allocation, delimitation, and demarcation.

3.1 Allocation:

Allocation is the first step of the agreement and it reflects the statesmen's directive about the international boundary, defined by Jones (1945) [4, 6] as "Allocation means the initial political division of territory between two states". Today, the split is usually the result of a compromise between two parties representing two neighboring countries. For proper implementation of the above-mentioned information-based environment, an expert, or a team of experts, should be designated. One or more experts should serve as technical consultants to the statesmen at an early stage of the boundary allocation. This technical support has additional importance since the allocation has a major influence on the delimitation, and, later on, on the demarcation and can prevent unexpected complications when implementing the boundary process.

3.2 Boundary Delimitation:

Curzon (1907) stated that "Delimitation signifies all the earlier processes for determining a boundary down to and including its embodiment in a Treaty or Convention" [1, 5]. Bounding means working with documents and the physical aspects of boundaries means setting a boundary. In order not to mix the various stages, the core model [5], refers to the modern boundary-making process, in which there is only one stage of delimitation, followed by demarcation. The negotiations during the delimitation stage are handled before the signing of the Treaty, and therefore they may be complex and tense, which may lead to serious disagreements among the parties. This is why the statesmen are still involved either directly or indirectly in this process together with the established Joint Boundary Commission. The joint team of experts should be assigned the task of defining and preparing all the necessary professional data and tools for the boundary and issues related to the treaty, including defining the wording and the graphical expression of the delimitation, which will be incorporated into the Treaty.

The essential tasks of the technical support of the joint team of experts during the boundary delimitation stage include: (a) Preparing for the delimitation, (b) defining geodetic datum, parameters, and techniques for implementing the relevant activities associated with boundary making. (c) Defining the mutual set of graphic aids, including maps, is required as a background for depicting the layout of the boundary line in the Treaty. (d) If the delimitation covers sections other than the land boundary, like a boundary line in a river, in a lake, or a maritime boundary, it is the task of the joint team of experts to define the technical parameters and methods for this delimitation (e) The joint team of experts at the delimitation stage is to precisely state the method of defining boundary coordinates, its order and the precedence of the various boundary definitions in the future. Usually, any boundary delimitation model project may include:-

(a) Designation of a mixed technical demarcation commission;
(b) Archival analysis (legal documents, textual or numerical geographical information);
(c) Selection of legal texts from which the delimitation will be done;
(d) Document inventory to be included in the technical dossier;
(e) Establishment of the operating foundation (geodetic pillars, leveling, astronomy, GPS);
(f) Technical specifications selection (geodetic system, map projection, cartographic scale, map legend), land and sea border markers.
(g) Definition of essential project fabrication phases (geodetic canvas, aerial photography or satellite imagery, stereo-preparation, aerial triangulation, recovery, process, structure and database integration, fieldwork, cartographic mapping, offset printing);
(h) Establishment of a technical procedure for each phase;
(i) Elaboration of a proposed project for each step of product fabrication; such as Map Index. Large-scale Orthophotos: Instructions for the boundary demarcation, Surveying, recording of coordinates, boundary documentation, Authorization of the list of coordinates, Maintenance, Schedule, and Joint team of experts [4, 5].
(j) Realization of works phase-by-phase based on interval planning;
(k) Control of each work phase execution, and
(l) Setting up the Joint Technical Commission for Boundary Demarcation [2].

3.3 Boundary Demarcation

In the delimitation process, the main objective is to physically mark the boundary described in the delimitation documents as precisely as possible. Demarcation requires high-precision methods for determining the land border, namely the geodetic and spatial methods. The type of monument or sign used depends on the nature of the landscape in which it is

http://ijses.com/
All rights reserved

placed. Then the boundary is defined as precisely as possible (using boundary markers and natural lines) and is then mapped. The demarcation process is completed with the signature of a treaty, which will be registered with the United Nations.

McMahon (Trotter, 1897), Holdich [July 28, 1902, in the letter to Under Secretary of State (Rushworth, 1997)] defined the demarcation as laying the boundary on the ground. Curzon (1907) called delineation "the last step in applying and delineating the outer surface of the boundary in situ [1, 3].

