Food and Agriculture Organization of the United Nations

REPUBLIC OF SUDAN

MEASUREMENT, REPORTING, AND VERIFICATION SYSTEM FOR REDD+

FINAL REPORT

FOREST CARBON PARTNERSHIP FACILITY

WORLD BANK GROUP

REDD+

REPUBLIC OF SUDAN

MEASUREMENT, REPORTING, AND VERIFICATION SYSTEM FOR REDD+

FINAL REPORT

Sudan's Forests National Corporation (FNC)
Khartoum, 2021

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Acronyms

AD	Activity Data
AFOLU	Agriculture, Forestry and Other Land Use
AP	Action Plan
BUR	Biennial Update Report
CBD	Convention on Biological Diversity
COP	Conference of the Parties
EF	Emission factors
ERP	Emission Reductions Programs
FAO	Food and Agricultural Organization of the United Nations
FCPF	Forest Carbon Partnership Fund
FNC	Forests National Corporation
FRA	Forest Resource Assessment
FREL	Forest Reference Emission Levels
FRL	Forest Reference Level
GCF	Green Environment Facility
GDP	Gross Domestic Product
GFOI	Global Forest Observation Initiative
GHG-I	Greenhouse Gas Inventory
HCENR	High Council for Environment and Natural Resources
ICA	International Consultation and Analysis
IPCC GPG	Intergovernmental Panel on Climate Change Good Practice Guidance
ICSP	International Carbon Sequestration Project
LCAS	Land Cover Atlas of Sudan
LCCS	Land Cover Classification System
LMS	Land Monitoring System
LULUCF	Land Use, Land Use Change, and Forestry
MRV	Measurement, Reporting, and Verification
NAMAs	Nationally Appropriate Mitigation Actions
NC	National Communications
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
SNFMS	Sudan National Forest Monitoring System
NGGI	National Greenhouse Gas Inventory
NRS	National REDD+ Steering
NRSC	National REDD+ Steering Committee
NWFPs	Non-Woody Forest Products
PAMs	Policies and Measures
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RBP	Results-based payments
RMU	REDD+ Management Unit
RoS	Republic of Sudan

RPGD	Range and Pasture General Directorate
R-PP	REDD+ Readiness Preparation Proposal
RSSA	Remote Sensing & Seismology Authority
SESA	Strategic Environmental and Social assessment
SFM	Sustainable Forest Management
TCNC	Technical Committee for the Preparation of National Communication
ToE	Ton of Oil equivalent
ToR	Terms of Reference
TWG	Technical Working Groups
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar

EXECUTIVE SUMMARY

1. The Republic of Sudan (RoS) is a party to the United Nations Framework Convention on Climate Change (UNFCCC) and along with many other parties holds a responsibility to take actions and contribute to global efforts to reduce greenhouse gas emissions.

2. The country's population of 39.6 million[1] comprises 30% urban, 63% rural, and 7% nomadic, thus a large percentage of the population are forest-dependent for livelihoods, wood fuel, and round timber for construction. RoS covers an area of 1,886,0068 km^2 with a forest cover area of about 15.85% (NFI 2020).

3. The forestry sector is important to the economy of RoS and provides 3-4% of GDP. However, Sudan´s forests have been facing encroachment from agriculture, urbanization, and unsustainable wood fuel extraction for several decades. Understanding the interplay of these drivers and underlying causes of deforestation and forest degradation is paramount and requires robust sectoral and institutional monitoring and reporting systems.

4. Based on an action plan developed in 2019, with technical support from FAO, this document presents the methodological approach that RoS will follow in establishing and implementing its REDD+ (Reducing Emissions from Deforestation and Forest Degradation) monitoring, reporting, and verification (MRV) as part of a multi-purpose Sudan National Forest Monitoring Systems (SNFMS). The SNFMS will enable adequate accounting for national greenhouse gas emissions from the forestry sector under REDD+ to meet international reporting obligations under the UNFCCC and other conventions' requirements. In addition, it can serve simultaneously as a 'monitoring' function and a 'Measurement, Reporting and Verification (MRV)' function.

State of REDD+ in RoS

5. REDD+ status will continue to evolve through the phases outlined in the Readiness Preparation Proposal (R-PP) to ensure establishment of institutional arrangements that comply with the UNFCCC Conference of Parties (COP) decisions concerning (i) a national strategy or action plan; (ii) a national forest reference emission level and/or forest reference level (FREL/FRL); (iii) a robust and transparent NFMS to meet MRV requirements for REDD+; and (iv) a system for providing information on safeguards.

6. A functioning SNFMS is a required condition to achieve REDD+ readiness and to enter Phase II of REDD+ implementation and subsequent participation in the results-based payments regime. Sudan has prepared a multi-year SNFMS Action Plan (AP), and this MRV document is part of its implementation. The SNFMS AP identifies the activities to be implemented to allow effective functioning and operationalization of the SNFMS through phases II and III of REDD+ readiness.

Scope and Objectives of the Sudan REDD+ MRV System.

7. The scope of the SNFMS and MRV system is national and will be used to provide incentives for Sudan to improve the management of its forest estates. For REDD+, the MRV functions will focus on the estimation and international reporting of national-scale forest emissions and removals based on three main components, or 'pillars':

   - the satellite land monitoring system (SLMS);
   - the national forest inventory (NFI); and

- the national GHG inventory (GHG-I).

8. The SLMS and the NFI pillars will provide inputs into the GHG-I to support Sudan's obligations regarding the Enhanced Transparency Framework under the Paris Agreement. In accordance with the SNFMS, Sudan will progressively develop and operationalize these three pillars to align them with the monitoring function in order to achieve a fully functional NFMS.

Institutional Arrangements

9. This document outlines the institutional arrangements for the MRV systems. The first step is the development of a long-term vision and a strategic plan, with clear institutional mandates and specification of roles and effective coordination mechanisms. Thorough processes should be established for collecting, processing, reporting and verifying data based on methodologies and tools which recognize the need for adequate and sustainable human resource arrangements.

10. The RoS recognizes both the social and economic value of data and information for informing evidence-based policies. Over the long-term it is necessary to incrementally establish robust coordination mechanisms and facilitate user input in the collection of both spatial and non-spatial data in line with the custodianship framework. Therefore, a key initiative of the RoS is the development of a Spatial Information Framework (SIF) to support the way government administers and uses data and information. The Framework is a set of standards, policies, guidelines, and procedures, which are implemented either manually or, where possible, automated through technology. This will allow data and information to be managed in a secure, structured, and consistent manner. It will ensure data and information can be appropriately shared or re-used by agencies, individual public sector staff, the community, or industry. This will allow for better services, improved performance management and a more productive public sector.

Methodological Approach for Monitoring (M)

11. The land use and land cover monitoring in Sudan seeks to comprehensively assess deforestation and forest degradation at pre-determined intervals (five-year intervals depending on resource availability) using the countries adopted definition of forest described in this document. Remote sensing provides the most practical option for monitoring land cover change over large areas and enables the preparation of benchmark maps and subsequent time series datasets to support evidence-based policy decisions on land management practices. Remote sensing will be an integral part of the methodological approach to estimate carbon emissions.

12. As such, to generate activity data, Sudan will use remote sensing and a forest inventory and gradually develop country specific guidelines. Mapping of LULC and change detection using remote sensing and GIS techniques is a cost-effective method of obtaining a clear understanding of the land cover alteration processes due to land use change and their consequences. This will be complemented by accuracy assessment processes in line with UNFCCC good practice guidance.

13. The National Forest Inventory is designed for multipurpose use, including providing accurate input into a national GHG inventory, facilitating national communication of carbon emissions and removals from land use and supporting national programs to mitigate emissions including REDD+. The NFI is designed with a long-term perspective with the objective of carrying national re-measurements every five years.

Methodological Approach to Reporting (R)

14. Sudan recognizes the emerging global discussions following the adoption of the Paris Agreement in 2015 to establish an enhanced transparency framework (ETF). Like all Parties to the Paris Agreement, Sudan will work towards establishing the necessary arrangements to implement the ETF. This recognizes the expected transition from Reporting of Biennial Reports (BR) and Biennial Update Reports (BUR) to Biennial Transparency Reports (BTR), and that modalities, procedures and guidelines (MPG) will supersede reporting of BRs and BURs and the international assessment and review (IAR) and international consultation and analysis (ICA) processes for Paris Agreement Parties as per decision 1/CP.24, para. 39. It is further noted that the final BURs by developing countries shall be those that are submitted no later than 31 December 2024 (1/CP.24, para. 38). This implies that Sudan must submit its final BUR prior to 2024. Sudan will follow the principles in line with IPCC GPG relating to *Transparency, Completeness, Consistency, Comparability and Accuracy*.

Methodological Approach to Verification (V)

15. According to the GPG-LULUCF (IPCC, 2003), the "purpose of verifying national GHG inventories is to establish their reliability and to check the accuracy of the reported numbers by independent means. Sudan will therefore perform verification at several levels: project, national and international." The IPCC has also stipulated that the overall goals of verification are to provide inputs to improve GHG inventories, build confidence on estimates and trends, and to help to improve scientific understanding. Sudan will achieve these goals through internal and external checks as follows:

- **Internal checks**, which are performed by the organizations, agencies or individuals responsible for the compilation of the inventory; and
- **External checks**, which are performed by other bodies not directly involved with the preparation of the GHG inventory (e.g., other government agencies, private companies, research institutions, independent scientists, non-governmental organizations).

Documents Structure

16. This document is divided into four parts. Part I outlines the background and context to the forestry sector, the purpose of the NFMS and guiding principles for Sudan's REDD+ MRV framework. Part II outlines the institutional arrangements and roles and responsibilities. A spatial information management framework is also outlined in Part II including definitions of data custodianship and accessibility. Part III and IV cover the key components of the monitoring, reporting, and verification methodological approach that Sudan follows. The satellite land monitoring system, national forest inventory, greenhouse gas inventory reporting and policy monitoring are described in more detail in these sections.

PART I: NFMS BACKGROUND, PURPOSE, SCOPE AND STRUCTURE

1.1 Background

17. The area of the Republic of Sudan (RoS) decreased from 2.5 million km² to 1.88 million km² after the cessation of South Sudan (SS). Out of this remaining area 50.7% is bare rocks and soil and/or other unconsolidated materials (BS). The remaining area consists of agriculture (AG, 12.6%); trees close-to-sparse in terrestrial and aquatic/ regularly flooded land (TCO, 10.0%); shrubs close-to-sparse in terrestrial and aquatic/ regularly flooded land (SCO, 11.8%); herbaceous close-to-sparse in terrestrial and aquatic/ regularly flooded land (HCO, 13.8%); urban areas (URB, 0.4%); and seasonal/perennial, natural/ artificial waterbodies (WAT, 0.7%). Forest/Rangeland area, which is represented by TCO, SCO and HCO amounts to 35.6% of the present-day area of Sudan, or 669,472 km²,

18. Forest cover has declined considerably and stands at approximately 19.2 million ha according to the Forest Resources Assessment (FRA 2015). This is just over 10% with an estimated annual rate of deforestation of about 542,000 ha, or about 2.4% placing Sudan among ten countries with the highest deforestation rates (FAO FRA, 2015).

19. In RoS, forests play a significant role in integrated land use systems in the sense of socio-economic development and environmental protection functions, in addition to provision of the needs of local community livelihoods. Of the total population (33.4 million) 77% is rural and nomadic and considered as forest-dependent for livelihoods, wood energy and on round timber for construction. The forestry sector contribution to GDP is in the range of 3-4%.

20. Globally, deforestation contributes between 17% and 20% to the global greenhouse gas (GHG) emissions (IPCC, 2007). The 2015 Paris Agreement aims to strengthen the global response to the threat of climate change by keeping the global temperature rise during this century to well below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives. The Agreement also provides for enhanced transparency of action and support through a more robust transparency framework.

21. Under the United Nations Framework Convention on Climate Change (UNFCCC), the Reduced Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+) has been designed to provide incentives for developing countries to improve the management of their forest estates.

22. To meet international reporting obligations, countries are expected to establish national forest monitoring systems (NFMS). The NFMS allows compliance with the REDD+ requirements and can serve simultaneous functions: a 'monitoring' function and a 'Measurement, Reporting and Verification (MRV)' function. This document

outlines how the RoS will implement an MRV system for REDD+ in line with international best practices and guidance. The evolution of the Sudan National Forest Monitoring System (SNFMS) is based on an action plan developed in 2019, with technical support from the Food and Agriculture Organization (FAO).

23. The existing framework for MRV under the UNFCCC for developing country Parties consists of several elements, which have been put in place gradually through a set of decisions by the Conference of the Parties (COP) over the period of 2004–2013. Some of these elements are implemented at the international level and others at the national level. At the international level, the MRV framework for non-Annex I Parties includes:

- Guidance on reporting through national communications and Biennial Update Reports (BURs);
- Guidance on setting up domestic MRV frameworks;
- A process for consideration of information submitted by non-Annex I Parties in their BURs through International Consultation and Analysis; and
- For those non-Annex I Parties that voluntarily implement REDD+ activities and wish to take the opportunity of a results-based payment, international guidance on MRV for REDD+ activities apply.

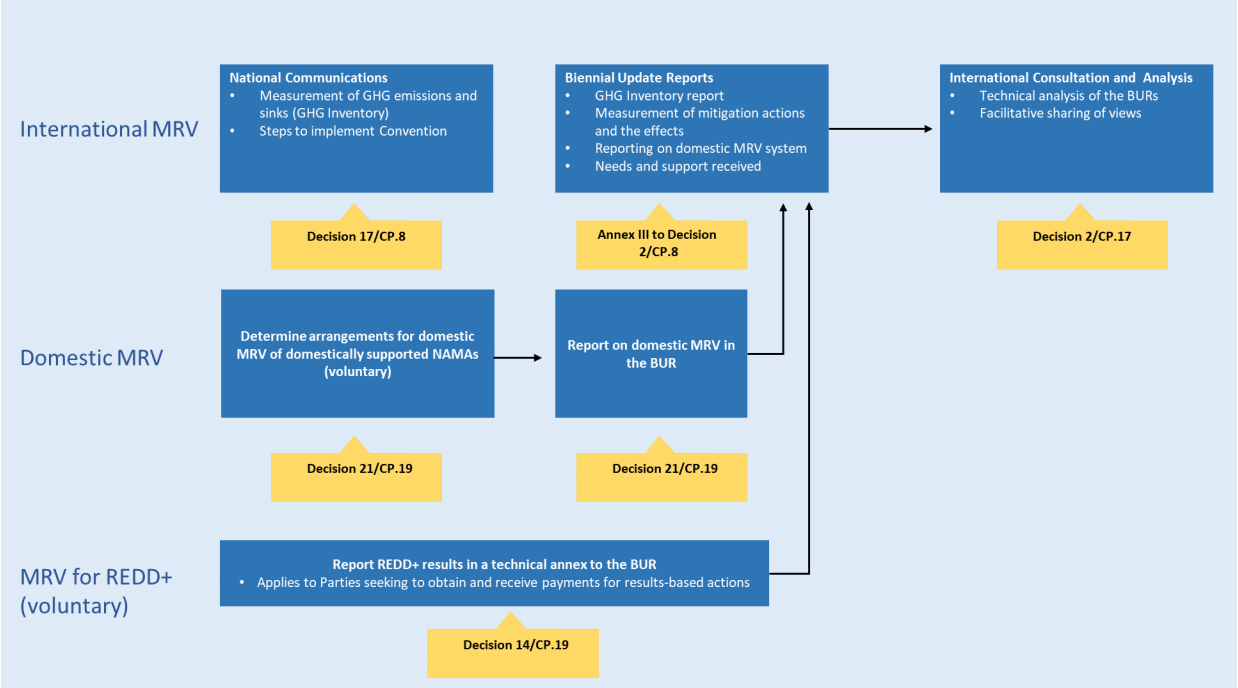
24. In line with this guidance, Sudan implements its domestic MRV frameworks and prepares and reports information according to the guidance on reporting through national communications and BURs, including information on GHG emissions and removals by sinks, mitigation actions and their effects, and support needed and received. Under the UNFCCC, MRV is a national level activity that is broader and more encompassing than just REDD+. In its simplest terms for a non-Annex I Party such as Sudan, MRV involves the following aspects:

25. **Measurement (M)** applies both to efforts to address climate change and to the impacts of these efforts. It occurs at the national level and refers to GHG emissions, mitigation actions and their effects, and the support needed and received. Measurement is therefore the process of estimating GHG emissions and removals and applies to national GHG inventories (NGGI) and to mitigation actions- REDD+ and Nationally Appropriate Mitigation Actions (NAMAs); It should be noted that the Sudan REDD+ Program of work is not separate from the NGGI; rather is it a component of the NGGI.

26. **Reporting (R)** is implemented through the National Communications and Biennial Update Reports (BURs), where Parties report on their actions to address climate change in their national communications. Reporting is where the 'Measurement' of greenhouse gas emissions is reported and is at present the National Communication and BURs (REDD+ and NAMAs are reported as part of the BUR);

27. **Verification (V)** is addressed at the international level, through the International Consultation and Analysis (ICA) of BURs; Verification can also occur at the national level but is voluntary.

Figure 2-1 Key elements of the National MRV Framework



1.2 Purpose

28. This document outlines the methodological approaches that the RoS will follow to implement its MRV system for REDD+. The RoS seeks to ensure that the SNFMS generally supports cross-sectoral evidence-based policy formulation, achieves consistency with international guidance such as the Warsaw Framework for REDD+ and supports international reporting obligations.

29. The RoS is signatory to a wide range of international, agreements, conventions and commitments including but not limited to the UNFCCC, United Nations Convention to Combat Desertification, Convention on Biological Diversity (CBD) and the Paris Agreement. The forestry sector has an important role to play in the economic development of Sudan. A range of national policies and legislation are in place and will continue to evolve over time in efforts to build a strong forestry sector, reduce deforestation and forest degradation and improve the livelihoods of forest and rangeland dependent communities. Some of the important policy and legislative instruments are listed Table 2-1. Effective implementation of these policies and legislative instruments requires robust, current and accurate sectoral data and information. The SNFMS will be implemented to support both federal and state institutions in effectively contributing to national economic development priorities and safeguarding of the country´s natural resources.

30. Sudan will transition through the three phases of REDD+ (Figure 2-2). For each phase, different capacities are required as outlined in the SNFMS Action Plan (SNFMS-AP).

Figure 2-2 REDD+ Phases

31. Out of necessity, roles and responsibilities to perform the monitoring and MRV functions of the SNFMS need to be clearly defined. The monitoring function will allow Sudan to assess its forest Policies and Measures (PAMs) including those specifically related to REDD+, focusing on national, regional and state level data and information on forests, their condition, uses and values to support forest-related decision-making at international, national, regional and state level by providing timely, relevant and reliable information.

32. The MRV Function will enable Sudan to ensure the establishment of a comprehensive process that will systematically collect, analyze, interpret, report and disseminate the national, regional and state level forestry and biodiversity related data. It will further derive the information and knowledge at regular intervals to allow the monitoring of forest changes, as well as forest related GHG emissions and removals over time through well-established LMS, NFI and GHG-I, and also enable monitoring of the effectiveness of national forest policies and other regulatory instruments.

