Technology Needs Assessment Report

Identification and Prioritization of technologies for Suriname related to climate change

November 2019

Preface

Suriname is classified as one of the most vulnerable nations in the Caribbean, if not in the world, due to its low laying coast and that the majority of its economic activities take place in the coastal area.

Various studies by international institutes, including the World Bank and the International Panel on Climate Change (IPCC), have found that without significant interventions, countries such as Suriname increase their vulnerability with persistent climate change. Sectors such as Agriculture, Mining, Infrastructure, Residential, Fisheries, Tourism, etc. are experiencing or will experience the negative effects of climate change.

In 2018, through its Parliament, *De Nationale Assemblee*, Suriname approved the Paris Agreement associated with the Framework Convention on Climate Change (UNFCCC) through the National Assembly. The Paris Accord mentions the importance of widespread technological change to reduce emissions and stabilize atmospheric concentrations of greenhouse gases.

Suriname's vulnerability to persistent climate change and its commitment to implement the Paris Agreement are fundamental for the Technology Needs Assessment (TNA) currently being conducted.

NIMOS thankfully acknowledges the work of the TNA National Team, Global Environment Facility, UNEP-DTU, UWI (Mona Campus) and all other partners for their support and guidance in completing this first step.

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Acronyms

AdeKUS	Anton de Kom University of Suriname, Faculty of Technology
AFOLU	Agriculture Forestry and Other Land Uses
BAEF	Barrier analyses and enabling framework
CCD	Climate Compatible Development
COP	Conference of Parties
DDFDB+	Drivers of Deforestation, Forest Degradation and Barriers to REDD+
DTU	Technical University of Denmark (Danmarks Tekniske Universitet)
EBS	NV Energiebedrijven Suriname (Energy Company Suriname)
EE	Energy Efficiency
ESP	Electricity Sector Plan
FREL	Forest Reference Emission Level
GEF	Global Environment Facility
GHG	Greenhouse Gases
GoS	Government of Suriname
HFLD	High Forest Cover and Low Deforestation
IDB	Inter-American Development Bank
IIRSA	Initiative for the Integration of the Regional Infrastructure of South America
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resource Management
MCA	Multi Criteria Analysis
NAP	National Adaptation Plan
NC	National Consultant
NCCPSAP	National Climate Change Policy, Strategy and Action plan
NDC	Nationally Determined Contribution
NIMOS	Nationaal Instituut voor Milieu en Ontwikkeling
NGO	Non-Governmental Organization
OP	Policy Development Plan
UDP	UNEP DTU Partnership
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

PDP	Policy Development Plan
PPP	Public-Private Partnership
RE	Renewable Energy
REDD+	Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
SIDS	Small Island Developing States
SNC	Second National Communication
SWG	Sector Working Group
SWS	Stakeholder Workshop
TAP	Technology Action Plan
TNA	Technology Needs Assessment
UNFCCC	United Nations Framework Convention on Climate Change
UWI	University of the West Indies
WFS	Stichting Waterforum Suriname

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Executive Summary

Since the ratification of the UNFCCC in 1997, the Republic of Suriname has conducted several studies and have implemented measures to assess and address its vulnerability to persistent climate change as well as determining its contribution, through its high forest cover, to fight this phenomenon.

Based on several studies, such as its Nationally Determined Contribution (NDC) and Drivers of Deforestation, Forest Degradation and Barriers to REDD+, it was determined that the Agriculture, Water Management and Infrastructure & Housing sectors would be the priority sectors under the Technology Needs Assessment (TNA) project.

The main objectives of the TNA project are:

1. To identify and prioritize through country-driven participatory processes, technologies that can contribute to adaptation and mitigation goals of the participant countries, while meeting their national sustainable development goals and priorities.

2. To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies and to recommend enabling frameworks for overcoming the identified barriers.

3. To develop Technology Action Plans (TAP) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the participant countries.

Chapter 1 and 2 outlines the policy and institutional arrangements and priorities in Suriname related to climate change mitigation and adaptation as well as the relevant stakeholders participating in the TNA.

Chapters 3, 4 and 5 highlight the process related to the objective 1 of the TNA Project as mentioned above for the three sectors, Water Management, Agriculture and Infrastructure & Housing, respectively. The results of the process was a selection of three priority technologies for the sector Water Management: Water modelling, Water resource Mapping & Water Storage and Harvesting. Three priority technologies for the Agriculture sector, namely Integrated farming systems, improved irrigation efficiency & climate resilient crop varieties and Livestock breeds. Two priority technologies were selected for the Infrastructure & Housing sectors, respectively Forest Specific Land use Planning & Energy Efficiency Building Design.

Chapter 6 provides the summary and conclusions, wherein the experiences of the National TNA Team are also expressed. The TNA Project enables Suriname to fulfill its long-standing objective of technology transfer to address its mitigation and adaptation needs.

Chapter 1 Introduction

1.1 About the TNA project

Climate change is considered one of the most significant challenges to human development in the 21st century. Applying new technologies can be a solution to reducing emissions and stabilizing atmospheric concentrations of GHGs at a level that would not jeopardize global climate (UNFCCC 2009). Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable development to proceed in a sustainable manner (UNFCCC, 2009).

The Global Technology Needs Assessment project is a Strategic Program on technology transfer, designed to support developing countries to carry out Technology Needs Assessments to achieve national Sustainable Development Goals and the Paris Agreement. Suriname has ratified the United Nations Framework Convention on Climate Change (UNFCCC) in October 1997 and its Paris Agreement on 13 February 2019 [1] , demonstrating Suriname's commitment to address climate change in collaboration with the international community. Within the framework of the UNFCCC and under the Paris Agreement, Suriname has been given the opportunity to assess the kind of technologies that are best suited to the country's specific climate change situation. The project is being funded by the Global Environment Facility (GEF) and executed by UN Environment Program through a partnership with the Technical University of Denmark (UNEP DTU Partnership or UDP).

1.1.1 Objectives of the TNA project

The purpose of the TNA project is to assist Suriname in identification and analysis of its priority technology needs that can support the country to avert the risks and impacts of climate change and to reduce national GHG emissions. This will form the basis for development of environmentally sound technology projects and programs to facilitate transfer and access technologies in accordance with Article 4.5 of UNFCCC. The main objectives of the project are:

[1] https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en

1. To identify and prioritize through country-driven participatory processes, technologies that can contribute to adaptation/mitigation goals of the participant countries, while meeting their national sustainable development goals and priorities

2. To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies.
3. To develop Technology Action Plans (TAP) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the participant countries.

The TNA process will also develop Concept Notes for attracting funding to implement selected technologies in priority areas of national relevance. This report is based on objective 1, namely to identify and prioritize technologies that can contribute to the adaptation and mitigation goals of Suriname, while meeting the country´s national sustainable development goals and priorities.

1.2. Existing national policies on climate change mitigation and development priorities

Being part of the Small Island Developing States, Suriname is extremely vulnerable to the effects of climate change. Most of the population resides in the low-lying coastline and sea level rise makes Suriname highly vulnerable to climate change. Policy makers are aware of the imminent threat of Sea Level Rise and its socio-economic effects, stating the Government of Suriname's intention to pursue a 'Green Economy'.

Located in the Amazon region, Suriname is classified as a High Forest, Low Deforestation (HFLD) country where 93% of the country's land area is covered by tropical forest, which serves as a greenhouse gas sink of global importance. Suriname's contribution to global greenhouse gas (GHG) emissions that drive climate change is very small and it acts as a net sink when absorptions from the Agriculture, Forestry and Other Land Use (AFOLU) sectors are taken into account. Therefore, even though Suriname´s contribution in CO_2 emissions is negligible on global scale, the Government takes its responsibility by enhancing the resilience of the country against climate change impact and by adapting to and mitigating the effects of climate change, thus leading the country towards sustainable development.

The Government highlights the relevance of climate change interventions in planning documents: for example, the Policy Development Plan 2017-2021 includes climate change adaptation and mitigation actions as a development pillar (Government of the Republic of Suriname, 2017). Likewise, the (Intended) Nationally Determined

Contribution [2] (2015) indicates Suriname's commitment to climate compatible development and recognizes the need for the international community to work collectively, responsibly and with urgency to address this issue through among others, critical elements such as technology transfer to engender large-scale adaptation and mitigation.

1.2.1 Governance

The Constitution of the Republic of Suriname provides the legal basis for a sustainable environmental policy in its Article 6g[3], which states that one of the social objectives of the state is focused on the establishment and stimulation of conditions required for the preservation of nature and the safeguarding of ecological balance. Adherence to these principles have been seen through Suriname's participation in major environmental conventions. Some legislation, policy documents and action programmes have been developed in order to address climate change issues in general and the UNFCCC commitments specifically.

The government's development policy is based on an integrated approach to economic, social and environmental sustainability. The 2017-2021 Policy Development Plan (PDP)[4] describes four 'pillars' upon which Suriname's growth and sustainability will depend. The 1st Pillar, 'Strengthening Development Capacity', points out the adequate development of enabling sectors such as physical infrastructure and the 4th Pillar 'Utilization and Protection of the Environment', emphasizes the prevention of threats such as CO_2-emissions as a result of human actions or disasters. In line with PDP 2017-2021, the aim of the National Climate Change Policy, Strategic and Action Plan (NCCPSAP) is to reduce the country's vulnerability through the implementation of climate resilience measures in the coastal area as well as in the interior while bringing development through sustainable and clean technology.

However, climate change mainstreaming is at an early stage in Suriname. The current legislative framework does not adequately support climate change governance (del Prado, 2014), because sectoral laws are fragmented and do not address climate change, and in addition, there is no standalone climate change law. Despite the design of climate change specific policies, action plans and proposals, there is no structural approach for mainstreaming climate change into daily operations. Notwithstanding that, an Environmental Law is currently under discussion in the National Assembly and is expected to finally be adopted in 2019. This law will be the foundation for environmental protection and good environmental governance in Suriname. The

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[2] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Suriname%20First/Suriname%20First%20NDC.pdf.

[3] Grondwet van de Republiek Suriname, S.B. 1987 no.116

[4] https://www.planningofficesuriname.com/wp-content/uploads/2017/05/OP-2017-2021-Ontwikkelingsprioriteiten-van-Suriname-1.pdf

Environmental Management Act will provide the legal base for the implementation of the Environmental Assessment Guidelines. It has a number of key provisions, among which are the following:

- Give effect within Suriname to many internationally-accepted principles of Environmental Law, including the principle of precaution, the polluter pays principle and the concept of environmental impact assessment;
- Introduce and give effect to the Environmental Impact Assessment Guidelines;
- Enshrine the principles of access to information, participation and legal protection for the Surinamese public.

The main policies on climate change and development priorities are briefly discussed below:

Development Plan 2017-2021

The Country's Development Plan 2017-2021 (OP) forms an overarching document for the country, provides development direction and forms the base for the national sectoral policies (developed by the respective ministries) and the yearly district plans. The OP aims at both strengthening the economic development capacity of the country and achieving sustainable development, by combining economic and social development with the responsible use of the environment. The four pillars that compose the National Development Plan 2017-2021 are (i) the strengthening of developmental capacity, (ii) economic growth and diversification, (iii) social progress, and (iv) the use and protection of the environment. Climate change and the sustainable use of the forests' economic value, including through REDD+, are considered within the last pillar on environmental protection but are also crosscutting. Furthermore, the OP aims at the following spearheads regarding energy: (1) energy access for everyone in the country, (2) promoting energy efficiency and (3) stimulating the use of renewable energy.

The National Climate Change Policy, Strategy and Action Plan (NCCPSAP) 2014-2021

The National Climate Change Policy, Strategy and Action Plan (NCCPSAP) finalized in 2015, builds on the first Climate Action Plan (2008-2013) and comprises Suriname's climate change mitigation and adaptation vision, policy and actions. Emphasis is placed on research to generate data on the vulnerability of Suriname, on awareness-raising campaigns and on delivering climate resilience measures cross-sectorally. The NCCPSAP provides a clear roadmap to respond to the challenges of a changing climate, to seize opportunities for climate compatible development and to attract climate finance. The NCCPSAP is consistent with the Development Plan and also articulates pursuing low carbon emission development through the application of sustainable and clean technology. It therefore stresses the importance of

developing partnerships to enable technology transfer, and promotes alternative financing sources for climate compatible development.

The (draft) National Adaptation Plan

The next logical step of the National initiatives for meeting the adverse effects of climate change is the National Adaptation Plan for Climate Change in Suriname (NAP), currently in its final draft stage. The objective of the NAP is to help Suriname conduct comprehensive medium and long-term climate adaptation planning. It encourages policy innovation, prioritizes adaptation measures, seeks technological solutions and recognizes the value of local knowledge in a participatory and efficient manner. The NAP is based on the NCCPSAP, but also expands from the latter. Other sectoral and other government and stakeholder plans are also considered in order to align the many piecemeal efforts occurring.

