Baseline report

Liberia's National GHGI and MRV System

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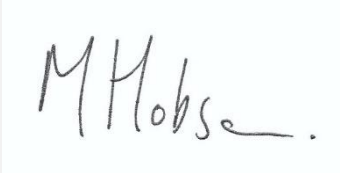
Signature	
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Glossary

BTR	Biennial Transparency Report
BUR	Biennial Update Report
CH_4	Methane
CI	Conservation International
CO_2	Carbon dioxide
EPA	Environmental Protection Agency
ETF	Enhanced Transparency Framework
FAO	Food and Agriculture organisation
FOLU	Forestry and other land use
GHG	Greenhouse gas
HFCs	Hydroflurocarbons
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial processes and product use
LDC	Least developed country
LULUCF	Land use, land use change and forestry
MoU	Memorandum of Understanding
MPG	Modalities, Procedures and Guidelines
MRV	Monitoring, Reporting and Verification
N_2O	Nitrous Oxide
NC	National Communication
NDC	Nationally Determined Contribution
NF_3	Nitrogen Trifluoride
PFCs	Perfluorocarbons
QA/QC	Quality Assurance and Quality Control
SBI	Subsidiary Body for Implementation
SDG	Sustainable Development Goal
SF_6	Sulphur Hexafluoride
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

1.1 Liberia's current state of play with UNFCCC reporting

Under the UNFCCC, Liberia is classified as a non-Annex I party and a Least Developed Country (LDC) and can submit National Communications (NCs) at their discretion. NCs include an inventory of sources and sinks of greenhouse gas (GHG) emissions, a description on the steps taken by the Party to implement the Convention and any other relevant information relevant to the achievement of the objective. Liberia submitted its initial NC in 2013[1]. This highlighted that in 2000, the energy and agriculture sectors contributed approximately 67.5% and 32% of Liberia's GHG emissions respectively, but that overall Liberia was a net sink of greenhouse gases due to the level of carbon removals from the land use change and forestry (LULUCF) sector. The Initial NC however highlighted that the accuracy and completeness of the inventory was constrained by a lack of reliable and up to date activity data, particularly for the forestry, agriculture and waste sectors.

In 2015, 196 Parties came together under the Paris Agreement to set the world on a course towards sustainable development, aiming at limiting warming to 1.5 to 2 degrees centigrade above pre-industrial levels. The Agreement requests each country to outline and communicate its climate actions in the format of Nationally Determined Contributions (NDCs). Liberia submitted its Intended NDC (INDC) in September 2015[2]. This re-iterated Liberia's targets set out in the 2009 National Energy Policy:

- Reducing GHG emissions by at least 10% by 2030
- Improving energy efficiency by at least 20% by 2030
- Raising the share of renewable energy to at least 30% of electricity production and 10% of overall energy consumption by 2030
- Replacing cooking stoves with low thermal efficiency (5 – 10%) with the higher efficiency (40%) stoves.

The INDC has also set a long-term strategy of achieving carbon neutrality by 2050 and identified mitigation measures for the energy and waste sectors to help them achieve these targets. In order for progress towards these targets to be tracked, the next step is for Liberia to develop a more up to date and complete greenhouse gas inventory in preparation for the implementation of the modalities, procedures and guidelines (MPGs) under the Enhanced Transparency Framework of the Paris Agreement[3]. The MPGs require all parties to submit their first biennial transparency report (BTR) and national inventory report (NIR) by 31 December 2024[4] with the added flexibility for LDCs to submit this information at their discretion.

Nonetheless, there is a present need to enhance the internal capacity within Liberia for the development of the national GHG inventory currently being prepared for Liberia's first Biennial Update Report (BUR1) and second National Communication (NC2) report, which are due to be submitted to the UNFCCC soon; as well as establishing a national

[1] https://unfccc.int/documents/124386

[2] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Liberia%20First/INDC%20Final%20Submission%20Sept%2030%202015%20Liberia.pdf

[3] https://unfccc.int/documents/184700

[4] https://unfccc.int/sites/default/files/resource/cma2018_3_add2_new_advance.pdf

MRV (Monitoring, Reporting and Verification) system for data sharing that will respond to the emerging implementation of the Enhanced Transparency Framework (see below).

1.2 The UNFCCC and Paris Agreement requirements summarised

The MPGs for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (Decision 18/CMA.1), establish a rubric against which national procedures and reporting structures can be evaluated. The 'enhanced transparency framework', as it is known in Article 13, sets out guidelines for providing clarity on Parties' progress, actions and support, whilst maintaining flexibility. Successfully executed, this transparency framework will underpin important investment and technology exchange decisions. The transparency framework will focus on providing clarity on mitigation and adaptation trends, projections, actions and support provided and received. A future proof national MRV system that is able to respond to the requirements of the MPGs needs to consider the key components that are covered by the Biennial Transparency Report (BTR):

- National Inventory Report
- NDC tracking
- Climate change impacts and adaptation
- Financial, technology transfer and capacity-building support needed and received

As part of the BTR requirements it is important for Parties to maintain and report on institutional, legal and procedural arrangements that facilitate sustainable and continued reporting on GHG inventory compilation, on the tracking of mitigation and adaptation actions and on the support needed and received.

Parties' reports will also undergo some forms of non-adversarial and non-punitive international review. The review will facilitate implementation, promote compliance and will report annually to the Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement (CMA). The transparency framework will need to be flexible to accommodate Parties' differing capabilities for data gathering, analysis, reporting and ability to respond to scrutiny.

At the same time as the full implementation of the Paris Agreement, Parties will continue to implement their existing commitments under the Convention. Discussions continue under the UNFCCC to enhance the existing system including reporting and review requirements.

1.3 Documents reviewed

This baseline report provides the results of a review of the recent greenhouse gas inventories compiled for Liberia in the draft NC2 and BUR1. The former provides estimated emissions for the year 2014 and the latter provides estimated emissions for the years 2015, 2016 and 2017[5]. In addition, where appropriate, reference is also made to the inventory compiled for 2000 for the NC1[2]. It is worth noting that only the reports were made available and no underlying calculation files were provided. In addition, a review has been undertaken of the current environmental systems in place in Liberia and makes recommendations for an MRV system.

[5] Although it is worth noting that emission estimates are provided as "Not Estimated" for 2017.

1.4 Emissions inventory scope

GHG emission inventories are being compiled for the NC2 and BUR1 for the following gases:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)

In addition, in a few cases for some sectors emissions have been compiled for the non-direct greenhouse gases (NOx, CO, NMVOCs and SO_2). No emission estimates have been compiled for the F-gases (HFCs, PFCs, SF_6 and NF_3).

The emission estimates have been compiled for the following sectors in line with the 2006 IPCC guidelines:

- Energy (including transport)
- Industrial processes and product use
- Agriculture
- Land Use and Land Use Change
- Waste

Each sector is then split into individual categories (for example, Energy - transport) and sub-categories (for example, road transport) and then further sub-divided into further categories where necessary (for example, passenger vehicles).

Under the IPCC guidelines, GHG emissions are reported by IPCC code. Where emissions data are not provided for any code, a notation key as provided in the box below should be used to explain why. This approach has been used in subsequent chapters to indicate whether emission estimates have or should be made for the sector and it is recommended that these notation keys are used by Liberia for GHG reporting going forward.

NO: Not Occurring. The activity does not occur within the Country / Regional inventory being reported.

NE: Not estimated. The reason for this, should be provided in the accompanying report to provide transparency.

NA: Not applicable. This is used for activities that do not result in emissions of that particular pollutant. For example, carbon dioxide from enteric fermentation from farm animals.

IE: Included elsewhere. This is used where emissions are included elsewhere in the inventory. For example, it is sometimes not possible for emissions arising from mobile machinery to be separated from stationary machinery within the industrial sector.

1.5 Emissions inventory methodology

The most common simple methodological approach is to combine information on the extent to which a human activity takes place (called activity data) with coefficients which quantify the emissions per units of activity. These are called emission factors. The basic equation is therefore:

Emissions = activity data * emission factor

For example, in the energy sector, at the simplest level, fuel consumption would constitute activity data and mass of carbon dioxide (CO_2) emitted per unit of fuel consumed, would be the emission factor. Some emissions sources will be more complex to estimate. In these cases, a number of different parameters may be combined with activity data in order to estimate emissions. The agriculture and waste sectors provide examples where influences such as soil conditions, specific animal characteristics and climatic features may all determine the generation of greenhouse gas emissions.

1.6 Emission inventory tiers

In GHG inventories, the IPCC guidelines provide methodologies using different complexities. These are known as Tiers. Tier 1 is the basic method and will often use the basic equation provided above and a default emission factor from the 2006 IPCC guidelines. Tier 2 is an intermediate level and uses more country-, or technology-specific emission factors and Tier 3 is the most demanding in terms of complexities and data requirements. Tier 2 and 3 are generally considered to be more accurate but require more complex input data.

Under the IPCC, countries are encouraged to compile emission estimates using a Tier 2 methodology or higher for key categories[6]. However, completeness is of high priority and therefore where it is not possible to compile estimates using a Tier 2 due to a lack of data, a Tier 1 methodology is appropriate.

The draft inventories compiled for the NC2 and BUR1 use a Tier 1 approach due to data availability and if appropriate moving to a Tier 2 methodology is discussed in the recommendations.

1.7 Emission inventory quality requirements

In order to promote the development of high-quality inventories, a collection of guidance is available and compliance with these are often referred to as good practice. Common across emission inventory guidance is the goal to develop inventories around the *TCCCA* principles. This consists of the following elements:

- Transparency: Providing sufficient and clear documentation, allowing individuals or groups other than the inventory compiler to understand how the inventory was compiled and to be assured that the inventory meets the good practice requirements.

[6] A key category is one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory in terms of the absolute level, the trend, or the uncertainty in emissions and removals.

- Completeness: Estimates are reported with full geographic coverage for all relevant categories. Where elements are missing, their absence should be clearly documented together with a justification for exclusion.

- Consistency: Inventory annual trends, as far as possible, should be calculated using the same method and data sources in 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 inventory is reported in a way that allows it to be compared with national inventories for other countries. This comparability should be reflected in the appropriate choice of reporting guidance and tables and use of the classification and definition of categories of emissions.

- Accuracy: The national inventory contains neither over- nor under-estimates so far as can be judged. This means making all endeavours to remove bias from the inventory estimates.

In the subsequent sections, comments are provided on the quality of the data that has been made available using the TCCCA criteria.

2 Energy industries (IPCC code: 1A1)

2.1 Background to the sector

This sector covers emissions from fuels combusted from the fuel extraction or energy producing industries. The emissions are categorised into:

- Emissions from the main activity producers of electricity generation, combined heat and power plants and heat plants. 'Main activity producers' are those organisations who primary activity is to supply the public. This sub-category has the IPCC code 1A1a. Emissions from auto-producers (sites which generate electricity wholly or partly for their own use) should be assigned to the sector where they are generated and not under 1A1a. Auto-producers may be in public or private ownership.

- Combustion activities occurring in the petroleum refining sector. This sub-category has the IPCC code 1A1b. This activity does not occur in Liberia and is therefore not discussed further in this report[7].

- Combustion emissions from fuel use during the manufacture of secondary and tertiary products from solid fuels including charcoal. This sub-category has the IPCC code 1A1c.

2.2 Input data required for public electricity and heat production (1A1a)

The following table outlines the data required for the different methodology tiers.

[7] It is noted however that there is an organisation called the 'Liberia Petroleum Refining Company', but it is thought that this does not undertaking refining of petroleum.

Table 1. Data required for calculation of energy industries activities

Tier	Data required
Tier 1	Annual total fuel used by the main electricity producers (for example, the Liberia Electricity corporation) in Liberia, disaggregated by fuel type. 2006 IPCC Guideline emission factors
Tier 2	Annual total fuel use by the main electricity producers, disaggregated by fuel type and by combustion plant technology. 2006 IPCC Guideline emission factors
Tier 3	Annual fuel use by facility. Type of technology used at each facility and emission factors by technology based on local measurements.

2.3 Data available for Public Electricity and Heat Production (1A1a)

According to the NC2, the Liberia Electricity Corporation (LEC) started operation in 1976 and has a mandate to plan, generate, transmit, distribute and sell electricity. It is estimated that approximately 19% of households in urban areas have access to electricity. Of which 4.5% have access to LEC power, 4.9% use a community generator, 4.4% have their own generator, 3.9% use vehicle batteries and 0.8% use other sources (page 14 of the NC2). Therefore, the amount of electricity supplied by LEC is a small proportion of that generated and supplied in the country. In rural areas, it is estimated that only approximately 2% of households have access to electricity.

Power from LEC is provided by diesel generators and the Mount Coffee hydropower plant. This was in a state of disrepair, but according to the BUR1 began fully operating again in December 2016 and was fully operational throughout 2017 resulting in a large reduction in estimated GHG emissions. The NC2 however states that the site faced more problems rendering it incapable of meeting its commitment of being fully operational by 2018 (page 14) and so the current status of the plant is uncertain.

As well as emissions arising from the LEC's activities, emissions from the independent power producers should also be included in this category. The fuel combusted from households using their own generators would be reported in the residential sector (see 1A4b).

A summary of the findings of the review of the public electricity generation sector emission estimates are provided in Table 3. Only the final emission estimates have been made available to review and the underlying calculations were not available and therefore no comments are made on the figures provided, apart from commenting on relative proportions or where estimates are zero where data is expected.

2.4 Input data required for the manufacture of solid fuels (1A1c)

The following table outlines the data required for the different methodology tiers for estimating emissions from the manufacture of solid fuels.

Table 2: Data required for calculation of solid fuel manufacture activities

Tier	Data required
Tier 1	Annual total fuel used by solid fuel manufacturers in Liberia for their own use (for example charcoal manufacturers), disaggregated by fuel type. 2006 IPCC Guideline emission factors
Tier 2	Annual total fuel use by solid fuel manufacturers in Liberia for their own use, disaggregated by fuel type and by combustion plant technology. 2006 IPCC Guideline emission factors
Tier 3	Annual fuel use by facility. Type of technology used at each facility and emission factors by technology based on local measurements.

2.5 Data available for solid fuel manufacture (1A1c)

The NC1 and NC2 (page 13) both refer to an estimate that 95% of households in Monrovia use charcoal and firewood for cooking and heating. Page 36 of the NC2 then goes on to say that the most recent Census (2008 data, published in 2009) shows that 70% of the urban population use charcoal for cooking and 5% of the rural population and that in Monrovia, the percentage of households using charcoal is even higher, 85%. Therefore, there is clearly a high demand for charcoal. Currently however, no emission estimates are included for the manufacture of charcoal in either the NC1, NC2 or BUR1.