33. An important consideration in MRV is the trade-off between the cost versus the accuracy of monitoring and evaluation systems for REDD+. Sudan seeks to identify cost-effective solutions, based on remote sensing and ground-based measurements. Remote sensing imagery and products, for example, aid in the design of efficient ground sampling schemes, in the assessment of change areas, and in the extrapolation of plot measurements to the federal or state level. Conversely, ground-based measurements are required for generating carbon data and to verify desktop forest mapping from remote sensing imagery.

Table 2-1 Environment Strategies, legislative instruments, conventions, and treaties ratified by RoS

#	Title	Date
	National strategies and legislations	
1	Environment Protection Act	2001
	Wildlife and Protected area Act	1986
	Forests and Renewable Natural Resources Act	2002
2	Sudan Interim National Constitution	2005
3	RoS Draft Forest Policy Statement	2006
4	25-Year National Development Strategy	2007-2031
5	Investment Act	2013
6	Sudan National Agricultural Investment Programme (NAIP)	2015-2020
7	Range and Pasture Act	2015
8	National Bio-safety Law No (15)	2015
9	Interim Poverty Reduction Strategy	2016
10	Utilization of Minerals Regulation	2016
11	Development of Mineral Resources Law	2017

12	Manual of Terms and Conditions for Environment Safety and Occupational Health in Minerals Sector	2017
13	Manual of Terms and Conditions for Safety and Occupational Health in Traditional Mining Sector	2017
14	Social Corporate Responsibility in Minerals Sector	2017
15	RoS's National Permanent Constitution under formulation	2018
16	Land tenure laws and policies	
	Sub-national Legislations	
1	Gadaref State Law for Protection and Promotion of the Environment	2007
2	Khartoum State Law for Protection and Promotion of the Environment	2008-2010
3	North Darfur State Environmental Protection Act	2009
4	North Darfur State Land Use Act	2009
5	North Darfur State Desertification Control Act	2012
6	North Darfur State Tree-belts and Wind Breakers Act	2013
7	North Kordofan State Law of Protection and Promotion of the Urban Environment No. (17)	2016
8	Blue Nile State Law requiring farmers to plant trees on 10% of rainfed agricultural land and 5% of irrigated land in line with the provisions of the Federal law	2018
	Regional and international conventions and treaties ratified by RoS	
1	The Statement of Forest Principles of Agenda 21	1992
2	Criteria and Indicators for SFM	2001
3	New Partnership for Africa's Development (NEPAD)	2001
4	Comprehensive African Agricultural Development Programme (CAADP)	2003
5	United Nations Convention to Combat Desertification (UNCCD)	1992
6	United Nations Framework Convention on Climate Change (UNFCCC)	1993
7	New UNCCD	2018-2030
8	UN Convention on Biological Diversity (CBD)	1992
9	Kyoto Protocol	1997
10	Paris Agreement	2017

1.3 SNFMS MRV Scope, Objectives, and Structure

1.3.1 Scope

34. The scope of the SNFMS and MRV system is national. Under the UNFCCC, REDD+ has been designed to provide incentives for developing countries to improve the management of their forest estates. REDD+ covers five activities, operationalized during the 16th Conference of the Parties (COP) to the UNFCCC in Cancun, Mexico, in Decision 1/CP.16, paragraph 70:

- Reducing emissions from deforestation;
- Reducing emissions from forest degradation;
- Conservation of forest carbon stocks;
- Sustainable management of forests; and

- Enhancement of forest carbon stocks.

35. The SNFMS will provide the necessary monitoring and MRV functions. The monitoring function of the SNFMS is primarily a domestic tool to allow assessment of a broad range of forest information, including REDD+ activities. The monitoring function will be implemented through a variety of methods and will serve a number of different purposes, including supporting evidence-based policy for key sectors of the economy including forestry and agriculture, where drivers of deforestation and forest degradation originate. The monitoring function focuses on the impacts and outcomes of the National REDD+ Strategy (NRS) Policies and Measures (PAMs) but may also include the impact of adaptation measures that directly or indirectly support emission reductions.

36. For REDD+, the MRV functions will focus on the estimation and international reporting of national-scale forest emissions and removals based on three main components, or 'pillars':

    i. the satellite land monitoring system (SLMS);

    ii. the national forest inventory (NFI); and

    iii. the national GHG inventory (GHG-I).

37. The SLMS and the NFI pillars will provide inputs into the GHG-I – the forest sector component of the national GHG inventory. In accordance with the SNFMS-AP, Sudan will progressively develop and operationalize these three pillars to align them with the monitoring function in order to achieve a fully functional NFMS.

1.3.2 SNFMS Objectives

38. The goal of the SNFMS is to generate consistent and reliable data as well as periodic information to provide strategic planning, supported by adequate budget, to facilitate development and ongoing monitoring, measurement, reporting and verification requirements of Sudan's REDD+ program. The SNFMS will integrate the various flows of information to produce the REDD+ reports that go into the Biennial Update Report (BUR). The SNFMS is designed with a broad multi-purpose framework to go beyond the measurement of forest carbon but include information on other parameters such as forest health, biodiversity, socio-economic and environmental functions of forests and legal frameworks.

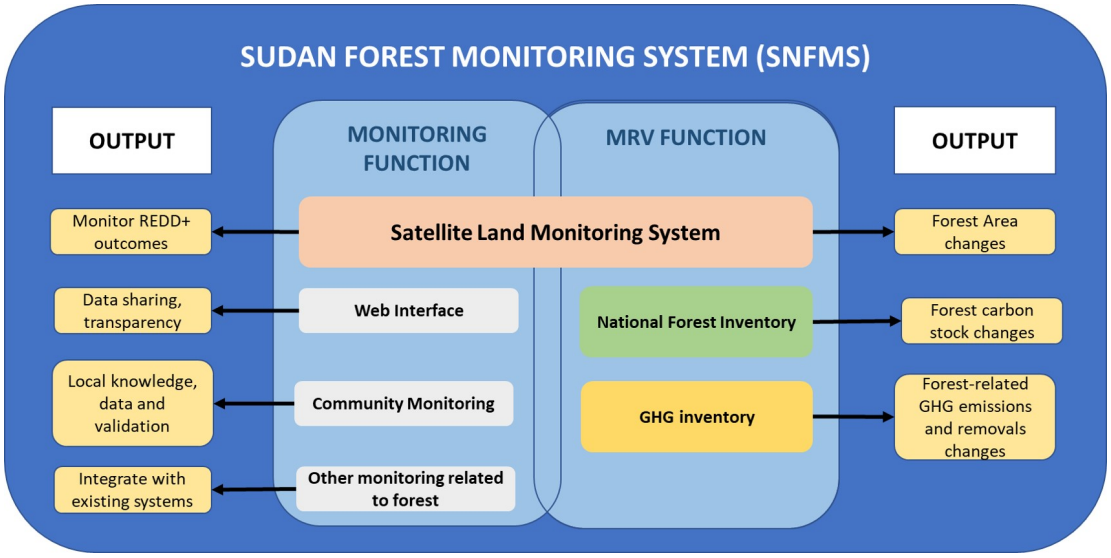
Table 2-2 SNFMS Objectives

Objective	Description
Objective 1	To adopt and implement a sustainable and participatory network of institutions with a necessary range of expertise and clearly documented roles and responsibilities to establish SNFMS.
Objective 2	To develop a transparent and integrated NFMS with complete separate functions of National Forest Inventory, the Land Monitoring System and Green House Gas Inventory in order to estimate GHG emissions and removals from the forestry sector through creation of consistent time series of forest cover, and periodically assess on-thd-ground conditions of all forest resources in Sudan (MRV Function).
Objective 3	To implement COP's decisions related to the establishment of robust and transparent NFMS for REDD+ and IPCC's guidelines for GHG Inventory of LULUCF sector.
Objective 4	To establish a central REDD+ Project Registry (RPR) as a database and archiving system including the provision of information on REDD+ Safeguards.
Objective 5:	To develop a national forest and land use web portal for ensuring transparency, accessibility and quality of information related to Sudan's LULUCF sector.

1.3.3 SNFMS Structure

39. This structure is informed by the SNFMS-AP. The Sudan REDD+ MRV system is a set of institutional arrangements (the people and organizations) and a technical system that supports all three elements of MRV: it provides the Measurement of emissions estimates (e.g., the National Forest Monitoring System emissions estimates under REDD+); it provides the estimates as outputs that can be used for Reporting; and, it provides the expertise, archiving, and information sources to support Verification (Figure 2-2). This structure allows the MRV system to be multifunctional and scalable to link to other existing systems thereby potentially avoiding duplication.

Figure 2-3 SNFMS Structure



1.4 Guiding Principles

40. The RoS MRV system is guided by the objectives of the SNFMS. Specifically, in accordance with Decisions 4/CP.15 and 11/CP.9 the SNFMS uses a combination of remote sensing and field-based forest carbon inventory approaches for the estimation of anthropogenic forest-related GHG emissions by sources and removals by sinks, forest carbon stocks and forest area changes. The RoS SNFMS is also designed to include national systems for the provision of information on how safeguards (see decision 1/CP.16, appendix I) are addressed and respected.

41. The MRV system is based on national capabilities and capacities and guided by the Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF) ensuring it provides data and information that are transparent, consistent over time and are suitable for MRV, as a result of the implementation of REDD+ activities. In line with the SNFMS, the MRV system:

- Builds upon existing systems;
- Enables the assessment of different types of forest in the country, including natural forest, as defined by the RoS;
- Is flexible and allows for improvement; and
- Reflects the phased approach for the implementation of REDD+ activities.

1.4.1 UNFCCC decisions and requirements

42. Sudan´s approach to estimation and reporting of REDD+ activities is influenced by UNFCCC COP decisions, GHGI methods produced by the IPCC and national circumstances, including those related to the SNFMS and forest definitions. As part of the UNFCCC Warsaw Framework for REDD+, decision 14/CP.19, sets out MRV modalities as they apply to REDD+. Decision 14/CP.19 recalls previous decision 4/CP.15, which amongst other things requests Parties to use:

- the most recent guidance of the IPCC, as adopted or encouraged by the Conference of Parties; and
- as appropriate, as a basis for estimating anthropogenic emissions and removals associated with REDD+ activities, a combination of remote-sensing and ground-based data.

43. Decision 14/CP.19 recognizes the need to develop capacity: that data and information used by Parties to estimate anthropogenic emissions and removals associated with REDD+ activities need to be transparent, consistent over time, and consistent with the Forest Reference Emission Levels and Forest Reference Levels submitted by Parties under another decision, 12/CP.17. Decision 14/CP.19 encourages improvements of data and methodologies, maintaining consistency with FRELs and FRLs. Parties seeking results-based payments for REDD+ activities are requested to provide a technical annex to their biennial update reports (BUR). This annex is to include:

- information on FRELs and FRLs;
- the results of the implementation of the REDD+ activities expressed in tons of carbon dioxide equivalent per year (tCO2eq/yr.);

- demonstration of consistency between results and FRELs and FRLs;
- information that allows recalculation of results; and
- a description of the NFMS

44. Sudan is cognizant of the critical issues in the UNFCCC negotiations on REDD+ concerning the geographical scale that should be used to account for emissions. Given, the commitments by the RoS under the Paris Agreement, Sudan will account for emissions at the national level across all sectors but, a stepwise process will be used in line with available operational and financial capacity for the national; sub-national, jurisdictional and project-level. Sudan will consider accounting at both national and sub-national levels following a "nested approach," where project-level and/or sub-national programs are integrated into national-level accounting. This integration will occur in stages (e.g., starting with sub-national accounting and moving up to national) or once the national accounting is in place. National-level accounting will provide a complete picture of how projects, policies and measures are contributing to the country's progress in reducing emissions.

45. With this approach, Sudan will follow guidance and agreements reached at the 17th session of the Conference of the Parties (COP17), where parties agreed that if the overall performance is measured at the national level, countries could still pursue project-level activities after the adoption of national (and potentially sub-national) reference levels (UNFCCC, 2011). For countries that wish to establish both national and sub-national accounting systems, it is important to ensure that the two systems are compatible in order to safeguard the integrity of the overall accounting process. This can be achieved through:

    - Identifying drivers of deforestation and forest degradation at the national and sub-national levels;
    - Establishing a clear legal, regulatory and accounting framework regarding the implementation of sub-national or project activities;
    - Identifying synergies between national and sub-national REDD+ activities; and
    - Ensuring the consistent use of definitions of forest parameters.

46. This approach forms the basis for determining the baseline for the Sudan, referred to as the Forest Reference Emission Levels (FREL). FREL refers to the emissions from deforestation and forest degradation, while the Forest Reference Level (FRL) also encompasses removals associated with forest enhancements. The FREL covers a historical period, often 10-15 years, to form the baseline. These two concepts form the basis against which all future emission scenarios will be assessed. The FREL relates directly to both the MRV and NFMS for a country; in that the methods and approaches for the FREL/FRL must be consistent with the NFMS and MRV. A framework for Sudan's National Forest Monitoring System (SNFMS) is already provided in the Sudan's R-PP document.

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1.4.2 IPCC Good Practice Guidance

47. The RoS REDD+ MRV system is further guided by the documents and the methodological guidance published by the IPPCC to which all countries have agreed to use in estimating GHG-I for reporting to the UNFCCC and the Kyoto Protocol. Table

2-1 summarizes the methodological guidance introduced by IPCC since 1996, covering all sectors, including those related to land use.

Table 2-3 Versions of IPCC guidance

IPCC Guidance Document	Description
1996 Revised IPCC Guidelines for National Greenhouse Gas Inventories (96GL) (Refined 2019)	First guidelines agreed for use under the UNFCCC.
2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (GPG2000)	Provides good practice guidance in implementing the 1996 Revised Guidelines. Covers all sectors except land use, land-use change and forestry. Introduces the definition of *good practice* – retained by all subsequent guidance and guidelines.
2003 Good Practice Guidance for land use, land- use change and forestry (GPG2003)	Extends good practice guidance to include land use, land-use change and forestry.
2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006GL)	Consolidates and updates previous guidance. Uses the same methodological framework as GPG2003. Combines agriculture and land use into a single sector (Agriculture, Forestry, and Other Land Uses or AFOLU).
2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands	Fills gaps and extends the 2006GL and updates emission/removal factors, including on wetlands and drained soils.
2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol	Provides guidance in support of the LULUCF accounting rules agreed for LULUCF for the second commitment period of the KP.

2. SUDAN FOREST MONITORING SYSTEM CONTEXT

48. Forest development in Sudan commenced at the beginning of the 20th Century. Since then, several important changes have occurred. These changes, legal and constitutional in nature, have introduced wide-ranging changes in forest management (FNC, 1989). Forests contribute about 12% (FAO, 2006) of the gross domestic product (GDP) through fuel wood, construction poles, charcoal, timber, food, gums, fodder, and native medicines. Contribution of the entire forestry sector is under-estimated as the formal national accounts reveal an under-estimation of the forestry sector to the GDP in the range of 3%. This contribution is primarily accounted from annual exports of gum Arabic, and from numerous direct and indirect benefits such as environmental protection, soil amelioration, and work opportunities for rural populations, building material and wood fuel.

49. Of the total population, almost 70% of rural and nomadic peoples are considered to be forest-dependent for livelihood, wood energy and on round timber for buildings. 66% of the rural population uses wood as the main source of fuel for cooking and as construction material. The industrial sector typically accounts for less than 10% of the total wood consumption, out of which, over 98% is consumed as firewood at industrial and commercial facilities with the remainder taken up by brick kilns, the lime industry, sawmills, and other wood-based industries in the country.

50. Historical per capita consumption of fuel wood was estimated to be 0.7 m^3/annum which, when converted into Ton/Oil Equivalent (TOE), could be valued at nearly 2.0 Billion United States dollars (USD). Moreover, Non-Woody Forest Products (NWFPs) are diverse and have substantial contribution to the livelihood at the household level and at the national economy. The revenue from the annual export of Gum Arabic makes up 2.4% of total non-oil exports and 0.7% of total exports.

51. Forests generate income for the government at both federal, state and local levels as well as for households and the private sector. Some of the income from direct sales of wood products such as fuel wood, construction timber and sawn timber are generally under the control of the government. There is also a diverse range of NWFPs that constitute potential sources for industrial development for local use and for export. Cottage industries could make up to 20-50% of rural household income, amounting to some USD 1 billion a year. Traditional cottage industry supplies the market with many products that are attractive to tourists.

52. Key statutory documents include the Wood and Forest Ordinance of 1901, The Forest Ordinance of 1908, Forest Conservation Rules of 1917, and the Forest Acts and Forest Policies of 1932. The statutes of 1932 have undergone continuous change by the development of the Forest Policy of 1986, Forest Legislation of 1989, and various ministerial decrees. The Forest and Renewable Natural Resources Act 2002is particularly notable in its call for the active participation of community and private sectors in forestry development and management. This legislation is widely perceived to have resulted in improved forest management practices, as well as increased levels of forest reserves and protected areas.

53. Forests are typically classified in Sudan as either natural or plantation forests. They are further distinguished by ownership, whether governmental, institutional, communal, or private sector. At the state and national levels, forest management is entrusted to various institutions, agencies and community sectors that support and/or benefit from forest products and services, (under the overall technical guidance of FNC as

stipulated under the Forest Act 2002). These institutions hold important roles and responsibilities of ensuring forests, under their jurisdiction, are able to benefit the country in terms of sustainable production levels and environmental protection. However, the lack of integrated land use plans and coordination across institutions has resulted in uncontrolled land use changes and conversion of vast forest tracts into agricultural areas over the past 40 years.

54. The SNFMS builds upon existing systems at Federal and State levels to enable the assessment of different types of forest with scope for improvement in line with the gradual implementation of REDD+ activities.

55. Well-established arrangements that can deliver the MRV functions of a NFMS, and are consistent with the above requirements, can strengthen the design and evaluation of policies and actions, consistent with sound forest policy and governance. This will increase transparency in GHG reporting, facilitate financing, and lead to the quantification and reporting of mitigation actions in terms of emissions reductions and potentially other non-GHG impacts.

2.1 Forest Area

56. Currently, forests cover 10.66% of the total area of the country, although the Quarter Century Strategy (2003–2027) intended to have 25% of the total area to be assigned for natural resources (Table 2-1).

Table 2-1 Sudan´s Land Cover Classes (2012)

Land Cover Class	Area (ha)	%
Agriculture in terrestrial and aquatic/regularly flooded land	23,710,025	12.6
Trees closed-to-sparse in terrestrial and aquatic/ regularly flooded land	18,733,182	10.0
Shrubs closed-to-sparse in terrestrial and aquatic/ regularly flooded land	22,231,327	11.8
Herbaceous closed-to-sparse in terrestrial and aquatic/ regularly flooded land	25,982,720	13.8
Urban areas	730,331	0.4
Bare Rocks and Soil and/or Other Unconsolidated Material(s)	95,277,727	50.7
Seasonal/perennial, natural/ artificial water bodies	1,290,000	0.7
Total Sudan area #	187,955,312	100.0

57. The total reserved area was 12.3 million ha by the end of 2012 consisting of public, institutional, community, private and wildlife protected areas and national parks. All reserved forests (public, community, private) represent 4.54% while protected areas (including wildlife protected areas) constitute about 7.12% of the total area of the country. The increase in public reserved forest area from 1.25 million ha in 1993, to approximately 12.3 million ha by the end of 2012 can be attributed to the Presidential Decree in 1993 and the community and private forest reservation which started in mid-1980s.