Second National Communication (base-year 2008)[5]

Suriname submitted its Second National Communication (SNC) to the UNFCCC in 2016. The National Communication serves as an important strategic tool for bringing climate change concerns to the attention of policy makers at the national level and helping to align national interests and priorities with the overall goals of the Convention. A Third National Communication (TNC) is currently being prepared, with its release scheduled for 2020. The TNC will provide an updated GHG Inventory for the 2000 – 2015 period.

Draft National REDD+ Strategy and FREL[6]

The draft National REDD+ Strategy was submitted in 2018 and has four (4) strategic goals to achieve: (1) Continue being a HFLD and receive compensation for economic transition. (2) Forest Governance, (3) Land Use Planning and (4) Conservation of forests and reforestation to support sustainable development. Within the REDD+ project a Forest Reference Emission Level (FREL) was assessed. The FREL for Suriname's REDD+ Programme (Government of Suriname 2018) was submitted to the UNFCCC for review in 2018. This report provides a fresh baseline to enable result-based payments for implementation of a REDD+ program.

NDC 2015[7]

Suriname submitted its INDC to the UNFCCC in 2015. Currently, Suriname is in the process of enhancing the country's NDC, the 2020 NDC. The 2020 NDC will seek to outline the most cost-effective pathway to decarbonization of sustainable economic development, maintaining the integrity of natural forest acting as a

[5] https://unfccc.int/resource/docs/natc/surnc2.pdf

[6] https://redd.unfccc.int/files/2018_frel_submission_suriname.pdf

[7] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Suriname%20Second/Suriname%20Second%20NDC.pdf

carbon sink, and strengthening resilience so as to enable adaptation and mitigation action. The sectors Forest, Energy, Agriculture and Transport and Urban infrastructure aretaken into consideration in the 2020 NDC.

1.3 Sector selection

Being in line with the OP, the NCCPSAP uses the National Development themes (National Development Plan 2012-2017) on which the Action Plan is built. For each of the 13 national planning themes (or sectors), a series of outcomes and programmes has been defined. The current Development Plan (OP 2017-2021) uses more or less similar planning themes, although clustered in two main sectors, the ´Encouraging Sectors´[8] and the ´Priority Sectors[9]´, the latter also called the Production cluster. Looking at the future projection of GHG and based on the planning themes, the following five sectors were assessed in the SNC: Infrastructure, Energy, Housing, Mining and Agriculture and Sustainable Forest Management.

Based on several studies and national priorities, such as its Nationally Determined Contribution (NDC) and Drivers of Deforestation, Forest Degradation and Barriers to REDD+, it was determined that the TNA project should focus on the following sectors: Agriculture, Water Management and Infrastructure & Housing.

1.3.1 An overview of sectors, projected climate change, and GHG emissions status and trends of the different sectors

The Climate Change Action Plan captures all programmes and associated actions under the following national development planning themes. Looking at the future projection of GHG, only five sectors were assessed in the SNC and are described in the table below. Table 1 describes the current and expected future projections of GHG emissions, as stated in the SNC and based on recent developments from other sources.

Table 1: Projection of sectors regarding GHG emissions and trends.

Sector	GHG emissions	Projected climate change and trends of the sector
Infrastructure	All transportation activities (water and road) depend on fossil fuels. The transport sector contributes approximately 16% to total GHG emissions of the energy sector and around 10% of total GHG emissions in	Emissions will increase due to increased transportation movements and increased asphalt paving. The plans for infrastructure development in the Interior are likely to have potentially enormous implications on Suriname's deforestation and forest

[8] The ´Encouraging Sectors´ are: Physical Infrastructure, Transport, Energy and Water, Knowledge, ICT and Education.
[9] The ´Priority Sectors´ are: Mining and Extractive Industry, Agrarian Sector and Agro-industry, Forestry and Related Industry, Export Industry (Food, Beverage and chemical products), Tourism and the Creative Industries.

	Suriname (SNC, 2013). Another emission source is asphalt paving, which releases non-methane Volatile Organic Compounds (SNC, 2013).	degradation. The Planning Office's 2017 Annual Plan aims to rehabilitate a number of road axes as per the Initiative for the Integration of the Regional Infrastructure of South America (IIRSA) (GOS 2016). Recent infrastructure developments in the Interior are expected to continue in the near future.
Energy	While the energy sector is the largest GHG emissions source (66% of total GHG emissions), electricity generation contribution is only 2% (SNC, 2013). Electricity is provided by hydropower and thermal power stations. Hydropower capacity is 189 MW, In 2016 it accounted for nearly 50 percent of all electricity generated in Suriname. Electricity in the interior is provided by diesel generators with a total capacity of 4.5 MW, but it is limited to around 30% of the population living in the interior (Elizalde et al., 2013).	Electricity demand is expected to increase and so will GHG emissions. Near future supply will be met by expanded thermal generation, solar power and hydropower usage. There are long term projections for hydropower expansion. The increase of electricity generation from hydropower from 93 MW to 157 MW will be possible (E. Fränkel, pers. comm., June 5 2014).
Housing	One of the main sources of emissions from domestic housing is electricity use, a subset of the 'energy sector' GHG emissions total. Domestic electricity subsidies limit interest in promoting energy efficiency.	While electricity demand is expected to increase in line with economic development, this may be countered to some extent by increased consumer awareness and green energy initiatives.
Mining	Within the mining sector, for decades the bauxite industry was the largest contributor to Suriname's overall GHG emissions, caused by the Bayer process (SNC, 2013). Suralco, the only bauxite company in Suriname, closed down in 2015 with its bauxite operations, operated on hydropower and thermal power and uses heavy fuel oil. It should be noted that 650 ha of mined-out bauxite areas have been re-vegetated, thus sequestering carbon, though trees have not yet reached maturity (SNC, 2013). Mining and quarrying of other products are also contributors of emissions.	It is government policy to continue expanding the mining industry and its contribution to GDP. As such, emissions will continue from this sector unless action is taken to mitigate them.
Agriculture, livestock and fisheries	The forest area covers 93% of the total land area of Suriname, establishing Suriname as a net sink country for GHG emissions with a total of 5770 Gg CO_2 eq sequestered. Reforestation of mined out bauxite areas and changes in unproductive agricultural land contribute	The SNC (2013) projects that emissions in the forestry sector will decrease from 832 Gg CO_2eq in 2008 to -1,433 Gg CO_2eq (net sequestration) in 2025 based on the projected balance of deforestation for construction of infrastructure, forest exploitation, wood processing, and forest and swamp protection.

	to carbon sequestration. Agriculture contributes 12% to total GHG emissions (SNC, 2013).	However, the SNC (2013) also projects that if historical trends continue and activities take place as planned, emissions from agriculture will increase from 953 Gg CO_2 eq in 2008 to 3,788 Gg CO_2 eq in 2025, an increase of 400%. The overall projection is thus one of net increase under this planning theme, in the absence of mitigation action.

(Adapted from the NCCPSAP and adjusted to current situation)

1.3.2 Process and results of sector selection

Within the framework of the UNFCCC and under the Paris Agreement, Suriname is working towards the protection of its forests with a coverage of 93% to contribute to global mitigation efforts. This is ensured by maintaining its status as a High Forest Cover and Low Deforestation country (HFLD) and taking pride in being a net-carbon sequestration country. The President of the Republic of Suriname highlighted this commitment through the statement made at the high-level segment of COP23 (Bonn, 2017).

> "I am very proud of the contribution we have made to environmental sustainability in Suriname, and under my stewardship, Suriname is committed to maintain its leadership position as one of the world's most carbon negative countries. I invite you to join our efforts to cap our forest cover at 93%. It is a commitment we make as a nation, meaning in fact an undertaking that will require science and technology, expertise, technical support, and above all, the necessary financial resources and the political will of the global community in a durable partnership." - President D. Bouterse

Box 1: Statement of Winston Lackin, Environment Ambassador for Suriname at COP 23, 2017[10]

However, without the correct interventions Suriname is at risk of losing the leadership position as one of the world's most carbon negative countries. Under the REDD+ project, in 2017 *the Background study for REDD+ in Suriname: Multi-perspective analysis of drivers of deforestation, forest degradation and barriers to REDD+ activities*[11] was conducted with the objective to identify crucial challenges and main points for improvement related to drivers of deforestation and forest degradation in Suriname, as well as to identify barriers for sustainable management of forests, conservation of forest carbon stocks and enhancement of forest carbon stocks. The DDFDB+ study stresses that the plans for infrastructure development in the interior are likely to have potentially enormous implications on Suriname's deforestation and

[10]https://unfccc.int/files/meetings/bonn_nov_2017/statements/application/pdf/suriname_cop23cmp13cma1-2_hls.pdf

[11] NIMOS, SBB and UNIQUE (2017). Background study for REDD+ in Suriname: Multi-perspective analysis of drivers of deforestation, forest degradation and barriers to REDD+ activities

forest degradation. There are a number of infrastructural development plans projected in the interior, for example:

- The Brownsweg-Pokigron Development Plan. This plan proposes the creation of a special development authority in charge with the infrastructure program for the Van Blommenstein storage lake and adjacent territories, involving ferry services and roads east and south of the lake to settlements at the shores of the Marowijne River and the Tapanahoni River.
- A signed loan agreement between the Government of Suriname with the Islamic Development Bank earmarks USD 300 million for road construction in the Interior
- Plans to rehabilitate a number of road axes as per the Initiative for the Integration of the Regional Infrastructure of South America (IIRSA) (GOS 2016).

The study also noted that there is no comprehensive or strategic regional development plan. The planned road infrastructure in the east, southeast and south Suriname are more or less based on decisions taken by independent stakeholders including the government, small scale gold miners and large scale corporations involved in gold exploitation, exploitation of bauxite and other natural resources.

The goal of the government is to preserve the HFLD status and to maintain its leadership position as one of the world's most carbon negative countries. The GoS therefore acknowledges the importance to preserve the biodiversity, but also to increase the contribution of the forests to the economy and welfare for this generation and future generations. This commitment to maintain the country's 93% forest cover will play a central role in the Nationally Determined Contribution (NDC), as the GoS is currently in the process of enhancing its (intended) NDC that was presented to the UNFCCC in 2015.

According to the NCCPSAP the ultimate climate change objective for the housing sector is as follows: ´Existing and new build housing is retrofitted, designed and/or built to be climate resilient and takes advantage of potential future green growth opportunities such as feed-in tariffs.´

Three outcomes are set to reach the objective:

- Improved knowledge of climate change impacts on housing provides the evidence base for informed decision making.
- Increased resilience and energy efficiency of new housing from effective zoning and development control.
- Increased resilience and energy efficiency from new building design.

The GoS is aiming for sustainable and affordable housing for families in accommodating residential communities that contributes in many ways to their economic, social and cultural development. In 2019 the Guarantee Fund Act and the Housing Fund Act have been passed by The National Assembly and approved. In addition to the government's own efforts to find solutions to the housing shortage, the Government also supports private initiatives.

The Affordable Housing Program (AHP) has a term of five years, which will run until the end of 2023. The available resources of this program will be used to provide national subsidies to lower income groups for building, expansion or renovation of more than 4.000 homes. Furthermore implementation will be given to the Low Middle Income Shelter Program (LMISP), a business housing finance program (self-build) based on a annual non-commercial mortgage interest of 6% for families who have a new home and want to build or renovate an existing home. Additionally, the agreement "Agreement for Implementing the China-Aided Low-Cost Housing Project in Suriname with the People's Republic of China in May 2017, will also give shape to the housing program. This is a donation to the Surinamese community. In total, work will be done on the construction of 1000 homes with the delivery of 350 turnkey homes in the first phase.[12]

Against this background, the GoS is fully aware that all these houses will ultimately lead to an increase in GHG emissions. Studies[13] show that demand growth is strong and mainly driven by increasing and new residential loads. Electricity production will have to meet the demand for energy and the energy supply should remain accessible and affordable. Households in the coastal area consume an average of 9 kWh per day at heavily subsidized electricity rates of US$ 0.07 to US$ 0.15 per kWh. This puts Suriname electricity consumers on the highest access level (Tier 5) of the SE4All multi-tier framework [14] when assessed by consumption / daily capacity. With current subsidized electricity rates, costumers are not encouraged to reduce their energy-consumption. In fact, subsidies create a hindrance in implementing Energy Efficient (EE) measures and are a heavy burden on government expenses.

In recent years the public and commercial sector have taken the initiative in improving energy efficiency, by adopting EE technologies such as LED lighting, fans, and remote refrigeration, however, the uptake of EE technologies, especially in the residential sector is lagging. Despite EE awareness campaigns from the government and the national Energy Company (EBS) the awareness level of EE is still low. The Government, with the support of the Caribbean Development Bank (CDB), is currently looking to develop an Energy Efficiency Framework (EEF) to further promote EE measures and awareness. This Framework is to be executed by the Electricity Company EBS in close coordination with the Ministry of Natural Resources (MNR).