Table 3: Summary of key findings for the energy sector (1A1)

Sector – IPCC code	Finding	Comments	Recommendations
1A1	NC2: Emission estimates are only provided for the 1A1 category as a whole and no breakdown is provided (page 39)	It is thought that the emissions provided relate solely to electricity production and that emissions from solid fuel manufacture has not been estimated as no reference is made to this sector (see below).	It is recommended that further detail is provided on the type of fuel(s) that have been consumed in the electricity sector and whether the estimates relate solely to the LEC plants or whether independent power producer plants are also included in the estimate. In addition, it is recommended that emissions are reported for the 1A1 sub-categories
1A1	NC2: CH_4 are estimated as zero in Table 2.3	It is expected that CH_4 emissions will arise from the electricity production sector. It is thought that perhaps the estimated CH_4 emissions are less than 0.5 Gg and that as no decimal places are shown that '0' is shown	It is recommended that emissions are reported to 2 decimal places. Alternatively, if emissions are zero, then it is recommended that the methodology and the emission factor used are reviewed.
1A1	NC2: N_2O emission estimates seem high in Table 2.3	It is thought that the N_2O emission estimate is too high in relation to the CO_2 emission estimate (and CH_4 if applicable)	It is recommended that the emission factor and calculation for estimating N_2O emissions from electricity production is reviewed
1A1	NC2: NOx emission estimates are provided for the total of 1A1 but are zero for the sub categories	It is unknown what sub-sector the NOx emissions relate to	It is recommended that emissions are reported for the 1A1 sub-categories where possible, so that a clear understanding of what sector the emissions relate to can be seen
1A1	NC2: NOx emission estimates are the same as N_2O and seem low	It is thought that the NOx emission estimate may be an under-estimate as it is likely to be higher than the N_2O emission estimate	It is recommended that the emission factor and calculation for estimating NOx emissions from electricity production is reviewed
1A1	NC2: Emission estimates for CO, NMVOCs and SO_2 are zero in Table 2.3	It is thought that emission estimates have not been compiled for these non-direct GHGs	It is recommended that where emission estimates haven't been calculated that the notation key "NE" (not estimated) is used to make it clear that emissions are not zero, but they haven't been estimated.
1A	NC2: Emissions for 1A are provided in Table 2.3. However, it is unclear how this has been calculated	A total emission estimate for 1A is expected to be the sum of all 1A sub-categories. For example, a figure of 4,969Gg of CO_2 is provided. However, 1A1 is estimated to be 2,502Gg and 1A3 is estimated to be 4,147 Gg so it is not clear how the 4,969 figure has been calculated	It is recommended that the total emission estimates for 1A and for the energy sector as a whole are reviewed for Table 2.3

Sector – IPCC code	Finding	Comments	Recommendations
Energy sector	BUR1: There are large differences between the Reference v Sectoral approach (page 72)	There is a large discrepancy between the sector and reference approach	It is recommended that the difference between the two approaches is minimised and that perhaps the reference approach is used if that is likely to result in better emission estimates.
Energy sector	BUR1: It is unclear why the data provided in Table 2.11, the text below and that provided in Table 2.12 and Table 2.13 and Figures 2.5 to 2.7 are all different	There are different emission estimates provided in these three tables and in the accompanying text and figures and it is unclear why the data is different. Table 2.12 in particular has very large values.	It is recommended that the data in Tables 2.11, 2.12 and 2.13 and the accompanying text and figures are reviewed and checked for accuracy. In addition, it is highly recommended that data is provided on an annual basis and that emission estimates are not summed across the years as it is thought that perhaps this is what one of the tables is currently showing.
Energy sector	BUR1: The emission estimates for CH_4 seem high in Table 2.11	If the fuel type being assumed is diesel, then the CH_4 emission estimates seem high in relation to the CO_2 emission estimates	It is recommended that the CH_4 data in Table 2.11 is checked for accuracy
Energy sector	BUR1: Emission estimates for the non-direct GHG are zero in Table 2.12	There will be emissions of NOx, CO, NMVOCs and SO2 from diesel combustion	It is recommended that emission estimates are calculated for these pollutants or that the notation key "NE" (not estimated) is used to make it clear that emissions are not zero but haven't been estimated
Energy sector	BUR1: Emission estimates for 1A1 equal 1A in Table 2.11	Emission estimates for 1A should comprise all of those sectors in 1A (1A1, 1A2, 1A3 etc) but currently only 1A1 are included in the total of 1A provided	It is recommended that the total emission estimates for 1A are reviewed and checked for accuracy
Energy sector	BUR1: It is unclear what the difference is between summary tables 2.1, 2.2 and 2.3	The table headings for Table 2.1 and 2.2 are the same, but it is thought that perhaps 2.1 contains data for 2015 and 2.2 for 2016 and 2.3 is data for 2015 + 2016?	It is recommended that the table headings for 2.1 and 2.2 are reviewed. Adding up the emissions across multiple years is not recommended. If Table 2.3 is to remain in the report, then it is recommended that the emission estimates for 1A-energy are checked as these are substantially lower than that provided in the sub-rows below
1A1c – solid fuel manufacture	No data is currently available	This source does not currently appear to be included in the NC1, NC2 or BUR1	It is recommended that the National Charcoal Union of Liberia is contacted to ascertain whether they could provide any data on annual fuel consumption by the charcoal manufacturers. If not, the amount of fuel consumed by the charcoal manufacturers could be estimated from the amount of charcoal estimated to be consumed in the country

2.6 Summary and brief recommendations

As identified in Table 3, it is recommended that further detail is shared on the calculations that have been undertaken to generate the emission estimates provided in the NC2 and BUR1 to enable further improvements to be undertaken. It is also recommended that additional information is added on the methodology to the reports to improve transparency. Lastly it is also recommended that the data in some of the tables is reviewed as outlined in Table 2.3

3 Combustion in manufacturing industries and construction (IPCC code: 1A2)

3.1 Background to the sector

This sector includes the emissions from the combustion of fuel in industry. A list of the major industries in operation in Liberia is provided in Table 2.9 on page 47/48 of the NC2. These include mining operation, an aluminium factory, breweries, a paint factory and the rubber plantation.

3.2 Input data required

The following table outlines the data required for the different Tiers.

Table 4. Data required for calculation of manufacturing industries and construction activities

Tier	Data required
Tier 1	Data on the amount of fuel combusted by source category by type and default emission factors from the 2006 IPCC guidelines
Tier 2	Data on the amount of fuel combusted by type by source category combined with a country specific emission factor for the source category and fuel
Tier 3	Plant specific emission factors

3.3 Data available

Currently the BUR1 does not report any emissions from combustion in manufacturing industries and construction. However, Table 2.8 (page 60) which provides a summary of completeness of the inventory implies that emission estimates have been made for this sector.

In the NC2, a total CO_2 emission estimate for this source in 2014 is provided (209 Gg). Emission estimates for the other gases are given as zero. No information is provided on what industrial sectors this covers or how the emissions have been estimated.

Table 5: Summary of key data available for the manufacturing industries and construction sector (1A2)

Sector – IPCC code	Findings	Comments	Recommendations
1A2	BUR1: Emissions from this sector are reported as "NA" for all gases, apart from for CH_4 and SO_2 for which a zero figure is given	The 2006 IPCC Guidelines use "NA" to mean 'not applicable' - This is used for activities that do not result in emissions of that particular pollutant. If emissions have not been estimated but do occur, using the notation key "NE" would be more appropriate	It is recommended that where emissions have not been estimated but which do occur in the country, then the notation key "NE" should be used for reporting purposes.
1A2	BUR1: As identified above, no emissions are estimated for this sector	A list of industrial sites is provided in Table 2.9 (page 47/48) of the NC2. It is unknown if this is complete, but this could be used as the starting point to estimate emissions	It is recommended that liaison is undertaken with the team compiling the NC2 to gather a list of industries and a discussion had as to how they have estimated GHG emissions from this sector.
1A2	NC2: A total CO_2 emission estimate of 209 Gg is provided	No information has been provided on how this estimate has been made. In addition, no estimates have been made for the other gases and it is unknown why	It is recommended that information is provided in the NC2 report on the methodology used to compile the CO_2 emission estimate provided. This should include what industrial sectors / sites have been included. It is also recommended that emission estimates are made for the CH_4 and N_2O. In addition, indirect GHG emission estimates could be calculated using factors from the 2006 IPCC guidelines / EMEP – EEA Guidebook. However, priority should be given to estimating the direct GHG emissions.

3.4 Summary and brief recommendations

As outlined in Table 5, it is recommended that a discussion is had between the BUR1 and NC2 team, so that a consistent approach is made across the two inventories and that emission estimates are made for all direct GHG gases and if the time and data allows for the indirect GHG. If data on total fuel consumption for this sector is unavailable within the country, then it may be possible to use data from UN Energy Statistics.

4 Transport (IPCC code: 1A3)

4.1 Background to the sector

GHG emissions arising from the combustion of fuel in the road transport, rail, domestic aviation and domestic maritime sector are included in this category. Emissions arising from international aviation and international navigation are reported separately as a memo item. Liberia has emissions arising from all of these sources.

4.2 Input data required

The following table outlines the data required for the different Tiers.

Table 6. Data required for calculation of transport activities

Tier	Data required
Tier 1	The amount of fuel by type is combined with default emission factors from the 2006 IPCC guidelines.
Tier 2	For CO_2, country specific carbon emission factors for each fuel type are utilised. For CH_4 and N_2O information is required on the amount of fuel combusted by each vehicle type (for road transport)
Tier 3	There is no Tier 3 for CO_2. For CH_4 and N_2O, detailed information is required on the road vehicle fleet composition

4.3 Data available

The BUR1 report provides background information on the road transport sector, rail, aviation, and navigation sector – for example, information is provided on the length of the road network in Liberia. However, no activity data (i.e. the fuel consumption by sector) that would be used to compile the emission estimates appears to be provided for 2015, 2016 or 2017. Only a total emission estimates for CO_2, CH_4 and N_2O for all of the transport sector is provided in Table 2.3 (page 52), with no breakdown of the contribution of the road, rail, aviation and navigation sectors provided.

The NC2 provides background information on the transport sectors – for example, for rail, information on the different lines operating is provided on page 143. However, table 2.4, which provides the estimated emissions for the transport sector only provides emission estimates for the road transport sector and domestic aviation and blank cells are provided for rail and domestic navigation.

Table7: Summary of key data available for the transport sector (1A3)

Sector - IPCC code	Findings	Comments	Recommendations
1A3	BUR1: Only total emission estimates for the direct GHGs are provided for the transport sector with no breakdown by road, rail, aviation or navigation	In order to improve the transparency of the emission estimates, further detail on the methodology followed and the breakdown by transport type is required	It is recommended that further detail is provided on the methodology followed for the different transport sectors and that emissions are reported at a greater level of detail i.e. by transport type
1A3	BUR1: In Table 2.3, the emission estimates for the transport sector are higher than the total energy estimate	In Table 2.3, the transport sector is stated as contributing 7,711 Gg of CO_2. This is the same estimate as for sector 1A4 and higher than the total estimate for the transport sector (3,561).	It is recommended that the emission estimates provided in Table 2.3 are checked for accuracy and amended if appropriate.
1A3	BUR1: Emission estimates for the transport sector for the indirect GHGs are provided as "NA"	The 2006 IPCC Guidelines use "NA" to mean 'not applicable' - This is used for activities that do not result in emissions of that particular pollutant. If emissions have not been estimated but do occur, using the notation key "NE" would be more appropriate	It is recommended that where emissions have not been estimated but which do occur in the country, then the notation key "NE" should be used for reporting purposes. However, priority should be given to estimating and improving the reporting of the direct GHGs.
Memo items	BUR1: Emission estimates for international aviation and international navigation are "N/A"	In Table 2.5, CO_2 emissions for international aviation and navigation are reported as N/A and for other gases / pollutants as zero. This is at odds with the text provided in 2.15.1.3	It is recommended that emission estimates are compiled for international aviation and international navigation and these estimates are included in the BUR1
1A3c and 1A3dii	NC2: No emission estimates are provided for the rail or domestic navigation sectors in Table 2.4	Descriptions of these sectors are provided in the NC2 report; however, no emission estimates are then provided	It is recommended that GHG emission estimates are compiled for the rail and domestic navigation sectors. This could be achieved from discussions with the BUR1 GHG inventory team or by using international datasets

1A3aii	NC2: Only CO_2 emission estimates are provided for the domestic aviation sector in Table 2.4	CH_4 and N_2O emission estimates are stated as zero. However, default emission factors are provided in the 2006 IPCC guidelines	It is recommended that CH_4 and N_2O emission estimates are calculated and reported for this sector
1A3aii and 1A3ai	NC2: Estimated CO_2 emissions for domestic and international aviation are almost identical	Table 2.6 provides estimated emissions from memo items. Estimated CO_2 from international aviation is 90Gg. However, the domestic aviation emissions provided in Table 2.4 are 91 Gg. It is unlikely that the emission levels are similar	It is recommended that the estimated CO_2 emissions for domestic and international aviation is checked and revised if appropriate.
Memo items	NC2: The text in Section 2.2.1.6.4.5 states: Domestic emissions are not included in the national total	Under the IPCC guidelines, the emissions arising from domestic aviation should be included in the national total. Emissions arising from international aviation are included as a memo item	It is recommended that the text in this section is reviewed and amended accordingly.
1A3ai and 1A3di	NC2: Table 2.6 only provides CO_2 emission estimates for these sectors.	CH_4 and N_2O emission estimates are stated as zero. However, default emission factors are provided in the 2006 IPCC guidelines for these sectors	It is recommended that CH_4 and N_2O emission estimates are calculated and reported for these sectors

4.4 Summary and brief recommendations

As identified in the table above, it is recommended that in both the BUR1 and NC2 that CO_2, CH_4 and N_2O emission estimates are provided for all of the transport sectors individually and that where estimates are currently provided, that they are checked for accuracy. If no activity data is available from national sources, then it may be possible to use international datasets such as UN Energy Statistics.

5 Fuel combustion: Other sources (IPCC code: 1A4)

5.1 Background to the sector

This sector includes fuel combusted in commercial and institutional buildings, households and agriculture, forestry and fishing. It is thought that all of these sectors are applicable to Liberia and therefore emissions should be reported.

5.2 Input data required

The following table outlines the data required for the different Tiers.

Table 8: Data required for calculation of other combustion activities

Tier	Data required
Tier 1	The amount of fuel by type is combined with default emission factors from the 2006 IPCC guidelines
Tier 2	Data on the amount of fuel combusted in each source category is combined with a country specific emission factor for each fuel / source
Tier 3	Detailed information on the technologies in use in each sector is required

5.3 Data available

The BUR1 in Section 2.15.1.2, page 69 states that estimates are only made for the residential and fishing sectors as activity data was not available for the other sectors. Only a combined emission estimate for these two sectors is provided. Some information is provided on the source of the activity data – for example, residential fuel use is obtained from the censuses conducted by the Liberia Institute of Statistics and geo-information System (LISGIS).

In the NC2, CO_2, CH_4 and N_2O emission estimates are provided for the majority of sub-sectors (commercial / institutional, residential, agriculture/forestry/fishing).