2.2 Biodiversity

58. Approximately 39% of Sudan is desert with another 26% being semi-desert. However, Sudan is still endowed with a wide range of ecosystems and species diversity that need ongoing monitoring, measurement and reporting under the CBD. There are some 184 species of trees and shrubs including 33 exotics, together with a few endemic and near endemic species. Special areas with a wealth of rare species are found along the Red Sea Coast. About 204 species were identified.

59. Most of the wildlife resources of the country are found within the High Rainfall Wood Savannas, while wetlands on the Red Sea Coast, desert oases, dams, reservoirs and in-land lakes are important habitats for resident and migratory birds. The River Nile and the Red Sea Coast are part of the fly over for soaring and migratory birds from Eurasia to Africa. There are remnants of mangroves, sea grass beds, and associated marine fisheries and biodiversity including sharks, dugongs, turtles, and variety of sea birds. The RoS established two protected areas (Sanganeb and Dongonab-Mukawar Island) with good representation of the Red Sea marine ecosystems.

60. Dungonab Bay and Mukawwar Island are turtle nesting sites and are recognized as internationally Important Bird Area. The Dugong population may be the most important remaining on the coast of Africa. The REDD+ will build and support established regional action plans (following regional surveys) already developed for corals, mangroves, turtles and breeding seabirds that are being implemented nationally.

2.3 REDD+ Context

61. The RoS has prepared a NRS[1], which has a vision to synergize with and contribute effectively to the National Development Strategy that aims to achieve a green prosperous country by 2030, while maximizing carbon and non-carbon benefits through improved sustainable natural resources management (SNRM).

62. The mission of the NRS is to:

- Reduce GHG emissions and increase carbon stocks in the forest sector by implementing policies, laws and regulations, and increasing investments to enhance conservation of forest resources and promote sustainable forest and rangeland management and restoration.
- Improve the functioning and capacity of national and sub-national institutions and actors in order to enhance the contributions of forests and rangeland ecosystem goods and services to the economy of the country and the wellbeing of the general population.

63. The primary goal of the NRS is to reduce deforestation and forest degradation, while promoting sustainable forest management (SFM), forest conservation and enhancing forest carbon stocks through afforestation and reforestation. The RoS REDD+ program broadly targets drivers of deforestation, forest and rangeland degradation and brings a significant part of the country's degraded lands, under forest and range cover, through forest and range restoration, afforestation, reforestation and range enrichment activities. The strategy focuses on promoting conservation and restoration of forest ecosystems, rationalization of biomass energy consumption,

[1] Expected to be revised and updated in 2020

promoting renewable energy production and usage, strengthening governance and development of local capacities and, putting in place the enabling environment for SFM.

64. The NRS provides strategic guidance for the implementation of an effective and efficient national REDD+ program. The key focus areas include (i) strengthening institutions at all levels, (ii) improving legal and regulatory frameworks, (iii) promoting stakeholder's engagement and coordination and (iv) by implementing strategic investments for SFM and livelihoods.

65. With a timeframe of 11 years, the NRS will be implemented in phases, and is designed to realize the objectives of the forestry sector's potential contribution to climate change mitigation (50% of the total national emission reductions in 2030) in a realistic planning and implementing of REDD+ Emission Reduction Programs (ERPs). Although the NRS will eventually be implemented at the national scale, the RoS shall initially prioritize REDD+ ERPs for addressing deforestation in hotspot areas and restoration along natural forest areas. Accordingly, the strategic period for implementation of the planned activities is divided into short, medium and long-term phases.

66. **Phase I: Short-term implementation goals (2022-2026):** In the short term, the NRS focuses on preparing the national REDD+ ERPs, improving enabling conditions (forest policy and legislation, land tenure, governance, micro/macro zoning and land use planning, MRV, financing, forest extension and awareness, inter-sectoral coordination and institutional capacity) for REDD+ implementation, operationalizing the national forest monitoring system, mobilizing non-results-based investments, and designing and implementing prioritized REDD+ policies, actions and measures in order to achieve a 10% reduction in national deforestation rate, while consolidating experiences for forest and land restoration.

67. **Phase II: Medium-term implementation goals (2027-2031):** In the medium term, the NRS focuses on increased investments and scaling up REDD+ ERPs at the national scale and starts operationalizing results-based payments (RBP) at sub-national levels. The main target in this period is to bring net deforestation rate to 25% of 2018 levels.

68. **Phase III: Long-term implementation goals (2032-Beyond):** This phase rolls out REDD+ ERPs at full national scale and operationalize national RBPs. In this period, RoS's forests and land areas shall become a net carbon sink and address 50% of national emission reduction targets by 2030 compared to the 2018 level.

69. The SNFMS and MRV system are designed to support these by interleaving strategic investment, capacity building and institutional coordination with the NRS pillars and the stated strategy components (Figure 2-1 and Figure 2-2).

Figure 2-1 NRS Pillars

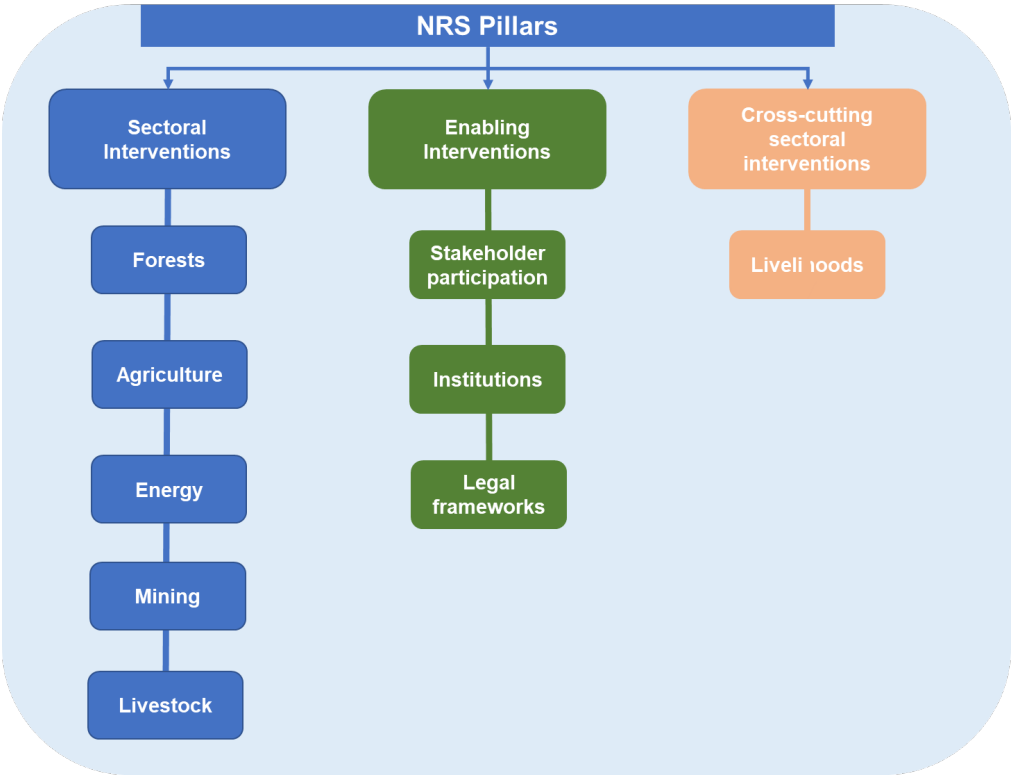
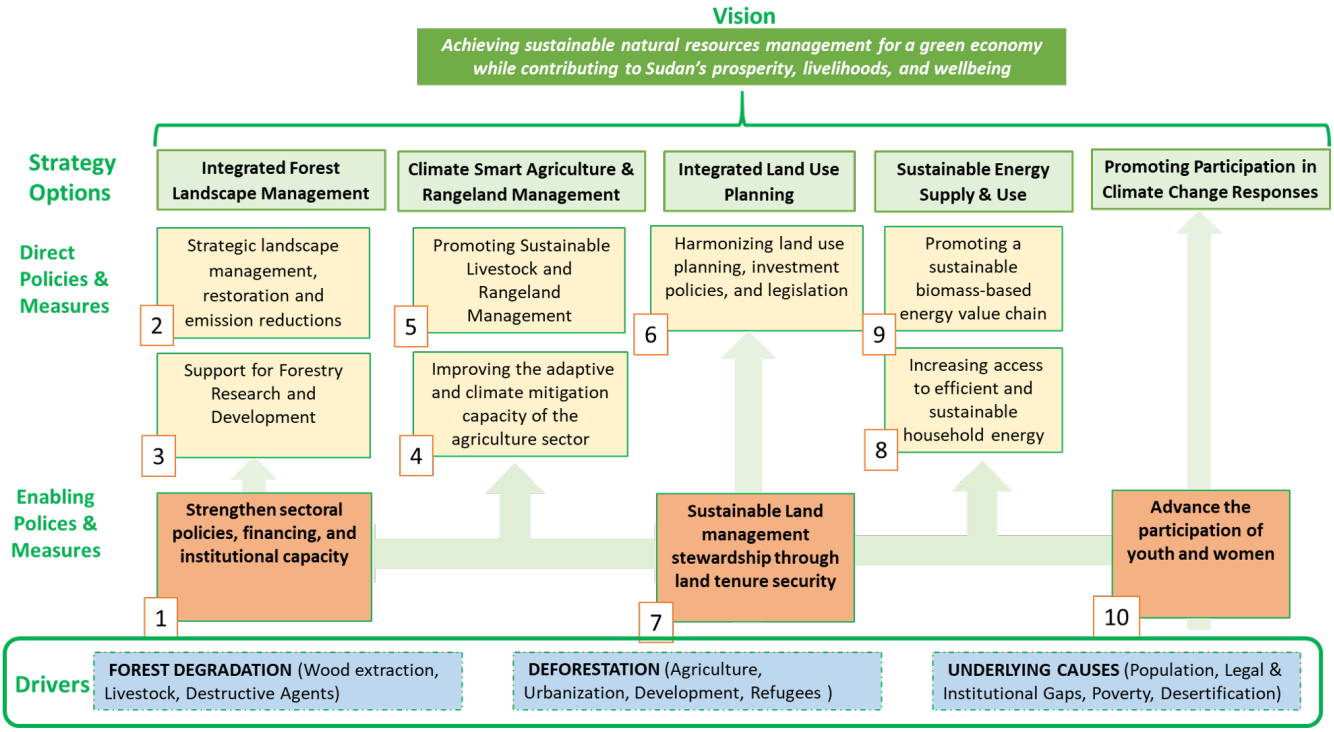


Figure 2-2 NRS Components



2.4 REDD+ Monitoring and Reporting

70. The RoS considers three options with regards to geographic scales. These include the national level; the sub-national, including jurisdictional and project-level; and both levels in a "nested approach." Taking note of agreements reached at 17th session of the Conference of the Parties (COP17), the RoS acknowledges that the overall REDD+ performance is measured at the national level, but will still pursue project-level activities after the adoption of national (and potentially sub-national) reference levels (UNFCCC, 2013). In this instance, Sudan initiated the development of the FREL, focusing on three states (Blue Nile, Sinnar and Gadarif). The RoS will ensure that the two systems are compatible in order to safeguard the integrity of the overall accounting process by:

- Identifying drivers of deforestation and forest degradation at the national and sub-national levels;
- Establishing a clear legal, regulatory and accounting framework regarding the implementation of sub-national or project activities;
- Identifying synergies between national and sub-national REDD+ activities; and
- Ensuring the consistent use of definitions of forest parameters.

Table 2-2 NFMS/MRV Relevance to the NRS objectives

	Actions	NFMS/MRV Relevance
1	Addressing policy, legal and institutional issues related to land use and tenure, together with forest governance to enable forest conservation and forest restoration.	Creating better understanding of interlinkages in drivers of deforestation, landscape governance and management.
2	Establishment of strong institutional mechanisms for an effective cross-sectoral coordination for the NRS implementation.	Supporting evidence-based policy formulation, spatial planning and reducing policy conflict.
3	Developing a robust and transparent approach and methodologies, consistent with international standards and procedures, for setting the baseline emissions and removals, and designing an effective monitoring, reporting and verification (MRV) system for determining verified emissions reductions and removals targeted to receive payments for performance.	Creating a robust framework for timely, transparent and complete reporting and monitoring policy impacts. The MRV is an important interlink for national GHG reporting.
4	Mobilizing resources (including non-results-based funding) and intensifying investments in forestry for increased emission reductions and carbon removals.	Having a clear MRV roadmap will enable strategic funding and resource mobilization.

5	Establishing and operationalizing a transparent REDD+ financial management mechanism and a fair benefit-sharing scheme.	A national benefit sharing framework needs to be backed by a robust MRV system to enable assessment of emission reductions potential and associated carbon revenue.
6	Identifying needs and taking appropriate measures for building national and sub-national capacity to support REDD+ activities of planning, implementation, monitoring and reporting at all levels.	Capacity building of local institutions needs to be complimented by adequate resourcing for data collection, management and dissemination.
7	Promotion of knowledge generation through education and research and strengthening public awareness, communication and information sharing on REDD+ issues to increase understanding and ownership of the program by various actors at different levels.	Having a robust NFMS MRV system will promote opportunities for strengthening research through better access to data and information.
8	Establishing mechanisms for active participation and engagement of a wide range of stakeholders including communities and the private sector in NRS formulation and implementation.	The NFMS and MRV System will allow effective stakeholder participation.
9	Implementing safeguards program for ensuring that RoS's REDD+ implementation observes globally acceptable social and environmental safeguard standards particularly the development of a benefit-sharing mechanism (BSM), consultation and participation plan and Grievance Redress Mechanism (GRM).	The NFMS and MRV system are important interlinks for monitoring effectiveness of REDD+ policies and measures and ensuring social and environmental safeguards are effectively implemented and monitored.

PART II: INSTITUTIONAL ARRANGEMENTS

3. INSTITUTIONAL ARRANGEMENTS FOR MRV

3.1 Relevant National Institutions

71. Land and forest management within Sudan is the responsibility of multiple Ministries and agencies, depending on the land cover specifications. These include:

- Higher Council for the Environment and Natural Resources
- Ministry of Agriculture and Forestry
- Ministry of Environment, Natural Resources and Physical Development
- Ministry of Animal Resources, Fisheries and Rangelands
- Ministry of Finance
- Ministry of High Education & Science Research
- The Remote Sensing and Seismology Authority
- Academia

72. **High Council for Environment and Natural Resources (HCENR).** HCENR was established in 1991 as the national body for policies and protection of the environment and natural resources.

73. The High Council for Environment and Natural Resources is hosted by the Ministry for Environment, National Resources and Urban Development. The Council consists of the Chair of the Council - the Minister of Environment - and the membership of ministers and heads of institutions of direct relevance, representatives of research and academic institutions and representatives of civil society organizations legal persons or experts in the field of the environment. The General Secretariat has technical capabilities in the areas of coordination and capacity building, studies, research, planning and implementation of projects.

74. The HCENR Secretariat includes a coordinating unit for international conventions, including the UNFCCC. Within this role, the HCENR is the focal point for the UNFCCC, and is responsible for submitting all reports to the UNFCCC, including the Biannual Update Reports (BURs), the National Communications, and the Technical description of the Forest Reference Emission Level (FREL) for review. The HCENR is not responsible for developing the technical description, as this is the responsibility of Forests National Corporation (FNC). Currently, the General Secretariat also coordinates the institutional linkage between the members of the Council from the institutions involved in the field of environmental issues at the state level. This resulted in many programs of action from joint work programs and projects being implemented in all states of Sudan.

75. **The Ministry of Agriculture and Forestry (MAF):** MAF is responsible for developing and implementing policies and programs related to mechanical and irrigated agriculture, as well as forest land. This responsibility extends to State-based activities. Land gazetted as "forest lands" is the responsibility of this Ministry, as is developing agricultural policies and natural resource policies. This includes developing and improving agricultural production to provide food security and modernize traditional agriculture, carrying out scientific and applied research in agriculture and natural resources, and supervising and investing in natural resources and follow up the implementation of laws that promote and protect forests.

76. **Forest National Corporation (FNC):** The FNC is a state-owned corporate institution, under the governance of MAF. Its role is to develop and implement forestry policies, rules, programs, and methods for ensuring sustainable use and development to ensure full protection of the environment. In this role, FNC is responsible for planning, research, technical supervision and raising awareness about forestry issues. Given the RoS ambition to increase the area of reserved forests to at least 20%, FNC is further responsible for afforestation and reforestation projects including developing gum Arabic and other non-wood forest products. Under the current institutional setting, FNC is responsible for the development and implementation of the REDD+ MRV system including collecting data and information relevant for the NGGI.

77. **Ministry of Environment, Natural Resources and Physical Planning (MENRPP):** The Ministry of Environment, National Resources and Urban Development, is responsible for environmental protection and urban development. The Ministry develops national maps of population and housing in accordance with the national strategy, and sorting of federal lands in accordance with the central legislation. The Ministry is also responsible for achieving balance between development while preserving the natural environment and biodiversity in accordance with Sudan's domestic and international obligations.

78. **Ministry of Animal Resources, Fisheries and Rangelands:** The Ministry of Animal Resources, Fisheries and Rangelands is responsible for national livestock production and improvements to support the country´s objective to achieve self-sufficiency, food security, and export. The functions and responsibilities of the Ministry include:

    - Developing policies and plans to maintain the development of the livestock sector within the framework of the State's public policies;
    - Developing veterinary extension programs and methods, developing veterinary services and improving animal health;
    - Developing animal production and raising the competitiveness of livestock and its products and production inputs in the markets regionally and globally;
    - To achieve integration in the production and exploitation of resources in coordination with other competent authorities;
    - Range and Pasture General Directorate (RPGD); and
    - According to, Constitutional Decree No (22) for 2010, RPGD was affiliated to Ministry of Livestock as General Directorate. It became one of the eight general administrations of the Ministry of Livestock, with 18 State RPA offices and 25 sub-offices in addition to 152 representatives all over Sudan who based at Locality or Administrative Unit.

79. RPGD is the sole institution responsible for improving rangeland management to meet the needs of the pastoral sector development and sustainability. The RPGD has many inter-ministerial relations developed among institutions through the involvement in the technical committees of funded projects and programs, interventions related to range resource - related conventions. This includes the development and implementation of the Rangelands Resource assessment.

80. Range and Pasture General Directorate Mandate:

81. A key task of public administration is to formulate policies and regulations that can protect pastures, plans and programs to improve and manage domain resources. The monitoring and assessment of the impacts of environmental changes on natural resources is also a priority, as well as the monitoring, evaluation and supervision of national scale management and improvement projects. The RPGD is also responsible for coordinating protection and improvement of natural resources, developing the pastoral sector, maintaining environmental balance, mitigating the effects of drought, and combating desert encroachments.