Suriname has highlighted these efforts and plans in its Intended Nationally Determined Contribution (INDC) (GOS, 2015). A process is now ongoing to develop a Nationally Determined Contribution (NDC), where the abovementioned issues will be taken into account.

[12] http://dna.sr/media/268893/270919_JAARREDE_VD_PRESIDENT_DIENSTJAAR_2020.pdf, p.13

[13] SNC (2016) and the Energy Sector Plan, 2018

[14] See the ESMAP website for reference materials https://www.esmap.org/node/55526 .

Chapter 2 Institutional arrangement for the TNA and stakeholder involvement

2.1 National TNA team

The main government institution with the mandate to steer all environment related programs in Suriname is the Coordination Environment under the Office of the President (CM) established in 2015. CM has the main task of coordinating and providing oversight to all environment related programs in Suriname, and currently serves as the focal point for climate change matters. The CM works in close collaboration with NIMOS (National Institute for Environment and Development in Suriname, also within the Office of the President) in preparation and implementation of environment related programs.

The different institutions and governmental departments integrate climate change mitigation at project level. However, at national level there is no structural approach for mainstreaming climate change into daily operations. Issues related to climate change are addressed through Coordination Environment (CM) within the Cabinet of the President.

A systematic approach to address mitigation and/or adaption (e.g. in the development of infrastructure or spatial planning) would allow increasing Suriname's resilience and reducing adaptation costs in the long term.

The implementation of the TNA is coordinated by the TNA Coordinator supported by the Technical Liaison Officer. The TNA coordinator provides information about the TNA project on a regular basis and shares his views with CM. The main structure of the national institutional set up for TNA is shown below in figure 1. The roles and responsibilities of each group is described hereafter.

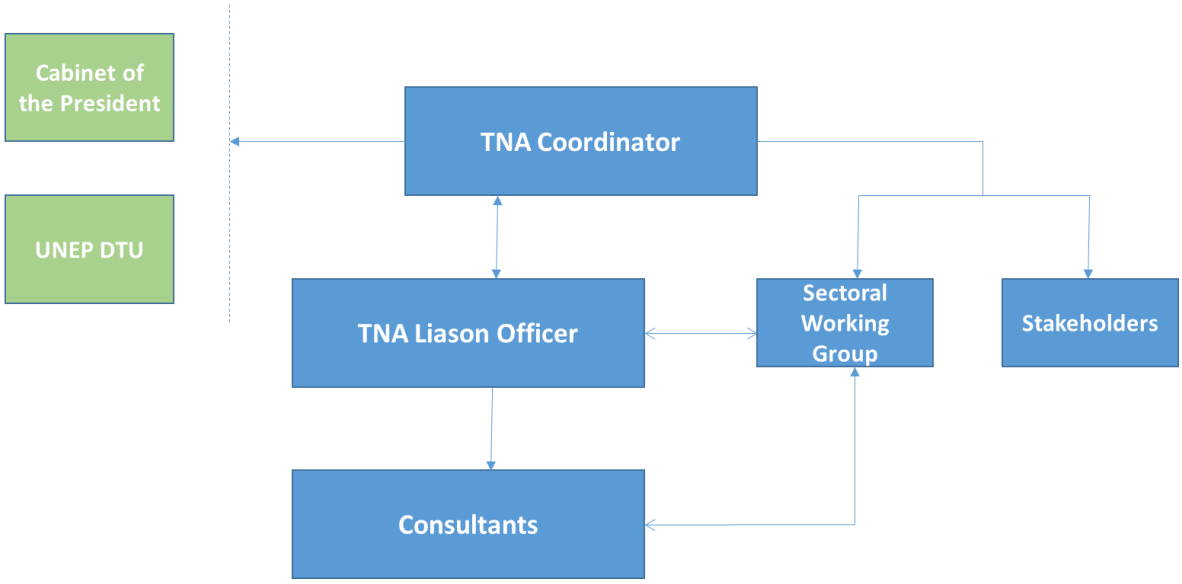


Figure 1: Structure of the TNA institutional set up.

TNA Coordinator

The structure consist of a national TNA coordinator who is the General Director of NIMOS and is supported by a Technical Liaison Officer also based at NIMOS. The national TNA coordinator is in charge of engaging stakeholders, providing the consultant with all relevant documents, reports, studies etc. of the selected sectors and is responsible for the day-to-day activities of the project. Initial review of draft and final reports is also performed by the TNA Coordinator.

Sectoral working groups

For the sector Infrastructure and Housing a sectoral working group (SWG) has been set up. The working group consist of representatives from the relevant ministries, NGO's, Public and Private sector, university and suppliers. The consultant interacts directly with the SWG and other stakeholders mostly through electronic mail and face-to-face meetings. The meetings are arranged on a needs basis and in particular, when the SWG is required to deliver specific outputs in the TNA process. Annex II gives a list of the stakeholders included in the SWG.

The Consultant

National Consultants (NCs) were recruited by NIMOS to undertake research, analysis and synthesis for technology transfer to strengthen climate resilience in Suriname. The NCs work in collaboration with the TNA Coordinator and the Technical Liaison Officer. The NC's overall task is to support the entire TNA process for the selected sectors ranging from identifying priority mitigation and adaptation technology needs, prioritization and assessment of technologies, to the development of a national TAP and setting the ground work for the formulation of concept notes for selected technologies.

2.2 Stakeholder Engagement Process followed in the TNA – Overall assessment

The TNA Coordinator hosted, on behalf of NIMOS, an Introduction meeting marking the TNA development process for all selected sectors. The purpose of this meeting was to introduce key stakeholders to the project, engage with them on the issues of climate impacts and low emission development in Suriname. The second meeting (a stakeholders Dialogue meeting) with a broad range of stakeholders took place later and the purpose of this meeting was to engage the stakeholders in the TNA process through a dialogue session about the climate change related problems occurring in selected sectors. In addition, a Sector Working Group (SWG) was established as an output of the Introduction meetings.

The Sector Working Group meetings were organized with the aim to select at least two to three technologies per sector from a number of technologies. The meeting also had the aim to understand and record the view of the stakeholders on ongoing works and projects, success criteria and best practices within both sectors. Figure 2 below shows the process of stakeholder meetings.

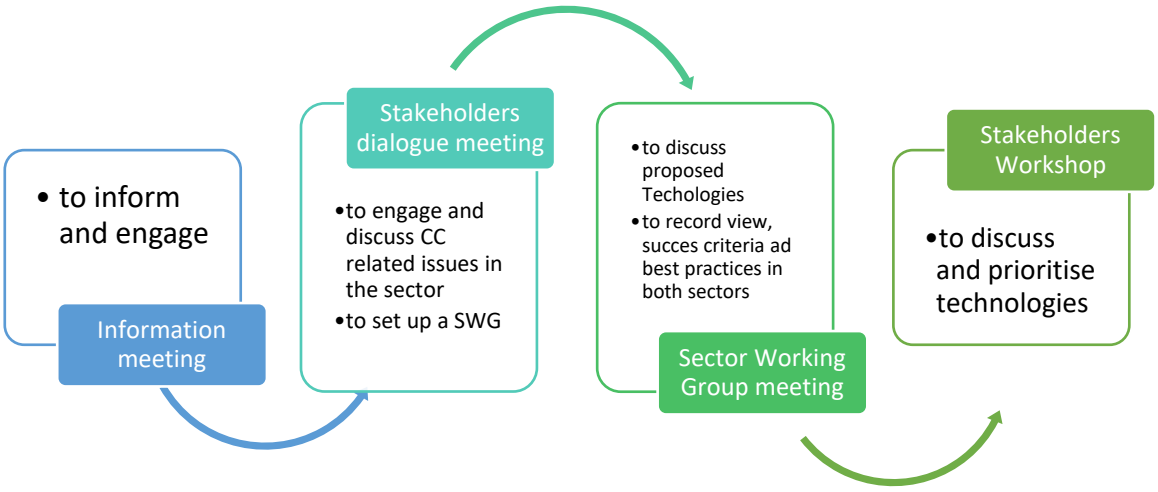


Figure 2: The process of stakeholder meetings

2.3 Consideration of Gender Aspects in the TNA process

Gender is a key determinant of social vulnerability and as such included in the sustainable development goals.

Gender participation in the TNA process

The National TNA team consists of two women and three men. The following pie charts give an overview of the gender participation in the TNA process with regards to the members of the Sector Working Group (SWG) within each sector and the participants of the Stakeholder Workshops (SWS) that were held.

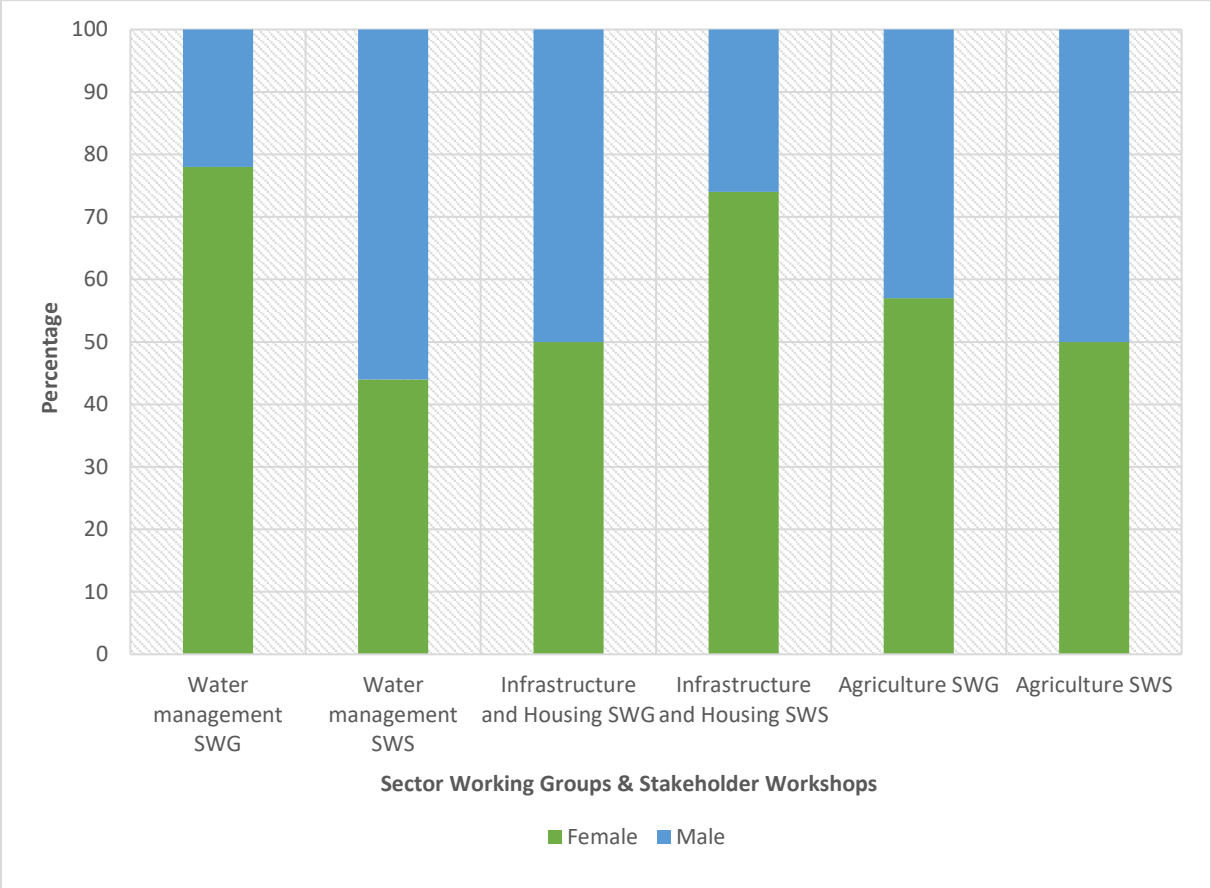


Figure 3: Gender participation in stakeholder meetings

Making sure that the gender balance is maintained is not always an easy task, because after sending an invitation to a stakeholder (institution, organization, company, business) the TNA coordinator cannot determine who participates in the meetings and who does not. It is also still a fact that in some areas of business, organization or government the majority of employees or officials can be male or female.

Gender policy in Suriname

In the past years, Suriname developed integral gender policy plans to work at promoting gender equality and equity and to meet international obligations. Among others, Suriname became party to CEDAW (Convention on the Elimination on All Forms of Discrimination against Women) in 1993. Bureau of Gender Affairs, which

resides under the Ministry of Home Affairs, coordinates and monitors gender affairs in Suriname. Activities conducted in relation to gender and climate change are:

- Gender Plan of Action 2019-2020[15] and the Gender Vision Policy Document 2021 – 2035 [16] that elaborate on Suriname's international and regional obligations to achieve gender equality and empowerment of women and girls.

One of the priority areas of the Gender Action Plan is climate change and environment. For example, activities under the Japan-Caribbean Climate Change Partnership project are projected in relation to the installation of solar panels (Pelelu Tepu, Curuni and Sipaliwini). Two women in the village will be trained in installing, repairing and maintaining solar panels. Villagers will also be trained in the importance of energy efficiency. Another projected activity is to better inform/educate the Community of Nickerie on the environment, biodiversity and climate change and the importance of preserving the swamplands.