In addition, the revolution in surveying tools, including satellite surveying and high-resolution commercial satellite imagery, greatly contributed to realizing fast, high-quality reconnaissance, high-quality mapping, precise measurements, and precise documentation of the demarcation. The development of international geospatial standards has contributed to collaboration between the surveying parties and has made possible the use of a common geodetic boundary datum in line with the United Nations Global Geodetic Reference Frame (UN-GGRF) [12, 13].

The main geodetic aspects of the Joint Boundary experts are the determination of a Reference Frame (datum), geodetic network, techniques, and technologies. Existing geodetic land control points are used to create a common geodetic grid. Coordinates are to be exchanged between the boundary parties. It should be noted that in several cases all around the world, this information is restricted from public use ("secret" or "for official use"), so delegations must make such exchanges by the law.

The creation of a common geodetic network includes (a) Development and approval by the demarcation commission of a technical project for the construction of a general geodetic network. (b) Survey of points of the general geodetic network. The survey includes finding the original points on the ground, establishing the safety of external signs, identifying landmarks, and clarifying the description of the location of points. (c) The main purpose of reconnaissance is to choose the final points of the general geodetic network; the location of the network points must ensure the long-term safety of the center, the stability of its spatial position, the possibility of unimpeded access, and convenient access to the point for the use of observers. (d) measuring works: To perform satellite observations, it is advisable to use two-frequency geodetic satellite equipment that works on dual-frequency signals from GNSS satellites [4]. To verify the quality of the measured data, the delegations subsequently exchange the results of their observations in full.

Field observations can be performed with the following recommendations: (a) Observations should be performed in static mode in two sessions with a resolution of 15' at the minimum angle of elevation for the satellites of 15˚; (b) Duration of one session not less than 3 hours. (c) Between observation sessions, re-install the antenna at each point when changing its height by at least 10cm. (d) In-house works: Processing of satellite observations and equalization of the general geodetic network. Creation of the catalog of points and their heights of the general geodetic network, that is, a technical report based on the results of the creation of the general geodetic network is prepared, which is subject to approval by the demarcation commission.

In general, the process of boundary delineation involves seven steps:

(1) Geodetic works: Adoption of geodetic system and projection; Equipment selection (GPS, total station, etc.); Data processing software acquisition; Site identification; Demarcation; Survey observation; Processing and compilation; and Analysis of results [4].
2. Aerial photography works Photo scale selection; Flight axis determination; camera selection; Flight elevation determination; Aircraft selection; Preparation of assembly sheet and tables; Execution of the mission.
3. Photogrammetric works: Adoption of geodetic system and projection; Over-flight programming (office stereo-preparation); Review and analysis of collected photos; aerial triangulation; Feature identification; photo Control.
4. Process and data integration in database: Data processes; GIS-compatible data structure; and Database data integration.
5. Photo identification and fieldwork: Acquisition of aerial photos covering the map sheet; Identification of unidentified details; Preparation and establishment of layers (tiling). Field Mapping of unidentified details on the ground; Verification and identification of vegetation; Verification of hydrography and orography; Toponym (name place) collection.
6. Field data integration during the database: Processes for collecting data from the field; and Integration.
7. Mapping: Symbolization; Processing; Map format; Draft version print; Control; Final version print; Control; and Offset printing.

3.4 Boundary Documentation

The element of stability and finality should be the underlying object of all international boundaries (ICJ, 1962 Preah Vihear Case) [1], that, joint comprehensive detailed documentation of the boundary is sufficient to support the achievement of accurate construction or reconstruction of every boundary mark (pillar). The recommended approach is to generally define boundary documentation as an important step in boundary determination, similar to land registration in the land management process [1], the difference being that the final approval and authority are not given by an authority of a single state but is given by the two neighboring states, along the relevant boundary line by their authorized representatives. The main legal strength of such documentation lies in the signatures of the authorized official representatives of both States. The existence of such documentation has the potential to prevent boundary disputes or to support quick resolutions with no need for Arbitration.