82. **Ministry of Finance:** The Ministry of Finance coordinates all funding that is to ultimately be provided to the Ministries. While there are options for funding for specific projects to be provided through the HCENR, as a body separate from the Ministries, funding dedicated to Ministries is required to go via the Ministry of Finance. In the context of the MRV system, funding will need to be earmarked for this purpose within the FNC budget and provided from the Ministry of Finance. To this end, to secure on-going funding from the national budget, the request would need to come from FNC.

83. **Ministry of High Education & Science Research:** The Ministry of Higher education plays a leading role in economic, social and cultural change through its impact on the individual and society. The main role of the Ministry to improve the quality of education, improve its outputs and build capacity in the education system to create competitive generations. Further, developing applied scientific research and publishing its results and contributing to the comprehensive development of the country. Also, the Ministry is responsible for responding to the needs of the labor market and community service and providing the necessary expertise in the fields of economic, social and cultural development and preserving its values. It aims to provide students with the necessary knowledge, skills and technologies to help them participate in the development of society and achieve their aspirations and develop universities to become centers of excellence in research and development, and the establishment of special units and centers of future studies in order to provide knowledge and applications to achieve economic and social development programs and projects.

84. **Remote Sensing and Seismology Authority (RSSA):** The RSSA was established in the late 70s and its role with respect to the SNFMS is to build strong knowledge in geoinformatics. RSSA staff play a multidisciplinary and specialist role in research, agriculture, forestry, environment, geology, disasters and hydrology. This includes implementation and application of remote sensing technology for natural resource management, climate change and disaster risk reduction. The RSSA operates as an autonomous institution. Its business model is based on engaging in projects on cost recovery basis. RSSA will play a continuous role in REDD+ by supporting MRV requirement such as the SLMS, FREL, and any other ad hoc projects requiring the application of geoinformatics. In this regard, RSSA will be the custodian and provide the dissemination of multiple datasets including satellite imagery and other derivative products. In addition, RSSA maintains an important role of identifying strategies for increasing application and use of geoinformatics, capacity-building and knowledge transfer and engagement with international remote sensing organizations.

3.2 MRV Institutional Roles and Responsibilities

85. Effective implementation of REDD+ activities requires sound institutional arrangements to support requirements for (i) implementation of the National REDD+

Strategy or Action Plan, (ii) preparation and continuous improvement of the national FREL/FRL, (iii) maintaining a robust and transparent SNFMS to meet MRV requirements for REDD+ and (iv) a system for providing information on safeguards. The first step is the development of a long-term vision and a strategic plan, with clear institutional mandates and specification of roles and effective coordination mechanisms. Thorough processes should be established for collecting, processing, reporting and verifying data, based on methodologies and tools which recognize the need for adequate and sustainable human resource arrangements.

86. In creating institutional arrangements to carry out the long-term vision and strategic plan, countries should build upon existing arrangements, such as those developed for greenhouse gas inventories (GHGI) that underpin National Communications. Building on and strengthening existing institutional arrangements in establishing a NFMS for REDD+ will reduce duplication of efforts and costs, facilitate use of official data sources, avoid institutional conflicts and help maximize co-benefits and consistency in reporting. As evident from their objectives and mandates, these Ministries detailed above all have links to environmental management and monitoring and could potentially benefit from the information that is gathered from the REDD+ MRV system. It is also expected that REDD+ will be coordinated and implemented by a wide range of Ministries directly and indirectly.

87. For the NFI, the key general functions of national inventory arrangements in Sudan are to ensure a single national-level entity has the overall responsibility for the inventory; and establishing and maintaining the institutional, legal and procedural arrangements between the government agencies and other entities involved in the preparation of emission and removal estimates from AFOLU. In doing so, there is a need to ensure enough capacity and technical competence of the staff involved in the inventory development process for:

- The timely collection of data needed to estimate anthropogenic GHG emissions by sources and removals by sinks; and
- The preparation of GHG inventories in accordance with the relevant UNFCCC reporting guidelines.

88. Specific functions of national inventory arrangements include collecting activity data (AD), selecting appropriate methods and emission factors (EFs), estimating anthropogenic GHG emissions by sources and removals by sinks, implementing uncertainty assessments and quality assurance/quality control (QA/QC) activities, and carrying out data verification procedures.

Table 3-1 Institutional roles and responsibility

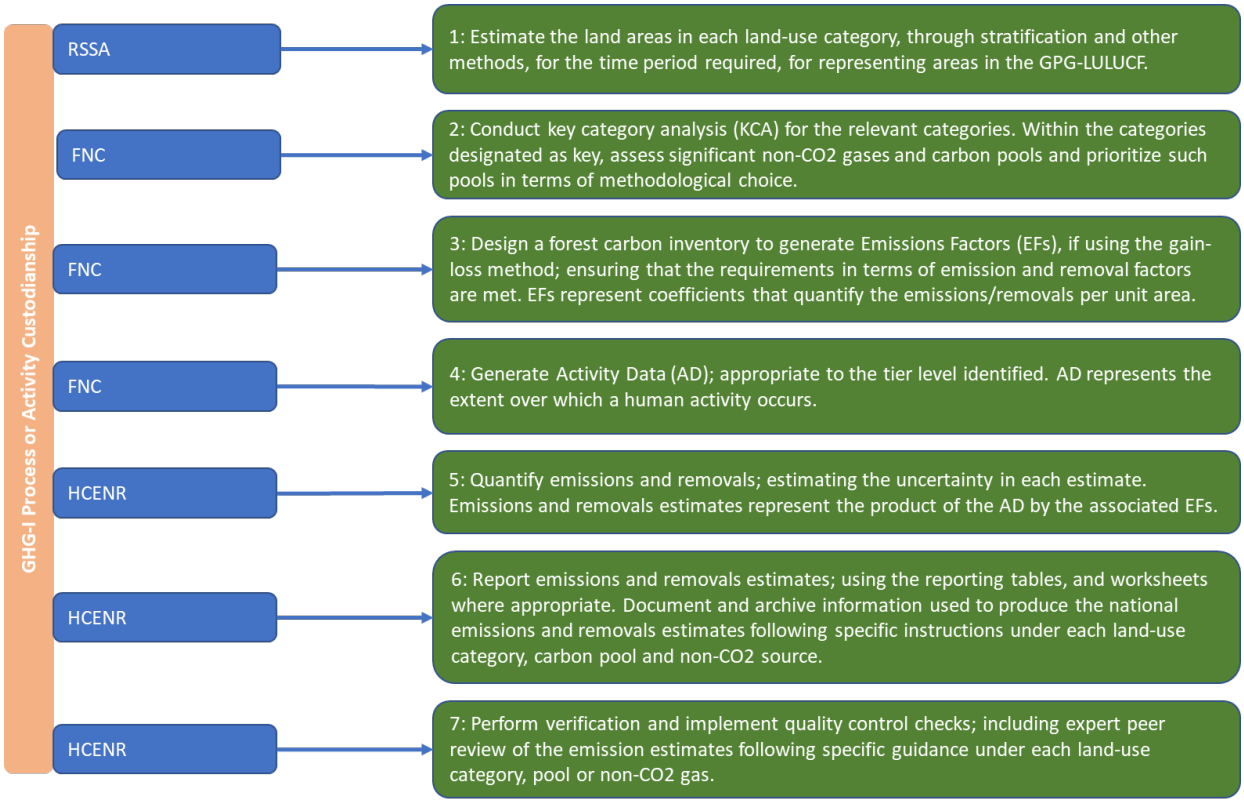
Institution	Role/Responsibility
Ministry of Agriculture and Forestry	• Developing and implementing policies and programs related to mechanized and traditional rain-fed agriculture, as well as forest land. • Developing agricultural policies and natural resource policies. • Developing and improving agricultural production to provide food security.

	• Carrying out scientific and applied research in agriculture and natural resources and supervising and investing in natural resources and following up the implementation of laws that promote and protect forests.
Forest National Corporation	• Developing and implementing public policies and making rules, methods and programmes for ensuring good use and forest development to ensure full protection of the environment. It also has the role of technical supervision of all forests in the country, raising awareness about forest issues and undertaking studies, assessments and management planning for all forests. • Implementing afforestation and reforestation programmes including developing gum Arabic and other non-wood forest products. • Implementing the policy objective of increasing the area of reserved forests to at least 20% of the country's area. • Development and implementation of the REDD+ MRV system. • FNC is also responsible for collecting information for the NGGI and providing this to the HCENR, although the team tasked with this is separate from the REDD+ MRV work.
The High Council for Environment and Natural Resources	• Developing public policies for environmental protection in coordination with the relevant Ministries. • Coordinating unit for international conventions, including the UNFCCC. • Focal point for the UNFCCC, is responsible for submitting all reports to the UNFCCC, including the Biannual Update Reports (BURs), the National Communications, and the technical description of the FREL/REL for review. • Coordination of national MRV.
The Ministry of Animal Resources, Fisheries and Rangelands	• Developing policies and plans to maintain the development of the livestock sector within the framework of the State's public policies. • Developing veterinary extension programs and methods, developing veterinary services and improving animal health. • Developing animal production and raising the competitiveness of livestock and its products and production inputs in the markets regionally and globally. • To achieve integration in the production and exploitation of resources in coordination with other competent authorities.
National Climate	• The NCCC is a permanent committee including members from relevant institutions to climate change such as Ministries of Agriculture, Animal

Change Committee (NCCC)	Wealth, Fisheries and Rangeland, Oil, Industry, Water Resources, Electricity and Dams, in addition to the Corporations and Companies that deals with waste management. The committee is chaired by the Secretary General of HCENR. This committee is responsible for approving progress reports, Annual Work Plans, annual progress reports and technical reports, with necessary clearance from UNDP-GEF Regional Technical Advisor (RTA). It also provides guidance for proper implementation of the project. Members of the committee include UNDP and representatives from all relevant institutions. All relevant Ministries, Universities, Research Institutions and Non-Governmental Organizations will take part of the project.

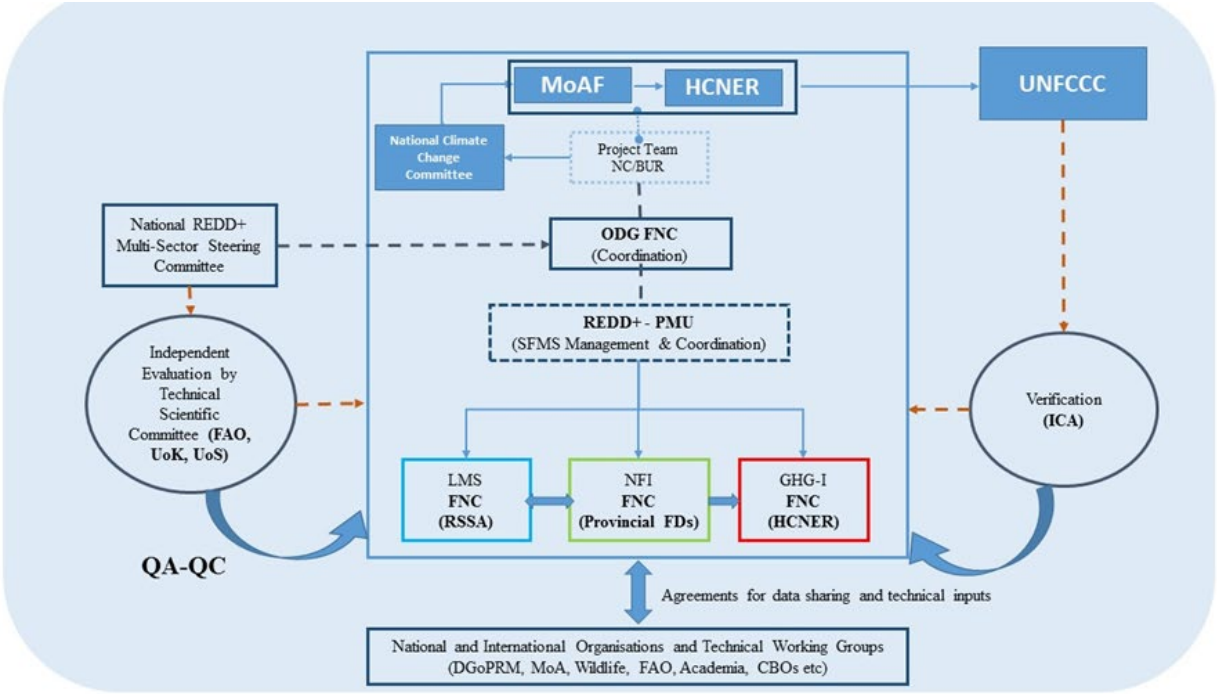
89. Figure 3-1 outlines the sequence of steps required for generating the Sudan national GHG-I and indicates process custodianship or owner. This outline recognizes that implementation of REDD+ and UNFCCC reporting activities involve many national actors and stakeholders supporting the work of a national-level entity or focal point. The interdisciplinary nature of REDD+ means institutional arrangements can strengthen the national policymaking process by enhancing coordination of all relevant stakeholders, raising awareness among various private and public institutions, and facilitating consultations and establishing relationships among stakeholders.

Figure 3-1 GHG-I Process custodianship



90. Figure 3-2 illustrates the necessary coordination mechanism between institutions to ensure the objectives of the SNFMS are achieved in both the short and long-term.

Figure 3-2 SNFMS Institutional Coordination



3.3 Spatial Information Management Framework and Custodianship (PROPOSAL)

91. A key initiative of the RoS is the development of a Spatial Information Framework (SIF) to support the way the government administers and uses data and information. The Framework is a set of standards, policies, guidelines and procedures, which are implemented either manually or, where possible, automated through technology. This will allow data and information to be managed in a secure, structured and consistent manner. It will ensure data and information can be appropriately shared or re-used by agencies, individual public sector staff, the community or industry. This will allow for better services, improved performance management and a more productive public sector.

92. Over time, Sudan will develop data custodianship framework through defining a set of principles for the management and maintenance of the national core data and information assets. The principles will align with national and international best practice, industry standards and practices.

93. The framework could subsequently be translated into policies that direct the development, implementation and management of data and information custodianship roles and responsibilities and the formal arrangements that create those roles and responsibilities within the RoS public sector (federal and state). Such a policy would also enable the defining of fundamental datasets.

94. The custodianship model is based on defined roles and responsibilities for individuals and/or organizations who may provide one or more functions. A custodian may delegate any or all its responsibilities for a dataset in its care to another organization. It will, however, remain accountable for the integrity of the dataset. The day-to-day

operation of the custodial responsibilities may be delegated or contracted to other parties, but the overall responsibility rests with the nominated data custodian at an agency level.

95. A custodianship framework is central to improving governance arrangements to allow access to spatial data across the Sudan community. Custodianship is particularly important for spatial data because:

- **Spatial data is valuable**, not only to the organization that creates and maintains it but to others. Being able to visualize your own information in the context of other infrastructure, features or land use brings more certainty, better decisions and improved communication.
- **Spatial data is often duplicated**, both within and between organizations. Identifying the 'authoritative source' of data (the Custodian) eliminates the need for others to duplicate work, thereby minimizing inefficiencies, eliminating less reliable decisions, and avoiding project delays and increased costs.
- **Spatial data is big data**, which means it can drive additional value through analysis or thorough integration with other types of data, but it also requires special technology and skills to utilize and manage.

96. RoS spatial data and infrastructure represents a valuable resource for government (federal and state), community and private sector. Their development also represents a major investment on the part of the state. Therefore, it is important that all spatial products are viewed, managed as important assets in order to derive the maximum economic, social and environmental benefits for the Sudanese people. Over the long-term, spatial data should be compatible in terms of format, reference system, projection, resolution and quality. Standards can be applied at different levels of spatial data within agencies and custodial agencies, who should:

- Capture spatial information through cooperation among organs of state.
- Promote effective management and maintenance of spatial information.
- Promote the use and sharing of spatial information.
- Facilitate coordination and cooperation among stakeholders.
- Eliminate data capture duplication.
- Promote universal access to spatial information.
- Protect copyright of the state in works relating to spatial information.
- Seek input from users to assist in defining appropriate standards for information in their custody.
- Define standards for access, collection, classification, description, accuracy format, metadata and structure of the datasets.

97. **Fundamental Geospatial Datasets:** These are base geospatial datasets identified as the minimum set of essential datasets that are widely used, as a reference base, at various administrative levels, to accomplish Sudan´s national and international priorities. The criteria for defining fundamental datasets will include:

- Diversity of users from different sectors deriving significant benefit from its use (compulsory).

- Cannot be substituted easily or generally (compulsory).
- Enough detail and accuracy for widespread use (compulsory).
- Complete coverage over the area of interest, preferably national (compulsory).
- Produced as a result of the core mandate of the custodian (conditional).
- Source for accurately referencing other datasets or for displaying the results of an analysis (conditional).

98. Custodians for Fundamental Geospatial Datasets would be considered as having mandated responsibility in order to ensure they are adequately resourced to have the necessary capacity and infrastructure.

99. The Higher Council for Natural and Environmental Resource (HCNER) is the national focal point to the UNFCCC and is responsible for submitting all reports to the UNFCCC, including the Biannual Update Reports (BURs), the National Communications, and the technical description of the FREL/FRL for review.

100. The SIFC objective is to underpin ease of access to information relevant for HCNER to meet its obligations. This will be formally achieved through data sharing agreements in the form of MoUs with ten different sectoral institutions for sharing, collecting and compiling of GHG relevant data and information at the national level. Figure 3-2 above illustrates the institutional coordination mechanism.

3.4 Data Management, Custodianship and Accessibility

101. This section describes existing datasets and current custodians (Table 4-5). Sudan has identified key emission categories for AFOLU sector - i.e. forest land remaining forest land (desert, semi-desert, low rainfall, in sand low rainfall, in clay, high rainfall), cropland remaining as crop land (rice land, biomass burning, urea and soil), and grass land remaining as grass land (enteric fermentation, manure management, savannah burning). Therefore, the relevant institutions to report on GHG inventory data from the AFOLU sector are identified based on key category analysis. The AFOLU sector institutions are Forest National Corporation, Ministry of Agriculture, and General Directorate for Range and Pasture Management and RSSA.