- Enabling, Gender - Responsive Disaster Recovery, Climate and Environmental Resilience in the Caribbean EnGenDER project (2019-2023)[17]

  This project is implemented in Antigua and Barbuda, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, St. Vincent and the Grenadines and Suriname. The main objectives of this program are:

1. Advance the gender-responsive implementation of National Adaptation Plans (NAPs) and Nationally Appropriate Mitigation Actions (NAMAs) at the sector-level according to national priorities.
2. Support representation of the needs and perspectives of the most vulnerable populations in cross-sectoral, inclusive governance and national climate change planning.
3. Build government capacity for gender-responsive inter-sectoral access to climate finance, through innovative solutions.
4. Building on the work of other partner's work at the national level to assist countries develop/strengthen gender- responsive and inclusive national recovery mechanisms and plans. From 2019-2023

To achieve the ultimate outcome of the project, which is improved climate resilience for women and girls and key vulnerable populations and future generations in the Caribbean, the work will be done jointly with the other responsible organizations for climate change, environment and disaster recovery as well as with dedicated support from UNDP Suriname.

[15] http://homeaffairs.gov.sr/media/1061/3-juli-nederlandse-printversie-genderactieplan-2019-2020-1.pdf
[16] http://homeaffairs.gov.sr/media/1058/3-juli-engelse-printversie-gender-vision-policy-document-2021-2035-1.pdf
[17] Coordinator of Bureau Gender Affairs, Sharon Saridjan-Tjokro, interview 24 February 2020

Chapter 3 Technology prioritization for the Water management Sector

3.1 GHG emissions/cc vulnerabilities and existing technologies of the Water management Sector

3.1.1 Vulnerabilities within the water sector

Water is a primary and essential natural resource for supporting life on earth. Although Suriname has large stocks of freshwater resources and is fortunate to have a lot of rainfall (with some seasonal and regional differences), water-related problems occur regularly and the residents of Suriname have the same problems every year[18]:

- Lack of access to safe and available drinking water in many regions in the country.
- In the rural area flooding of agricultural land due to excessive rainfall and/or high sea water levels causes losses of harvest and damage to public space, houses, transportation means; flooding occurs every year, more or less severe, depending on the location.
- Droughts in agricultural areas lead to loss of harvest, especially since irrigation is not present
- Flooding of urban areas due to excessive rainfall and/or high sea water levels causes damage to public space, buildings transportation means. Some streets are flooded during every big rainfall event. Urban flooding increases the risk of waterborne diseases.
- In the interior high river levels cause flooding of villages.
- Droughts in the interior lead to limited availability of good quality water for domestic/drinking water use.

Furthermore, the quality of water in Suriname is threatened by:

- Inadequate waste disposal which compromises surface and groundwater.
- Inadequate waste water management: there are no wastewater treatment plants, and most of the septic tanks are not working properly, resulting in pollution of water resources.
- In the interior of Suriname most wastewater is discharged directly into rivers and creeks.
- Very few industries have some kind of wastewater treatment, most of the industrial waste water is discharged directly in surface water.
- Small scale (illegal) gold mining in the interior causes several water quality problems, especially use of mercury is a big problem, polluting the rivers and fish and making the surface water unsuitable for drinking and fishing.
- Increased use of pesticides in the agricultural sector (but also within household and government) has serious health effects on people and other organisms.

[18] Capacity Building for Integrated Water Resource Management in Suriname", Water forum Suriname, July 2019

In the near future, climate change may worsen these water-related problems. Sea level rise threatens the low-lying areas of the coastal region and enhances salt intrusion. Decreases in rainfall lead to a further decrease in the availability of fresh water for drinking purposes. Lower rainfall combined with rising temperatures lead to less availability of irrigation water for agriculture and food production.

To illustrate the trend in annual rainfall and annual mean temperature please see the two graphs below of a meteorological station in Paramaribo[19]:

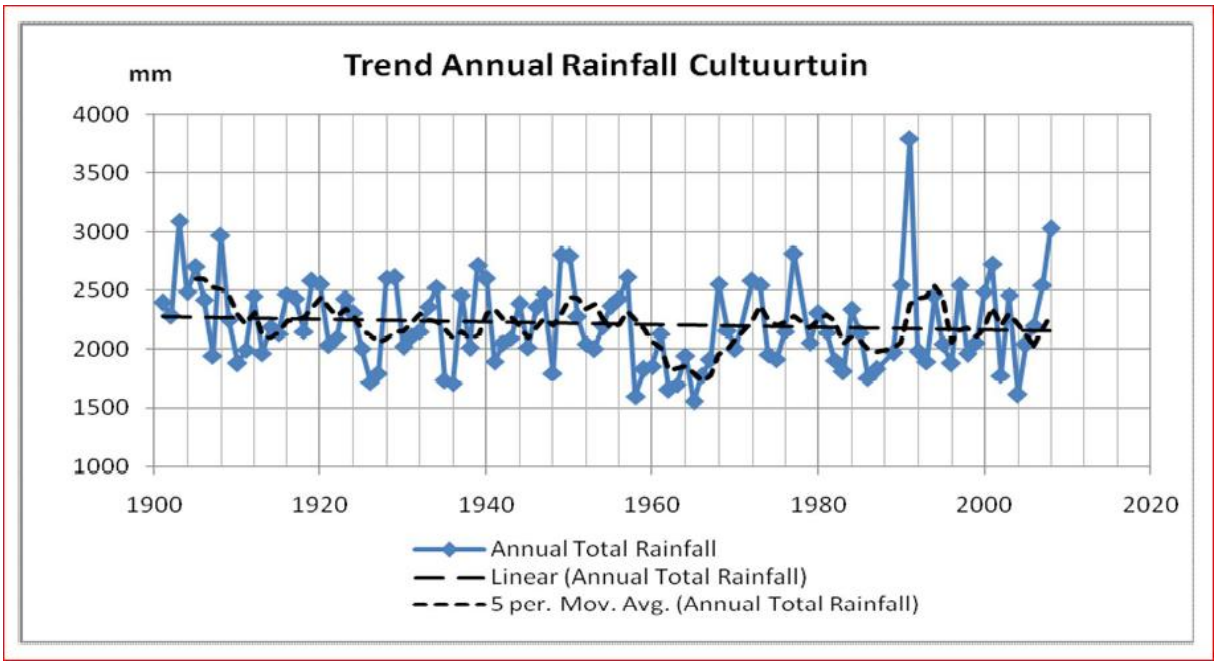
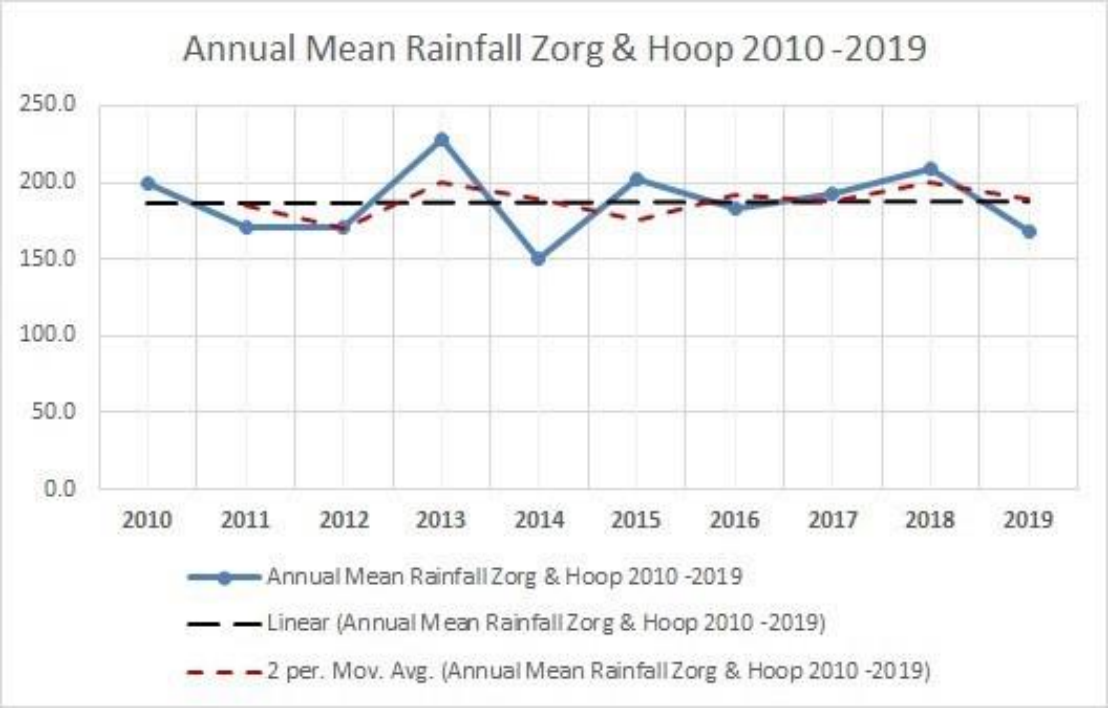


Figure 4: Trend Annual Rainfall

[19] *Source: Amatali, M.A. 2013. Technical Paper Present Profile, Second National Communication on Climate Change Suriname, Sector Water Resources. Ministry of Labor, Technological Development and Environment Suriname, Paramaribo. 106 pp*



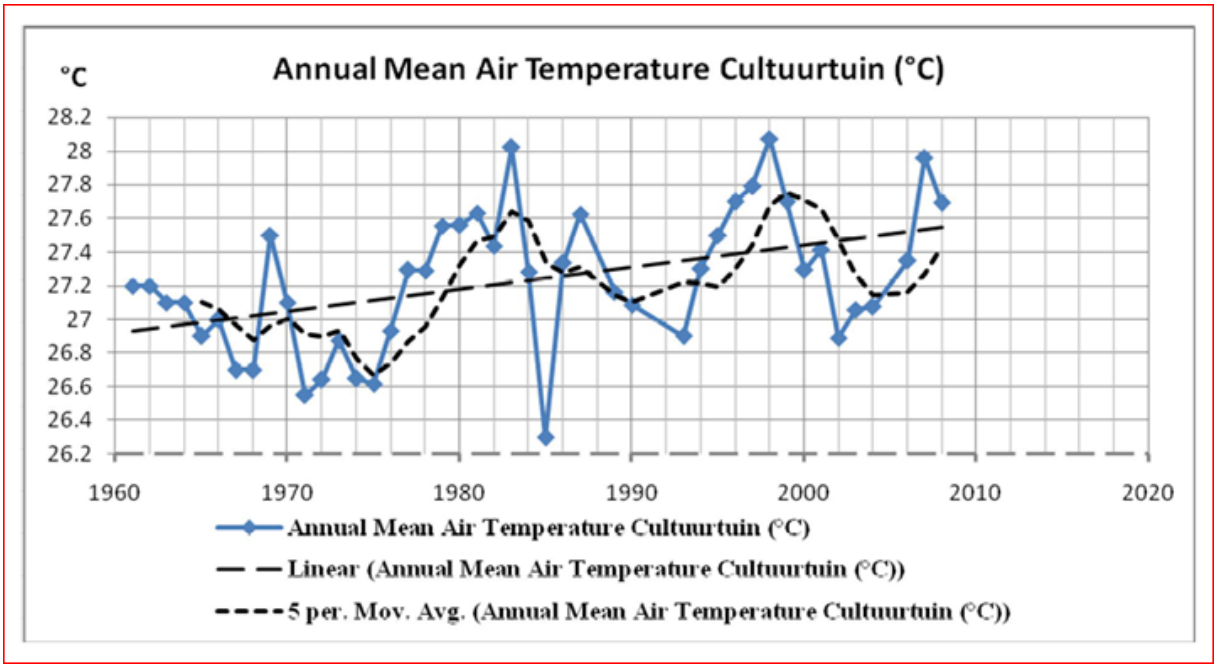
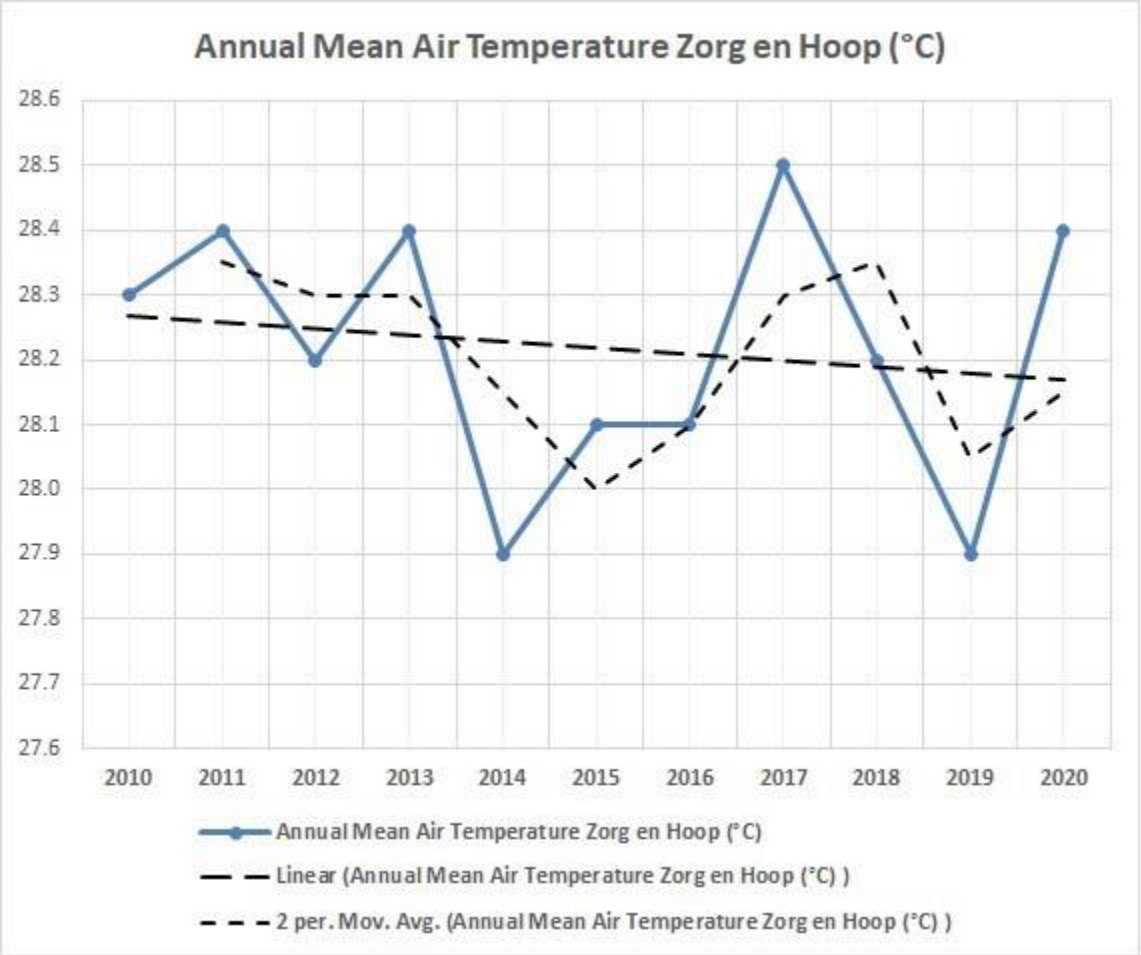