The content of the documentation shall background data about concepts, chronology, and data about the boundary line route, a description of the documentation procedure, general data about the survey, equipment, data processing, technical issues and border maintenance. In all cases, Precise Detailed Documentation will be obtained from the demarcation that follows a treaty or an agreement between two states. It consists of a list of coordinates of boundary points and/or boundary points, preferably with a common base point. In addition, the

http://ijses.com/
All rights reserved

detailed document usually includes a map or a layout showing the boundary line route and the boundary pillars. The document should declare whether the coordinates or the maps are binding.

3.5 Boundary Maintenance

The field-demarcated boundary is very important for maintaining the existence of the boundary's appearance in the field by maintaining the boundary pillars and the associated arrangements, which are constructed along the boundary line between the pillars for that purpose. The easiest maintenance, to be considered can refer to minor actions, such as repainting a pillar. For more complicated boundary maintenance actions in the reconstruction or replacement of boundary pillars, proper detailed technical documentation is required. To achieve successful maintenance of the boundary line, the following are to be taken into consideration as formation of a joint active technical team, preplanning of the location of the boundary pillars, as well as their types and materials, detailed technical boundary documentation should be prepared and authorized by the parties of the two States, periodical reconnaissance tours in the field are required, and maintenance actions for repair or reconstruction, etc., should not be delayed for a long time in order not to cause deterioration of the boundary condition.

3.6 Boundary Administration

Boundary Administration is the stage that follows the Treaty between the States and includes all the activities about the area close to the boundary line and sometimes even the boundary zone. It mainly refers to the administrative rules and behavior on both sides, but also to the behavior of the inhabitants. It includes interrelations like the passage of people and the passage of goods, including the existence of passage stations and passage control, security control, including trespassing and smuggling, roads and other means of traffic and communication, usage of water, agriculture, etc. and it covers the boundary maintenance as well and forms a well-maintained boundary line.

IV. Sudan International Borders

The previous Sudan Boundary-Making Model was mainly based on border drawing methods based on the quarter-million map as an official document for the demarcation of the borders. It is a map that was produced during the British rule of Sudan (Figure 3). The quarter-million map shows the internal and external borders of the state, its geodetic reference datum was Adindan based on Clarke1880 ellipsoid. In old boundary-making processes in Sudan, aerial photography and satellite imagery were not frequently used. Instead, the reliance was on maps (such as given in Figures, 2, 3, 4, and 5), documents, and agreements, and after demarcation, tables of coordinates and border marks descriptions were documented.

In border demarcation, the method is based on border marker monumentation, observation, validation, and documentation. All previous border points are in the (Off) position because they are not connected to national/neighboring countries or international reference frames, this may result in displacements of the locations of the border points. According to the Sudanese method, geodetic network/ geodetic control points were not established to monitor the situation of the borderline between the neighboring countries. In such a method, the Joint Technical Commission on Demarcation could be able to complete its work only due to the mutual understanding and sense of brotherhood that prevailed between the border teams (Examples are the work done for Sudan-Chad border demarcation and Sudanese Ethiopian delimitation teams), in which border work activities were built on mutual trust and understanding.

Concerning the above figures and many other international maps, Sudan border issues can be easily handled by addressing international practices of the principle of "current possession" and the OAU adopted a resolution, undertaken in 1964 by all African member States "the resolution stating that the borders of the colony that existed at the date of its formation as an independent state are a reality".

V. Sudan Chad Border (Case Study)

The Sudan-Chad border is about 1,403 km long and extends from the Triple Point with Libya in the north to the Triple Point with the Central African Republic in the south; access to Wadi-Hawar. The border then forms a very irregular line up to the tri-point with the Central African Republic, bordered by many small streams and hills. The northern part of the border lies within the Sahara, the central areas extend into the Sahel region, and the southern areas consist of grasslands and savannas. The length of it that was demarcated is 368 km, and its signs were fixed on nature, and its coordinates were recorded. The rest of the distance is desert, in which the borders are in the form of a straight line with a known beginning and end.