Table 9: Summary of key data available for other combustion (1A4)

Sector – IPCC code	Finding	Comment	Recommendations
1A4	BUR1: Table 2.3 provides a total emission estimate for 1A4	The methodology would be more transparent if emissions by sub-sector were provided	It is recommended that emissions are reported at a greater level of detail i.e. by sub-sector – for example that residential emissions were reported separately to fishing
1A4	BUR1: Table 2.3. The emission estimates for 1A4 are exactly the same as for 1A3. However, different figures are provided in Table 2.11	It is unlikely that the emission estimates are exactly the same for the transport sector as for the "other sectors"	It is recommended that the emission estimates provided in Table 2.3 and Table 2.11 of the BUR1 report are checked for accuracy and amended if appropriate.
1A4	The sub-sectors included in the BUR1 are different from that in the NC2	The NC2 includes estimates from the commercial / institutional and agriculture and forestry sectors	It is recommended that the BUR1 team liaises with the NC2 team to share data and methodologies so that the BUR1 estimates emissions from more sources
1A4a	NC2: Table 2.4 provides a CO_2 estimate for the commercial / Institutional sector but no CH_4 or N_2O estimates	Default emission factors are available in the IPCC guidelines for CH_4 and N_2O	It is recommended that emission estimates are compiled for CH_4 and N_2O for the commercial / institutional sector
1A4b	NC2: Table 2.4 provides the estimated emissions from the residential sector and the figure for CH_4 is higher than for CO_2	It is unlikely that the CH_4 emissions are higher than CO_2. In addition, N_2O emissions seem on the high side	It is recommended that the emission estimates reported in Table 2.4 of the NC2 are checked for accuracy and revised if appropriate.
1A4c	NC2: Table 2.4 provides a CO_2 estimate for the agri/forestry/fishing sector but no CH_4 or N_2O estimates	Default emission factors are available in the IPCC guidelines for CH_4 and N_2O	It is recommended that emission estimates are compiled for CH_4 and N_2O for the agriculture, forestry and fishing sector
1A4	NC2: Estimates of the indirect GHG emissions are only reported for some sectors / pollutants	An inventory should be complete where possible and where estimates haven't been made but the source occurs the notation key "NE" should be used	It is recommended that where emission estimates haven't been made for the indirect GHGs, but the source does exist that the notation key "NE" should be used. However, priority should be given to improving the completeness of the direct GHG emissions in the first instance

5.4 Summary and brief recommendations

As outlined in the table above, it is recommended that a discussion is held between the BUR1 review team and the NC2 team so that data and methodologies can be shared, and completeness improved. It is also recommended that estimates for CH_4 and N_2O are included where they are currently missing.

6 Fugitive emissions (IPCC code: 1B)

6.1 Background to the sector

This sector includes the intentional or unintentional release of greenhouse gases that may occur during the extraction, processing and delivery of fossil fuels to the point of final use. Emissions of the direct GHGs from these sources not applicable in Liberia as there is no petroleum refining taking place in the country or any coal mines. Therefore, this emission source is not discussed further. Both the BUR1 and NC2 report these emissions as zero (although Section 2.2.1.5.3 of the NC2 implies that emissions have been estimated for this source). In order to be in line with IPCC reporting guidelines, it is recommended that the emissions are reported as "NO" (not occurring).

7 Industrial processes and product use (IPCC code: 2A – 2H)

7.1 Background to the sector

The Industrial Processes and Product Use (IPPU) sector includes emissions from all industrial processes and emissions from the use of products. This sector does not include the combustion of fuel from industrial and mining activities, which are captured in the Energy sector. The IPPU sector is considered to be a minor sector for Liberia considering the level of industrialisation in the country.

The IPPU sector encompasses a huge range of industrial activities that may result in emissions from CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. An important element of assessing the IPPU sector is considering those activities that are applicable to the country across the time series of the inventory. The full and detailed list of possible activities can be found in the 2006 IPCC Guidelines, Volume 1, Chapter 8, Table 8.2. This list is aggregated in the table below, which also provides a completeness assessment using the information in the NC1, NC2 (draft) and BUR1 (draft). This summary shows that there is an inconsistency between the NC2 and BUR1 draft reports. It also provides some findings from a provisional completeness assessment for Liberia conducted by the project team.

These three reports were considered for this baseline study. NC1 assumed no emissions from IPPU for the year 2000. The draft NC2 and BUR1 each provided helpful yet rather different information. It is noted that emissions of CO_2 and of the precursor carbon monoxide (CO) were estimated in the draft NC2. Emissions from CH_4, N_2O, HFCs, PFCs and SF_6 were not estimated.

The project team appreciates that it is challenging to obtain data for the IPPU sector considering the institutional arrangements present in Liberia, as discussed in the NC2 and BUR1 draft reports.

Table 10: Completeness assessment of the IPPU sector

Element	NC1 final	NC2 draft	BUR1 draft	Comments
Inventory Year	2000	2014*	2015-17	There is no overlap in the years, it is unclear why different years are used for the NC2 and BUR1.
2.A: Mineral Industry	NO	CO2, CO	-	It is not clear which sub-categories are included – likely to include Cement production
2.B: Chemical Industry	NO	NO		
2.C: Metal Industry	NO	CO2, CO	CO2	It is not clear which iron and steel process is present in Liberia. The mining and crushing of iron ore should not be included.
2.D: Non-Energy Products from Fuels and Solvent Use	NE	CO2	-	It is not clear which sub-categories are included – likely to include lubricant use and paraffin wax use.

2.E: Electronics Industry	NE	-	-	This is likely to be NO.
2.F: Product Uses as Substitutes for Ozone Depleting Substances	NE	-	-	Emissions may be applicable from refrigeration and air conditioning as well as other sub-categories.
2.G: Other Product Manufacture and Use	NE	NO	CO2	Emissions may be applicable from electrical equipment. Emissions from Paraffin Wax and Lubricants should be included under 2.D. Emissions from zinc processes should be reported under 2.C whilst emissions from mining of zinc minerals should not be included under IPPU.
2.H: Other	NE	-	-	Emissions may be applicable from food and beverage industry.

* Section 2.2.2.7.2 of the draft NC2 refers to a time series inventory 1993-2014, but emission estimates are only included for 2014. It is not clear if emissions have been estimated for the years 1993-2013.

7.2 Input data required

The following table outlines the data required for the different Tiers.

Table 11. Data required for calculation of IPPU activities

Tier	Data required
Tier 1	2.A-2.C, 2.H: production data for each industrial activity as well as a simple level of understanding regarding the type of activities that are present at the facilities in Liberia. 2.D, 2.F, 2.G: import/export/production data of the substance that is consumed under the category and some information on how the substance is used. This can be based on IPCC default factors and assumptions.
Tier 2	2.A-2.C: material input data for each industrial activity by type and/or detailed knowledge of the output data and the type of activity present in Liberia. The use of country-specific or default emission factors that correctly reflect the specific type of activity present in Liberia. This often requires a good knowledge of the production process at the facility level. 2.D, 2.F, 2.G: import/export/production data of the substance that is consumed under the category and a good knowledge of how the substance is used by sub-application. Sufficient knowledge of the consumption behaviour in Liberia to apply Tier 2 EFs and country specific EFs.
Tier 3	2.A-2.C: detailed and plant-specific data on input and output material for each process type in each facility or direct measurement of emissions from the individual facilities. 2.D, 2.F, 2.G: Tier 3 is not applicable for most of these categories, though where Tier 3 is available, detailed input and output data of substances are required at the appliance level.

7.3 Data available

Very few categories are estimated under the IPPU sector within the NC1, NC2 (draft) and BUR1 (draft). It will be important to conduct a comprehensive completeness assessment as part of the pilot study to ensure that all relevant activities are included in the inventory so that the final estimates are complete and in line with the IPCC Guidelines. The table below provides a provisional list of sub-categories that may be applicable to Liberia. It includes information, where available, from the draft BUR1 and NC2, and sub-categories that the project team considers may be present in Liberia.

It is noted that the IPCC Software is being used to compile the GHG inventory for the draft BUR1 and NC2. It is assumed that the default EFs are used for all categories as provided in the IPCC Software which are, therefore, consistent with the 2006 IPCC Guidelines. The EFs referenced in Table 2.15 of the draft BUR1 are correct and consistent with the guidelines. During the pilot study, it would be useful to clarify which version of the IPCC Software is used and, therefore, confirm which EFs and parameters are used in the inventory estimates. It would also be useful to obtain the underlying data used to compile the emission estimates in the draft BUR1 and NC2.

It is noted that Table 2.9 in the draft NC2 provides a list of major industries in Liberia including the business name and address. This will be a useful resource when conducting the pilot study and completeness assessment. During this baseline study it was noted that some of these businesses appear to have closed and that some of them may be performing activities that are not applicable to the IPPU sector.

Activity data for the IPPU sector has mainly been obtained from the Ministry of Commerce. It has been possible for the BUR1 team to obtain import and export data. It is assumed that activity data on lubricant use has been obtained, potentially from the national energy balance. It is not clear which years are readily available for these activity data. For the draft NC2, activity data have been obtained directly from companies, as shown in Table 2.10. This suggests that the NC2 team has good access to facility-level data, which could enable the implementation of Tier 2 methodologies for the mineral industry, cement industry, food and beverages industry. It is not clear whether these facility-level data incorporate all relevant facilities in the country or are a proportion of the total market. It is also not clear whether the facilities that have provided data are conducting activities that are applicable to IPPU: mining of minerals is not considered under IPPU.

Table 12: Summary of key data available for the IPPU sector (CRF: 2A – 2H)

Sector - IPCC code		Data available*	Data reference	Comments on TCCCA	Can estimates be compiled with available data?	If not, can surrogate data be used instead?
2.A.1: Cement production		Environmental reports provide information on clinker fraction and clinker imported.	Possibly facility-level	Emissions from the production of clinker should be included. If clinker is imported, then emissions should be reassessed.	Yes, if made available by NC2 team.	No
2.A.2: Lime production	Emission estimates for 2.A are reported in the NC2, so data are available, but it is not clear which sub-category this was. It may be from Arcelor Mittal; however, this looks to be a mining operation so not applicable to IPPU.	Possibly facility-level	Some of these sub-categories may be 'NO'. It is not clear which activities are reported or present in Liberia.		No	No
2.A.3: Glass Production					No	No
2.A.4.a: Ceramics					No	No
2.A.4.b: Other Uses of Soda Ash					No	No
2.C.1: Iron and Steel Production	Emission estimates are provided for 'steel' in draft BUR1, so data are available, but it is not clear which processes are in place in Liberia and, therefore, whether GHG emissions are relevant.	Unknown		There is a lack of transparency regarding the activities and source of activity data. This may be 'NO' depending on the activity.	Yes, if made available by BUR1 team.	No
2.C.6: Zinc Production	Emission estimates are provided for 'zinc' in draft BUR1, so data are available, but it is not clear what zinc processing is performed in Liberia and, therefore, whether GHG emissions are relevant. Mining of	Unknown		There is a lack of transparency regarding the activities and source of activity data. This may be 'NO' depending on the activity. Relevant emissions should be	Yes, if made available by BUR1 team.	

	zinc minerals should not be considered in the IPPU sector.		reported under 2.C.6 rather than 2.G (as in draft BUR1).		
2.D.1: Lubricant Use	The draft BUR1 references activity data on the production of lubricants. However, GHG emissions are from the use of lubricants rather than production, so it is not clear whether the data should be used to estimate emissions from the use of lubricants.	Unknown	There is a lack of transparency regarding the activity that is being reported and source of activity data. Emissions should be reported under 2.D.1 rather than 2.G (as in draft BUR1).	Yes, if made available by BUR1 team.	
2.D.2: Paraffin Wax Use	The draft BUR1 references activity data on the production of paraffin wax. However, GHG emissions are from the use of paraffin wax rather than production, so it is not clear whether the data should be used to estimate emissions from the use of paraffin wax.		There is a lack of transparency regarding the activity that is being reported and source of activity data. Emissions should be reported under 2.D.2 rather than 2.G (as in draft BUR1).	Yes, if made available by BUR1 team.	
2.D.3: Solvent Use	NMVOC emissions from this category are not reported in the draft BUR1 or NC2. Emissions could be estimated based on population data.	World Bank	This is not a mandatory category under UNFCCC reporting, so it may be more appropriate to keep this as 'NE' considering the uncertainty in the per capita EFs.	Yes	Yes
2.F.1: Refrigeration and Air Conditioning	Not currently estimated, so further investigation of national import/export data is required. This may come from the Ministry of Commerce.	Not yet available	It is very likely that there are emissions from this category, so estimates should be made to ensure a complete inventory.	No	No
2.F.2: Foam Blowing Agents					
2.F.3: Fire Protection					

2.F.4: Aerosols					
2.G.1: Electrical Equipment	Not currently estimated, so further investigation of national import/export data or information from national electricity network operator is required.	Not yet available	It is likely that there are emissions from this category, so estimates should be made to ensure a complete inventory.	No	No
2.G.3.a: Medical Applications	Not currently estimated, so further investigation is required. This is considered a minor source.	Not yet available	This is a minor source and not a priority.	No	Yes
2.G.3.b: Propellant for pressure and aerosol products	Not currently estimated, so further investigation is required. This is considered a minor source.	Not yet available	This is a minor source and not a priority.	No	No
2.H.2: Food and Beverages Industry	Table 2.10 of the draft NC2 indicates that facility-level data have been obtained for this sector.	Facility-level laboratory reports	It is not clear how or whether emissions from this source are included in the inventory.	Yes, if made available by NC2 team.	Yes, assuming national production data is available.

7.4 Summary and brief recommendations

The IPPU sector was not included in the NC1, so the draft BUR1 and NC2 are the first national IPPU inventories for Liberia. These are currently in draft form and are still being developed by the respective teams. During the pilot study, a comprehensive completeness assessment should be conducted with the teams from the NC2 and BUR1 because this baseline study shows that the two teams are estimating emissions from different categories, which should not be the case. This assessment would also ensure that the identified activities are included in the relevant sector of the inventory; this could be the Energy sector or IPPU sector depending on the source of the emissions for each activity.

This baseline study was conducted by assessing the draft NC2 and BUR1 reports. The underlying compilation spreadsheets and IPCC Software outputs were not made available to the project team. This considerably reduced the scope and depth of the baseline study. It would be helpful if this underlying information were provided to the project team for the pilot study.

It will be important to confirm the availability of activity data in Liberia for the time series of the inventory under this project. It is likely that there will be considerable difficulty obtaining the relevant data. Collecting activity data and understanding where there may be gaps will be another priority for the pilot study.

8 Agriculture (IPCC code: 3A & 3C)

8.1 Background to the sector

8.1.1 Scope of the agriculture sector

Emissions reported under the agriculture sector (IPCC codes 3A and 3C) relate to those arising from biophysical processes associated with livestock and agricultural soils due to agricultural activities.