Table 3-2 Current Data or Information Custodianship

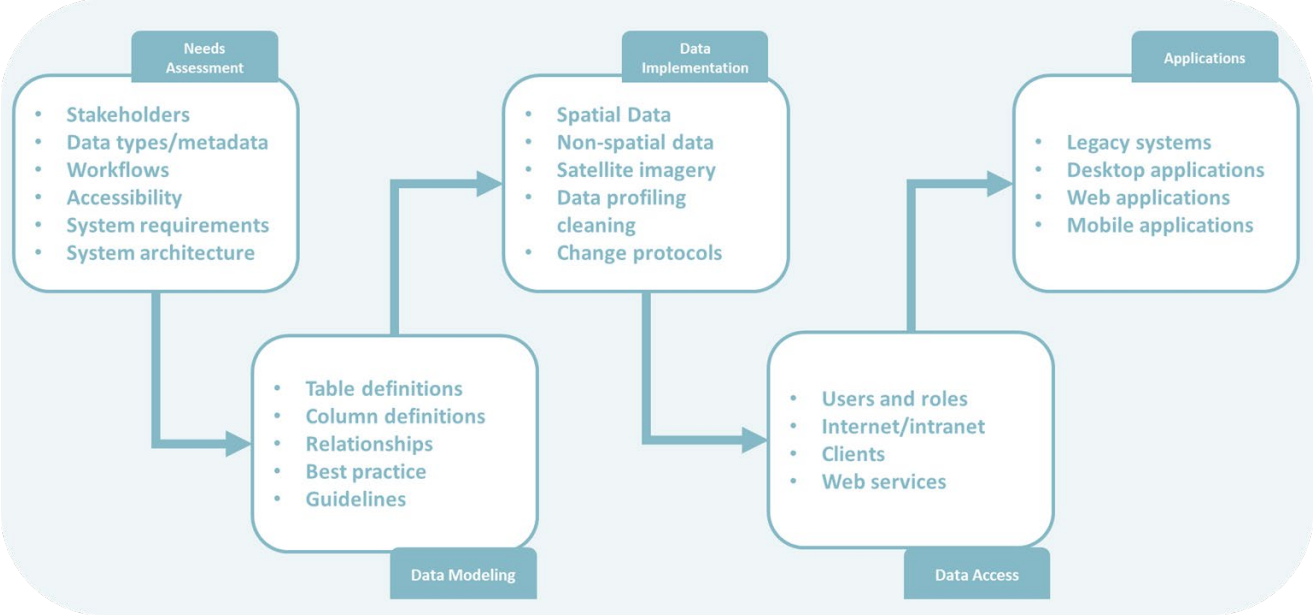
Data/Information or Guidance	Custodian
Land Use Atlas of Sudan 2000 and 2010 available both in digital and analogue format	RSSA
Satellite imagery • Aster data (15 m) for 2006 • Landsat data (30 m) for years 2010, 2014 and 2018 are available only for three states i.e. El Gadarif, Sinnar and Blue Nile. The data is available both in digital and analogue (hard copies) format	RSSA
• Country specific forest definition is available (0.4 ha, 10%, 4m) followed for forest related land use maps, however for other land	FNC

use categories the guiding definitions from PCC/ FAO-FRA were followed • Ground truthing followed by systematic grid sampling has been done through navigational GPS for 2000 and 2010 forest cover maps i.e. Forest Atlas. The GPS coordinates are available • IPCC methodological guidance (1996, 2003 & 2006) followed to produce forest/land cover maps • The maps can be freely accessed in digital format from online web map service (ref)	
• Satellite images with spatial resolution of 30m and spectral resolution of Landsat 7 and Landsat 8 covering parts of Sudan are available • Aerial photographs of the year 1983 covering Blue Nile State area are available in analogue format • GT Sheets of scale ____ covering _____ (area) available • Land Use Atlas of Sudan 2000 and 2010 available both in digital and analogue format • The processes and outputs are normally documented in the form of annual reports	FNC
• Land Use/ Land Cover maps of productive areas are produced within the organization on annual basis (by in-house capacity or external sources?) • Guiding definitions from IPCC/ FAO-LCCS were followed • Ground truthing followed by systematic sampling has been done through navigational/differential/mobile GPS. The GPS coordinates are available • IPCC methodological guidance (2003 & 2006) followed to produce crop land cover/ change maps • The maps can be freely accessed in digital format from online web map service (ref) and can also be accessed in analogue format (hard copies) • The processes and outputs are normally documented in the form of annual agricultural outlook report	MoA
• Land cover maps of 2000 and 2010 are available for each state in Land Cover Atlas of Sudan which was developed under the Africover Project • Aster and Landsat maps are available for Sinnar, Blue Bile and El Gadarif • Aerial photographs of 1983 are available for Blue Nile state	Forestry Departments

3.4.1 Data Management and Archiving

102. The RoS recognizes both the social and economic value of data and information for informing evidence-based policies. Over the long-term, it is necessary to incrementally establish robust coordination mechanisms and facilitate user input in collection of both spatial and non-spatial data management system in line with the custodianship framework. Figure 3-3 below shows key data development and management tasks in the form of a workflow diagram. Representing these tasks in a flow diagram recognizes their dependencies on preceding tasks and/or their outputs. This process is underpinned by the NFMS-AP that will be implemented over three years.

Figure 3-3 Development of data management system



PART III: MONITORING: METHODOLOGICAL APPROACH

4. SATELLITE LAND MONITORING SYSTEM (SLMS) - BACKGROUND

103. Land use and land cover monitoring in Sudan seeks to comprehensively assess deforestation and forest degradation at pre-determined intervals (the initial proposal is five years). Remote sensing, especially satellite-based approaches, provides the most practical option for monitoring land cover change over large areas and enables the preparation of benchmark maps and subsequent time series datasets to support evidence-based policy decisions on land management practices.

104. As recognized under the UNFCCC, for land use, two methods to estimate carbon emissions can be used and these include the stock change method and the gain-loss method (IPCC, 2003). For remote sensing, Sudan methodological approaches will evolve over time and will consider both methods. The gain-loss method is where estimates of changes between uses is a specific input to emissions estimates and the stock-change method would be applied in the case of stratification of forests for field sampling.

105. The Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance (GPG) for Land Use, Land-Use Change and Forestry (GPG-LULUCF) is a key resource that Sudan will use in addition to country specific approaches to remote sensing of land use. Additional valuable resources include the Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) Sourcebook (GOFC-GOLD, 2013), the Global Forest Observations Initiative (GFOI) Methods and Guidance Document (MGD) ((Global Forest Observation Initative, 2013)).

106. Sudan has undertaken land cover assessment remote sensing and to date has produced several datasets. The first assessment was conducted in 2000 through the development of Land Cover Atlas of Sudan (LCAS), with subsequent sub-national assessments undertaken in 2006, 2010, 2014, and 2018 (Table 4-1). The LCAS provides information on the land cover distribution by administrative divisions. The LCAS is based on FAO's Land Cover Classification System (LCCS) and divided the country's land into six land cover classes (i.e. Woody Lands, Water Bodies, Urban, Range Lands, Bare Areas and Agriculture) using object-based classification approach.

Table 4-1 Historical land use and forest cover monitoring

Name	Year	Geographic Coverage	Description
Land Cover Atlas	2000, 2010	National	
Forest Cover Maps	2006	Sub-national (Blue Nile, Sinnar and Gadarif)	
Forest Cover Maps	2010	Sub-national (Blue Nile, Sinnar and Gadarif)	
Forest Cover Maps	2014	Sub-national (Blue Nile, Sinnar and Gadarif)	
Forest Cover Maps	2018	Sub-national (Blue Nile, Sinnar and Gadarif)	

107. Going forward, Sudan will undertake multi-purpose land use and land cover mapping to support the objectives of the National REDD+ Strategy, emission reductions and landscape restoration programs. The objective of the MRV system is to undertake:

i. Deforestation hotspot assessment (annual)

ii. Forest degradation (to be determined)

iii. Land use and land cover change (five yearly)

iv. Reference scenario (to be determined)

108. Sudan will assess land cover and land use change using a combination of remote sensing (satellite imagery), field verification and statistical analysis in line with internationally agreed methodological approaches.

4.1 Forest Definition

109. In accordance with the SNFMS-AP, a harmonized forest definition will be established in due course and is one of the key actions under the SNFMS-A. Existing definitions used for various activities are included in (Table 4-2).

Table 4-2 Forest Definitions

	Forest Definition	Source Document
FNC Definition:	Forest means land bearing a vegetative association and spanning more than 0.5 ha (or 0.42 ha =an equivalent of a Sudanese feddan) with trees at least 2m high and a minimum tree canopy cover of 10%; or young forest stands that have not yet reached but are expected to attain these thresholds in situ. It does not include land that is predominantly under agricultural and/or agro-forestry production systems or urban land use.	NFI Guideline
	FAO's LCCA Land Classification Scheme	

4.2 Land Cover Classification

110. The land cover classification system used by Sudan is based on a dichotomous approach and includes three different levels.

111. **The first level** is composed of the global classes designed for the assessment of resources at the global level and is based on the six top-level land categories defined by the GPG-LULUCF and AFOLU which include Forests, Other wooded land, Other land and Inland water:

Table 4-3 Key Category classes

Forest land	Forest land includes all land with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory, sub-divided into managed and unmanaged, and by ecosystem type. It also includes systems with

	vegetation that currently fall below, but are expected to exceed, the threshold of the forest land category.
Cropland	Cropland includes arable and tillage land, and agro-forestry systems with vegetation below thresholds used for the national definition of forest land.
Grassland	Grassland includes rangelands and pastureland that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land category and are not expected to exceed, without human intervention, the threshold used in the forest land category. The category also includes all grassland from wild natural grasslands, such as páramo, to recreational areas, as well as agricultural and silvipastoral systems, subdivided into managed and unmanaged consistent with national definitions.
Wetlands	Wetlands include land that is covered or saturated by water for all or part of the year (e.g., peatland) and does not fall into the forest land, cropland, grassland or settlements categories. Wetlands can be subdivided into managed and unmanaged according to national definitions.
Settlements	Settlements include all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with the selection of national definitions.
Other land	Other land includes bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total identified land areas to match the national area, where data are available.

112. **The other levels** are country specific, and include additional classes designed to meet specific national and sub-national information needs. They can be applied to differentiate between land use/cover categories according to criteria such as species composition, phenology, vegetation canopy cover (closed/ open/ sparse), naturalness (primary/ secondary forest) (Table 4-4).

Table 4-4 Expanded land cover classification

Level 1	Level 2	Level 3	Brief description	Code
Forest	FAO Definition: Area ≥ 0.5 ha; Tree canopy cover ≥10%; Tree height ≥ 5 m at maturity in situ; Width > 20 m. Excludes land that is predominantly under agricultural or urban land use (orchards, agroforestry systems…). FNC Definition: Forest means land bearing a vegetative association and spanning more than 0.5 ha (or 0.42 ha =an equivalent of a Sudanese feddan) with trees at least 2m high and a minimum tree canopy cover of 10%; or young forest stands that have not yet reached, but are expected to attain these thresholds in situ. It does not include land that is predominantly under agricultural and/or agro-forestry production systems or urban land use.			F
	Natural regenerated forest	Forest predominantly composed of trees established through natural regeneration.		
		Evergreen forest	Naturally regenerated forest composed of more than 75% of evergreen trees species. Includes: Moist forest Dry forest	FE
		Deciduous forest	Naturally regenerated forest composed of more than 75% of deciduous trees species. Includes: Moist forest Dry forest Secondary young	FD
		Semi-deciduous forest	Naturally regenerated forest where trees are at least 25% each of evergreen and deciduous species. Includes: Moist forest Dry forest Secondary young	FSD
		Bamboo forest	Naturally regenerated forest predominantly composed of bamboo vegetation.	FB
		Raffia/Palms	Naturally regenerated forest predominantly composed of palm or raffia vegetation.	FRP
	Plantation	Forest predominantly composed of trees established through planting and/or deliberate seeding. Includes coppice from trees that were originally planted or seeded.		
		Broadleaved planted forest	Planted forest composed of more than 75% of broadleaved species. Includes:	FPB

			Eucalyptus sp. Acacia sp. Gravillia	
		Coniferous planted forest	Planted forest composed of more than 75% of coniferous species. Includes: Cupressus lustinca Juniperus Pinus patula	FPC
		Mixed planted Forest	Planted forest of at least 25% each of coniferous and broadleaved species.	FPM
Other wooded lands	Area ≥ 0.5 ha, tree crown cover 5- 10% or shrubs/bushes canopy cover ≥10%			W
	Woodland	Includes: Acacia comiphora Combretum terminalia Others (bushes,..)		W
	Wooded grassland	Land covered by natural growth of graminea and herbaceous vegetation, with some scattered trees (tree canopy cover between 5-10%) and shrubs; Land not covered seasonally or permanently by water. Includes: Acacia sp. Others (Combretum sp...)		WG
	Wooded wetland	Land seasonally or permanently covered by water with natural growth of graminea and herbaceous vegetation and some scattered trees (canopy cover between 5-10%).		WW
Other Land	Land not classified as forest or other wooded land, as described above (Includes land with tree canopy cover <5% or with shrubs/bushes <10% or with predominant agricultural/urban land use or with shrubs/ trees<0.5ha).			O
	Natural	Barren Land	Land where vegetation cover is less than 2%. Includes land covered by sand, soil and rocks.	OX
		Natural Grassland	Land covered with natural growth of graminea and herbaceous vegetation.	OG
		Marsh	Land seasonally or permanently covered by water and dominated by natural growth of graminea, reed and other herbaceous.	OM
	Cultivated	Improved pastures	Land sown with introduced grass and leguminous for the grazing of livestock.	OP
		Annual Crop	Area covered by crops that are sown and harvested during the same	OCA

			production season/ agricultural year.	
		Perennial crop	Crops that are sown or planted once and need not to be replanted after each annual harvest. Includes trees (e.g. apples or other fruit trees), bushes and shrubs (e.g. berries, coffee…), palms (e.g. dates), vines (e.g., grapes), herbaceous stems (e.g. bananas) and stemless plants (e.g. pineapples).	OCP
		Mixed annual and perennial crop	Association of annual and perennial crops.	OCM
		Fallow	Previously cultivated land kept free from crops or weeds during at least one growing season, where woody vegetation is and will not reach 5m height.	OF
		Wood lot of Bamboo	Bamboo areas spanning between 0.2 and 0.5 ha , with trees >5m at maturity mainly used is for wood stock	OWB
		Wood lot	Other areas spanning between 0.2 and 0.5 ha , with trees >5m at maturity mainly used is for wood stock	OW
	Built up area	Populated areas with significant constructions. Includes homes scattered in the field. Notes: a road is considered as a distinct Land Use/Cover Section (built-up area) if wider than 15 meters (from bottom of ditch on one side to the bottom of ditch on the other side when ditches exist, otherwise the width of the road bank) and if not a forest road.		OB
	Quarry/Mining site	Areas used for extraction of minerals, rocks, sands, clay… includes: quarry, mining, extraction areas, oil/gas wells.		OQ
Inland water	Area occupied by major rivers (width ≥ 15m), lakes, ponds and reservoirs.			IW
	Perennial River	Rivers (width ≥ 15m) that maintains water in its channel throughout the year.		IRP
	Intermittent River (seasonal)	Rivers (width≥ 15m) that flows only at certain times of the year.		IRS
	Lake	Large body of salt or fresh water surrounded by land.		IL
	Dam	Reservoir created by a barrier constructed to hold back the water and raise its level.		ID
	Pond	Small body of still water formed naturally or by hollowing or embankment.		IP

4.3 Methodological Approach: Land use and land cover change monitoring

113. The IPCC (2006) describes three overall approaches, not to be confused with tiers, for the representation of land use. Sudan will gradually transition from Approach 1 to Approach 3 for estimating activity data for each land use category. Sudan takes note of the 2019 Refinement of IPCC GPG Volume 4: AFOLU. Specifically noted with relevance to this section is the updated guidance on use of remote sensing data (satellite data) and products in assessing changes in land areas and land use changes over time. Sudan will need to combine different data sources and types of information, while ensuring the coherence between national land-use classification systems and IPCC land-use categories, uncertainty and accuracy of activity and remote sensing data.

114. **Approach 1** identifies the total area for each land category. This information is usually provided by non-spatial country statistics and does not provide information on the nature and area of conversions between land uses (i.e., it only provides "net" area changes), for example deforestation minus forestation, and thus is not suitable for REDD+.

115. **Approach 2** involves tracking of land conversions between categories, resulting in a non-spatially explicit land-use conversion matrix.

116. **Approach 3** extends Approach 2 by using spatially explicit land conversion information, derived from sampling or wall-to-wall remote sensing mapping techniques.

117. Given the overall objective is for Sudan to participate in REDD+ results-based payments, Sudan´s aspiration is to achieve the use of Approach 3 as it is the most informative and applicable to REDD+. For Sudan the development of forest mapping for REDD+ activities will be considered as a trio of components: creation of a forest benchmark map, stratification of forests within the map extent and estimation of changes within the map extent to produce a land use change matrix (Table 4-5).

Table 4-5 Land use change matrix (template table)

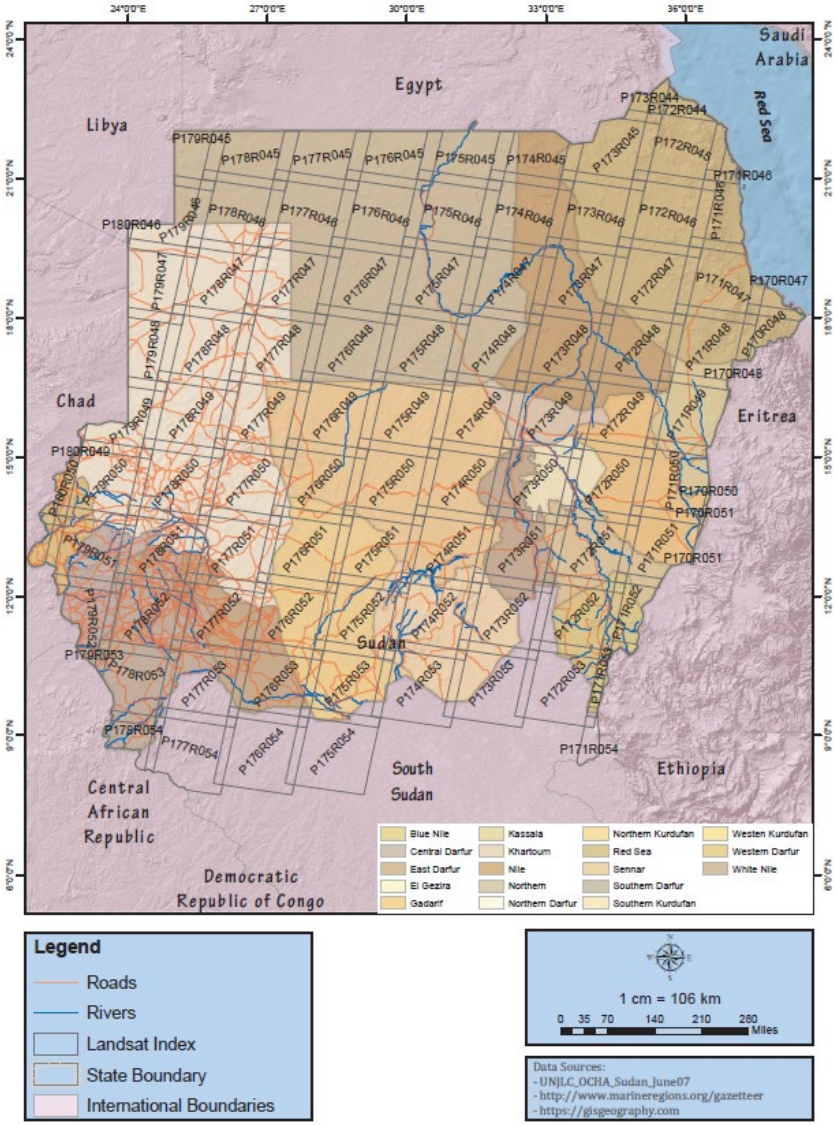
	Forest land	Cropland	Grassland	Wetlands	Settlements	*Other land*	Total
Forest land							
Cropland							
Grassland							
Wetlands							
Settlements							
Other land							
Total							

118. The methodological approach for land use and land cover change is still to be fully developed including preparation of an illustrated satellite image interpretation guideline [an Annex to this document] – but this will build on methodological approaches already established for forest cover change analysis.