Sudan has many and varied borders, so demarcating the borders between (Sudan-Chad) is one of the most important aspects of borders border-making process as all nations strive, as it affects the security of the state and the absence of border disputes between the two countries. The Sudan-Chad boundary-making process can be considered as a practical example, which has been delimited, demarcated, marked in the field, documented, and signed. The following processes were considered by the two countries:

(1) Negotiations (Allocation**):** in this stage, the collection of the available documents and information, agreements, and maps. The existence of documents, protocols, and agreements, as well as the interest in local customs and traditions facilitate the work of the commissioned border committees as they are acquainted with the detailed and natural description of the border area and have knowledge of the history of the borderline. Thus, the Sudanese committee and the Chadian committee were formed. Each of these committees was formed in a very professional manner and is composed of security authorities, technical authorities, financial authorities, and legal committees as well as the involved diplomatic bodies, and representatives of civil administrations from the region.

http://ijses.com/
All rights reserved

Volume 8, Issue 7, pp. 12-22, 2024.
ISSN (Online): 2456-7361

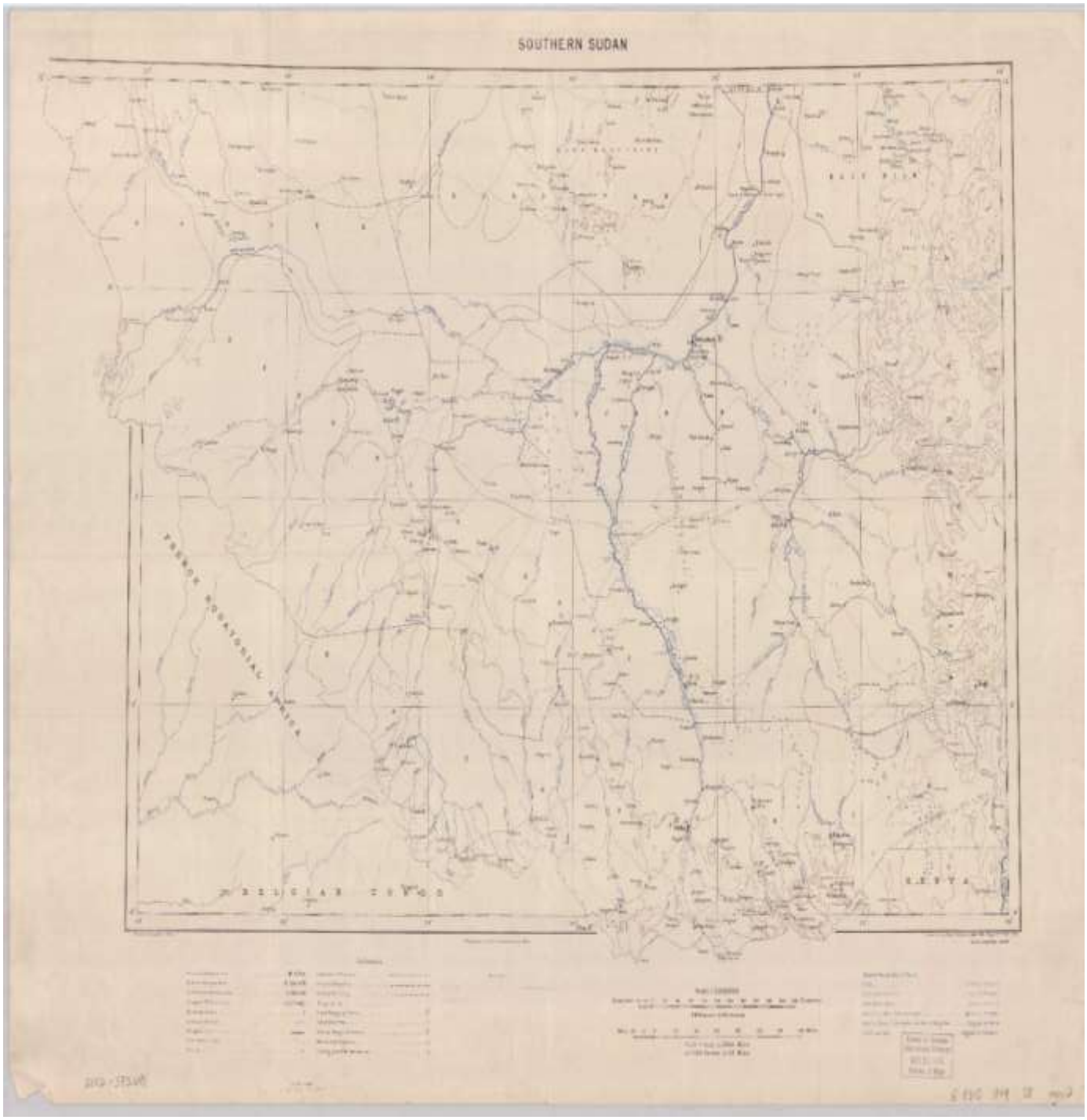

Fig. 2. Sudan – South Sudan Administrative Boundary 1949

All rights reserved

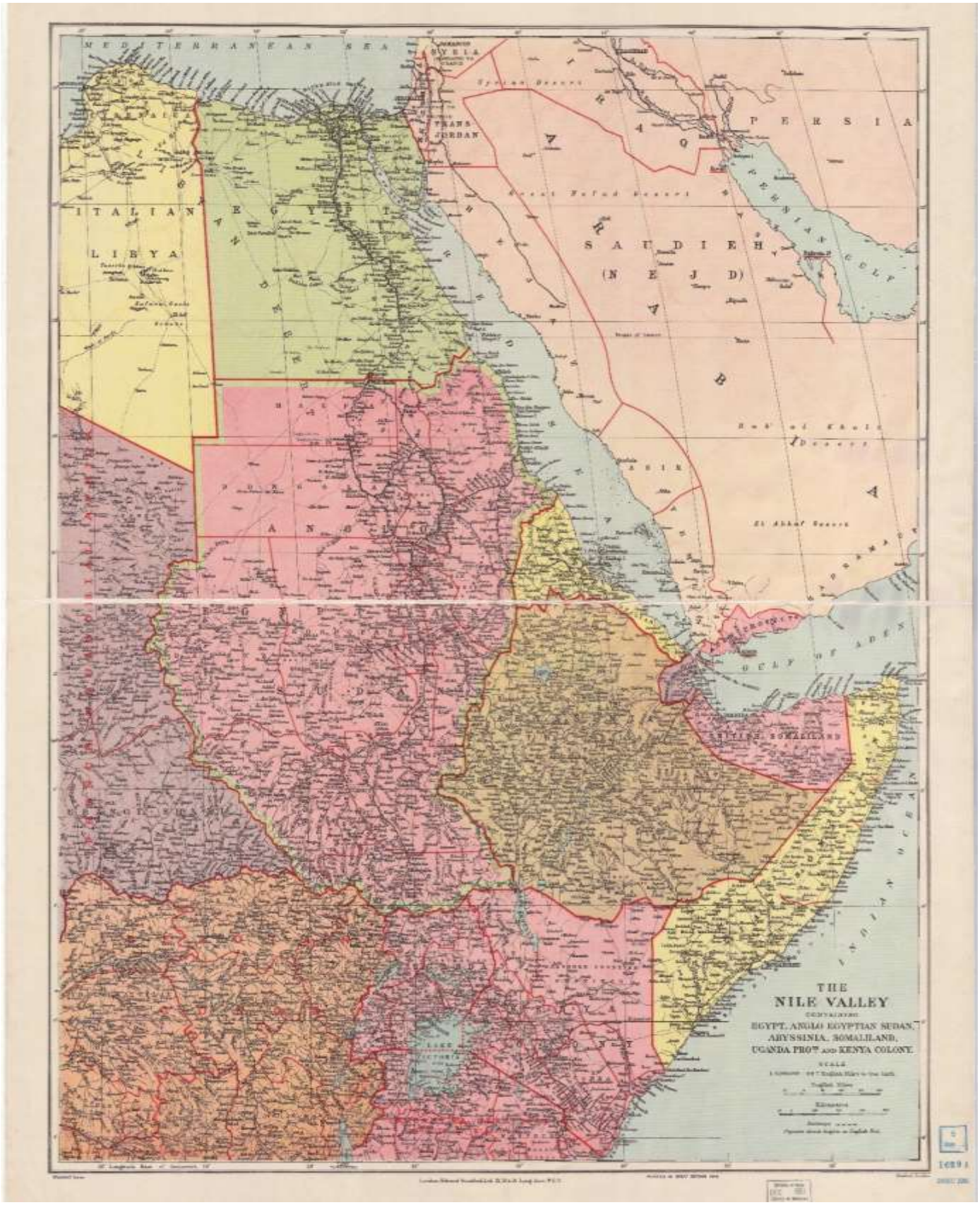

Fig. 3. Anglo-Egyptian Sudan - The Nile Valley: Containing Egypt, Anglo-Egyptian Sudan, Abyssinia, Somaliland, Uganda, and Kenya, 1951)

http://ijses.com/
All rights reserved

Fig. 4. Agypten Germany G4 1941: Sudan Egypt Boundary

Fig. 5. Italian map showing Sudan, Ethiopia, and Eretria Border (1925)

http://ijses.com/
All rights reserved