Figure 5: Annual Mean Air Temperature



3.2 Decision context

All the water-related problems, mentioned in the former section, will lead to limited access to drinking water for everyone, and to serious threats to public health and ecosystems. More so these water-related problems result in significant financial and economic losses, notably direct costs because of flood damages in urban and rural areas, losses in agricultural production because of droughts, as well as indirect costs such as increased costs for water transport, water purification, health issues etc. These costs are likely to increase in the near future if unchecked[20].

Generally, hydrological data and technical capacity is limited. Various measures can – and should – be taken to improve the situation. For example, measures directed at reduction of the probability and impacts of flooding, prevention and reduction of losses in agriculture as a result of droughts, safeguarding the quality and quantity of groundwater resources, guaranteeing safe drinking water for all, etc.

However, as experience demonstrates these measures do not happen by themselves, but require a concerted and coordinated effort and commitment from various parties.

There is also lack of an integrated water management system. Several governmental agencies and institutions are involved in the protection and monitoring of water

[20] Capacity Building for Integrated Water Resource Management in Suriname", Water forum Suriname, July 2019

resources, without clearly defined roles, leading to fragmentation, sometimes duplication of efforts, and inefficiency in the water sector. Capacity of institutions is limited, in particular with respect to knowledge and capabilities of personnel[21].

There is a significant need for more knowledge to support water management actions, however structural data and information sharing arrangements are very limited. The Suriname Water Resources Information System[22] is rarely used by the stakeholders. Public awareness of and political attention for water related problems are low. There is insufficient budget for investments and recurrent costs, which lead to downsizing of recurrent activities.

The technologies for the water sector are mainly motivated by current and future risks with regard to water availability, but also manageability (drought and floods) and the need for adaptation measures for water users.

3.3 Possible adaptation/mitigation technology options in the Water Management sector

This section provides an overview of the pre-identified main existing technologies for the water sector.

3.3.1 Identification of potential technologies

The first preparations of the long list of potential technologies for the water sector related to climate change were done by the consultant team. A number of subareas of the water sector were pre-identified, that could serve as a guide to identify possible water technologies in each of these areas. The list below is not in particular order of importance, nor is it exhaustive of all aspects of the water sector, however, it covers the main aspects:

- Drinking water
- Rain water
- Surface water
- Flooding
- Agriculture & Irrigation
- Waste water
- Meteorology
- Water & Energy
- Water data

[21] "Situational Analysis on IWRM in Suriname", R. Rusticus et al, May 2019

[22] SWRIS is digital platform to exchange national data on water. Several national water institutions participate in this platform. It is managed by the Department of Infrastructure of the University of Suriname.

- Water Management Systems

3.4 Criteria and process of technology prioritization for the water management sector

3.4.1 Working group session on identification of technologies

The first session of the Sector Working Group for the Water Management Sector was held on September 26, 2019. The main purpose of this session was to brainstorm on the possible technologies for the water sector, and to obtain feedback on, among others: the link with climate change; the state of technologies currently being used; the relevance of a suggested technology; and the ease of implementation of a new technology.

The session started with a presentation by the consultant team about the current and future challenges the water sector of Suriname is facing. The main conclusions of the current situation in the water sector are:

- While Suriname enjoys an abundance of water, water related problems occur regularly.
- Lack of drinking water in some regions of the country, flooding during heavy rainfall, and shortages of irrigation water in dry seasons are quite common.
- Water pollution, inadequate wastewater treatment, the use of pesticides in agricultural areas and the use of mercury in the mining sector in the interior, challenge the quality of water resources.
- Climate change effects, such as changing precipitation patterns and rising sea levels, increase the urgency to act.

It was agreed by the members of the Working Group that an integrated approach for these water problems is required. Integrated Water Resource Management (IWRM) provides a solid overall framework for this integrated approach.

After the presentation the Working Group was engaged in a discussion about the currently available information on our water resources and how the impact of climate change on these resources could be measured. One of the limitations is the fact that there is no detailed information available on how much water there actually is in the country, making it difficult to assess the impact of climate change on the water resources.

It was mentioned that climate change is a slow process, but the dangers are already very close around us, even though we do not realize this enough. With available radar models the Meteorological Services publishes its forecasts every two weeks, so it is known how much rainfall there will be in the coming period. However, not many people use this data. Early warning systems for droughts and flooding need to be developed.

Another recommendation was to include water resource mapping technologies, to be able to know precisely how much water is available in the country. It was suggested that a model should be developed to measure the effect of climate change on water resources; this hydro model could serve as an early warning system.

The effect of sea level rising on the drinking water supply in the coastal zone was also discussed. Sea level rising will accelerate salt water intrusion, and the existing fresh water wells may become useless in the future.

Water use efficiency, water savings technologies and water re-use models were also mentioned. In Suriname the focus is not so much on water savings, since there is the feeling that there exist more than enough available water. Still the introduction of water saving technologies should be considered, because Suriname may face the effects of climate change on its water resources earlier than expected. Rainwater harvesting for domestic use could be a solution for the villages in the interior without proper drinking water. Surface water harvesting could be an option for the agricultural sector.

Calls were made to pay also attention to water quality. Due to climate change, water resources could become faster contaminated by inorganic and microbiological substances, increasing the risk for water related diseases and thus reducing the possibilities for human consumption. A national water quality monitoring system is considered very important.

Important national plans and strategies in relation to climate change and water were listed by the Working Group: National Development Plan 2017-2021; National Climate Change Policy, Strategy and Action Plan for Suriname 2014-2021; Suriname Water Supply Master Plan; Drainage Plan for Suriname.

3.4.2 The long list of technologies

After discussing the several implications of climate change on the water resources, the Working Group made an inventory of possible technologies related to water. Below is the list of the suggested technologies that came out of the brainstorming session.

1. Water resource mapping
2. Climate modeling
3. Hydro modeling
4. Data collection and monitoring
5. Water safety plans
6. Water re-use models
7. Water saving technologies
8. Water storage
9. Drip irrigation
10. Land leveling of rice fields
11. Rain water harvesting for domestic use
12. Rain water harvesting for agriculture
13. Non-revenue water
14. Purification of surface water
15. Desalinization
16. Security of wells for water production
17. Sentinel organisms
18. National water quality monitoring system
19. Small scale hydropower plants
20. Large scale hydropower plants
21. Mangrove planting along coast

3.5 Criteria & process of technology prioritization for the Water sector

This section of the report presents an overview of the technology options identified and prioritized through the TNA process for the water sector.

3.5.1 Scoring of technologies on the long list

To get from the long list of identified technologies to a short list a pre-screening scoring system was applied. The pre-screening criteria for short listing the technologies were:

- Technical potential of the technology
- Benefits of the technology on climate change adaptation and/or mitigation
- Synergy with national strategies and policies

In accordance with these criteria, scores were applied to each of the 21 technologies on the long list, ranging from 1 (not applicable) to 5 (fully applicable). Where there was overlap technologies were clustered. The results of the scoring is given in table 2 below.

Table 2: Long list of water technologies

Scoring of water technologies on long list						
No	**Proposed technology**	**Technical potential of the technology**	**Benefits of the technology on climate change adaptation/ mitigation**	**Synergy with national strategies and policies**	**Total score**	**Cluster**
1	Water resource mapping (ground -, surface -, subsurface water)	5	5	5	15	Water monitoring
2	Climate modeling (Seasonal-forecasting)	5	5	5	15	Early warning systems
3	Hydro modeling	5	5	5	15	Early warning systems
4	Data collection and monitoring (Automation of weather stations)	5	5	5	15	Early warning systems
5	Water Security Plan (safety)	2	5	5	12	Early warning systems
6	Water re-use models (a.o. grey-water)	3	3	2	8	Water use efficiency
7A	Water saving technologies (High efficiency irrigations)	4	4	2	10	Water use efficiency
7B	Water Saving technologies (Domestic)	4	4	2	10	Water use efficiency
8	Water Storage (reservoirs Natural + Structures)	4	4	2	10	Water use efficiency
9	Drip irrigation	3	3	2	8	Water use efficiency
10	Land leveling of rice fields	4	4	2	10	Water use efficiency
11	Rainwater for domestic use (inner land)	4	3	2	9	Water harvesting
12	Rainwater for agriculture	5	5	2	12	Water harvesting

13	Non-Revenue Water (Reduce leakage in distribution systems)	5	2	2	9	Drinkwater management
14	Purification of surface water (alternative drink water production)	5	3	4	12	Drinkwater management
15	Desalinization	5	3	1	9	Drinkwater management
16	Security of water wells for water production	3	3	3	9	Drinkwater management
17	Sentinel organisms (monitoring/Lab)	2	2	1	5	Water Quality & Health
18	National water quality monitoring System	4	3	2	9	Water Quality
19	Small scale hydropower plants	4	3	2	9	Hydro Energy
20	Large scale hydropower	4	3	2	9	Hydro Energy
21	Mangrove planting along coast	4	4	1	9	Coastal zones

3.5.2 The short list of technologies

Based on the scoring of the long list of technologies, four technologies with the highest scores were selected for the short list (table 3).

Table 3: Short list of water technologies

Short list of water technologies						
No	**Proposed technology**	**Technical potential of the technology**	**Benefits of the technology on climate change adaptation/ mitigation**	**Synergy with national strategies and policies**	**Total score**	**Technology name**
1	Water resource mapping (ground -, surface -, subsurface water)	5	5	5	15	**Water resource mapping**
2	Climate modeling (Seasonal-forecasting)	5	5	5	15	**Water modeling**
	Hydro modeling	5	5	5	15	
	Data collection and monitoring	5	5	5	15	
	Water Safety Plan	2	5	5	12	
3	Rainwater for agriculture	5	5	2	12	**Rainwater & surface water harvesting and storage**
4	Purification of surface water (alternative drink water production)	5	3	4	12	**Purification of surface water**

These four shortlisted technologies were jointly reviewed and thoroughly discussed by the consultant team, the TNA liaison officer, the members of the Working Group Water and a broad range of stakeholders. The next paragraphs present the procedures and results of these reviews and discussions.

3.5.3 Review of the short list by the Working Group

To review the short list of water technologies the Working Group Water was called for its second session on October 3, 2019. The session started with an evaluation of the first brainstorming session of September 26, 2019, during which the possible technologies were identified and the long list of technologies was established.