Mechanical sources related to agriculture, such as fuel combustion in stationary and mobile machinery and equipment, are not included; these are accounted for in the energy sector and elsewhere. The agriculture sector includes the following non-mechanical source categories:

- Livestock (3A)
  - 3A1 Enteric fermentation – CH_4
  - 3A2 Manure management – CH_4 and N_2O
- Agricultural soils (3C)
  - 3C1b Biomass burning in croplands - CH_4, N_2O, NO_x, CO, and NMVOC (CO_2 emissions are not reported as these are assumed be reabsorbed the following growing cycle).
  - 3C2 Liming – CO_2
  - 3C3 Urea application – CO_2.
  - 3C4 Direct N_2O emissions from managed soils. These result from anthropogenic nitrogen additions including synthetic and organic fertiliser application, urine and dung deposited by grazing animals, crop residues, and mineralisation of nitrogen in soil organic matter.
  - 3C5 and 3C6 Indirect N_2O emissions from managed soils and manure management respectively. These arise when a fraction of the NH_3 and NO_x volatilised and leached from manure and soils is later converted to N_2O.
  - 3C7 Rice cultivation (paddies) – CH_4

Emissions and removals of carbon dioxide and other greenhouse gases due to carbon stock changes or biomass burning on forest and other non-agricultural land use types are accounted for under the "Land use, land use change and forestry" sector (Section 9).

8.1.2 Agriculture and reporting in Liberia

According to the drafts of the second national communication (NC2) and first biennial update report (BUR1), the agriculture sector contributes up to 38.8% of Liberia's GDP, and employs more than 70% of the population. The main crops cultivated are rubber, oil palm, rice, cassava and cocoa, although may other crops are grown at a smaller scale. The sector is characterised by a mixture of smallholder cooperatives, subsistence production and large multinational corporations and concessionaries.

The livestock sub-sector currently accounts for around 14% of Liberia's GDP. It has grown in recent years, following the large reduction in animal numbers during the civil war. Most livestock production is currently small-scale, in traditional husbandry systems.

The contribution of agriculture to total GHG emissions has not been summarised in the NC2 (draft), but the first national communication (NC1) indicated that in 2000 the agriculture sector was responsible for around 32% of the total emissions – a significant

source, and likely an underestimate as N_2O emissions and CH_4 emissions from rice cultivation were not estimated. According to NC2 (draft), around half of agricultural GHG emissions (in CO_2e) are contributed by CH_4 from enteric fermentation, and N_2O from manure deposited on pastures by grazing livestock.

The status of reporting of emissions from agriculture in Liberia is summarised in the table below by source category, for NC1, NC2 and BUR1.

Table 13: Completeness assessment of the agriculture sector

IPCC Code	NC1 final	NC2 draft	BUR1 draft	Comments
Inventory year	2000	2014/ 2015	2015-2017	
3.A.1: Enteric fermentation	CH_4: T1 (assumed)	CH_4: T1	-	
3.A.2: Manure management	CH_4: T1 (assumed)	CH_4 and N_2O: T1	N_2O only	NC2 Tables 2.15 and 2.16 differ – CH_4 is "NO" in the former.
3.C.1.b: Biomass burning in croplands	CH_4: T1 (assumed)	CH_4 and N_2O: T1	-	NC2 Tables 2.15 and 2.16 differ – this source category is 0 and "NO" in the former for CH_4 and N_2O respectively
3.C.2: Liming	-	-	-	Liming is not mentioned or reported in any of the three reports
3.C.3: Urea application	-	-	-	CO_2 emissions from Urea application is not mentioned or reported in any of the three reports.
3.C.4: Direct N2O emissions from managed soils	NO	N_2O: T1	-	NC2 Tables 2.15 and 2.16 differ – this source category is "NO" in the former. NC2 does not seem to include emissions from synthetic fertilisers or N mineralisation on mineral soils within the scope of this category
3.C.5: Indirect N2O emissions from managed soils	-	-	-	Indirect emissions are not mentioned in any of the 3 reports – may or may not be included.
3.C.6: Indirect N2O emissions from manure management	-	-	-	Indirect emissions are not mentioned in any of the 3 reports – may or may not be included.
3.C.7: Rice cultivation	NE	CH_4: T1	-	

The symbol "-" is given where the particular source is not reported or has 0 emissions, but no notation key is provided.

The comparison of NC2 (draft) and BUR1 (draft) highlights some inconsistency in coverage and methodology used. In particular, the BUR1 (draft) appears to be still very incomplete, with 0 or "N/A" reported for the majority of activity data, parameters and emissions estimates in tables 2.22 – 2.34. Challenges with insufficient data are mentioned on pages 107-109, but it is not clear the extent to which this has or will limit

estimation of emissions, or if the gaps are largely due to the early stage of drafting. The NC2 (draft) is much more complete. It uses IPCC 2006 Tier 1 methods for all sectors whereas the commentary and tables on pages 106-107 of BUR1 suggests a Tier 2 methodology was undertaken for livestock characterisation and for estimation of enteric methane and manure management emissions. The NC2 and BUR1 both highlight challenges in data collection, which are discussed below.

Regarding emission factors and other parameters, the NC2 cites use of IPCC 2006 default emission factors, whereas BUR1 refers to some data and expert judgement being used to define Liberia-specific parameters as part of the Tier 2 livestock characterisation.

8.2 Input data required

The following table outlines the data required for the different Tiers.

Table 14. Data required for calculation of agricultural activities

Tier	Data required
Tier 1	*Livestock:* • Average animal population by livestock species and broad subcategory • Typical animal mass (defaults by region are available, but country specific data is desirable) • Proportion of livestock manure managed under different systems • Average temperature *Soils:* • Quantity of nitrogen applied to soils in synthetic (mineral) fertilisers, animal manure applied to soils or deposited whilst grazing, sewage sludge and other organic fertilisers • Crop production (fresh yields) and area harvested by crop type • Area of crop residues burned by crop type • Carbon stock change of soil organic matter in cropland • Area of cropland and managed grassland on organic soils (histosols) • Quantity of lime, dolomite and urea applied to soils • Area of rice cultivated and cultivation period (as a minimum)
Tier 2	*Livestock:* as per Tier 1, but a more detailed animal characterisation based on feed intake, digestibility and protein content. A more detailed categorisation of manure management systems is also required. Default parameters are available but country-specific values are encouraged. *Soils:* For most sources as per Tier 1, but using country specific emission factors and other parameters. For methane emissions from rice cultivation, area cultivated is broken down further into zones differing in cropping practices, agroecological characteristics, water regimes (e.g. upland, irrigated, rainfed) and organic amendments
Tier 3	Any more detailed methodology than tier 2 to better capture national circumstances; country specific parameters and emission factors based on research are used as standard, and regularly updated.

8.3 Data available

8.3.1 Livestock

Activity data

The NC2 uses data from FAO statistical database (FAOSTAT) for livestock population, citing reasons of *"There are huge data gaps especially gathering data on agriculture activities and land resources from the Ministry of Agriculture suitable for GHGs calculation"*. Nevertheless, BUR1 reports estimates from the Ministry of Agriculture (MoA) Annual Report 2010-2013 on page 36. These numbers are considerably lower than the FAOSTAT estimates, so the choice of livestock population data source will make a substantial difference to emissions estimates in categories 3A, 3B and 3C4-6. Further investigation is required to understand the comparative suitability of these two data sources.

Other parameters

None of the three reports mentions the data source of method used to estimate proportion of manure managed in different systems, which is a key parameter for estimating N_2O emissions from manure management with Tier 1 methodology.

The BUR1 mentions that some data on feed characteristics are available to support a Tier 2 livestock characterisation, but that expert judgement was required for other parameters due to lack of data.

8.3.2 Crop production and soils

No activity data is presented, nor data sources cited in NC2 for crop production or non-manure related sources (e.g. synthetic fertilisers, other organic fertilisers, rice production), but emissions are estimated so the origin of these data needs to be investigated further. NC1 cites use of FAOSTAT data on rice production, although emissions for that source category are not estimated. However, BUR1 on pages 34 and 35 cites crop production data available from the Central Bank of Liberia, and FAO/GIEWS Country Cereal Balance Sheets.

The table below summarises the current data availability as judged from NC1, NC2 and BUR1, and potential surrogate data sources in the absence of country-specific data

Table15: Summary of key data available for the agricultural sector (IPCC codes: 3A and 3C)

Sector - IPCC code	Data available	Data reference	Comments on TCCCA	Can estimates be compiled with available data?	If not, can surrogate data be used instead?
3.A.1: Enteric fermentation	Livestock population	NC2: FAOSTAT BUR1: MoA Annual Report, 2010 - 2013; Kwaku Agyemang, 2013	Large differences between FAO estimates and Liberian data	Yes	
3.A.2 and 3.C.6: Manure management direct and indirect emissions	Livestock population	As above	As above	Yes, but expert judgement / other data required to estimate N_2O emissions	
3.C.1.b: Biomass burning in croplands	Data source not provided but emission estimates have been calculated	N/A		Unclear what data is available	FAOSTAT data available
3.C.2: Liming	Not estimated	N/A		Unclear what data is available	Requires further investigation
3.C.3: Urea application	Not estimated	N/A		Unclear what data is available	Requires further investigation
3.C.4 and 3.C.5: Direct and indirect N2O emissions from managed soils	Manure applied to soils and deposited on pastures: Livestock population	As above	As above	Unclear the what data is available for estimating fraction of manure deposited on pastures.	FAOSTAT data available
	Crop residues: Crop production (tonnes)	Central Bank of Liberia, FAO/GIEWS Country Cereal Balance Sheets	Completeness of crop production data is not known, and area harvested also required.	Estimates were made, but requires investigation	FAOSTAT data available
	Synthetic fertilisers: Not estimated	N/A		Unclear what data is available	Absent from FAOSTAT, but other sources (e.g. of import data) likely available.

Sector - IPCC code	Data available	Data reference	Comments on TCCCA	Can estimates be compiled with available data?	If not, can surrogate data be used instead?
	Other organic fertilisers: Not estimated	N/A		Unclear what data is available	Requires further investigation
	Mineralisation of soil N in mineral soils: Not estimated	N/A		Data on soil carbon stock changes from LULUCF calculations should be available.	Requires further investigation
	Cultivation of organic soils: Data source not provided but emission estimates have been calculated	NC2 estimates possibly use LULUCF estimates of cropland remaining cropland by soil type, sourced from the Forestry Development Authority		Unclear what data is available	FAOSTAT data available
3.C.7: Rice cultivation	Rice production volume	FAO/GIEWS Country Cereal Balance Sheets		Unclear. Area harvested and time under cultivation is required to implement Tier 1 method.	FAOSTAT data available

8.4 Summary and brief recommendations

It is clear that there are significant challenges in collecting appropriate activity data, especially for a time series due to the hiatus during the civil war.

The NC2 (draft) presents the most complete inventory to date, covering most of the emissions source categories expected to occur in Liberia. However, there are notable subcategories for which emissions would be expected, but which appear to have been excluded or are not mentioned specifically:

- Direct N_2O emissions from application of synthetic fertilisers and non-manure organic fertilisers (e.g. sewage sludge / compost)
- Direct N_2O emissions from mineralisation of N in soil organic matter following management changes
- Indirect N_2O emissions from manure management and agricultural soils
- CO_2 emissions from liming and application of urea.

It is recommended that improvements to the inventory include establishing if these sources are relevant for Liberia, and if so attempting to locate suitable activity data to quantify emissions. Where Liberian data sources are not available or of insufficient quality or completeness, FAOSTAT data can be used as a surrogate in many cases.

There are also cases for NC2 (draft) where the source, quality or completeness of the data used in emissions calculations is unclear, in particular for livestock population and manure management systems and crop production. It is recommended that the existing and potential alternative data sources are reviewed.

The BUR1 appears to begin to use a Tier 2 approach for enteric fermentation and manure management emissions from cattle. This is good practice, as the BUR1 suggests that cattle are the most important livestock category for these source categories. It is recommended that if data are available, Liberia continue to follow a Tier 2 approach for cattle.

9 Land Use, Land Use Change and Forestry (IPCC code: 3B, 3C1a, 3C1c & 3D)

9.1 Second National Communication vs First Biennial Update Report

Large discrepancies between the reporting of emissions from the LULUCF sector were identified on review of the drafts of the second national communication (NC2) and first biennial update report (BUR1). A summary of the main differences between the NC2 and BUR1 are presented in the table below. Overall, it is considered that more detailed information is included within the NC2 and therefore this has been used as the basis for the LULUCF baseline report.

Table 16: Information available in the NC2 and BUR1 for the LULUCF sector

Element	Draft NC2	Draft BUR1	Comments
Inventory Year	2010*	2015 and 2016	There is no overlap in the years, it is unclear why different years (and maps) are used for the NC2 and BUR1
Land Use Classes Included	FL, CL, GL, OL and SL from 11 country-specific land use classes	FL, CL and GL	The more recent maps in the BUR1 are less complete compared to 2010
Total emission/ removal estimates	-20,406.6 (Table 2.17 for 2010)	-17,920.6 (Table 2.21 for 2015 and 2016)	Similar estimates for 2010 and 2015/16
Climate/soil type	Areas split by TRW/ TMon/TMSD and HAC/LAC	No disaggregation	Detailed information on land use areas is provided in the NC2
Biomass burning	FL included	NE	
Harvested wood products	NE	NE	The BUR1 references SGS and FAOSTAT as data sources but does not compile estimates

*Notes: * 2004 is also referenced as the inventory year in the NC2, it is not clear from the results tables which year the emissions/removals represent. FL = forestland, CL = cropland, GL = grassland, OL = other land, SL = settlements, NE = not estimated*

9.2 Background to the sector

According to the NC2, Liberia is characterised by coastal plains containing mangroves and swamps, rising in the northeast rise to a plateau and low mountains. The natural forest of Liberia covers 4.8 million hectares, with disturbed productive (unprotected productive forest) forest constituting 45% of the total ha available. However, the current inventory assumes that all land is managed for reporting purposes. It is estimated that in 2001 that approximately 4 % of land was arable and 2% of land was used for permanent crops. The land representation used in the NC2 identifies 11 country-specific land use classes which have been mapped to the IPCC categories. No land has been allocated to wetlands:

- Open dense forest (FL)
- Closed dense forest (FL)
- Agriculture degraded forest (FL 65%, CL 35%)
- Mixed agricultural and forest area (FL 35%, CL 65%)
- Agro-industrial plantation (CL)
- Predominant rural agricultural domain (CL)
- Agricultural area with small forest presence (CL)
- Savanna or bare soil (GL)
- Urban areas (SL)
- Free water (OL)
- Littoral ecosystem complex (OL)

The NC2 estimates emissions and removals for 2010, overall, the LULUCF sector is estimated to be a net sink of emissions primarily due to carbon sequestration in forest land and other woody biomass stocks. A summary of the current reporting by IPCC code is presented in the table below.