(2) Boundary Delimitation Process: Delimitation operations were done in the presence of both parties, the area was studied, the borderline was determined, and maps were reviewed. Delimitation is considered to be one of the most important major operations in boundary-making processes between Sudan and Chad, taking into account the following steps: -

(a) Natural features and areas between Sudan - and Chad: these include, natural landmarks that were identified, agreed upon, and approved by the technical committees, such as mountains, valleys, and rivers. There is a desert in the northern part and one of the famous border areas between the two countries is Lake Tize, which contains huge and very large markets that bring together all regions of West Africa, such as Nigeria. Other well-known areas are Um Dukhun and Batris areas in the north, Forbaranga, Kulbus, and Al-Taybeh areas.

(b) Determining the boundary line: The Sudan quarter-million and the Chadian 1:200,000 maps approved by both sides were used. To show the borderline, in the beginning, the description used relied on several factors, such as topographical area, a complete study of the region, including the economic situation of the region and its natural borders, the ethnic or tribal status of the region, the human and natural resources. The borderline, in some cases, is straight. At the intersection of the 25th longitude line with Wadi Hawar, the line heads north to the State of Libya without any meanders (i.e., extends northward to the Al-Uwainat area, as it is a desert area without disputes). At the beginning of this line, stone piles were made every 10 km, but with the desert encroachment these piles faded and disappeared, but they are known in all agreements as well as their coordinates.