The consultant team presented the pre-screening criteria to come from the long list to the short list, namely: (i) the technical potential of the technology; (ii) the benefits of the technology on climate change adaptation and/or mitigation; and (iii) the synergy with national strategies and policies.

Prior to reviewing the short list, some general issues were discussed by the members of the Working Group, among others: whether hydropower has a positive net balance on greenhouse gases; the importance of capacity building and human resources; monitoring of groundwater levels; water safety plan; water risk management; resource mapping via satellite and remote sensing.

After the general discussions the consultant team presented the scoring system to come from the short list to the list of prioritized technologies in the water sector. The scoring system includes: the Multi Criteria Analysis, the weighting of the scores, and the sensitivity analysis.

After thorough step-by-step applying of these scoring system there was broad approval among the members of the Working Group on the scores and the resulting list of prioritized technologies.

The scoring system and the resulting prioritized technologies are discussed in the next chapters.

3.5.4 Factsheets of the shortlisted technologies

Prior to the Stakeholders Workshop four factsheets were prepared by the consultant team to guide the insights on the four short listed technologies. The factsheets provide the following information about each technology:

- Short description of the technologies
- Objective
- Beneficiaries
- Ease of implementation
- Coherence with national policies, strategies and plans
- Institutional aspects
- Social benefits
- Economic benefits
- Environmental benefits
- Cost
- Time frame

This information in the factsheets is considered helpful for the reader to get a better understanding of the technology, allowing for a better assessment of the scoring and the priority of the technology.

3.5.5 Review of technologies by the Stakeholders Workshop

On October 11, 2019 a Stakeholders Workshop was held. The main goal of this workshop was to obtain feedback from a broad range of water stakeholders on the identified technologies and on the results of the various scoring procedures. Participants of the Stakeholders Workshop were: Environmental Section of the Cabinet of the President; Meteorological Services; Hydraulic Division of the Ministry of Public Works; Ministry of Natural Resources, Ministry of Agriculture, Animal Husbandry and Fisheries; Ministry of Regional Development; Suriname Water Company; University of Suriname, etc.

The workshop started with an introduction by the national TNA coordinator, in which he explained the TNA project of Suriname. Thereafter the consultant team gave a review of why we need good water management in Suriname. Climate change effects increase the urgency to act to solve our water related problems. The consultant team zoomed in on different existing climate change adaptation technologies for water, and the technologies prioritized by other countries.

Next the consultant team presented the long list of identified technologies and explained the pre-screening criteria that were used to establish the short list of four technologies. These four technologies were assessed by the stakeholders. The factsheets were also reviewed, to have factual information about the technologies. After several rounds of discussions there was general consensus that these four technologies were viable water technologies for Suriname.

Following the approval of the technologies on the short list, the scoring system prioritize these technologies was reviewed: the Multi Criteria Analysis, the weighing of the scores, and the sensitivity analysis. During the review there were discussions about whether water harvesting and storage for agriculture should be on the short list of the water sector, since the agricultural sector has its own TNA. It was agreed that there is quite some overlap between the water sector and the agricultural sector, and that a joint meeting is advisable to review each other's outcomes. There were also remarks about whether water harvesting and storage was also applicable to rainwater harvesting for households in the interior. It was agreed that harvesting surface water for crop irrigation and harvesting rainwater for drinking purposes were different techniques. There were suggestions whether water modeling and water resource mapping could be clustered as one technology. After some discussions it was agreed that these were two different technologies. There was also a discussion if purification of surface water is a national priority, since there is only one large scale project of this nature in Suriname. It was agreed that surface water purification could be a potential alternative source of water for areas with lack of drinking water from deep freshwater wells.

In general there was consensus among the participants on the application of the scoring system, on the applied scores, and on the resulting prioritized list of technologies for the water sector.

The scoring system and the prioritized technologies are discussed in the next sections.

3.5.6 Multi-Criteria Analysis

The Multi Criteria Analysis (MCA) was applied to the short list of four water technologies. The different criteria were derived from the international TNA guidebook. A score of 0 means not applicable at all, a score of 100 means fully applicable. There is always some subjectivity in individual scoring, but to reduce that effect the applied scores were first discussed within the consultant team, and the score jointly agreed upon was noted. These scores were presented to first the Working Group and thereafter the stakeholders for their review and comments. The results of the MCA are presented in the table 4 below.

Table 4: Multi Criteria Analysis

		Short listed technologies			
		Water resource mapping	**Water modeling**	**Rainwater & surface water harvesting and storage**	**Purification of surface water**
	Criteria				
A	Minimize cost of set up	75	75	35	30
B	Minimize cost of maintenance and implementation	70	70	50	30
C	Coherence with national adaptation plans and development goals	90	90	75	80
D	Ease of implementation	70	70	50	40
E	Protect biodiversity	90	75	70	50
F	Protect environmental resources	90	70	60	50
G	Support ecosystem services	90	70	60	50

H	Reduce poverty	50	60	60	60
I	Improve health	50	60	50	75
J	Encourage private investments	60	60	60	50
K	Improve economic performance	60	80	70	50
L	Create jobs	50	75	70	50
M	Reduce greenhouse gas	30	30	30	30
N	Reduce vulnerability and build climate resilience	90	90	80	80
O	Rapid rate of technology diffusion	80	80	70	50
P	Efficiency of technology compared to other alternatives	90	90	60	50
	Total	**1135**	**1145**	**950**	**825**
	Mean	**70.94**	**71.56**	**59.38**	**51.56**

Based on the Multi Criteria Analysis the ranking among the four technologies on the short list is as follows (highest scores ranked highest):

1. Water modeling
2. Water resource mapping
3. Water storage and harvesting
4. Water purification

3.5.7 Weighted scores

In addition to the Multi Criteria Analysis the weighted score system was applied to the four shortlisted technologies. The weighted score system takes into account: cost benefits; institutional and political benefits; environmental benefits; social benefits; economic benefits; climate benefits; and technological benefits. A weight percentage has been assigned to each of these criteria, in which the total of the weights must equal 100%. The weights were first discussed in the consultant team. Then the weights were presented to the Working Group and the stakeholders for their feedback.

After setting the weights the scoring of the technology took place. The higher the score the greater the beneficial contribution of that technology. The results of the weighted scores system is presented in table 5 below.

Table 5: Weighted scores

			Technology			
			Water resource mapping	**Water modelling**	**Rainwater & surface water harvesting and storage**	**Purification of surface water**
	Mean of criteria	**Weight (%)**	**70.94**	**71.56**	**59.38**	**51.56**
1	Cost benefits	10	6	8	6	4
2	Institutional and political benefits	10	7	7	6	6
3	Environmental benefits	15	8	7	6	6
4	Social benefits	15	6	8	6	8
5	Economic benefits	15	8	8	8	7
6	Climate benefits	20	9	8	6	6
7	Technological benefits	15	8	8	7	7
	Score	**100**	**53.91**	**55.46**	**38.30**	**33.00**

Based on the weighted score system the ranking among the four technologies on the short list remains identical compared to the MCA scores:

1. Water modeling
2. Water resource mapping
3. Water storage and harvesting
4. Water purification

3.6 List of prioritized technologies

After applying both the Multi Criteria Analysis and the weighted score system the final ranking of the four technologies on the short list is as follows:

Table 6: Prioritized technologies for the water sector

List of prioritized technologies	MCA SCORE	WEIGHT SCORE
1. Water modeling Purpose: to develop and implement an Early Warning System based on climate forecasting and hydro modeling to be able to predict seasonal periods of flooding and/or severe droughts.	71.56	55.46
2. Water resource mapping Purpose: to assess the quantity and quality of available water resources, including groundwater, surface water and subsurface water, to observe trends and to support long term planning and strategy development in relation to climate change	70.94	53.91
3. Rainwater & surface water harvesting and storage Purpose: to create natural and artificial reservoirs to harvest and store excess rainwater to be able to use in periods of water shortages in the agricultural sector.	59.38	38.30
4. Purification of surface water Purpose: to use surface water as an alternative source for drinking water production in areas where deep and shallow water wells are drying up and/or are becoming saline.	51.56	33.00

3.6.1 Sensitivity analysis

The sensitivity analysis was carried out after the prioritization of technologies to determine whether the ranking order would be amended for small changes in the scoring system. Four different scenarios with changing weights for the several criteria of the weighted score system were worked out. The scenarios are the following:

Scenario 1: Equal weight (all criteria are equally important).
Scenario 2: Political influence is relatively high and considering climate change is high as well.
Scenario 3: Political influence is relatively high and considering climate change and environment is only limited.
Scenario 4: Engineering influence, with relative high attention to technological benefits, and relative less weight for institutional and political benefits.

Table 7 gives an overview of the original weights compared to the weights of the four different scenarios.

Table 7: Weight comparing of scenarios

		Original weight	Scenario 1	Scenario 2	Scenario 3	Scenario 4
No	**Mean of criteria**					
1	Cost benefits	10	12.28	20	20	20
2	Institutional and political benefits	10	12.28	20	20	10
3	Environmental benefit	15	12.28	10	10	10
4	Social benefits	15	12.28	10	10	10
5	Economic benefits	15	12.28	10	15	20
6	Climate benefits	20	12.28	20	10	10
7	Technological benefits	15	12.28	10	15	20
	Total	100	100	100	100	100

After applying these different scenarios of the sensitivity analysis the end scores are presented in table 8.

Table 8: Sensitivity analysis

	Original end score	Scenario 1 end score	Scenario 2 end score	Scenario 3 end score	Scenario 4 end score
Technology					
Water modeling	55.46	55.21	55.10	55.10	55.82
Water resources mapping	53.91	52.70	52.49	51.78	52.49
Rainwater & surface water harvesting and storage	38.30	38.17	37.41	38.30	38.19
Purification of surface water	33.00	32.41	30.94	31.45	31.37

The ranking order among these four technologies is not changing in none of the scenarios with changed weights. Therefore, it is safe to say that the order of prioritized technologies stands as is.

3.7 Results of technology prioritization for the water management sector

The final outcome of the rigorous scoring system, including the pre-screening, the Multi Criteria Analysis, the weighing of the scores and the sensitivity analysis, is thus as follows:

1. Water modeling
2. Water resource mapping
3. Water storage and harvesting
4. Water purification

Since the number of prioritized technologies should allow for efficient further analysis of the next steps of the TNA process the final list of prioritized technologies is as follows:

Box 1: three selected priority technologies for water management

1. **Water modeling**
2. **Water resource mapping**
3. **Water storage and harvesting**

There was a general consensus among members of the workgroup with this final outcome of the MCA prioritization of technologies for the water sector.

Chapter 4 Technology prioritization for the Agriculture Sector

4.1 Vulnerability and existing technologies of the agricultural sector

4.1.1 Overview of the agricultural sector

Suriname extends over 164,000 square kilometers on the northeast coast of South America, 1.5 million ha, most of it located in the coastal area, have potential for agriculture. About 64,000 ha are currently used for crop production, animal husbandry and aquaculture. Its climate is generally controlled by twice-a-year passage of the Inter –Tropical Convergence Zone (ITCZ) over the country; once during the period December to February (known as the short wet season), and the second, during May – mid August (long wet season). The periods in between are the short dry season (February to the end of April) and the long dry season (middle of August to the beginning of December).

Extreme weather conditions often occur when these coincide with the El Niño and the La Niña events. A positive trend has been presumed in general between the extreme droughts conditions in Suriname and the strong El Niño events at one hand, whilst at the other, extreme wet conditions with strong La Niña events. Extreme weather conditions are also observed during the heavy rains events, when wind speeds up to 30m/s are observed, comparable with stormy conditions and accompanied by significant damages if occurring in the urban areas. Suriname lies outside the hurricane zone so the most extreme weather conditions are unexpected heavy rains or longer dry periods than expected. Occasionally small tornados cause some damage to houses and agricultural crops.

Smallholder agriculture play a key role in agriculture in Suriname. Most agricultural activity in Suriname outside the Nickerie district is focused in small family-run farms, ranging from an area of a few hundred m^2 to 2-3 ha. This type of agriculture in most cases can be qualified as a secondary occupation (most of the small farmers are part time farmers). The cultivated areas are diverse and include field crops, vegetables, various types of orchards and pasture land. During the last agricultural census held in Suriname in 2008 the total number of farms counted was 10,234. Of these 10,188 were qualified as small farms run by a single family. Of these small farms 40% can be qualified as subsistence farms while the rest focus mainly on commercial production.

In general, the small farms in Suriname can be characterized by lack of specialization, low specific knowledge, poor technology, low capital investment level, uncertain production (level) and low productivity. One can conclude that the private agriculture entrepreneur is weak, not well organized, lags behind international development and

cannot optimally make use of the development and investment opportunities in the sector.

There are still many constraints to the development of small and medium scaled agriculture businesses among which;

- gaps in what farmers professionally ought to know and their actual specific and practical knowledge and experience, the gap in affordable and specialized starting and (re)financing facilities in agriculture and the easiness to make use of these funds.