Table 17: Completeness assessment of the LULUCF sector

IPCC Code	Current reporting in Liberia
3.B.1.a: Forest land Remaining Forest land	T1
3.B.1.b: Land Converted to Forest land	NE *
3.B.2.a: Cropland Remaining Cropland	T1
3.B.2.b: Land Converted to Cropland	NE
3.B.3.a: Grassland Remaining Grassland	T1
3.B.3.b: Land Converted to Grassland	NE *
3.B.4.a: Wetlands Remaining Wetlands	NE
3.B.4.b: Land Converted to Wetlands	NE
3.B.5.a: Settlements Remaining Settlements	NE
3.B.5.b: Land Converted to Settlements	NE
3.B.6.a: Other land Remaining Other land	NE
3.B.6.b: Land Converted to Other land	NE
3.C.1.a: Biomass burning in forest lands	T1
3.C.1.c: Biomass burning in grasslands	NE
3.D.1: Harvested Wood Products	NE
3.D.2: Other (please specify)	NO

Note: Emission under IPCC category 3C from other land uses are included in the agriculture sector.
** It's not clear whether this category is included, emissions are estimated from "forest and grassland conversions"*

9.3 Input data required

The following table outlines the data required for the different Tiers.

Table 18. Data required for calculation of LULUCF activities under 3B

Tier	Data required
Tier 1	Land use areas (approach 1 or 2), default IPCC parameters and emission factors. Areas of disturbed land (e.g. wildfires, controlled burning, disease).
Tier 2	Land use areas (approach 1, 2 or 3), country-specific biomass data and emission/removal factors. Areas of disturbed land.
Tier 3	Country-specific method: data on biomass is available to estimate changes in carbon stocks using dynamic models or allometric equation.

9.4 Data available

9.4.1 Land Use Data

It is assumed that the IPCC **Approach 1** to land representation has been implemented as no detailed information related to the conversions between land uses is provided. The land representation is assumed to be incomplete however as the total and overall change in land use areas have not been tracked over time to enable the disaggregation between the "land remaining" and "land converted" categories. All land has been treated as managed land and therefore any resulting emissions or removals should be reported. However, the NC2 states that *"natural forest of Liberia covers 4.8 million ha, with disturbed productive (unprotected productive forest) forest constituting 45% of the total ha available."* this would suggest that the remaining 65% of the natural forest is not managed and therefore should be excluded from emission/removal calculations. The most recent land cover dataset from the Forestry Development Authority, developed through funding by the World Bank, was used in the NC2. The year of the land cover dataset is assumed to be 2010, but this is unclear from the NC2.

The IPCC software was used to compile emission and removal estimates. As no further information is provided, it is assumed no country-specific parameters are available and that IPCC default values were applied.

9.4.2 Biomass burning (excluding cropland, see Section 8)

Emissions of "On-Site Burning of Forests: Emissions of Non-CO2 Trace Gases" have been estimated, it is therefore assumed that activity data on burnt areas of forest land is available, however no information is provided in the NC2.

9.4.3 Harvested wood products

No information is provided in the NC2.

Table 19: Summary of key data available for the LULUCF sector

Sector - IPCC code	Data available*	Data reference	Comments on TCCCA	Can estimates be compiled with available data?	If not, can surrogate data be used instead?
3B	Areas by land use class, climate and soil type for one year (2010)	Forestry Development Authority	Incomplete as data is only available for one year Potential accuracy issues relating to growth rate assumptions	Yes, but without better land representation only minimal improvements to the inventory can be made.	
3C1a	Data source not provided but emission estimates have been calculated	N/A	Lack of transparency	Unclear what data is available	No
3D	Harvest wood and fuel wood removal data (referenced in the BUR1 but not used to compile estimates, not references in the NC2)	SGS and FAOSTAT	This data is references and it is noted that there is very high uncertainty surrounding commercial wood harvest, but no emission estimates have been calculated.	Unclear what national data is available	FAOSTAT can be used in the absence of any national data

9.5 Summary and brief recommendations

Overall, only limited information on the data and methodologies applied for calculating emission/ removal estimates from the LULUCF sector is available. The information presented in the draft NC2 and BUR1 is not consistent, and it is therefore unclear what national data is available. The primary focus for updating and improving the LULUCF sector should be to review the available land use data and compile as comprehensive land use change matrix as possible, ideally across multiple years.

10 Waste (IPCC code: 5A – D)

10.1 Background to the sector

This sector covers greenhouse gas emissions arising from solid waste disposal, biological treatment of solid waste, incineration and open burning of waste and wastewater treatment and discharge.

An overview of the waste sector in Liberia provided in the draft BUR reports categorised in accordance with the 2006 IPCC guidelines is summarised in the following table. The notation keys are inserted to identify the sectoral categories "Occurring" in Liberia and estimated (E), Occurring but not estimated in the Latest Liberian Inventory (NE) in the BUR1, and which categories do not occur (NO).

The summary table indicates Liberia estimated emissions from category 4.D.2 -Industrial wastewater handling in meat processing in the BUR-1 but only for NMVOCs (an indirect GHG). All other categories in the waste sector are considered as "Not Available (NA)"[8] based on the present status of waste handling practices in Liberia and non-availability of data.

In the NC2, CH_4 emission estimates are provided for solid waste disposal and wastewater handling. Therefore, it would be beneficial if a discussion was held between the team compiling the GHG emission estimates for the NC2 and for the BUR1 so that information can be shared.

These categories may not be key categories even if estimated using Tier 1 methods based on the Decision Trees of the 2006 IPCC guidelines. However, every effort should be made to engage the key waste sector stakeholders to provide estimates so that a complete inventory can be provided. In addition, this would feed into continuous improvements towards meeting the reporting requirements of the MPGs under enhanced transparency framework of Article 13 of the Paris Agreement.

[8] Note that whilst the BUR1 report quotes "N/A" and uses it to mean "Not Available", the correct notation key to have used would have been "NE" i.e. not estimated. In accordance with the IPCC guidelines, "NA" means "Not Applicable", which is used when a source occurs in a country but that that particular gas does not arise from that activity.

Table 20: An overview of the waste sector as provided in the BUR1

Category Codes and Name					Gases	Notation Key		National Circumstances	References
						Consultant	BUR-1		
4	A	Solid Waste Disposal			CH4, N2O, NMVOCs			Country pathways of solid waste Collection and disposal practices documented in the BUR-1. ;	BUR Section 2.18.2
4	A	1	Managed Waste Disposal Sites		CH4, NMVOCs	NE	NA	Occurring. One **landfill site in the country**, which is in the Paynesville region for the disposal of general and hazardous waste generated within the City of Paynesville. The fraction of country waste to the landfill site should be estimated	BUR Section 2.18.2 para 3
4	A	2	Unmanaged Waste Disposal Sites						
4	A	2	a	Deep>5m	CH4, NMVOCs	NE	NA	Rubbish pits need examination to enable estimation of fraction of pits greater 5 m depth	
4	A	2	b	Shallow<5m	CH4, NMVOCs	NE	NA	Occurring. 37.2 % of the total population's waste regularly collected, 19.8 % of the populati's waste disposed in rubbish pits or dumped on roadside; while 1.4 % of the population's waste remain uncollected.	BUR Section 2.18.1
4	A	3	Uncategorized Waste Disposal Sites		CH4, NMVOCs	NE	NA	Occurring. 30% of urban households wastes and about 5 % of rural households.basis is collected on a regular basis.	BUR Section 2.18.2
					CH4, NMVOCs	NE	NA	Other smaller deposal site in the region around Montserrado County receive waste from Monrovia and its environment	BUR Section 2.18.3
4	B	Biological Treatment of Solid Waste			CH4, N2O	NO	No	Not Occuring	
4	C	Incineration and Open Burning of Waste							
4	C	1		Waste Incineration	CO2	NE	NA	**Could be occurring** but not significant. Verify hospital waste incinerators as sources of non-biogenic emissions from the proportion of plastic waste.	
4	C	2		Open Burning of Waste				**OCCURRING**: 10.8% population have their garbage collected and disposed off through open burning.	
4	C	2	a	Non-biogenic	CO2	NE	NA	Proportion of degradable inorganic should be estimated to form biogenic emissions	
4	C	2	b	Biogenic	CO3	NE	NA	Proportion of plastics should be estimated to form non-biogenic emissions	
4	D	Wastewater Treatment and Discharge							
4	D	1		Domestic Wastewater Treatment and Discharge		NE	NA	**OCCURRING**. Waste water generation, as well as handling and disposal pathways are documented in the BUR. 36.5 % of the population is connected to a sewer system, 3% (septic tanks/ cesspool systems) and 9.3 % use pit latrines. Appropriate Default EF should be selected for methane emissions	BUR Section 2.18.3 Table 2.35
4	D	2		Industrial Wastewater Treatment and Discharge		E	0.0001	Meat processing is estimated. Other sources of industrial waste should be estimated based on the production capacities	
4	E	Other Country-specific (please specif							

10.2 Input data required

10.2.1 4A: Solid Waste Disposal

Table 11: Data required for calculation of solid waste disposal activities

Tier	Data required- Solid Waste
General	Country Mass balance of Solid waste generation by disposal and treatment pathways. Facilitates the determination of waste handling fractions for the estimation of weighted average of methane correction factor (MCF)
Tier 1	Applying the IPCC FOD method, mainly default activity data and default parameters. These include population, per capita solid waste generation; waste composition based on 5-year national waste inventory, collection efficiency, mass of waste deposited at solid waste disposal sites (SWDS) by various practices and categories
Tier 2	Using the IPCC FOD method and some default parameters, requires good quality country-specific activity data based on waste inventory of current and historical waste disposal at SWDS. They include a) country-specific measured Activity Data of the parameters in Tier 1) b) waste composition based on 5-10 year national waste inventory, collection efficiency, mass of waste deposited at solid waste disposal sites (SWDS) by various practices and categories c) Historical waste disposal data for 10 years or more based on country-specific statistics, surveys or other similar sources. Data are also needed on amounts disposed at the SWDS on annual basis.
Tier 3	Using FOD method require good quality country-specific activity data, namely (1) nationally developed key parameters, or (2) measurement derived country-specific parameters of the parameters in Tier 2 in addition to specific data, namely: the half-life, and either methane generation potential (Lo) or DOC content in waste and the fraction of DOC which decomposes (DOCf).

10.2.2 4.C-Incineration and Open Burning of Waste

Table 22: Data required for calculation of incineration and open burning of waste activities

Tier	Data required
General	Types and quantities of waste incinerated or openly burned including municipal solid waste (MSW), industrial waste, hazardous waste, clinical waste and sewage sludge. Specifically, waste of fossil origin (e.g., plastics, certain textiles, rubber, liquid solvents, and waste oil). it is common for developing countries to incinerate hazardous clinical waste.
Tier 1	Default Amount of waste incinerated/open-burned and default data on characteristic parameters (such as dry matter content, carbon content and fossil carbon fraction) for different types of waste (MSW, sewage sludge, industrial waste and other waste such as hazardous and clinical waste) as well as biomass materials (e.g., paper, food, and wood waste) contained in the waste are biogenic emissions
Tier 2	Country specific (C-S) amount of waste incinerated/open-burned; and C-S Waste fraction (WF): % of each component mainly for MSW , default data on characteristic parameters (such as dry matter content, carbon content and fossil carbon fraction) for different types of waste
Tier 3	Plant- / management specific data on amount of waste incinerated/open-burned; C-S waste fraction (WF); % of each component mainly for MSW , default data on characteristic parameters (such as dry matter content, carbon content and fossil carbon fraction) for the different types of waste

10.2.3 4.D: Wastewater Treatment and Discharge (Domestic and Industrial Waste)

Table 23: Data required for calculation of wastewater activities

Tier	Data required
General	• Mass balance of wastewater sources based on the wastewater treatment systems and discharge pathways[9] • Mass of waste water fractions collected and treated by treatment type (aerobic, anaerobic);Mass of waste water fractions collected and untreated (open and closed sewers); River discharge, mass of wastewater fractions uncollected and untreated (septic tanks, Open pits/Latrines, River discharge)[10]
Tier 1[11]	Default values for the emission factor and activity parameters of the treatment systems. outlined. *This method is considered good practice for countries with limited data like Liberia.* They include: a) average country BOD per capita[12]; b) total organics in wastewater in inventory year, kg BOD/yr c) organic component removed as sludge in inventory year, kg BOD/yr d) fraction of population in income group (rural/urban) in inventory year, e) emission factor for each treatment system[13] (kg CH_4 / kg BOD)
Tier 2	Same as Tier 1; but incorporates country specific emission factor and country specific activity data of the parameters enumerated in Tier 1. For example, a specific emission factor for a prominent treatment system based on field measurements. The amount of sludge removed for incineration, landfills, and agricultural land should be considered
Tier 3	For a country with good data and advanced methodologies, a country specific method could be applied as a Tier 3 method. A more advanced country-specific method could be based on plant-specific data from large wastewater treatment facilities

9 2006 IPCC Guidelines, Chapter 6: Wastewater Treatment and Discharge, Figure 6.1, https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf
10 TABLE 6.1 CH4 AND N2O emission potentials for wastewater and sludge treatment and discharge systems 2006 IPCC Guidelines, Chapter 6: Wastewater Treatment and Discharge,
11 Table 6.3 Default MCF Values for Domestic Wastewater; 2006 IPCC Guidelines, Chapter 6: Wastewater Treatment and Discharge
12 TABLE 6.4 Estimated BOD5 values in domestic wastewater for selected regions and countries
13 2006 IPCC Guidelines: Volume 5, Chapter 6. Wastewater treatment and discharge

Table 14: Summary of key data available for the waste sector (4A-4D)

Sector – IPCC 2006 GLs code	Activity Data	Reference	Comments on TCCCA	Can estimates be compiled with available data?	If not, can surrogate data be used instead?
4.A.1 4.A.2 4.A.3	• Population (urban and rural); Urban populations' waste management: (37.2 % regularly collected), 19.8 % disposed in rubbish pits or dumped on roadside. 5 % of rural households regularly collected. • Disposal in one landfill site in the Paynesville region for the disposal of general and hazardous waste generated.	BUR Section 2.18.2 para 2 and para 3	Completeness would require institutional arrangement for the sector for the collection of activity data for estimation of waste sector categories occurring in Liberia	YES – data is available in the NC2 and this could also be used in the BUR1	N/A
4.C.2	10.8% population have their garbage collected and disposed of through open burning. Two thirds of rural households' practice open burning of waste			NO	YES
4.D.1	36.5 % of the population is connected to a sewer system, 3% (septic tanks/ cesspool systems) and 9.3 % use pit latrines.			YES	N/A
4.D.2	The meat processing industries data exist.			YES – data is available in the NC2 and this could also be used in the BUR1	N/A

Summary and brief recommendations

Currently in the BUR1 and NC2, there is limited emission estimates provided for this sector. The waste sector categories may not be key categories even if estimated using Tier 1 methods based on the Decision Trees of the 2006 IPCC guidelines[14]. However, every effort should be made to engage the key waste management stakeholders to provide estimates to establish the emission levels at the present state of development in the sector. This is because waste sector emissions are largely driving by population and government waste management policies and measures. It is key development monitoring indicator of population growth, and impact of governments policies and programs for water, sanitation and health towards the attainment of the UN's Sustainable Goals – for example: SDG 6 (water and sanitation) ; SDG 3 (health and well-being; and SDG 12 (waste resources efficiency based on reduce, recycle, recovery, reuse).