(c) The technical committees from both countries met in Khartoum and Chad, and the steps of the boundary-making processes were defined and detailed. Examples of such details were that the work was divided into three parts with a total length of 368 km, including the northern part, starting from Kulbus, 50 km north, and 50 km south. The central part, with a length of 100 km, starts from Wadi-Songa and passes through ForBaranga and Lake Chad (Tize), it is located within the Chadian borders and has the triple border mark, the border mark was installed at a distance of approximately 2 km from it, and it is a point where the triple borders between Sudan - Chad - Central Africa are intersected. There are zigzags in these lines, but they contain natural signs like named mountains. After clarifying the borderline between the two countries knowing its beginning and end, and defining the borders on the ground in the next stage, it is agreed that boundaries in lakes (sometimes called lacustrine boundaries) are commonly treated in a similar way to maritime boundary delimitation. Thus, such boundaries will frequently be drawn as straight lines, although they may take into account the presence of islands. There may sometimes problems arise, when lakes dry out (as is the case with Lake Chad) or when a man-made lake is created along a river boundary (as is the case with Lake Kariba along the Zambia-Zimbabwe boundary), thus obliterating the river's original median.

(3) Boundary Demarcation process: It is the process that comes immediately after the delimitation process, and it is the process in which the setting of the borderline is carried out on the ground and implemented by the technical committee. This demarcation process can be summarized in the following main steps: -

(a) Scheduling of the mobilization dates and camps by the technical committees.

(b) GNSS RTK Trimble devices owned by the Sudanese side and approved by the Chadian side were used to carry out the fieldwork surveys.