4.3.1 Application of Remote Sensing for Land Use and Land Cover (LULC)

119. To generate activity data, Sudan uses remote sensing and is gradually developing country specific guidelines. Mapping of LULC and change detection using remote sensing and GIS techniques is a cost-effective method of obtaining a clear understanding of the land cover alteration processes due to land use change and their consequences. To date, Sudan has completed a forest cover and forest cover change map using SPOT (20 m for 2006) and Landsat (30 m for 2010, 2014 and 2018) satellite imagery. Figure 4-2 illustrates the Landsat image footprints. Sudan will continue to evaluate new image sources including the evolving European Space Agency (ESA) program.

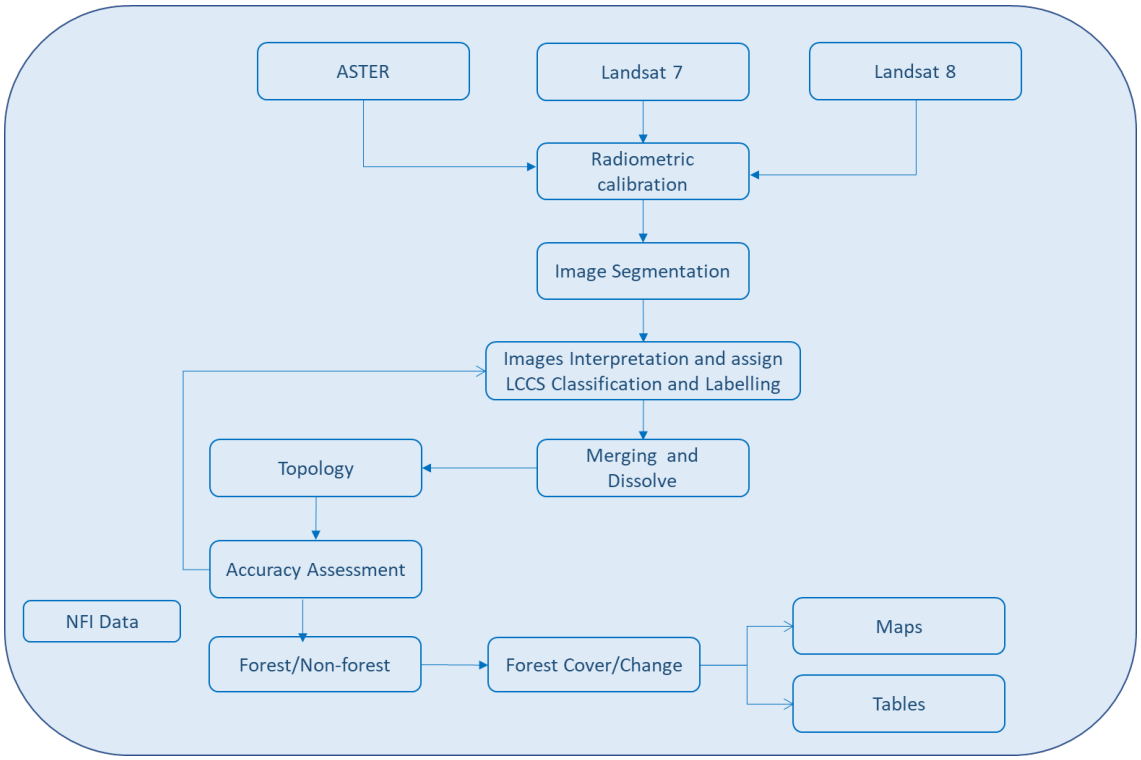
Figure 4-1 Landsat satellite image footprints



120. For methodological approaches Sudan has various options at its disposal. Figure 4-2 illustrates a simplified workflow process used to generate forest and forest cover change maps. This is a country specific process.

121. Once the forest cover mapping process is completed, the time-series analysis is then conducted, including the consistency checks to generate activity data concerning deforestation and carbon stock enhancement (restoration / afforestation / reforestation / natural regeneration) activities. However, the feedback mechanism regarding consistency checks to confirm deforestation and afforestation/reforestation activities are not clear at the moment. The accuracy assessments process is described in Section 4.3.2.

Figure 4-2 Simplified mapping workflow



122. Sudan further collaborates with the Food and Agricultural Organization (FAO). FAO has developed a series of practical tools to support countries in data collection for:

- multi-phase National Forest Inventories
- Land Use, Land Use Change and Forestry (LULUCF) assessments
- Monitoring agricultural land and urban areas
- Validation of existing maps
- Collection of spatially explicit socio-economic data
- Quantifying deforestation, reforestation and desertification

123. The tools developed by FAO include:

- **Collect Earth** - a tool that enables data collection through Google Earth. In conjunction with Google Earth, Bing Maps and Google Earth Engine, users can analyze high and very high-resolution satellite imagery for a wide variety of purposes. The data gathered through Collect Earth is exportable to commonly used formats and can also be exported to Saiku, a tool that facilitates data analysis.
- **SEPAL** – a tool that allows users to query and process satellite data quickly and efficiently, tailor their products for local needs, and produce sophisticated and relevant geospatial analyses quickly. Harnessing cloud-based supercomputers and modern geospatial data infrastructures (e.g. Google Earth Engine), SEPAL enables access and processing of historical satellite data, as well as newer data from Landsat and higher-resolution data from Europe's Copernicus programme.

4.3.2 Accuracy Assessment

124. Sudan will perform accuracy assessment of all thematic maps, in order to estimate errors in the map and to quantify uncertainty and map validity. Accuracy assessment represents a very important component of the process. Uncertainty is the error in a particular estimate, in this case the estimate of an area of change over time. Accuracy equals one minus the error value, and thus accuracy assessment also refers to assessment of error or uncertainty.

125. The main elements of an accuracy assessment are the error matrix, or confusion matrix, and associated statistics (Congalton R. , 1991). The error matrix is generated by comparing the classification results with reference data. The statistics include overall accuracy, and the producer's and user's accuracy for each class in the product. Both the land-use change and error matrices are common formats for reporting land-use change and errors. While they differ from the reporting-table format of the IPCC, the data can easily be transferred.

126. In preparing time series land use change, Sudan will estimate errors in land-use change estimates over time using multi-date accuracy assessments, utilizing the information available from two dates. An appropriate approach is the use of careful, cross-checked, visual interpretation of a combination of very high-resolution imagery, along with imagery used in the classification itself. Multiple interpreters can be used, and the consistency of their interpretation can indicate confidence of the validation dataset itself. Field surveys will be undertaken for the classes that are the most difficult to interpret, even with very high-resolution imagery, such as degraded forest. Once the error for a particular area of change, or activity data (AD), is estimated, it can be combined with the error of the change in stocks per unit area estimated via field inventories. This can be done using Equation 5.2.2 from the UNFCCC "Good Practice Guidance for LULUCF" (2003) for the propagation of errors, similarly to the application described in Chapter 4.

127. Error-adjusted area estimates, such as those described in Olofsson *et al.* (2013), use the information available in the matrix, together with the total area of each class identified in the map, to generate area-adjusted errors based on the proportional area of each class and errors identified in the matrix. Error matrices and accuracy assessments can also be extended to provide confidence interval (CI) information. This is especially important as it quantifies the confidence of a particular class, thus providing very pertinent additional information. Olofsson *et al.* (2013) describe a process for creating CI bounds based on area-adjusted error matrices.

128. Multiple literature sources exist to inform Sudan´s accuracy assessment methodological approach, including Section 3.7 of the GFOI MGD (GFOI, 2013), which provides guidance on considerations for generating reference data and performing an accuracy assessment. These include: i) ensuring the reference data are of a higher quality than the map data (for example, manual interpretation of an image by an analyst is generally considered higher quality than an automatic classification algorithm) and ii) combining reference data sources (i.e., field and aerial surveys which can be particularly cost effective if resources are limited). The GFOI MGD also provides two example approaches for performing an accuracy assessment and area estimation: one stratified and one model-based approach.

129. Olofsson *et al.* (2014) also provide a full review of good practice recommendations for producing transparent and "scientifically rigorous" accuracy estimates and estimates

of area based on change between time one and time two. They detail three separate steps that should be undertaken to complete an accuracy assessment including: i) the sampling design, which answers the question 'what is a suitable subset area to sample', understanding that evaluation of the entire map is not possible ii) the response design, which answers the question 'are the maps and reference data in agreement' and iii) analysis, which answers the question of 'how to calculate accuracy and quantify uncertainty' (cited in (Hewson, 2014).

5. NATIONAL FOREST INVENTORY

130. Sudan´s commitments to the UNFCCC and opportunities from REDD+ requires robust national forest data. A **national forest inventory (NFI)** is the systematic collection of data and forest information for assessment or analysis. An estimate of the value and possible uses of timber is an important part of the broader information required to sustain ecosystems. When undertaking a forest inventory, the following items are important to measure and note: species, diameter at breast height, site quality, age and defects. From the data collected, the number of trees per unit of area (e.g., hectare, acre), the basal area, tree volume, and timber value can be calculated. Inventories can be performed for purposes beyond calculating the value of timber (e.g., to provide comprehensive information about the state and dynamics of forests for strategic and management planning).

131. The Sudan NFI is designed for multipurpose use, including providing accurate input into a national GHG inventory, facilitating national communication of carbon emissions and removals from land use, and supporting national programs to mitigate emissions including REDD+. In line with the NFMS-AP, the NFI is designed with a long-term perspective with the objective of carrying national re-measurements every five years.

132. The purpose of the Sudan NFI is to assess and monitor forest, other natural resources, land use and land use practices, in order to provide ongoing qualitative and quantitative data on the state of a wide range of biophysical and socio-economic variables to support evidence-based policy formulation and economic planning. Periodic monitoring (such as every five years) will enable the development of more harmonized policies to ensure sustainable forestry and land management, continued biodiversity conservation, and improved food security and livelihoods of rural populations.

5.1 Sudan NFI Design

133. Sudan will use the UNFCCC latest guidelines in data compilation and analysis of forest resources using a multitude of data sources, including field inventories and remote sensing, to estimate relevant forest characteristics at particular points in time. The first NFI in Sudan was completed in 1998, but no other national inventory has been undertaken to assess forest volume or biomass. However, forest inventories are regularly undertaken at individual riverine and in plantation forests across the eighteen States. While it is the mandate of each State to plan and conduct inventories in forests reserves, the objective is to have a full and consistent national inventory.

134. With regards to methodological approach, Sudan adopts IPCCC guidelines with the objective of subsequently enabling reporting at higher order Tier methods. IPCC guidelines outline three reporting tiers for national GHG reporting where:

- **Tier 1** methods are designed to be simple to use. The GPG-LULUCF and the 2006 IPCC Guidelines provide equations and default parameter values (e.g., emission and stock change factors) so the inventory compiler does not need specific data for these equation parameters. Country-specific land-use and management data are needed, but for Tier 1 there are often globally available sources for these estimates (e.g., deforestation rates, agricultural production statistics, global land cover maps, fertilizer use, livestock population data). However, the Tier 1 method

alone is unlikely to be sufficient for REDD+ requirements and reporting for results-based payments.

- **Tier 2** uses the same methodological approach as Tier 1, but the emission and stock change factors are based on country or region-specific data. Country defined emission factors are more appropriate for the climatic regions and land-use systems in the country or region. Higher temporal and spatial resolution and more disaggregated land-use and management categories are used in Tier 2 to correspond with country-defined coefficients for specific regions and specialized land-use categories.
- **Tier 3** uses higher order methods, including models and inventory measurement systems tailored to address unique national circumstances. Assessments are repeated over time and employ high-resolution land-use and management data, which are generally disaggregated at the subnational level. These inventories use advanced measurements and/or modeling systems to improve the estimation of GHG emissions and removals beyond Tier 1 or 2 approaches (Angelsen, 2008).

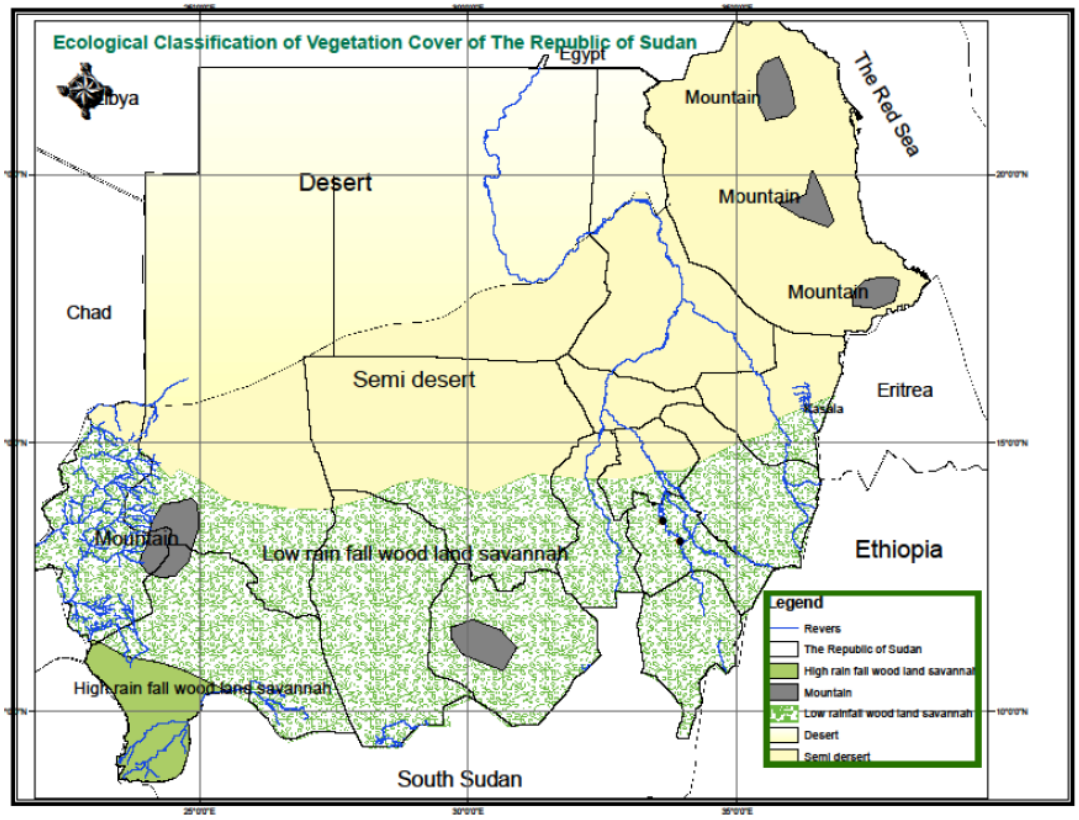
135. The Sudan NFI is designed and based on geophysical and biophysical stratification in order to prioritize resource allocation for ongoing re-measurements. Sudan is defined by five ecological zones listed and described in Table 5-1 and illustrated in Figure 5-1.

Table 5-1 Sudan Ecological Zones

Zone	Description/definition
The desert	The annual rainfall is below 75mm. The vegetation is virtually absent except along water courses represented by Fagonia cretica , Indigofera oblongifolia and Aerva javonica . Ephemerals and herbs appear after the rare rain showers.
The semi desert	The rainfall varies from about 75- 300mm, very variable and unreliable. The vegetation is a variable mixture of grasses and herbs with a variable scatter of low shrubs and bushes interspersed with bare areas. The belt is represented by various vegetation formations according to changes in rainfall and soils. Acacia toritllis and Maerua crassifolia in the eastern clay plains, Acacia mellifera and Commiphora africana in the sandy soil of the west.
Woodland savannah	It is a mixture of vegetation types composed of grasses, shrubs and trees thriving under annual rainfall between 300 to over 1500mm. In view of the wide range of rainfall and soil variation, the woodland savannah is sub divided into a) low rainfall savannah and b) high rainfall savannah. The boundary between the two types lies between the isohyets 800-1000mm.
Mountane Vegetation	The vegetation on the three mountain masses has very little in common except that it differs from the surrounding areas because of the effect of altitude and/or the higher rainfall. On the Red Sea Hills, the vegetation is composed of Juniperus procera, Olea chrysophylla, Pittosporum viridifolium and Maba abyssinica . Jebel Marra is largely cultivated, among which are species of Cordia africana, Azanza garkeana and Ficus gnaphalocarpus.

136. Under REDD+ Readiness, Sudan developed a comprehensive forest classification based on the existing forest types and ecological zones in order to efficiently facilitate forests and GHGs inventories. Forest stratification was an issue of importance in the context of forest inventory. The states of Sudan initially developed forest classification and categorized forests as Dry Zone Forests, Moist Deciduous Forests, Wet Zone and Montane (Figure 5-1).