The main constraints of the agro sector were analyzed to be:

- low productivity of land, capital and labor and a weakly developed private sector
- low organization level and, excluding paddy and broiler chicken production, a traditional and low technological production approach
- diminished institutional support which needs a paradigm shift, strengthening and restructuring
- poor financing facilities, which are underdeveloped and not goal-specific organized
- lack of (detailed) knowledge of agricultural development in the rest of the world. This is also the case in all sub sectors on farm level.

The sector in general is analyzed as being inefficient, to produce with relatively high costs, has a lack of innovation and there is insufficient cooperation between and within the production chains and the sub-sectors. The policy implemented over the years has not been directed enough to ensure sustainable long-term improvements and output growth which meant that the effectiveness of the policy was rather low.

With the exception of rice, crops in Suriname are mainly rain fed. About 25% of all farms in Suriname do irrigate their crops. Most of the farms which irrigate their crops are rice producing farms. Only a small percentage of the vegetable and fruit producers irrigate their crops

4.1.2 Overview of climate change vulnerabilities in the agricultural sector

A team of local experts in climate change, that are part of the SWG, has produced a list of the expected impacts for Suriname as part of the work done to produce the Second National Communication report regarding climate change.

The following six most important vulnerabilities were listed for Suriname:

1. Breaching of dams and dikes / damage to water defense infrastructure due to the rising sea levels;
2. Increase in frequency and depth of flooding;
3. Decrease of fresh water availability;
4. Decrease of draining potential, particular valid for the urban areas situated in the coastal zone;
5. Decrease of productive land due to salinization promoted by sea level rise;

6. Increase of heavy rain events with bursts of strong localized rotating wind.

In this respect, Suriname is vulnerable to threats resulting from sea level rise and changes in the rainfall pattern.

Agriculture crops in the coastal zone as well in the Interior are sensitive to these events. Prolonged drought, which is often triggered by the presence of a strong El Niño, has negative impacts on the various crop harvests on the shifting cultivation grounds in the Interior, while in the coastal zone prolonged drought promotes penetration of the salt wedge further upstream the rivers, thereby decreasing the availability of freshwater to the agriculture lands in this zone.

On sub-sector level the different constraints on agriculture growth and development becomes manifested in the following:

- Sea level rise will have a negative impact on wetland rice production which takes place in the young coastal area. A significant part of the low laying geologically young coastal plain is expected to be inundated if sea level rises. Freshwater availability for irrigation of rice can become a problem in certain areas in the case of unexpected long dry periods
- Since agricultural activities are mainly concentrated in the coastal zone there is a threat from salt water incursions through inundation and intrusions
- In many regions where vegetable and fruit production take place and where cattle production takes place drainage is not optimal or poor.
- Most of the vegetable producers do not irrigate their crops and if they do irrigate their crops the irrigation system in use is not very efficient
- Controlled environment horticulture is practiced on a very small scale

Regarding livestock production the following vulnerabilities are identified.

- Lack of forage at the end of the dry season and in the case of unexpected longer droughts
- Flooding of pastures in the case of intense rains
- Drop in productivity of dairy and beef cattle if environmental temperature increases
- Drop in productivity of poultry and an increased mortality if environmental temperatures are high
- Drop in productivity of pigs if environmental temperatures are high

4.2 Decision context

The focus of the TNA for the agricultural sector is to identify technologies which are suitable to adapt to the impacts of climate change.

Suriname has outlined climate resilience measures as part of the 2012-2016 National Development Plan and is currently undertaking projects and actions as a direct response to climate change[23].

[23] Ontwikkelingsplan 2012-2016, Suriname in transformation page 141-145 (2012)

In the Intended Nationally Determined Contribution (INDC) for Suriname regarding agriculture the following unconditional commitments were made:

- Promotion of sustainable land management
- Applying innovative technologies in the use of land

The Development Plan 2017-2021 describes the following intentions:

- Research, application of technology and services by efficient (knowledge) institutes;
- Competitive micro-, small, medium-sized and large companies in the agriculture sector;
- The agro-industry guarantees food safety and security of the Surinamese population;
- Export to regional and international markets;
- Employment in various subsectors.

The Agricultural Master Plan formulates the following goals:

- To enlarge the contribution of the agricultural sector to the national economy;
- Realizing and guaranteeing food security;
- Guaranteeing healthy agriculture and food safety;
- Developing a sustainable agricultural sector;
- Developing the agricultural sector to become the food producer and supplier for the Caribbean;
- Creating spatial conditions for developing a sustainable agricultural sector
- Managing the boundary conditions and risks whilst executing the agricultural policy.
- Intensive agriculture, concentrated in relatively few areas, which does no harm to environmental values.
- Guiding development to land which is already cultivated, or has been cultivated in the past and since abandoned, in order to avoid clearing natural growth in new areas

The National Climate Change Policy, Strategy and Action Plan for Suriname is focused on the following targets:

- Food security, safety and export is maintained and expanded in the context of a variable and changing climate.
- More efficient production systems are implemented, reducing energy consumption and incorporating the reuse of already exploited or abandoned fields.
- Opportunities are seized for the production of renewable energy in the agricultural sector, attracting climate finance.
- Sustainable land management in Suriname takes into account the impacts of a changing climate and the need for low carbon development.

4.3 An overview of possible adaptation technology options in the sector agriculture, their vulnerability reduction potential and other co-benefits

Based on the challenges faced by the agricultural sector with climate events over the past two decades and the vulnerability of the agricultural sector to predicted climate change, a long list of adaptation technologies was produced to improve the resilience of the agricultural sector and the livelihood of farmers. The technologies were identified through expert views and brainstorming with relevant stakeholders.

The identified technologies were regrouped under different categories. The classification of the identified adaptation technologies and their status are summarized in table 9 below

Table 9: Classification of the identified adaptation technologies and their status

Category	Adaptation technology	Status of the technology in Suriname
Water use and -management	Laser land leveling of rice fields	Technology not applied
	Improvement of irrigation infrastructure for wetland rice	Projects are in execution to improve the irrigation infrastructure
	Improved irrigation efficiency	very small scale applied
	Sprinkler and drip irrigation	very small scale applied
	Water harvesting	Small scale applied
	Alternate wetting and drying of rice fields	Technology not applied
Planning for climate change variability	Agrometeorological system for weather forecasting and early warning	Not applied yet
Sustainable crop management	Integrated crop management	Limited application
	Climate smart pest management	Limited application
	Development and / or use of climate resilient crop varieties	Very limited application
	Climate controlled greenhouses	Limited application until now, Growing interest
	Mulching	Limited application
	Raised bed culture	Limited application in certain areas Growing interest
	Crop diversification	Applied in the hinterland
	Crop rotation	Limited application
Sustainable livestock management	Use of climate resilient livestock breeds and / or crossbreeds	Limited application
	Climate controlled poultry houses	Limited application

	Climate smart feeding and feed utilization for livestock	Not applied yet
	Forage conservation for ruminants	Not applied yet
Sustainable farming systems	Agroforestry	Limited application
	Integrated farming systems	Not applied yet
	Climate smart landscaping	Limited application

4.4 Criteria and process of technology prioritization for the agricultural sector

The first version of the long list of adaptation technologies for the agricultural sector was produced by the agricultural consultant. The identified technologies were selected based on improvement of the resilience of the agro-ecosystems and the livelihood of farmers. These technologies were drawn from multiple sources and the national context. During two working group sessions the members of the sector working group contributed in the production of the final long list of technologies.

During the second working group session evaluation of the technologies from the long list based on the 3 pre-screening criteria was executed by the consultant and the sector working group members.

A preliminary short list of technologies based on pre-screening criteria was produced. The pre-screening criteria for short listing were:

- Technical potential of the technology
- How will the technology contribute to improvement of climate resilience; adaptation benefits
- Synergy with national development strategy and policy

For these 3 pre-screening criteria a score between 1 and 5 was assigned for each technology in the long list whereby score 5 was the highest level and score 1 the lowest level.

Reasons for non-selection of a technology were:

- Technology not considered as urgent priority
- Technology available locally
- National programs exist/ measures underway for strengthening
- Overlap with other technologies
- Technology has limited technical potential
- Technology did not satisfy TNA definition: hardware, software and orgware

It is worth mentioning that the work done by the sector working group was far from complete at the second working group session, where the compilation of the short list based on the 3 pre-screening criteria took place. It is important to work with a representative pool of experts and stakeholders during the selection process focused on the identification of the most suitable adaptation technologies.

For this reason, it was decided by the consultant, after alignment with the liaison officer and the TNA coordinator, to discuss the outcome of the shortlisting process with the stakeholders during the stakeholder's workshop.

4.5 Results of technology prioritization for the agricultural sector

During the stakeholder's meetings a few well substantiated proposals were made for adjustments in the short list of technologies. Based on these suggestions the final short list of technologies was compiled.

After long discussions the following technologies were selected for the final short list:

- Climate resilient crop varieties and livestock breeds
- water harvesting and improved irrigation efficiency
- climate controlled greenhouses and livestock facilities
- integrated farming systems
- agro-meteorological system for weather forecasting and early warning

The main adjustments made to produce the final short list were:

- merging of technologies
- substitution of climate smart landscaping by integrated farming systems

Out of the 5 technologies listed in the short list, three technologies were selected for the final list of technologies. The selection of technologies for the final list was done through Multi-Criteria Analysis. For the Multi-Criteria Analysis, 17 independent validated criteria were used.
These criteria are listed in table 10 below:

Table 10: the criteria used for the execution of Multi-Criteria Analysis

Criteria category	code	Criteria
Costs	A	-Minimize costs of set-up
	B	-Minimize costs of maintenance and implementation
Institutional/ policy	C	-coherence with national adaptation plan and development goals
	D	-ease of implementation
Environmental	E	-protect biodiversity
	F	-protect environmental resources
	G	-support ecosystem services
Social	H	-reduce poverty
	I	-reduce inequity
	J	-improve health
Economic	K	-Encourage private investments
	L	-Improve economic performance
	M	-Create jobs
Climate related	N	-Reduce greenhouse gas
	O	-Reduce vulnerability and built climate resilience
Technology related	P	-Rapid rate of technology diffusion
	Q	-Efficiency of technology compared to other alternatives

Table 11: Results of application of multi criteria analysis

	Costs		Benefits														Total score
			inst/ policy		Environmental			Social			Economic			Climate rel		techn.rel		
Technology	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	
climate resilient crop varieties and livestock breeds	80	80	80	70	60	60	40	80	80	80	90	80	70	60	100	80	60	69.8
Water harvesting and improved irrigation efficiency	90	90	80	90	60	70	80	90	90	90	80	80	70	60	100	80	60	73.2
climate controlled greenhouses & livestock housing facilities	40	80	80	80	50	50	50	80	80	90	80	90	70	40	100	80	60	66.5
Integrated farming systems	90	90	80	80	90	90	90	90	90	90	80	80	80	80	100	70	60	76.0
agro meteorological system for weather forecasting and early warning	80	60	80	60	50	60	60	90	60	80	90	90	70	60	100	70	60	65.4
Criterion weight (%)	3	7	7	7	5	7	5	7	5	5	6	7	5	5	7	5	7	100
weight /category		10		14			17			17			18		12		12	100

Based on consensus in the stakeholders group scores between 0 and 100 were assigned to each criterion for each technology on the short list.

The criterion weight factors were also determined based on consensus in the stakeholder's group.

The outcome of the multi criteria analysis is presented in table 12

Table 12: Ranking of the technologies from the short list after application of Multi Criteria Analysis

Priority number	Technology	Total score	Selected for barrier analysis
1	Integrated farming systems	76.0	Yes
2	Improved irrigation efficiency*	73.3	Yes
3	Climate resilient crop varieties and livestock breeds	69.8	Yes
4	Climate controlled greenhouses and livestock housing facilities	66.5	No
5	Agro meteorological system for weather forecasting and early warning	65.4	No

*Since water harvesting was also selected by the water sector working group for inclusion in the short list it was decided that the second selected agricultural technology will be "*improved irrigation technology"* instead of "*water harvesting and improved irrigation technology".*

Table 13: Effect of sensitivity analysis (scenario 2 and 3) on outcome of the MCA

Priority number	Technology	Total score	Scenario 2	Scenario 3	Selected for barrier analysis
1	Integrated farming systems	76.0	75.3	76.2	Yes
2	Improved irrigation efficiency	73.3	72.6	70.3	Yes
3	Climate resilient crop varieties and livestock breeds	69.8	68.9	69.1	Yes
4	Climate controlled greenhouses and livestock housing facilities	66.5	65.3	66.2	No
5	Agro meteorological system for weather forecasting and early warning	65.4	64.4	65.2	No

The three technologies prioritized for the agriculture sector are:

Box 2: Three selected priority technologies for Agriculture

1. **Integrated farming systems**
2. **Improved irrigation efficiency**
3. **Climate resilient crop varieties and livestock breeds**

Chapter 5 Technology prioritization for the Sector Infrastructure and Housing

The carbon footprint of the existing global infrastructure stock in 2008, assuming current technologies, is estimated to be 122 (-20/+15) Gt CO_2. In order to not exceed the 1.5 °C. This makes the need for a low-carbon and high-resilience infrastructure is crucial. The OECD (2017) states that sustainable infrastructure – infrastructure that is socially, economically and environmentally sound – is a key foundation for economic activity and for reaching the Sustainable Development Goals (SDGs). Thus, sustainable infrastructure can boost growth, reduce poverty, improve air quality and create jobs, while building low-carbon, climate-resilient economies.
Suriname has a unique natural capital where 93% of the country's land area is covered with tropical forest, which serves as a greenhouse gas sink of global importance. Suriname's contribution to global greenhouse gas (GHG) is therefore of great importance. However, this natural capital is at risk under traditional approaches to infrastructure development as it has its limitations in meeting economic development, inclusive growth, and climate goals.