(c) The reference system or datum agreed to be used is the WGS84.

(d) The geometric shape of the border signs was determined and a private company was assigned to implement the border sign.

(e) The process of fixing the border signs and reading the coordinates of the border points has been completed and it is considered a preliminary reading only. After the mark is poured and implemented, the device is placed again to make the final reading and recording and it is approved by both sides.

(f) Any point that is read as an initial reading from the Chadian and Sudanese Teams, including extracting the average of the two readings and adopting it. If there are significant differences between the two, the reading is reviewed again.

(g) The location of the signs is determined according to the natural conditions of the area. The distance to look at can be sometimes 2 km, sometimes 1 km, sometimes 500 meters, and sometimes less. The final decision is made by the technical committees of the two countries.

(h) When the location extracted from the map differs from the location on the ground, the current location on the ground is approved if it is described in the documents, and the boundary mark is fixed.

(i) The observations of the Sudanese side were represented in the presence of a difference in the location when fixing some border points extracted from the quarter-million map and approved by the two sides, and in these cases, the location described in the documents and agreed upon on the nature, and the installation and reading of the mark are relied upon.

(j) A follow-up committee (border management committee) has been formed, and it consists of security, administrative, and technical formations, and its mission is to monitor the borderline and report violations of border signs, so the competent authorities from both sides visit the site and take the necessary action.

(k) The daily activities that occurred were recorded in the form of daily reports and kept by both sides.

(l) The Sudanese side noticed a displacement in the coordinates of the points that were extracted from the map 1:250,000 in the southern and middle line, all of which are displacements in the direction of the Sudanese border, so it was agreed between the two committees to darken the situation on the ground in the event of displacement and difference.

http://ijses.com/
All rights reserved

(m) The total distance that was demarcated and marked is 368 km divided as follows: 100 km in the north in the Kulbus region, 100 km in the middle in the Forbaranga region, and 168 km in the south in the Umm Dukhun region.

The tripartite border sign between (Central Africa) which is located near Lake TEZE has not been installed because when installing the triple border sign, it is always required that the three parties be present in the field to install it.

(4) The Documentation: The agreements that have been completed and the final field documents that were agreed upon are considered the final documentation of the Sudanese borders and can be referred to and approved to resolve the border disputes that arise in the future. Therefore, the field photography document is also considered to be one of the most important documents that help to prevent future conflicts, associated with the border coordinates documents and border descriptions.

It is also necessary for documentation purposes, to invite a team consisting of radio and television authorities to document the agreed physical boundary lines, the pillars, and the natural features in terms of photographs, video, official and community participation, and the approved documents. This can also be considered reliable documentation of the boundary-making process.

(5) Border maintenance: - Border maintenance and management is considered one of the most important works that must be carried out after the border work between the two countries is completed. Therefore, committees were formed to maintain the borders between Sudan and Chad, and it was decided that these committees would meet every year or two to carry out field visits to the border signs between the two countries to determine their current condition and work for maintenance on the signs that were damaged, whether due to natural factors or because of the local population. As well as re-establishing the border signs that were displaced or destroyed. These committees have not met since the completion of the demarcation of the border in 1994, due to many reasons, mostly political disputes.

VI. International New Trends for Boundary-Making Model

Boundaries in the international boundary industry are delineated using modern integrated geomatics technologies. High-resolution aerial photography/ satellite imageries could be used to map the border between neighboring countries [3], as well as the use of Geospatial information programs to produce more accurate and reliable maps and geospatial information such as those adopted by United Nations Global Geospatial Information Management (UNGGIM) adopting its well-known frames [12, 13] of Global Geodetic Reference Frame (GGRF) and the Integrated Geospatial Information Frame (IGIF), modern positioning techniques and international strategies to determine the land and marine borderlines.

In this regard, Sudan already adopted the ITRF2008 epoch as its national reference frame to be in line with the agreed unified African Reference Frame (AFREF), designed its geodetic network that consisted about more than 600 geodetic control points taking consideration of all existing ground control points [4]. Additionally, Sudan launched its national digital base map as a unified base map to integrate all federal governments, state governments, and public and private sector organizations' geospatial information [6].