Figure 5-1 Map of Sudan ecological zones



5.1.1 Sample Plots

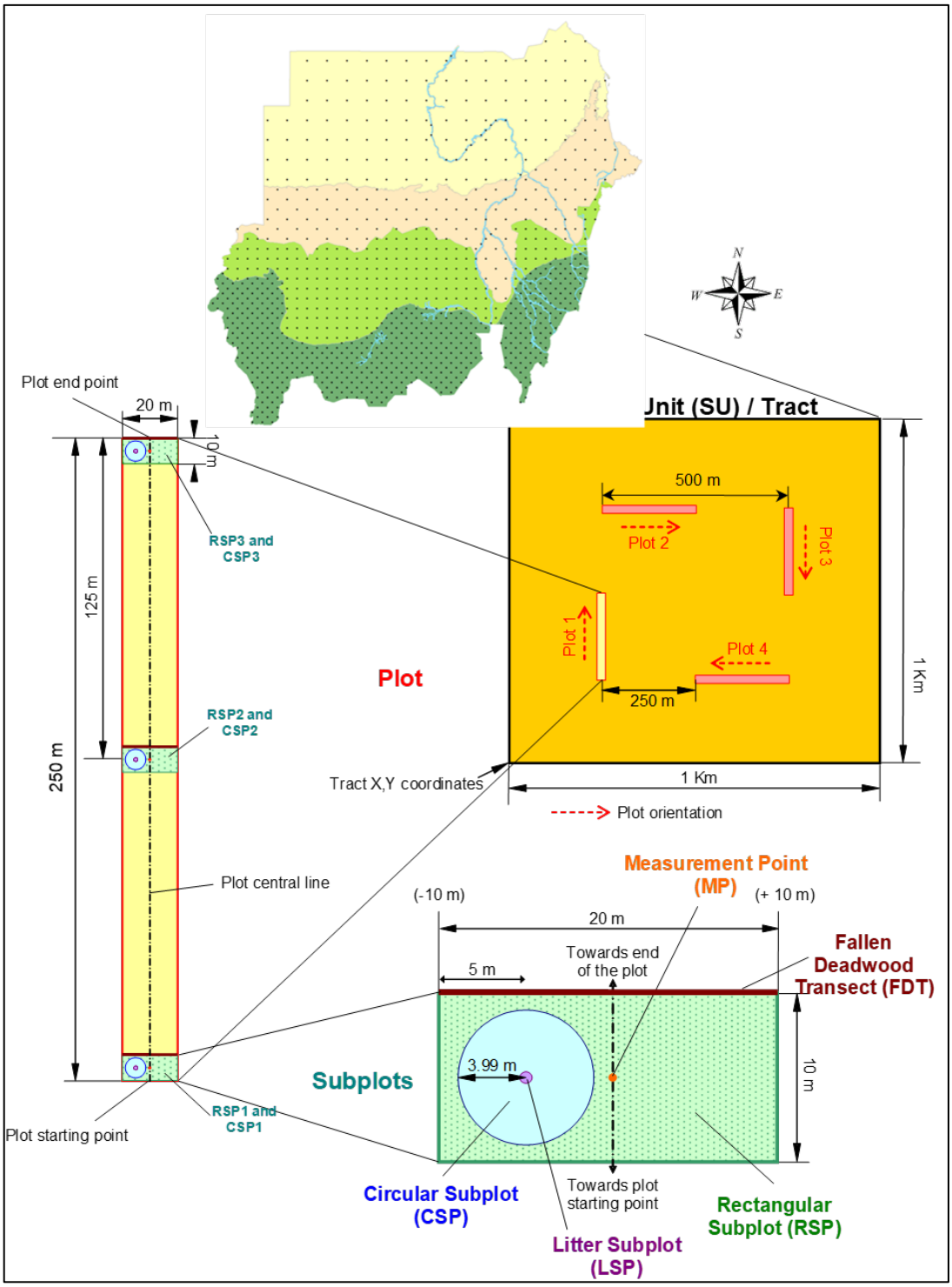
137. In 2018, Sudan developed the first near-comprehensive NFI manual. The manual is based on the multi-purpose information needs, targeted variables and accuracy for provision of relevant data to support national forest policy and to report for REDD+ under the UNFCCC. The NFI manual follows IPCC guidelines to ensure that the outputs from the NFI are consistent and in line with the UNFCCC reporting requirements transitioning from Tier 1 to Tier 2 and subsequent Tier 3 resulting in country specific emission factors. The manual has been tested in the field in 2017 – 2018 to assess EFs for the development of sub-national FRELs and will continue to be refined.

138. A stratified sampling approach is adopted for NFI covering 705 sampling units with 20 x 40 km grid spacing. Stratified sampling is accomplished by dividing the sampling area into relatively homogenous sub-areas, and separately sampling each sub area. Stratification increases efficiency of sampling, giving more precise estimates for the same or less effort. Within each stratum, a systematic sample or simple random sample is conducted. Carbon stock (or stock change) is estimated for each stratum,

then the stocks of the strata are summed to estimate the stock (or stock change) of the entire area.

139. The stratification approach is in line with IPCC recommendations of stratifying by climate, soil, ecological zone, and management practices (Vol. 4, Chapter 3.3.2.1).

Figure 5-2 NFI Sampling framework



5.1.2 Forest Reference Emission Level

140. The NFI design is closely coupled with the development of Forest Reference Emission Level (FREL). Sudan will take a stepwise approach to developing its FREL and has elected to commence with a sub-national FREL in three states (Blue Nile, Sinnar and Gadarif). These states face greater risk of deforestation, as well as high potential for sustainable landscape management and restoration and avoided emissions through REDD+. The sub-national FREL covers 9% of the total land area and 15% of the total forest land cover of Sudan as of 2015.

141. Sudan follows an approach based on historical average of net emission from deforestation and removals from enhancement of forest carbon stocks over the past 12 years from 2006 to 2018. The reason for the choice of this approach is due to the variable factors for assessment of national circumstances, which are still being studied.

142. Sudan has adopted a systematic grid sampling approach and stratified the forests based on climatic zones to develop a historical time series analysis covering three epochs and four time points (i.e. 2006, 2010, 2014 and 2018). Achieving rigour in the FREL development requires a time series and in the case of Sudan, there are three periods covering activity data for change assessments which are considered sufficient to create a regression line for the predication of future trends. The past trends in gross and net deforestation, and carbon stock enhancement are acquired through activity data mapping. Modelling the historic emissions and removals relies on the production of activity data with the documented SLMS methodology and time-series analysis.

143. The SLMS methodology document will be developed under the NFMS-AP. Sudan will further develop a land use and land cover classification as a continuation of the forest cover and forest cover change assessment developed from the 2006 20m SPOT, and 2010, 2014, 2018 30m Landsat satellite imagery for each of the reference years.

5.1.3 Carbon Pools

144. The NFI will provide data for enabling Sudan to report on relevant carbon pools. Sudan has identified Above Ground Biomass (AGB) as a significant pool and included AGB pool and Below Ground Biomass (BGB) pool to report on the sub-national FREL. The other three pools (i.e. dead Wood (DW), Litter (Lit) and Soil (S) are not included in the sub-national FREL, due to missing information. In the interim or until deemed necessary, Sudan will report emissions only related to carbon dioxide, while other gases are excluded from the current sub-national FREL. Each of the carbon pools is described in Box 5-1.

Living Biomass:

Aboveground biomass: All living biomass above the soil, including stem, stump, branches, bark, seeds, and foliage. Dead branches still attached to a living plant are included as part of the aboveground live tree biomass pool, but typically do not make up a significant fraction of the pool. In cases where forest understory is a relatively small component of the aboveground biomass carbon pool, it is acceptable for the methodologies and associated data used in some tiers to exclude it – provided the tiers are used in a consistent manner throughout the forest inventory time series (as specified in Chapter 4).

Belowground biomass: All living biomass of live roots. Fine roots of less than (suggested) 2mm diameter are often excluded, or measured as part of the soil carbon pool, because it is impractical to try to remove very fine roots and root hairs from the soil.

Dead Organic Matter:

Dead wood: Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the country. Typically, standing dead trees must be large enough to meet the definition of "tree" that is used for live trees by the country. Carbon stocks in lying dead wood are also called coarse woody debris.

Litter: Includes all non-living biomass with a diameter less than a minimum diameter chosen by the country for dead wood (for example 10 cm, and possibly also a minimum length), lying dead, in various states of decomposition above the mineral or organic soil. This includes the litter, fumic, and humic layers. Live fine roots (of less than the suggested diameter limit for belowground biomass) are included in litter where they cannot be empirically distinguished.

Soils:

Soil organic matter: Includes organic carbon in mineral and organic soils, (including peat) to a specified depth chosen by the country and applied consistently through the time series. Live fine roots (of less than the suggested diameter limit for belowground biomass) are included with soil organic matter where they cannot be distinguished

Box 5-1 Carbon pools

Table 5-2 Activities and carbon pools included in Sudan's sub-national FREL/FRL

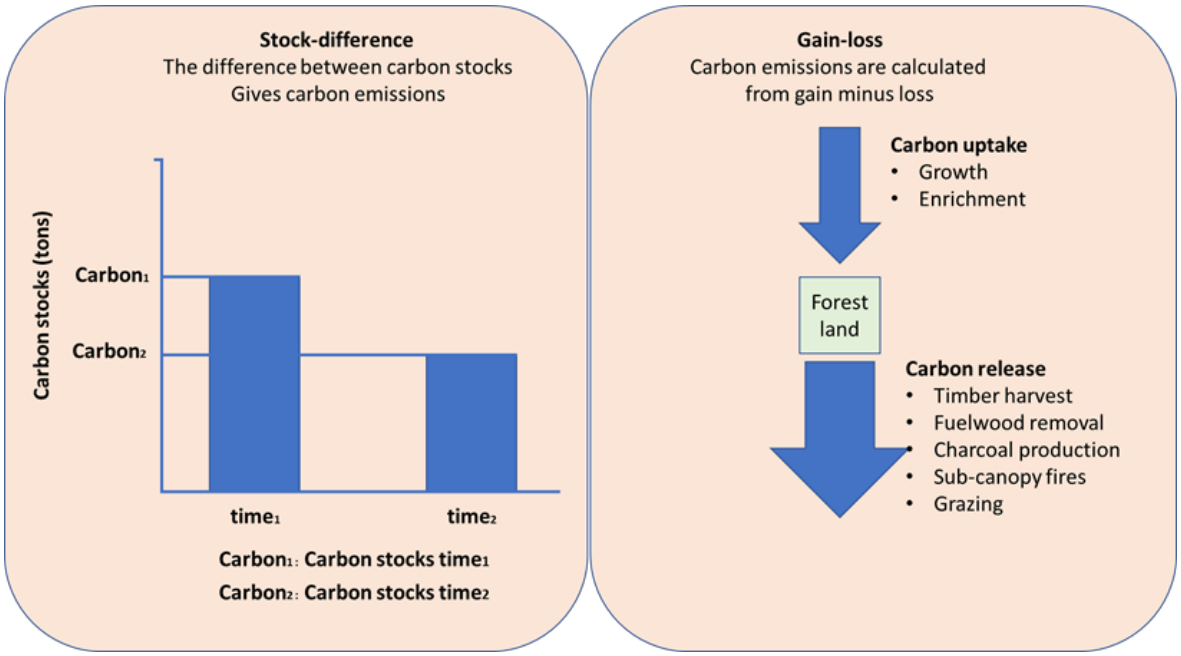
Activities	Terrestrial Carbon Pool				
	Aboveground	Belowground	Deadwood	Litter	SOC
Deforestation	Included	Included	Excluded	Excluded	Excluded
Forest Degradation	Excluded	Excluded	Excluded	Excluded	Excluded
Carbon stock enhancement	Included	Included	Excluded	Excluded	Excluded
Sustainable Forest Management	Excluded	Excluded	Excluded	Excluded	Excluded
Conservation	Excluded	Excluded	Excluded	Excluded	Excluded

5.1.4 Emission Factors and Carbon Stock Calculation

145. Emission factors are developed with the national level forest inventory data of forest carbon stocks. The recent NFI was carried out in 2017 – 2018 covering mostly the sub-national FREL states as part of the national REDD+ readiness process. The inventory measured above ground tree, shrubs, deadwood, and litter biomass. Sudan is following a step-wise approach giving due consideration to the national circumstances. Due to limited availability or missing information, the sub-national

FREL follows "Gain Loss Method "using combination of Tier 1 (default) and Tier 2 (country specific) level information (Figure 5-4).

Figure 5-3 Stock-difference and Gain-loss method



146. Estimating comparatively "rare" and small changes in biomass distributed over a large landscape, like those produced from selective cut timber extraction activities, is challenging. More so where the objective is to resolve those changes with even modest levels of statistical significance. Therefore, probability-based sampling approaches, even with permanent plots would typically require very high and costly sample intensities using the stock-difference method.

147. A more efficient approach to estimate small changes in comparison to the stock size is to focus directly on measurement of fluxes to and from the stock (i.e. the gain-loss method) and as indicated in previous sections, the IPCC recognizes gain-loss as an alternate method to estimate carbon changes (IPCC, 2006). Typical fluxes (i.e., sinks and sources) tracked by a gain-loss type approach would include:

- Sequestration from forest growth;
- Emissions from natural mortality (competition-related and senescence) and disturbance (mortality due to wind, fire, diseases); and
- Emissions from wood removals due to logging and fuel wood collection.

148. With regards to compliance with key UNFCCC decisions concerning FREL, Table 5-3 summarizes Sudan's approach.

Table 5-3 Compliance with UNFCCC Decisions

UNFCCC reference	Description	Sudan's FREL/FRL
Decision 12/CP.17 Paragraph 1	Stepwise approach	Sudan is following a step wise approach giving due consideration to the national circumstances. Due to limited availability or missing information, Sudan has decided to establish sub-national FREL following "Gain Loss Method" using combination of Tier 1 (Default) and Tier 2 (country specific) level information.
Decision 12/CP.17 Annex, paragraph (c)	Pools and gases	Sudan has identified Above Ground Biomass (AGB) as significant pool and included AGB pool and Below Ground Biomass (BGB) pool to report on sub-national FREL. The other three pools (i.e. Dead Wood (DW), Litter (Lit) and Soil (S) are not included in the current sub-national FREL due to missing information. Sudan will report emissions only related to CO2 while other gases are excluded from the first sub-national FREL.
Decision 12/CP.17 Annex, paragraph (c)	Activities	Sudan has decided to account for only two activities i.e. Deforestation to report on emissions and Enhancement of forest carbon stocks to report on removals. The data on other REDD+ activities i.e. degradation, conservation and sustainable management of forests is currently considered insufficient or missing. Carbon stock enhancement takes place through forest restoration, afforestation, reforestation and natural regeneration. Forest degradation is not included in the emission/removal factors for the forest remaining as forests, as there are high uncertainties involved with limited information available and these uncertainties cannot be quantified. The sustainable forest management and conservation activity inclusion would require forest management inventory data and harvesting statistics consistently throughout the country.
Decision 12/CP.17 Annex, paragraph (d)	Forest definition applied in the GHG inventories	The proposed national forest definition is used as a basis to develop the sub-national FREL for Sudan which is currently in process. So far, Sudan has submitted two GHG inventories through National Communication (NC) to UNFCCC. Due to limited capacities and resources, Sudan used default values from the Emission Factor Data Base (EFDB) of IPCC to report its GHG emissions from the AFOLU sector. The third NC is under process and due to be submitted in June 2020. Sudan has decided to report emissions from the AFOLU sector in the upcoming NC based on default values. However, the results of the current NFI and FREL study will be included as a technical annex to the next BUR.

Decision 12/CP.17 Annex	The information contents guided by the most recent IPCC guidance and guidelines)	Sudan is following the IPCC Guidance 2006 (Refined 2019) to report on emissions by sources and removals by sinks from the AFOLU sector.
Decision 12/CP. 17 II. Paragraph 9	Submission of information and rationale on the development of forest FRLs/FRELs, about the details of national circumstances and their consideration	National circumstances are assessed under sub-national FREL activity to identify the need to adjust (above or below) the sub-national FREL to the current trend of historical emissions.

149. With regards to the development of emission factors, for Forest Land remaining Forest Land, the data on average annual growth rate, average annual harvest (legal and illegal) and average annual disturbance rate in tC/ha/year is normally required to calculate the removal factors using the following formula:

> Removal factor ($\mathbf{R_{FF}}$) tCO2 eq/ha/Year = Average annual growth rate (tC/ha/year) – Average annual harvest (legal and illegal impacts) tC/ha/year – Average Annual Disturbance rate (may include fires etc) (tC/ha/year)

150. Due to the lower significance, uncertainties and consistency aspects related to deadwood, litter and soil organic carbon, the emission and removal factors account only for Above Ground Carbon and Below Ground Carbon. Table 5-4 below needs to be updated for Sudan to indicate how the emission and removal factors have been derived using available data and formulas for each climate stratum.

Table 5-4 Emission and removal factor calculation table

	Term	Variable definition / Formula	Eco zone/ Forest type 1	Eco zone/ Forest type 2	Eco zone/ Forest type 3	Eco zone/ Forest type 4
Forest remaining as forest	A	Annual growth rate, ton C/ha/year *(IPCC table 4.9)* [1]				
	B	Annual harvest (legal and illegal) impacts, ton C/ha/year				
	C	Annual disturbance rate, ton C/ha/year		(IPCC table 3A.1.13) ha/year (FAO, GRA 2015)		
	R_{FF}	(A – B – C) x 44/12				
	R_{FF}	Removal factor, ton CO_2 -e/ha/year				
Forest converted to non-forest	D	Forest carbon density (AGC+BGC), ton C/ha				
	F	Non-forest carbon density (AGC+BGC), ton C/ha				
	E_{FN}	(D – F) x 44/12				
	E_{FN}	Emission factor, ton CO_2-e/ha				
Non-forest converted to forest	G	Non-forest forest carbon density (AGC+BGC) + *Upper 95 % confidence interval limit*				
	F	Non-forest carbon density (AGC+BGC)				
	R_{NF}	(G – F) x 44/12				
	R_{NF}	Removal factor, ton CO_2-e/ha				

6. OTHER MONITORING

151. The monitoring function will help Sudan to monitor the government policies and measures targeted to address the varied drivers of deforestation and forest degradation (DoDD) in the country. A big challenge, however, is to identify the drivers of deforestation and forest degradation and ways to address these drivers given due consideration to the country's ability to address these drivers. A detailed study was conducted in 2017, which identified various DoDD. A draft National REDD+ Strategy (NRS) is also developed, which highlights several options to address these drivers and envisages that the successful implementation of the REDD+ programme will ensure 50% of the national emissions reduction target by 2030 as set in RoS's Nationally Determined Contributions (NDC). This NRS sets the strategic period for implementation of the planned activities into three phases of short, medium and long-term.

152. For the successful implementation of NRS, it is very important to develop national level standard mechanisms/ protocols to monitor the implementation of NRS, which are currently very limited and inadequate in the country. The current forest monitoring system is based on a bottom-up system of reporting from the forest circles (the smallest management unit) up to the state forest and then to FNC at the national level. The data reported includes both qualitative and quantitative information on forest resources with more focus on reserved forests, afforestation and reforestation areas, harvest and production, fires, personnel, etc. This reporting system is done on both a monthly and annual basis.

153. Incrementally, Sudan will establish broader frameworks and tools for forest management plans beyond those already available for forest plantations. Management plans and schemes are important in ensuring the sustainable management of riverine forests/ plantations, watershed protection, to address local firewood demands and desertification issues.