Waste sector emissions inventory should be considered more importantly as a key development indicator while meeting completeness criteria of the MPGs reporting requirements of the enhanced transparency framework under Article 13 of the Paris agreement. As outlined in the previous table, information is likely to be available in order for a complete set of emission estimates to be made available.

It is also recommended that a discussion is held between the BUR1 and NC2 inventory compilers to share data and knowledge so that improvements can be made.

[14] Figure 3.1 Decision Tree for CH4 emissions from Solid Waste Disposal Sites
https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf
Figure 5.1 Decision Tree for CO2 emissions from incineration and open burning of waste,
https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_5_Ch5_IOB.pdf
Figure 6.2 Decision Tree for CH4 emissions from domestic wastewater
https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf

11 Monitoring, Reporting and Verification system

11.1 Background and approach

This section of the report provides details of the current state and recommendations for Liberia's Monitoring, Reporting and Verification (MRV) system that will support its tracking and communication of the GHG Inventory and NDC progress. The MRV system will support reporting to the UNFCCC (under the Paris Agreement Decision 18/CMP1), as well as supporting national and sub-national decision makers on issues related to climate action. There are three important concepts to understand when considering a national MRV system:

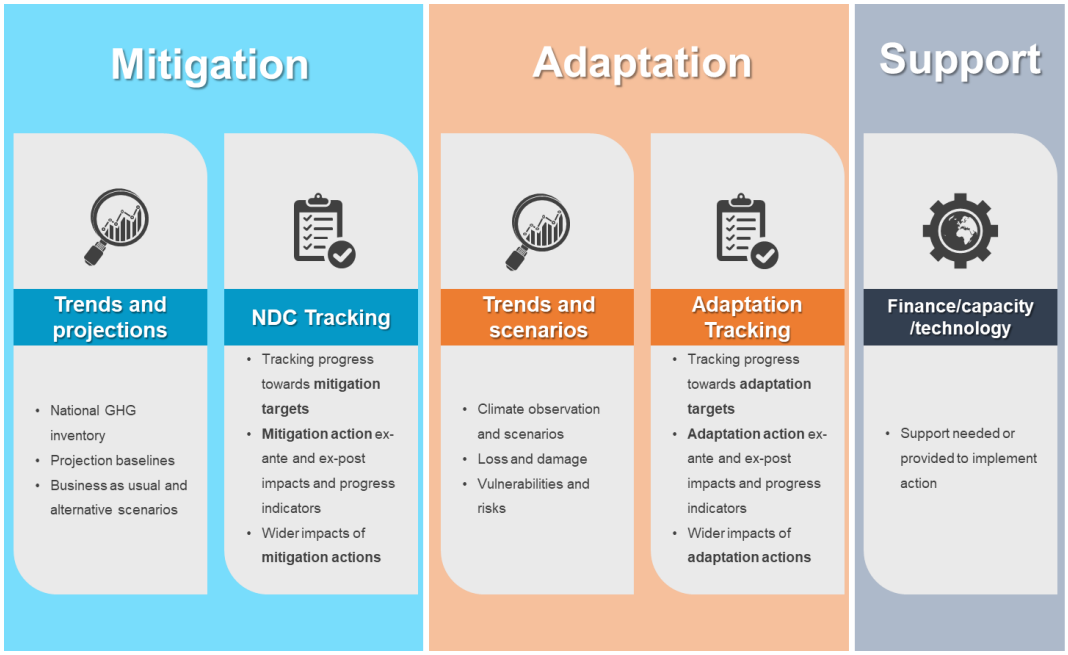
1. **MRV themes** help to sub-divide the subject matter into manageable chunks. (e.g. themes and subthemes of mitigation, adaptation and support).
2. **MRV system components** sub-divide the functions of the MRV system into manageable components (e.g. the organisation mandates, data flows, expertise, systems and tools and stakeholder engagement).
3. **Monitoring elements** provide some useful structuring to the administrative (e.g. stakeholders, datasets, workplans etc) and thematic (mitigation and adaptation) information managed in or signposted from an MRV system.

The sections below explore each of these concepts in turn.

11.1.1 MRV themes

Figure 1 illustrates the thematic information that can fall under the scope of the MRV system and helps to define necessary roles and responsibilities for different organisations. Clearly defining themes will be useful for managing the scope and structure of both the institutional arrangements and their roles and responsibilities as well as the data flows. Using themes will also help in categorising data inputs and outputs, scopes of work, MRV system improvements and even the details of climate change in reports. Figure 2 provides an overview of the MRV themes that can be used to help break down and define the scope of institutional arrangements.

Figure 1: Summary of the climate transparency themes included in the MRV system



The themes above can have additional detail (sub-themes) which can provide further categorisation of sectors and their activities, impact areas, timeframes, related entities (organisations) and geographies.

It is important to note that whilst the Paris Agreement's Enhanced Transparency Framework (ETF) separates mitigation and adaptation, the underlying MRV systems (data and governance structures) for adaptation and mitigation could be very similar. It is often the same sectoral stakeholders that lead on mitigation and adaptation through key public or private decision-making processes focusing on energy systems, infrastructure, transport, agriculture, forestry, water, biodiversity, human health, waste etc. Although both adaptation and mitigation actions will have associated investment/support activities that are tracked at the action (project) level, there should also be centralised tracking of support/finance/investment. To account for this, we have also included a theme on **support/investment** to ensure this information is prioritised. This baseline assessment and the development of Liberia's MRV system will focus on the **Mitigation** theme, including GHG Inventory (trends and projections) and NDC Tracking (mitigation targets, actions, co-benefits and indicators). However, our assessment will highlight potential synergies with adaptation and support tracking where relevant and possible.

11.1.2 MRV system components

We split the MRV system into five key components as shown in the figure below.

Figure 2: Key components of an MRV system

1. **Organisation mandates** cover roles and responsibilities as well as agreements, laws and commitments
2. **Expertise** including data, modelling, compilation and reporting experts across a range of themes.
3. **Data flows** for the data necessary for the MRV system to be of value.
4. **Systems and tools** for information, communication and engagement
5. **Stakeholder engagement** to build value for the data and to drive public participation in the political process of climate change decision making.

These components cover a range of formalities and activities across several different organisations. These organisations might include government ministries and/or agencies, academic/research institutions, local self-government, private organisations and consultants.

Well-functioning MRV systems will be flexible and sustainable and ensure that expertise is available for recurring and continuously improving data gathering, compilation, analysis and reporting.

These components are described in more detail below.

11.1.3 Organisation mandates

Organisation mandates will include the agreements and terms of reference that ensure organisations and individuals in organisations are able to work together to gather, analyse, compile, report/communicate, archive useful information and monitor progress with the national climate agenda and the Paris Agreement. Overarching organisational structures and agreements will often need to be defined and formalised with agreements for data provision and reporting. These can range from national climate laws to organisational mandates, individual contracts and data supply agreements (see Legal and policy frameworks).

A well-functioning MRV system will ensure that there are sufficient laws, agreements and terms of reference in place to enable the availability of experts, flow of data, systems and tools in place and sufficient communication and engagement with stakeholders for the MRV systems data to be useful to decision makers and for national engagement in the Paris Agreement.

11.1.4 Expertise

National experts should be capable of regularly gathering and processing the required data to produce the necessary outputs. The team should have suitable back-up expertise, training material, recruitment initiatives and, where possible, succession and progression to motivate longer term involvement. The technical team may need to be complimented by contracted external support while it is being established and/or for certain developments or review of outputs.

A well-functioning MRV system will ensure that there is a technical team of experts trained and available to produce regular outputs, inform decision makers as necessary and provide material to inform wider audiences on progress and ambition. This will ensure that knowledge is retained and passed down from senior experts to junior experts and that junior experts stay and can progress in their roles.

11.1.5 Data flows

Data flows need to be identified and secured. This includes managing the required datasets and data providers for an efficient data flow on trends (statistics, measurements, GHG emissions and removals), risks and vulnerabilities (from climate change), pressures (from GHG emissions) and the character, costs, benefits and impacts of adaptation and mitigation actions. Identifying and engaging with stakeholders who supply data will be key. Data Sharing Agreements (DSAs) can be established where appropriate.

A well-functioning MRV system will ensure that data is available for monitoring challenges, progress, ambition, and the generation of indicators, ensuring that reports are available and continuously improving. This will ensure that data providing stakeholders are engaged and understand that their data is used for a valuable national purpose.

11.1.6 Systems and tools

This requires managing the production, summarisation and archiving of data and analysis on climate trends, risks and impacts, GHG Inventory, projections and targets, support (including climate finance) and adaptation and mitigation actions. It includes the development and maintenance of indicators, regular production of reports, data analysis tools and QA/QC.

A well-functioning MRV system will ensure that systems and tools are available for the technical experts to manage the data flow, perform QA QC and produce timely outputs of a sufficient quality that improve over time.

11.1.7 Stakeholder Engagement

Stakeholder engagement (public, local communities and self-governments, business and other decision makers) is required for collecting data and for making use of the outputs

from the MRV system for sound evidence-based decision making for action. It can include finding and offering stakeholders the benefits of their involvement and ensuring efficient outputs for publications (BUR, NC, NDC). There is an important link to consider in the wider impacts of climate change action and National Economic and Sustainability goals. This work also keeps the profile of improvement needs of the MRV system high.

A well-functioning MRV system is able to reach out to a broad range of stakeholders (public awareness and education, national government, local government, private sector businesses, NGOs and the media) to bring its knowledge to their decision-making processes. It includes stakeholders involved in the implementation of action and the provision of data to the MRV system.

11.1.8 Monitoring elements

It is important to consider what is monitored, and how, within the MRV system. This includes:

- **Administrative information** needed for the MRV system to function, such as the datasets, stakeholders, expertise needed, the improvement plans, nomenclatures and classifications used and workplans for developing outputs
- **Thematic information** that is at the core of the system and its outputs are reports, briefings, engagement and support tools. This includes key challenges relating to loss, damage, risks, GHG trends, the actual mitigation, adaptation actions and their support.

Further details are provided below.

11.1.9 Administrative information

The administrative information includes a range of lists necessary to keep the MRV system functioning. This information represents the MRV system's institutional memory of who does what, when and with what. It also includes information on how it ensures it meets its quality objectives and on its plans for improvement. This information can include:

- **Details of the MRV system scope & components** to determine its contents. This will include the thematic areas it covers (e.g. all parts or none of mitigation, adaptation and or support) and the outputs required.
- **Outputs**: A list of the systems outputs linked to the data and experts required to produce them. The priorities of different outputs will link to and set priorities for datasets, data flows, the need for experts and the engagement of stakeholders.
- **Data flows:** understanding of data flows is required to determine the datasets needed, their availability and update timings and mechanisms.
- **Roles and responsibilities** illustrated by the links between organisations involved in the MRV system. This will include the hierarchical aspects for managing the work needed in the MRV system.
- **Lists of Datasets** linked to the stakeholders that curate them and can provide them into the MRV system.
- **Lists of Stakeholders** that include data providers, data users, experts and other interested parties. The list identifies key contact points within an organisation and defines the role(s) that the organisation fulfils. It allows users to track the

needs of the organisation and any Memorandum of Understandings that are in place.

- **QA/QC systems** which provide details of the planned activities and procedures (the plan), and a log and evidence of the completed QA/QC activities.
- **Improvement plans:** Improvement Plans provide a place to record ideas for improvements and track the progress of these improvement items. This is to encourage continual improvement of the System and the information it holds. The list contains information on the benefits of the improvement item, the item's progress and status and the resources needed to carry out the improvement. It also prioritises improvement items and links individual items to responsible individuals and organisation.

11.1.10 Thematic information

The thematic information includes the data, evidence and links to background information on the key challenges relating to the agreed themes covered by the MRV system (e.g. loss, damage, risks, GHG trends, the mitigation, adaptation actions, their support). The structuring of this data and / or metadata, where possible, will enable the system to efficiently support the preparation of a narrative on progress, ambition and transparency on the action. Figure 3 below outlines the linkages between the thematic information that will be gathered/organised/prioritised by the MRV system.

Figure 3. Monitoring elements for the domestic MRV system

- **Challenges:** include information on key risks and challenges for including vulnerabilities (for adaptation) and pressures (for example, for GHG emissions for mitigation). These are the challenges that the climate actions should address. The structuring can allow for a simple quantification of the challenge by

assessing the level of exposure to the risk, the sensitivity of a system to the risk and the ability to respond.

- **Targets:** records numerical and non-numerical targets and objectives in a hierarchical manner. The information can be categorised by sector, geography and action type. The list also links targets to indicators and other forms of evidence that can be used to track progress.
- **Actions:** A list of actions is central to the MRV system. This list pulls together the information under specific climate actions/projects/policies and measures into a consistent, coherent and engaging form. Actions can be categorised, prioritised, linked to responsible individuals and organisations, quantified using estimated emissions reductions and linked to supporters, indicators and wider impacts.
- **Indicators:** allow the recording of data and information that track climate challenges, targets and actions. Information on indicators includes a description of progress, a description of the indicator (methodology, unit and update date) and links to key datasets.
- **Support/Investments:** Includes information on the support available for the implementation of climate actions and the MRV system. The support list can also be linked to a climate action, supporters, recipients and beneficiaries. Support opportunities can be categorised by status, type and channel with information being provided on amount and progress of the support.
- **Wider Impacts:** Wider impacts are the additional impacts (positive and negative) that a climate action can have on other national strategies (e.g. economic, social and environmental) and on the UN's Sustainable Development Goals. The analysis of these wider impacts can strengthen the justification for the implementation of a climate action. It can also reveal potential areas of conflict where caution should be taken. The wider impacts can be subjectively classified using agreed classification approaches.

11.2 Review of existing overarching MRV system

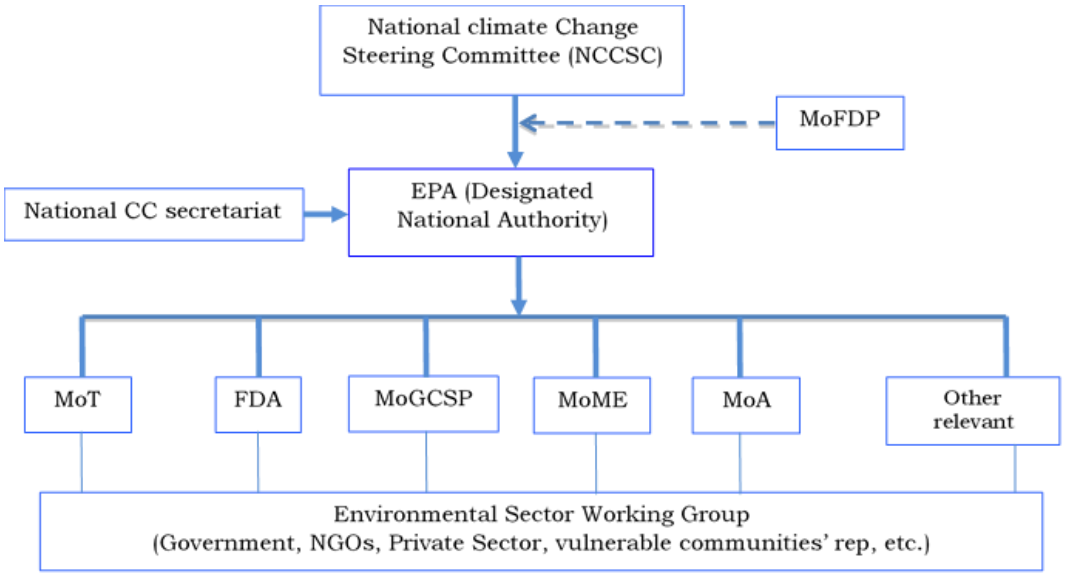
Liberia's First BUR (draft), First NC (28th June 2013) and Second NC (draft) highlight the current situation and steps for improvement to the way Liberia collects and manages data relevant to the Paris Agreement Enhanced Transparency Framework.