As a result of the consideration of the international model, the regional treaties, and international laws and guidelines, the ideal implementation of boundary-making processes between countries can easily be made in the future.

VII. Conclusions

The study illustrated that the joint smooth implementation of the border model processes taking consideration of the mutual and regional treaties, as well as the international laws and the United Nations resolutions and international UN-Maps boundaries between countries all around the world can easily be handled with no or minimum disputes. The study also pointed out that, if countries abide by the mutual agreements and international laws including the wisdom of maintaining the status quo of the colonial boundaries, and the need to take further actions to safeguard the borders can be built and the boundary-making process shall not pose problems today and in the future.

For a sound and smooth boundary-making process in Sudan, governments and joined boundary committees should consider the: -

(1) the Anglo-Egyptian maps together with all relevant maps at that time, such as German, Italian, and United States of America maps in the years before 1956.
(2) Abide with the regional agreements (AOU), international laws, and the agreed United Nations resolutions, no doubt that the challenges in border-making processes especially in the delimitation and demarcation of Sudan boundaries are daunting.
(3) Political will is required to engage neighboring countries in long-term meaningful dialogue for the implementation of reliable Border making processes.
(4) The Sudan- Chad boundary-making process, lasted for more than 30 years without any boundary problems, and the treaty was successfully implemented for the border-making process and management and the prevention of boundary disputes.
(5) Periodic maintenance of the borders between countries, must be carried out to preserve the border lines from damage, no need to process the border model again.

Acknowledgment

The author's deepest gratitude and special thanks to Eng. Al Amin Mohammed Banaga, the Director General of the Sudan Survey Authority and to Eng. Al-Sadiq Suleiman [11] of the Sudan Border National Commission for his support and provision of information and documents. Special thanks Eng. Mohammed Abker [10] a collaborator at the National Border Commission for his support and provision of a lot of information related to the practical Sudan boundary-making process.

http://ijses.com/
All rights reserved

REFERENCES

[1] International Boundary Making, the International Federation of Surveyors (FIG) PUBLICATION NO 59, December 2013.
[2] Adler R., (1995) Positioning and Mapping International Land Boundaries, Boundary & Territory Briefing 2)1), IBRU, Durham.
[3] Nepali, Chitta, Ranjan (1964), Nepal–China Boundary (in vernacular), Kathmandu.
[4] Engineering Surveying, Sixth Edition, W. Schofield & M. Breach, Nottingham Trent University 2007.
[5] Adler R., (2001) Geographical Information in Delimitation, Demarcation and Management of International Land Boundaries, Boundary and Territory Briefing 3(4), IBRU, Durham.
[6] Shrestha, Buddhi Narayan (2004), Boundary of Nepal ((in vernacular), Kathmandu.
[7] The Egypt-Israel Arbitration Tribunal, (1988) Award of the Egypt-Israel Arbitration Tribunal, 29 September 1988.
[8] Srebro H., Shoshany M., (2009) Comprehensive Process-Driven Boundary Making Model: A Case Study of the Israel–Jordan Boundary, Survey Review, 41, 312 pp. 174–191, April 2009.
[9] Delimitation and Demarcation of Boundaries in Africa 2nd edition, August 2014.
[10] An interview with Eng. Muhammad Abkar - a collaborator at the National Border Commission.
[11] An interview with Eng. Al-Sadiq Suleiman - Deputy Director of the National Border Commission.
[12] Sudan Country Report1 (2022), Sudan National Base Map System; Implementation Status of Sudan National Geospatial Information System for Committee of Experts on Global Geospatial Information Management, Sudan Survey Authority, United nation Committee of Expert meeting, New York. https://ggim.un.org/country-reports/documents/Sudan_Basemap_UNGGIM_12-Event_2022.pdf
[13] Sudan Country Report2 (2022) Sudan National Geodetic Control Network, United Nations Committee of Expert meeting (12) New York. https://ggim.un.org/country-reports/documents/Country_Report_Sudan_2022.pdf

http://ijses.com/
All rights reserved