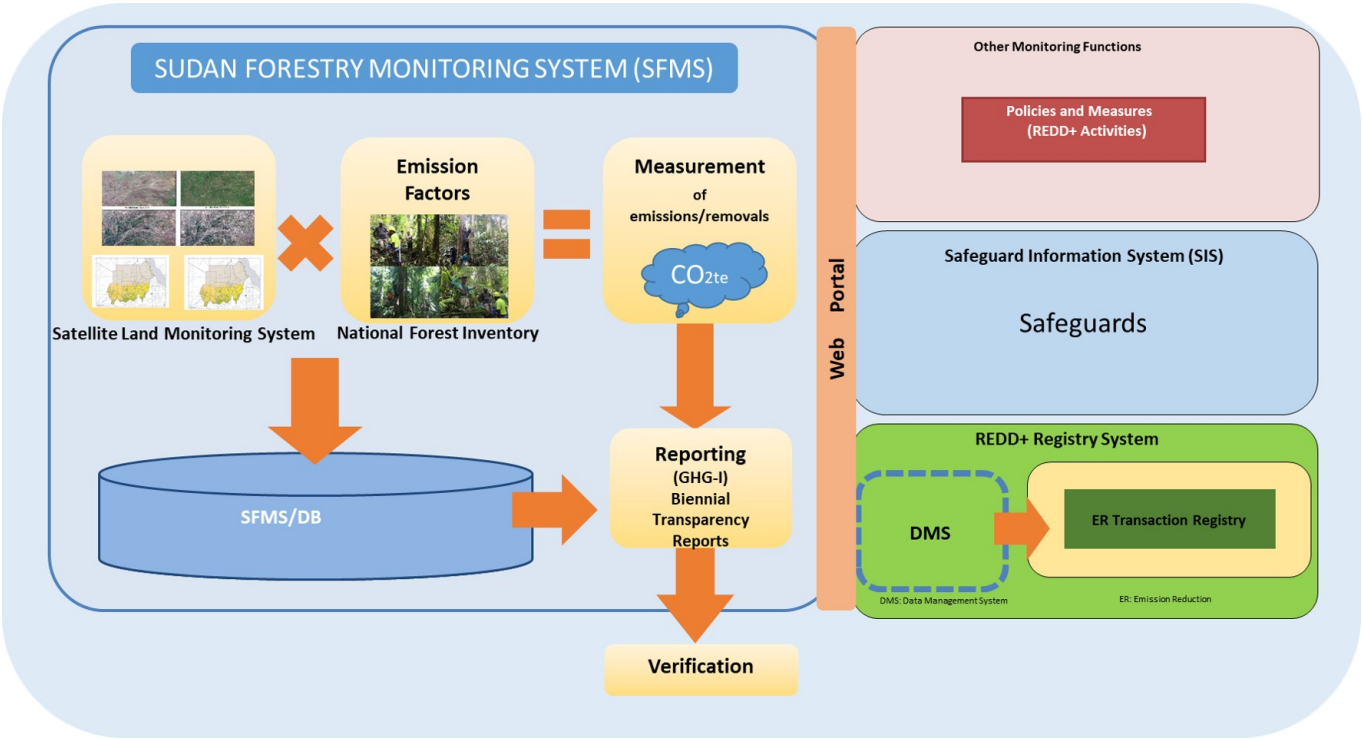
154. Sudan will further refine monitoring indicators under REDD+ and mainstream such indicators across relevant sectors. This will be achieved through a stepwise process of developing methodological standards and protocols for monitoring and strengthening the implementation of REDD+ policies and measures, benefit sharing mechanisms including non-carbon, safeguards implementation, and ensuring long-term procedural standardization and consistency.

155. As noted earlier in the document, the achievement of these will occur through a strategic set of activities, that include capacity building, investment, monitoring and evaluation. Table 2-1 below summarizes the qualitative traits that Sudan plans to monitor along with the quantitative data generated through the SNFMS. Following guidelines for the UNFCCC on REDD+ reporting and lessons learnt from other programs established under REDD+ readiness process, Sudan integrates both quantitative and qualitative reporting requirements under the SNFMS as illustrated in Figure 6-1. This approach enables an integrated approach, sectoral MRV and supports Sudan´s endeavor to meet the emerging enhanced transparency framework under the 2015 Paris Agreement.

Table 6-1 General activities to be monitored under REDD+

1	Addressing policy, legal and institutional issues related to land use and tenure together with forest governance to enable forest conservation and forest restoration.
2	Establishment of strong institutional mechanisms for an effective cross-sectoral coordination for the NRS implementation.
3	Developing a robust and transparent approach and methodologies, consistent with international standards and procedures, for setting the baseline emissions and removals, and designing an effective monitoring, reporting and verification (MRV) system for determining verified emissions reductions and removals targeted to receive payments for performance.
4	Mobilizing resources (including non-results-based funding) and intensifying investments in forestry for increased emission reductions and carbon removals.
5	Establishing and operationalizing a transparent REDD+ financial management mechanism and a fair benefit-sharing scheme.
6	Identifying needs and taking appropriate measures for building national and sub-national capacity to support REDD+ activities of planning, implementation, monitoring and reporting at all levels.
7	Promotion of knowledge generation through education and research and strengthening public awareness, communication and information sharing on REDD+ issues to increase understanding and ownership of the program by various actors at different levels.
8	Establishing mechanisms for active participation and engagement of a wide range of stakeholders including communities and the private sector in NRS formulation and implementation.
9	Implementing safeguards program for ensuring that RoS's REDD+ implementation observes globally acceptable social and environmental safeguard standards particularly the development of a benefit-sharing mechanism (BSM), consultation and participation plan and Grievance Redress Mechanism (GRM).

Figure 6-1 SNFMS and other monitoring functions



PART IV: REPORTING: METHODOLOGICAL APPROACH

7. GREENHOUSE GAS INVENTORY

156. This section outlines Sudan´s steps for estimating emissions and removals for activities to reduce emissions from deforestation and forest degradation, plus the role of conservation, sustainable forest management, and enhancement of forest carbon stocks in developing countries (REDD+), the main carbon pools and land-use types. It also provides an overview of the methodologies for estimating emissions and removals, including a discussion on the activity data (AD) and emission factors (EFs) needed.

157. Sudan recognizes the emerging global discussions following the adoption of the Paris Agreement in 2015 to establish an enhanced transparency framework (ETF). Like all Parties to the Paris Agreement, Sudan will work towards establishing the necessary arrangements to implement the ETF. This recognizes the expected transition from Reporting of Biennial Reports (BR) and BURs to Biennial Transparency Reports (BTR) and that modalities, procedures and guidelines (MPGs) will supersede reporting of BRs and BURs and the international assessment and review (IAR) and international consultation and analysis (ICA) processes for Paris Agreement Parties as per decision 1/CP.24, para. 39). It is further noted that the final BURs by developing countries shall be those that are submitted no later than 31 December 2024 (1/CP.24, para. 38). This implies that Sudan may submit its final BUR prior to 2024.

158. Sudan will follow the principles in line with IPCC GPG as follows

> **Transparency**: There is sufficient and clear documentation so that individuals or groups other than the inventory compilers can understand how the inventory was compiled and can confirm the quality of the data (to include Operationalization of the Enhanced Transparency Framework);
>
> **Completeness**: Estimates are reported for all relevant activities and gases. Where data are missing, their absence should be clearly documented;
>
> **Consistency**: Estimates for different inventory years, gases and categories are made in such a way that differences in the results between years and activities reflect real differences in emissions. The inventory of annual trends, as far as possible, should be calculated using the same method and data sources for all years and should aim to reflect the real annual fluctuations in emissions and not be subject to changes resulting from methodological differences;
>
> **Comparability**: The GHG inventory is reported in a way that allows it to be compared with GHG inventories from other countries; and
>
> **Accuracy**: The GHG inventory contains neither over nor underestimates, so far as can be judged, and uncertainties have been reduced as much as is practical. This requires undertaking all efforts to remove bias from the inventory estimates.

7.1 Sudan GHG-I Status

159. Sudan has submitted two NC documents with chapter information on GHG inventory where net emissions from LULUCF sector were reported based on IPCC default values. Sudan's first National Communication (NC) was submitted in 2003 and the 2nd one was submitted in 2013. For the first NC, the assessment of GHG-I was carried out using IPCC revised guidelines of 1996 and emissions were calculated using both IPCC Beta v1.0

and Beta v1.1 Software. Three land use management practices i.e. change in forest and other woody biomass stocks, forest and grassland conversion, and abandonment of managed lands were reported to result in net emissions. GHGs measured include CO_2, CH_4, N_2O, NOx, and CO.

160. The 2nd NC assessment was carried out also using the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1996). In addition, the Good Practice Guidance 2000 (IPCC, 2000) and the Good Practice Guidance for Land Use, Land–Use Change and Forestry (IPCC, 2003) were also consulted. Default IPCC emission factors were used, and the calculation of carbon dioxide-equivalent (CO_2eq) values was based on Global Warming Potentials from the IPCC's Second Assessment Report. Version 1.3.2 of the non-Annex I GHG Software (UNFCCC, 2007) was used to derive the estimates and tabulate emissions from different sources and sinks.

7.2 GHG-I Methodological Approach

161. HCNER has data sharing agreements in the form of MoUs with ten different sectoral (including AFOLU sector) institutions for sharing, collecting and compiling of GHG relevant data and information at the national level.

> **Identified key emission categories for AFOLU**:
>
> - forest land remaining forest land (desert, semi-desert, low rainfall in Sand, low rainfall in clay, high rainfall).
>
> - cropland remaining as crop land (rice land, biomass burning, urea and soil), and grass land remaining as grass land (enteric fermentation, manure management, savannah burning).

7.2.1 Data Sources and estimation of emissions

162. The information on national level Activity Data is drawn from various sources including FAO's FRA studies in the previous NCs. The EFs are developed at the national level through National Forest Inventory using IPCC's Tier 3 methodological approach. Sudan will continue to use IPCC Tier 1 default values until country specific EFs become available. Sudan is collecting data on forest area changes, carbon inventory and emission factor data for developing a sub-national FREL for Gadarif, Blue Nile and Sinnar. This will form the basis for national level methodological approach.

163. It is also worth noting that the efforts under REDD+ Readiness preparations enabled Sudan to develop a database that will contribute to some Tier 2 level parameters. The sub-national FREL and SNFMS development processes and products are to serve as key inputs of the AFOLU Forest Land Table 3.B.1. (Table 3) and AFOLU land use types data. However, for the current sub-national FREL, country specific sub-national AD is being generated. The IPPCC basic equation used to estimate land use related activities is:

Emissions	**=**	**EF x AD**
Where:		
E	=	Emission
EF	=	Emission Factor
AD	=	Activity Data

164. In Sudan, land use and forestry features that are most relevant to the development of the GHG inventory are briefly described in the bullets below.

- **Social value:** In rural areas, where the majority of the population lives, wood is the main source of fuel for cooking and construction materials for buildings. In addition, forests are important natural grazing areas, for both wildlife and livestock and for obtaining forest food in the form of tree leaves, fruits and tubers.
- **Encroachment:** Forests have been facing encroachment by agriculture, urbanization, and unsustainable wood fuel extraction for several decades. By the end of 1997, forest reserves comprised of only 8.3 million hectares, less than 17% of the target of 46.3 million hectares called for in the Comprehensive National Strategy 1992–2002.
- **Sustainable forestry:** Recognition of the need to confront the decline in forest area has led to several sustainable forestry initiatives, particularly the adoption of community-based forestry management practices and switching from firewood/charcoal to LPG. These initiatives are expected to protect forest cover in the long-term.
- **Industrial wood consumption:** The industrial sector typically accounts for less than 10% of the total wood consumption. Over 98% is consumed as firewood at industrial/commercial facilities with the remainder taken up by brick kilns, the lime industry, sawmills, and other wood-based industries in the country.

165. Table 7-1 summarizes the AFOLU land use types and data sources. As of necessity, Sudan will incrementally improve the quality of data and sources.

Table 6-1 The forest land tables (3.B.1.a /3.B.1.b) AFOLU land use types data sources

3.B.1.a Forest Land remaining as Forest Land / 3.B.1.b Land converted to Forest Land	Sub-National FREL (Gadarif, Blue Nile, Sinnar)
Area Entry Table	Area entry tables for forest and non-forest estimates for 2018 over the FAO's LCCS is under process. Sudan has also developed a national forest classification system which needs to be harmonized with IPCC guidance on Land Representation to develop National FREL.
Land use conversion matrix	Land use conversion matrices are not available for the periods 2006-2010, 2010-2014, 2014-2018. Forest cover change matrices will become available in the future, including ensuring consistency in satellite data used to build the

	forest cover change maps for the 2006 forest cover map, 2010, 2014 and 2018 which are generated from a combination of Landsat, ASTER and SPOT imagery
Annual increase in carbon stocks in biomass	Forest growth rates are derived from literature / Average forest cover increment
Loss of carbon from wood removals	To be based on the annual wood removal statistics if available from the FNC
Loss of carbon from fuel wood removals	To be based on the annual wood removal statistics if available from the FNC
Loss of carbon from disturbance	On carbon losses due to deforestation included.
AFOLU land use types	
Land use Subcategory	Land Use Sub-Categories are defined in recently developed national land-use/ forest classification system. However, for the current sub-national FREL, FAO's LCCS is used to generate only forest cover/ change maps at tier 2 level. Country specific Activity Data and Emission Factors for agriculture and grass land will be developed in the future. Disturbances from agriculture and grassland will be reported using Tier 1 default values.
Carbon fraction of above-ground biomass	IPCC default value (0.47) will be used
Ratio of belowground biomass to above-ground biomass	IPCC default values based on Table 3.A.1.8 (IPCC 2006) will be used

7.2.2 Emission Factors (EF) and Tiers

166. Data on emissions factors will come from the combination of a forest inventory, allometric equations and remote sensing.

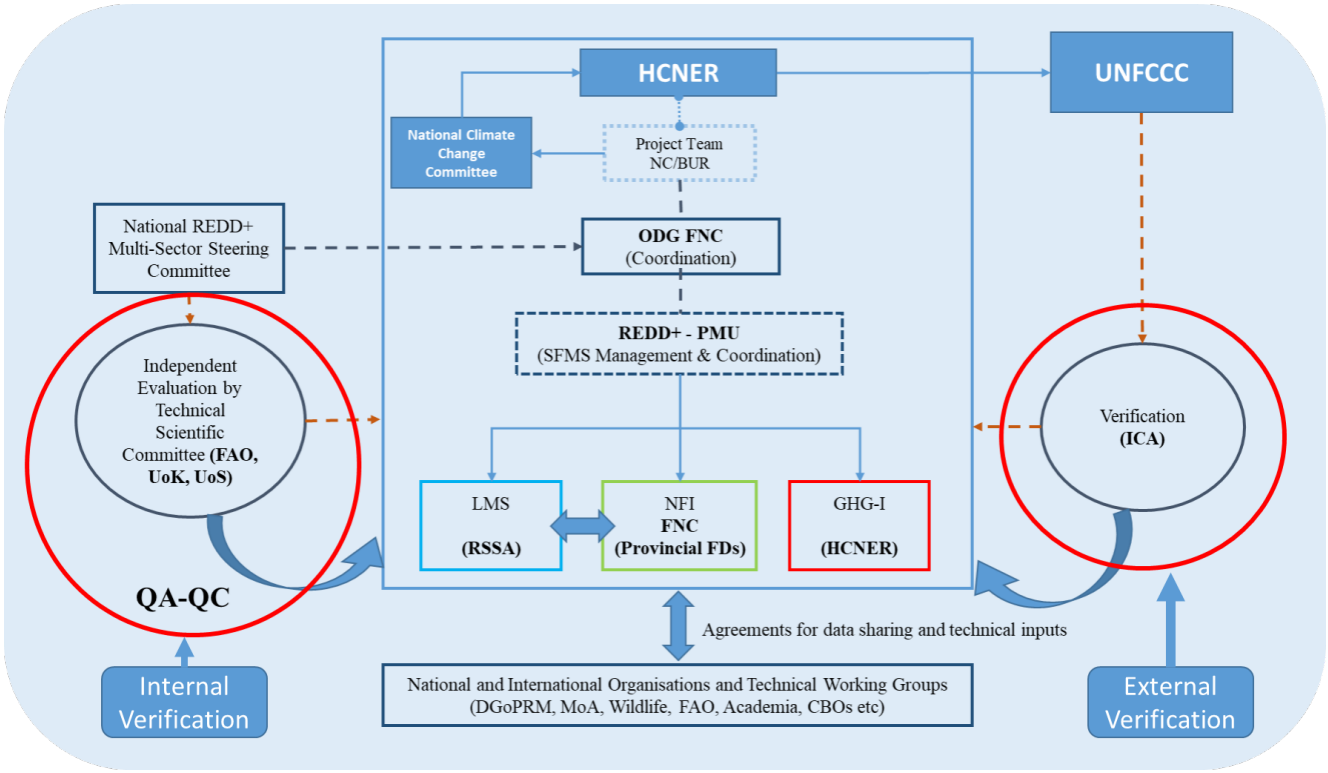
167. The objective of the RoS is to progressively move from Tier1 to Tier 3. This progression from Tier 1 to Tier 3, in general, represents a reduction in the uncertainty of GHG estimates through an increase in the complexity of measurement processes and analyses (refer to Section 5.1.4).

8. VERIFICATION

168. According to the GPG-LULUCF (IPCC, 2003), the "purpose of verifying national GHG inventories is to establish their reliability and to check the accuracy of the reported numbers by independent means. Sudan will therefore perform verification at several levels: project, national and international." The IPCC has also stipulated that the overall goals of verification are to provide inputs to improve GHG inventories, build confidence on estimates and trends, and to help to improve scientific understanding. Sudan will achieve these goals as illustrated in Figure 8-1, through internal and external checks as follows:

- **Internal checks**, which are performed by the organizations, agencies or individuals responsible for the compilation of the inventory; and
- **External checks**, which are performed by other bodies not directly involved with the preparation of the GHG inventory (e.g., other government agencies, private companies, research institutions, independent scientists, non-governmental organizations).

Figure 6-1 SNFMS Verification



169. To achieve the rigor necessary for verification, Sudan will incrementally build capacity for

- Sufficient independent expertise;
- Ensuring documentation of the verification is included in the inventory report;
- Ensuring uncertainty estimates and QA/QC documentation is included in the report;

- Ensuring other available national verification activities are described;
- Applied verification methods are transparent, rigorous and scientifically sound;
- Ensuring verification results are reasonable and well-explained; and
- Ensuring final calculations can be reasonably linked to underlying data and assumption."

170. For each agency with a role or responsibility the compilation of GHG-I, Sudan will drive for the development of string QA/QC and verification plans that:

- **Identify the criteria for selecting the inventory elements for verification**. For example, key source/sink categories should be given priority for verification. At the same time, non-key categories can also be selected for verification if they are of particular relevance to mitigation efforts, or their uncertainty is high, or they are expected to change significantly over the inventory reporting period.
- **Decide how the inventory elements will be verified**. In addition to the suitability/availability of a particular verification approach, other criteria to be used for selecting a particular approach include: the type of data to be verified; the spatial scale of the inventory coverage; the quantity and quality of the data to be verified; and the accuracy, precision and cost of the approach itself.

171. For international verification, and specifically with regard to REDD+, Sudan will make its submission in line with the Warsaw Framework for REDD+ given the motivation to participate in results-based payments. In accordance with decision 12/CP.17, Sudan will submit its FREL to the UNFCCC for a technical assessment. Such a submission will be made on the recognition of objectives of such a technical assessment are:

- To assess the degree to which the information provided is in accordance with the guidelines for submissions of information on FREL/FRL (annex to decision 12/CP.17) for the construction of the FREL/FRL;
- To offer a facilitative, non-intrusive, technical exchange of information on the construction of FRELs/FRLs with a view to supporting the capacity of developing countries for the construction and future improvements, as appropriate, of their FRELs/FRLs subject to national capabilities and policy.

9. OPERATIONAL FUNDING AND CAPACITY BUILDING

172. The SNFMS will be funded from a combination of sources, including federal government annual fiscal allocation at the federal and state levels. Sudan will continue to mobilize additional resources from international development partners through bilateral and multilateral sources. One of the objectives of this MRV document is to enable mainstreaming of REDD+ monitoring functions within and across sectors and ensure financing of monitoring functions becomes business-as-usual.

173. The RoS will constantly prepare proposals and solicit funding for various mitigation and adaptation projects, via international climate funds such as the Green Climate Fund, Global Environmental Facility, and other sector specific funds. Project proposals will be expected to include budgets to support monitoring functions that contribute to the overall objectives of the REDD+ MRV system.

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REPUBLIC OF SUDAN

MEASUREMENT, REPORTING, AND VERIFICATION SYSTEM FOR REDD+

FINAL REPORT

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