The sections below provide a descriptive review of Liberia's ability to monitor, report and to verify its evidence and data on climate change. Analysis focusses on the organisation mandates, data flows and technical capacity, tools and systems and stakeholder engagement needed to gather and continuously improve its evidence for the GHG Inventory and NDC tracking.

11.2.1 Organisation mandates

Liberia's UNFCCC reporting provides outlines for the different roles and responsibilities within the national system. These relate to the GHG Inventory system and, although not explicitly stated, tracking of climate action also. Figure 4 below illustrates which organisations and bodies are involved in the national system and how they are related to each other. The section below provides a summary of our understanding of the national system and a review of constraints and barriers.

Figure 4: Organogram of Liberia's national climate change reporting system (taken from draft BUR1)



The **Environmental Protection Agency** (**EPA)** is the designated National Authority, UNFCCC Focal Point and GHG Inventory Agency. Within the EPA, **the Multilateral Environmental Agreements (MEA)** department is responsible for climate change matters. MEA oversees the compilation of the GHG Inventory and coordinates contributing experts. MEA also oversees strategic short- and medium-term actions relevant to the NDC such as the Nationally Appropriate Mitigation Actions (NAMAs), National Adaptation Plan (NAP), National Adaptation Plan of Action (NAPA), National Climate Change Secretariat (NCCS) and National Disaster Management Agency (NDMA). As part of this role, MEA is responsible for mainstreaming climate change concerns and policy goals into broader national strategies. MEA successfully integrated climate change mitigation and adaptation goals (for 2030) into the development agenda *Pro-Poor Agenda for Prosperity.* However, integrating these elements into long term development planning coordinated by other agencies e.g., National Land – Use Policy and Plan, has proved more challenging.

The **Ministry of Finance and Development Planning (MoFDP)** play an important role in supporting the EPA with their responsibilities. MoFDP are responsible for planning, budgeting and coordination of climate change policy activities. MoFDP mobilise and allocate financial resources for climate change in Liberia and provide Monitoring and Evaluation (M&E). The division of labour between MoFDP and EPA is not clear relating to climate change activities, with both organisations contributing to the development of policy design and guidance documents such as data collection and management protocols.

A focal point for collaboration, the **National Climate Change Steering Committee (NCCSC)** brings together a broad range of stakeholders to collaborate on nationally important cross-sectoral strategies**.** Established by presidential decree in October 2010, the mandate of the NCCSC is to coordinate and supervise the implementation of climate policy. NCCSC provides oversight and high-level support for climate change policy (including GHG inventory reporting). NCCSC is responsible for ensuring that Liberia achieves its policy goals which requires engaging key decision-makers and reviewing legislature to secure adequate and accessible funding. NCCSC's role also involves authorizing any external support needed and annually reporting on progress made

towards implementation of the climate change policy, although it is unclear whether NCCSC produce these reports. Membership of the NCCSC is far reaching and includes representatives from the following organisations:

- President of the Republic of Liberia-ex-official
- Energy, Environment and Climate Change Advisor to the President of Liberia
- Heads of Standing Committees on Environment and Natural Resources of the Senate and the House
- Minister of Planning and Economic Affairs (MoPEA)
- Minister of Mines and Energy (MME)
- Minister of Agriculture (MoA)
- Minister of Finance (MoF)
- Minister of Gender and Development
- Minister of Transport
- Minister of Finance & Development Planning
- Managing Director of the FDA
- Executive Director of the EPA
- Chairman, National Investment Commission
- Commissioner of Liberia Maritime Authority
- World Bank
- University of Liberia
- Civil society
- Fauna & Flora International
- National Climate Change Secretariat Coordinator

The **National Climate Change Secretariat (NCCS)** is an operational body supporting the activities of the NCCSC. The NCCS is housed within the EPA and is reportedly responsible for the administrative and coordination capacities of the NCCSC. The NCCS maintain the records of the NCCSC and keep track of policy implementation. Several identified barriers and constraints listed relate to strengthening and engaging NCCSC and NCCS which suggests these bodies do not currently have the resources to actively engage with the national system. NCCSC and NCCS are periodically active, heavily dependent on budgeting for meeting attendance.

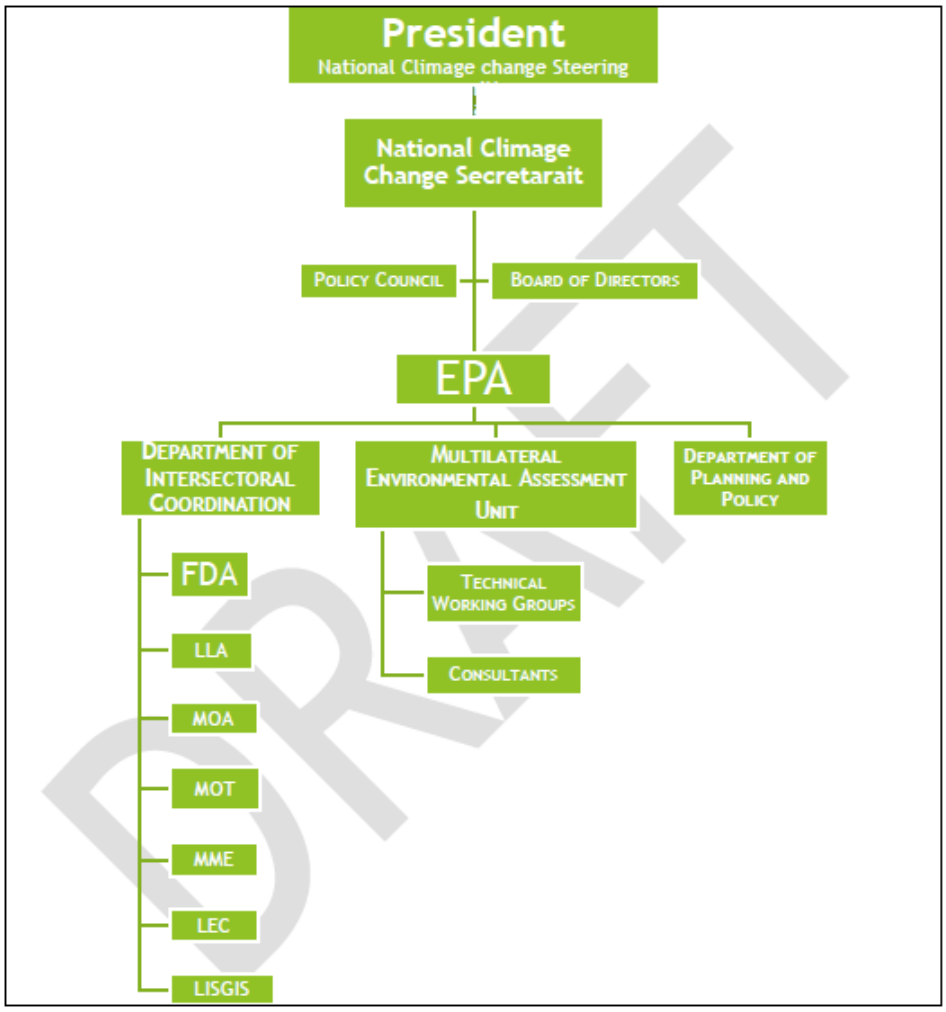
A number of organisations support EPA with the implementation of climate change policy including:

- Ministry of Transport (MoT)
- Forestry Development Authority (FDA)
- Ministry of Gender, Children and Social Protection (MoGCSP)
- Ministry of Mines and Energy (MoME)
- Ministry of Agriculture (MoA)
- Liberia Land Authority
- Liberia Institute of Statistics and Geo-Information Services

These organisations are also involved in data collection for the GHG inventory under the BUR project through **Technical Working Groups (TWGs)** established by EPA. This is a development from the NC1 project which saw the compilation of the GHG Inventory undertaken by external consultants. However, it is unclear as to whether the role of the TWGs is formalised and backed by a legislative instrument or if it is project funding dependent. The TWGs are responsible for data collection activities, with the compilation of the GHG remaining the responsibility of the MEA. It is unclear how these

responsibilities relate to climate action tracking. The TWGs are working under the supervision of coordinators within the MEA unit. A revised, proposed set of roles and responsibilities is also included in the BUR1 (Figure 5) however, it is unclear as to the operational status of these arrangements. These arrangements include the TWGs, but also introduce a Department of Intersectoral Coordination to coordinate input from various organisations.

Figure 5. Proposed roles and responsibilities set out in the BUR1



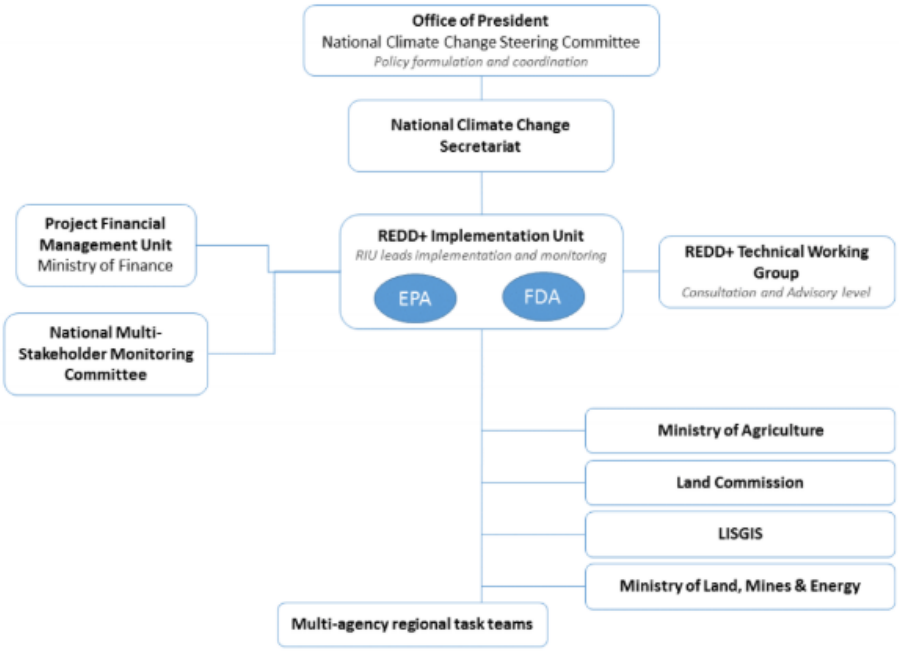
Stakeholder engagement and barriers and constraints in the draft BUR1/NC2 documents have highlighted the gaps in the **legal framework** underpinning the MRV system. The NC2 flags that MEA has a weak mandate for requesting and sharing data for the GHG Inventory and on climate action. There are no formalised data sharing agreements or other Memorandums of Understanding (MoUs) that facilitate the flow of information across the whole national system. Similarly, Liberia is lacking overarching legislation to provide EPA or MoFDP with a means to request resources for the national MRV system (including for the regular engagement of the NCCSC).

In addition to the roles, responsibilities and legal framework that has been defined at the national level, across all sectors, national institutions have also developed an **MRV system focused on REDD+ implementation**. Figure 6 illustrates the specific roles and responsibilities identified for REDD+ implementation. Common elements with the national MRV system include the role of NCCSC and NCCS, input on project financing

from MoFDP, the presence of a REDD+ Technical Working Group, which mirrors the TWGs established by EPA for the BUR project, data input from a range of institutions, and the central role of EPA as the main coordinating body. In addition, the REDD+ implementation MRV system proposes a coordinating role for the Forestry Development Authority (FDA) and includes an M&E role for a National Multi-Stakeholder Monitoring Committee. There exists a form of MoU between FCA and EPA that could be replicated and expanded for the national MRV system, although it is not an explicit data sharing agreement.

Interestingly, the National Strategy for REDD+ in Liberia[15] (FDA REDD+ Implementation Unit, 2016) highlights the lack of institutional strength within the NCCSC as a body and the challenges that presents in integrating REDD+ into national policy. The strategy document suggests integrating REDD+ planning with development planning under **The Liberian Development Alliance (LDA).** The LDA is the Government's most strategic forum for engaging state and non-state actors on the national development agenda. It is chaired by the president and led by MoDFP. This has implications for the national MRV system and the integration of the climate change agenda more broadly which does not feature significantly in either Liberia's 2013-2018 *Agenda for Transformation* or the long-term development strategy *Vision 2030: Liberia Rising.* This is an important consideration as climate change mitigation and adaptation affects cross cutting issues for a number of topics included under Agenda for Transformation's Pillar II – Economic Transformation, e.g. agriculture and food security, infrastructure and forestry and protection.

Figure 6. Roles and responsibilities for REDD+ implementation



The BUR1 also identifies a list of key resource needs and barriers for the operationalization of the MRV system:

[15] Available here: https://drive.google.com/file/d/1syrwnfZpFpjJzr0xAkAAJFU3gFr8fAb0/view

- Sectoral working groups need to be identified (financial support requested $30,000)
- NCCSC continuously engaged (estimated at $150,000 per year)
- Establishment of a GHG inventory Technical Advisory Committee requested led by EPA ($60,000 per year)
- Inventory management team within EPA ($50,000 per year)
- MoUs put in place

Below are a set of recommendations and next steps for the project with regards to organisation mandates. The project team will action these steps once MEA and CI have approved the Baseline Report.

Recommendations and next steps

1.1. Defining the scope of the MRV system – the project team will work with key stakeholders within MEA to clarify and define whether the same organisation mandates apply for both GHG inventory compilation and climate action tracking.

1.2. Identify individual national MRV coordinator(s) to work alongside the project team to build awareness and understanding of the national MRV system.

1.3. Explore options for practical strengthening of NCCSC. This will involve developing a clear mandate for supporting the collection, refinement and use of information needed to track progress and drive ambition in mitigation and adaptation action. This could also include coordination with LDA to promote climate change issues within the development agenda. Outcomes of this could include the mobilisation of climate change funds for development activities and leveraging more political will and attention for the national MRV system.

1.4. Identify and engage academic institutions to provide additional capacity and continuity to the MRV system through existing expertise and the development of the curriculum.

1.4. Map and define a single set of roles and responsibilities that incorporate all relevant organisations, is consistent between the national MRV system and the REDD+ MRV system, and builds on previous work to define these. This should include details of the MRV system objectives and outputs. This should also consider other reporting regimes such as SDG reporting or the Montreal Protocol.

1.5. Identify list of legal arrangements needed to facilitate flow of data and information throughout the MRV system and ensure continuity (laws, MoUs, data sharing agreements).

11.2.2 Technical experts

The draft BUR1 identifies a lack of technical capacity to compile the national GHG Inventory or to analyse, develop or cost climate change policies and measures. The establishment of the TWGs is a positive first step in building teams of experts but as outlined in the section above it is unclear what expertise has been recruited into the TWGs. One of the key challenges identified in the BUR1, is that the lack of a dedicated, effective climate change committee or task force means that for each new climate change activity, new technicians are nominated by parent institutions who have no previous knowledge of climate change issues.

The draft BUR1 and NC2 highlight that in-house technical capacity is limited in the following areas:

- Compilation of the GHG inventory
- Assessment of climate change mitigation and adaptation options
- Effective participation in the UNFCCC negotiation process
- Development of planning and policy documents, for example the Low Emissions Development Strategy
- Development of nationally or regionally specific emission factors

Below are a set of recommendation and next steps for the project with regards to the development of technical experts and the establishment of access to relevant expertise.

Recommendations and next steps

2.1. Develop person specifications for key expert roles. The right individuals need to be identified to fill roles of experts and to receive technical training. The project team will work with MRV coordinators to develop specifications.

2.2. Identify, interview, and recruit key experts and junior support to receive technical training on GHG Inventory compilation and NDC tracking. Based on the person specifications, key experts and junior support roles should be filled by individuals with the appropriate quantitative skillset.

2.3. Develop training plan and identify opportunities for continued development. Working alongside identified experts and juniors, map out a training plan and scout future opportunities for continued development for example UNFCCC certification and participation in international reviews.

2.4 Track skills and training needs within the MRV system. Using the Improvement Plan (see Systems and Tools) track ongoing training needs and skill shortages to prioritise future support.

2.5 Explore practical opportunities to integrate climate change technical skills into higher education curriculum. Academic institutions can provide capacity and training for the continued develop of technical skills. The project team propose to support the MRV coordinator(s) to engage university contacts within Liberia in scoping out opportunities to integrate training of technical skills needed by the climate change system into the curriculum.

11.2.3 Data flows

The review of each sector in the sections above highlights the data availability, and indicates which datasets are regularly and reliably available for the data compilers. The formation of the TWGs looks to improve data availability and provide more coordination between data providers. Neither current nor proposed organisation mandates include the representation of industry and private sector level data suppliers. These are an important data source for the GHG inventory and of grass-roots climate action and often requires comprehensive legislation and active engagement to encourage their participation in the MRV system. One or more ministries can coordinate this. **The Liberia Institute of Statistics and Geo-Information Services (LISGIS)** has a key role to play in ensuring consistency across datasets for example on demographics, population, GDP etc. International sources of these datasets (e.g. World Bank, UN Energy Statistics or FAO) are also helpful in ensuring consistency across sectors.

The NC1 and draft BUR1/NC2 highlight that sustained access to a reliable body of scientific and technical information remains a challenge, and that ground level data collection has been difficult with monitoring stations deteriorating or lost leading to data gaps. Liberia has explored climate smart agriculture options[16] through supporting projects, the outputs of which relating to challenges for the agriculture sector and land use and will be important to incorporate in the national system.

Liberia's draft UNFCCC reports include project specific information on climate change actions, including a table with information on status of individual actions, the implementing agency, progress indicators and co-benefits. This demonstrates a good base to build on and the beginnings of a climate action database to further develop. During this project, it will be important to build on this climate action data and identify the flows of information that can support regularly tracking of this information. Existing data collection processes are reported as informal and ad-hoc. Data requests are sent as needed between national experts and staff of relevant ministries, departments, and agencies but are not currently supported by a legal mandate. The climate action data could also be improved with additional information on climate action and project level financing. This information often requires the coordination between several different ministries responsible for managing, overseeing or tracking the actions. The draft BUR1 flags a lack of transparency around the data flows on support needed or received and on tracking actual government expenditures on climate change. A 'bottom-up' approach to project level identification and tracking can support this.

Below are a set of recommendation and next steps for the project with regards to the development of data flows, access to datasets and engagement of data providers.

Recommendations and next steps

3.1 Map relevant sectoral datasets and data sources. The section above had started to map available data for the GHG inventory sectors. The project team will continue to build an understanding of the datasets and data sources needed for the GHG Inventory and for climate action tracking as defined by the monitoring elements of the MRV system (Figure 3).

3.2. Develop, maintain and manage a network of data suppliers and data supply agreements. The MRV system should establish strong and sustainable links with datasets and data providers. This should include agreements for data supply and roles and responsibilities in gathering and QA QC of data. A list of datasets should highlight potential improvements and link to the improvement plan and link to the relevant stakeholders needed for those improvements. This is relevant for the GHG Inventory, NDC tracking and support/finance information. For finance, this will include the datasets on national and international investments as well as those for individual specific actions. This will include ODA, Public, Private, national, regional, bilateral, banks, aid agencies, beneficiaries etc. and can be used to inform policy and in prominent reports and strategies (e.g. NDC, NC, BUR and Climate Strategies).

3.3. **Engage with and enhance collaboration with the LISGIS to establish roles and responsibilities for the provision of national statistical data** and in ensuring consistency both within data used for the greenhouse gas inventories for the NC2 and BUR1 and data reported elsewhere (e.g. livestock data to FAO).

[16] Wilson, Joe. (2018). Climate Smart Agriculture: A Strategy to Increase Smallholders Farmers Production and Mitigate Liberia's Dire State of Food Insecurity.

3.4 Set-up data structures and forms for collecting details of climate actions and support and investment need and received. This should build on existing data on climate actions and indicators and also include information on support and investment needs, that provided and the stakeholders providing support.

3.5 Update and maintain details of stakeholder and datasets relevant to the MRV system. Consolidating the information gathered in the steps above, the project team will support Liberia to build a list of key stakeholders and datasets which should be maintained within the MRV system.

11.2.4 Systems and tools

Through this project, it will be important to consolidate information of the range of different systems and tools being used by Liberia to monitor and track MRV system elements. It is noted that Liberia used the IPCC Software for the compilation of its GHG inventory for the draft BUR1. The NC1 proposed the development of a GHG archiving system for collecting and tracking inventory data, however this has not yet been implemented.

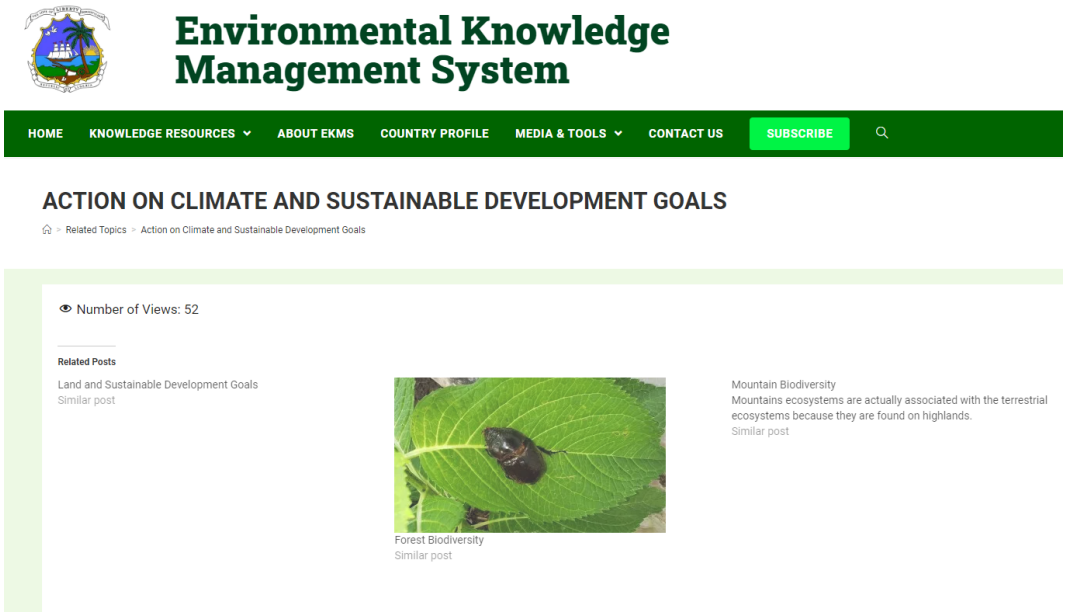
The most significant development in terms of knowledge or data management systems is the development of the **Environmental Knowledge Management System (EKMS)**[17] under the GEF funded Cross-Cutting Capacity Development Project (CCCD). Information of EKMS states that:

"The EKMS provides free and open access to information from key government and other institutions in Liberia relating to the implementation of the Rio Conventions – The United Nations Framework Convention on Climate Change, The United Nations Convention to Combat Desertification, and The United Nations Convention on Biological Diversity. The EKMS is deployed under the supervision of Environmental Protection Agency (EPA) in collaboration with twelve relevant government institutions. Information access on this platform include reports, publications, case studies, tools and guidelines, institution's technical documents, and other related materials."

EKMS provides a hub for linking datasets between Multilateral Environmental Agreements, as well as linking other existing data systems such as the Liberia REDD+ Safeguards Information system, the Liberia Data Portal, the Liberia Forest Atlas and the Liberia Farmers Registration Data. There a number of pages earmarked for listing information relevant to the MRV system such as on climate actions and SDGs (Figure 7 below), however, these have not yet been populated with any information. In its current form, EKMS is a useful tool for public engagement and disseminating general information about climate change and various other environmental issues. However, it does not appear to be operational in terms of effective management of climate action information, tracking against NDC targets or providing effective institutional memory for the whole MRV system. More information is needed on the in-built infrastructure that would allow tracking of information on climate actions, indicators and key administrative information (Section 11.1.9). It would be useful to get a better understanding of the backend of the system and what a coordinator with appropriate user access rights has access to. Visually, the site could be an effective public engagement tool, however it would also require a developed database back-end to provide effective management of the MRV system data.

[17] Available here: https://ekmsliberia.info/

Figure 7: EKMS page for climate action



EKMS is also linked to a number of other existing data systems, these are summarised in the table below:

Table 25: Overview of Liberia's existing data systems linked to EKMS

Data portal	Description
Liberia REDD+ Safeguards Information System	A database interface that allows the user to generate reports showing the extent to which social and environmental safeguards have been addressed and respected in REDD+ activities. Allows the user to filter projects based on year, type, region, program and project. Generates a report (with the option to print) with safeguarding information organised by principles, criteria and indicators. No information available on the project activities themselves or climate change mitigation/adaptation impacts. User sign in also available.
Liberia Data Portal	Site storing statistics, datasets and data visualisations such as GDP and financial information. Topics include Agriculture, Economics, Education, International Trade and Poverty. Sponsored by the African Development Bank and owned by LISGIS. High level information on SDGs available. No data on climate observations or actions.
Liberia Forest Atlas	A database of GIS layers and datasets relating to Forest Management, Conservation, Agro Industry, Oil & Gas, Infrastructure and Administrative Boundaries. Also, a document archive for community forests documents, commercial forests documents, conservation documents and REDD+ documents. Administered by FDA and World Resources Institute (WRI)
Water Sanitation and hygiene (WASH)	Data portal with information about Liberia's WASH program, WASH survey data and datasets relevant to the WASH program.

	Limited overlap with data relevant for the climate change MRV system.
Liberia Farmers registration Data	The link to this page was non-responsive but information available on the Ministry of Agriculture's website indicates that the purpose of the platform is to provide information to Liberian farmers on the latest knowledge and information on farming varieties, breeds and fertilizers to improve productivity and efficiency.
Infrastructure Implementation Unit	A citizen engagement portal linked to a mobile app to submit information on infrastructure issues such as damaged roads, landslides and collapsed bridges.

Below are a set of recommendation and next steps for the project with regards to the development of data flows, access to datasets and engagement of data providers.

Recommendations and next steps

4.1. Draft conceptual framework for GHG archiving system and for collecting, managing and tracking climate action. Based on the monitoring elements key to the MRV system and the identified need for a GHG inventory archiving system, the project team will develop a conceptual framework for structuring an online data management platform that links GHG inventory archiving and climate action tracking elements.

4.2 Review backend access to EKMS and explore integration options. Any proposed solution for online data management platform should integrate with existing systems. The project team will need to understand more about the technical details of EKMS and on who administers the site.

4.3. Develop Improvement Plan to track and monitor the progress of the MRV system. Keep this list up to date, prioritised and use it when seeking resources for improvement to the MRV system.

11.2.5 Stakeholder engagement

The BUR1/NC2 highlights a key gap in public awareness of climate change issues as well as a low-level awareness from decision makers. There is limited engagement from non—state actors in the development, review and reporting of climate change actions or the GHG inventory. Several initiatives have tried to address these gaps, including the development of EKMS and the introduction of climate change issues into the national curriculum (proposed, not implemented).

There are two key aspects for stakeholder engagement:

- Engagement of a wide range of stakeholders (state and non-state) for data inputs into the MRV system
- Dissemination of the outputs of the MRV system to the general public, decision makers and the education system through engaging data visualisations, establishing channels of regular engagement to provide feedback on outputs of the MRV system (the GHG inventory, BUR/NC drafts, summarised policy options and impacts for national strategies) and integrating climate change issues into the curriculum.

The first of these elements is developed through the roles and responsibilities within the national system and establishing a vessel for feedback and communication. The NCCSC

and TWGs provide channels for this but are not active in this space due to a lack of resources and political mandate. Currently, EKMS provides the primary platform for climate change information dissemination but is still in early phases of development. The integration of climate change issues into the national curriculum has been identified as a need within the draft BUR1/NC2. This could also include the development of the higher education curriculum and tie in with the development of a supply chain of technical expertise through university level training programmes. Active membership and engagement of NCCSC could provide an efficient channel for disseminating and consulting on the outputs of the MRV system, but as noted above it is only periodically active.

Below are a set of recommendations and next steps for the project with regards to improving wider stakeholder engagement with the MRV system.

Recommendations and next steps

5.1 Establish a schedule for NCCSC coordination of stakeholder engagement in coordination with Recommendation 1.3, for both inputs into the MRV system and for consultation on outputs (the GHG inventory, BUR/NC drafts, summarised policy options and impacts for national strategies).

5.2 Develop communications plan for disseminating MRV system outputs. Identify key outputs of the system, the best way to represent that information with most impact (infographics, data visualisations, briefing notes etc.) and draw up a timeline for regular engagement of decision makers and the general public.

5.3 Explore the integration of climate change issues into education curriculums. Open a conversation with the Ministry of Education and higher education institutions (in coordination with Recommendation 1.4), to explore possibility of raising awareness of climate change mitigation and adaptation issues at different levels of the education system. Aether have some experience of developing engaging awareness raising material for schools in the UK and on delivering lectures at UK universities (Imperial College London, Oxford Brookes University) and can advise on presenting the issues at an appropriate level.

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