5.1 GHG emissions and existing technologies of the Infrastructure and Housing sector

5.1.1 Infrastructure

The AFOLU sector establishes Suriname as a CO_2 -negative country due to Surinamese forests sequestering enormous quantities of CO_2. But, the sector also contributes to GHG emissions through exploitation of tropical forests for logging, forest clearing for shifting cultivation and deforestation for gold mining. Infrastructure development is a major part of these activities, which leads to significant clearing of large areas of land, hence driving deforestation.
In 2017, the *Background study for REDD+ in Suriname: Multi-perspective analysis of drivers of deforestation, forest degradation and barriers to REDD+ activities*[11] identified Infrastructure (mainly road construction) as the second largest driver of deforestation, responsible for 16% of total deforestation in the 2000-2015 period. New road construction and the increased pressure on forest areas due to improved access, is a particularly important driver of forest degradation and deforestation. In addition to the direct impact of forest clearing, they can also support a great number of other, significant drivers for forest loss and degradation. Deforestation, particularly led by artisanal small-scale gold mining (ASGM) activities, takes place mostly in the proximity of existing road networks. These ASGM activities needs accessibility and infrastructure

can provide improved access in difficult to reach areas, and therefore is linked in indirect way to other deforestation and forest degradation drivers with a cascading effect.
Sustainable infrastructure can act as a response to this gap. Sustainable infrastructure is defined as “infrastructure projects that are planned, designed, constructed, operated, and decommissioned in a manner to ensure economic, financial, social, environmental (including climate resilience), and institutional sustainability over the entire life cycle of the project .”
Sustainable infrastructure in the interior must address the challenge of maintaining Suriname’s natural capital — securing the forest, rivers, and healthy ecosystems. Suriname has made progress through the REDD+ project in protecting the forest and reducing deforestation to secure its natural capital. However, deforestation continues and has increased in recent years.

5.1.2. Housing

The most recent Greenhouse Gasses (GHG) emissions inventory was prepared with the base-year 2008 as part of the Second National Communication (SNC) and submitted to the UNFCCC in 2016. The SNC concludes that Suriname acts as a net sink when absorptions from the Agriculture, Forestry and Other Land Use (AFOLU) sector are taken into account. The energy sector was identified as the largest GHG source, contributing over 59% (3,788.15 Gg CO2) of the total GHG emission. Of that, the Residential sector accounted for 38.09 Gg CO2. According to the draft Energy Sector Plan (ESP), there is potential for increased use of energy efficiency (EE) technologies and measures in Suriname. Under the new legal and regulatory regime established by the Electricity Act of 2016, EE measures and guidelines will be included in the ESP. This ensures that EE is included as part of the country’s energy reform. Conducted as part of the ESP, an assessment shows that EE uptake is highest among the public and commercial consumers, while remaining fairly low among residential consumers. Currently a small number of technologies are implemented within the housing sector, as seen in table 14.

The table shows that the most common measure implemented is the use of fans for ventilation (above 80 percent). Government efforts to promote EE in the public sector seem to be effective as the public and commercial sector is leading in the adoption of EE technologies. However, despite EE awareness campaigns, residential EE uptake continues to be low.

Table 14: Estimated Current Uptake of EE Technologies for the housing sector in Suriname

Energy Efficiency Technology	Residential
LED Lighting	25%
Fans	>80%
Window AC Inverters	15%
AC Inverters	20%
Low-Flow Water Fixtures	5%
Efficient Computer Equipment	30%
Efficient Motors	<5%

Source: Draft Energy Sector Plan, 2018

5.2 Decision context

5.2.1 Infrastructure

Infrastructure can be defined as the built infrastructures, such as urban buildings and spaces, energy systems, transportation systems, water systems, wastewater and drainage systems, communication systems, health-care systems, industrial structures, and other products of human design and construction that are intended to deliver services in support of human quality of life. Focusing on infrastructure as a driver of deforestation, the scope within this study can be defined by the two following causes of deforestation: transportation system (e.g. roads) and energy systems in the interior. Both causes lead to direct deforestation, with additional deforestation and degradation being caused by the improved access to areas that were previously harder to access.

According to the 2017 *Background study for REDD+ in Suriname: Multi-perspective analysis of drivers of deforestation, forest degradation and barriers to REDD+ activities* large-scale road infrastructure is a major driver of deforestation, mainly through direct impacts from (illegal) mining and by opening up new areas in the forest. This could undermine Suriname's natural capital, and correspondingly undercut national and global goals for sustainable development, poverty reduction, climate, forests, biodiversity, and the rights of indigenous and maroon people.

Another emerging cause of deforestation and forest degradation besides road development, is energy infrastructure development. For example, dams for hydroelectric power, have a significant impact on forests as well as constructing renewable electricity plants and distribution lines. The policy of the GoS focuses on access to (renewable) energy in the interior. Currently various projects are being implemented or are in the pipeline regarding renewable energy in the interior. The installation of electricity distribution and transmission lines usually requires clearing in

forest areas. Depending on the specific location and requirements, transmission line establishment and maintenance can require significant forest land clearance.

Addressing infrastructure as a driver of deforestation will directly result in emissions being reduced from forests.

5.2.2 Housing

With the nation's current and near-future reliance on GHG emitting fossil fuels, an innovative approach is needed to respond to the threat of climate change. As the population continues to grow, thousands of houses need to be built, energy demand is expected to increase, as well as the need for food and drinking water and the energy to produce it. A warming climate is also likely to increase the demand for energy. Against this background mitigation measures are needed. Under the new legal and regulatory regime established by the Electricity Act of 2016, energy efficiency (EE) measures and guidelines are included in the draft Energy Sector Plan. This ensures that EE is included as part of the country's energy sector reform.

Energy efficiency improvements provide an enormous opportunity which has been picked up by EBS. EBS has started an energy efficiency programme, providing awareness to consumers and is also in consultation with the Association of Architects to promote energy efficiency in building design. EBS also has a strategic plan for the period from 2014 to 2024 to establish a zero CO_2 grid within 10 years. The abovementioned efforts clearly indicate the Government's willingness to mitigate climate change. As is illustrated in the Development Plan 2017-2021 which indicates that the energy policy will (among others) focus on:

- Accessible electricity supply for everyone who lives in the Republic of Suriname;
- Promoting energy efficiency;
- Stimulating the use of renewable energy.

5.3 An overview of possible mitigation technology options in the Infrastructure and Housing sector and their mitigation potential and other co-benefits

5.3.1 Infrastructure

Several mitigation technologies exist for the sector infrastructure. For the sector Infrastructure focusing on the forest, the following technology options are possible. Note that these options are also in discussion within the enhanced (2020) NDC.

Protected Area´s: The protection and management of protected areas is the highest priority for biodiversity preservation in the environmental strategy of the OP 2017-2021. This can be done by increasing the coverage of protected areas and by providing for

their protection through measures including the involvement and participation of the indigenous and maroon communities.

Ecosystem services framework: Incorporating ecosystem services information throughout the design and implementation of road projects can help minimize risks and maximize benefits while also enhancing social benefits. Ecosystem service models and decision support tools can help identify key areas that provide erosion control or flood mitigation services to infrastructure and local communities that rely on that infrastructure. Applying an ecosystem services approach to planning, preparation, and Implementation of road projects can improve returns on investment by producing more reliable and durable roads that contribute to sustainable and equitable economic benefits

Promote international carbon-trading funds: Protecting the forests is one of the most effective ways to stabilize global climate change. By investing in the protection of forests through offsetting emissions, it helps to protect forests from being burned and cleared for instance to construct roads, releasing their stored carbon. Given that tropical deforestation is a massive source of greenhouse gas emissions, international carbon-trading funds should be used to better plan and mitigate road projects, to establish new protected areas in advance of road construction, and to halt the most ill-advised road projects altogether.

Effective enforcement of SEA decree/regulation: sustainable infrastructure policies and guidelines that fully incorporate social and environmental costs for project selection and preparation. The primary tool that government uses to review sustainability components of major projects is Environmental and Social Impact Assessment (ESIA). But the EIA review generally comes too late in the project cycle for sustainability considerations to inform project alternatives and selection. The SEA could therefore be a better choice as this tool focusses on a more strategic level.

Promote railroads in forest: Forest road building is being driven not only by national plans for infrastructure expansion, but mainly by industrial timber and mineral projects in the forests. Most illegal gold mining occurs near roads. Instead of high demanding roads, railroads can be a better alternative rather than highways in tropical wilderness regions. Because railroads stop only at fixed locations, the spatial patterns of forest exploitation and movement of forest products can be more easily controlled and monitored than with roads. Railroads have less impact on forest resources and wild-life.

Promote forest specific Land Use Planning: In fact Infrastructure planning and in a much broader sense, Forest specific Land use planning is needed to ensure sustainable management of forests and land resources and to provide protection of areas identified as significant for conservation. Land Use Planning can be seen as a broad tool that by using it can result in optimal use of Suriname's forest and natural resources across sectors, including mining, infrastructure and agriculture, favoring different uses of the forest by different actors at different scales, as well as taking into

account the development of forest communities and their rights to the land and natural resources.

Enforcement, control and monitoring forest: Many forest roads are illegal or unplanned. Special attention should be paid to the more aggressive timber and mining companies that want unrestricted access to forests. The ability to govern and maintain a proper control over the forest resource can be challenged by weaknesses in monitoring capacities and enforcement. While forest monitoring serves many purposes in forest governance, it has an important role in the quantification of forest change and carbon stocks within a REDD+ Program, as well as enabling the detecting of illegal activities and for the overall supervision of the forest resources. It also encourages the participation of different actors in forest governance and will enable the promotion of sustainable forest management practices. The OP 2017-2021 anticipates strengthening forest regulatory and supervisory institutions.

5.3.2 Housing

Energy efficient household appliances and energy conservation: Equipment labelling and performance standards can help promoting EE household appliances. Labelling provides consumers with information, which enables them to compare the energy efficiency of the different appliances available for purchase. Performance standards steer suppliers towards removing less efficient appliances from the market. Suriname could consider adopting international minimum performance standards and enforce those at the port of entry.

Subsidy reform: This can create incentives for investment in energy efficiency by sending the right price signals. The heavy subsidized electricity tariffs create an incentive for over-consumption which can result in increased energy demand. Reducing subsidies should encourage more energy efficient consumption, have positive impacts on energy security and make renewable energy and technologies more competitive.

Energy efficient building designs: The design of energy efficient buildings relies on a selection of appropriate techniques that are suitable for the local tropical climate. The two important elements to be considered are the cooling technology and the electrical appliances (including the lighting system). An energy efficient house is a house which achieves comfortable conditions by including natural ventilation, shading devices, thermal insulation (to minimize direct solar gain), zoning to avoid cooling and ceiling fans where possible with minimal dependency on heating-cooling devices.

5.4 Criteria and process of technology prioritisation for the Infrastructure sector

Out of a long list of six technologies, a short list was composed during the Sector Working Group meeting in August 2019. The consultant facilitated the discussion where the short-listed technologies were identified and selected based on the country's

priorities, the impacts in the sector, the type of technology and its application to the local context. For the sector Infrastructure three (3) technologies were short-listed. The next stage in the TNA assessment was the preparation of Fact sheets (see Annex I) and completion of the Multi Criteria Analysis (MCA).

The MCA was used to prioritize technologies through a participatory process involving a number of stakeholders. A Stakeholders workshop for criteria weighting and technology prioritization was held at the office of NIMOS on 13th of September 2019 where 12 key-stakeholders comprising government, academia and technical experts participated. The list of participants is given in Annex II. The consultant started with giving an overview of both sectors with emphasis on the impact of climate change and the short list of targeted and market specific technologies. Next the discussion started and some brown paper work, comprising the weighting of the criteria and scoring the technologies for both sectors. Following to the discussion of weighting and scoring the short-listed technologies against the criteria, a dot-voting exercise was performed. Each participant was given the opportunity to vote their preferences/ judgment regarding the weighting and scoring of each technology against the criteria as seen in figure 4. This dot-voting exercise was useful to prioritize and set a hierarchy of technologies that can be the most promising in terms of climate change mitigation, but also to perform the sensitivity analyses.

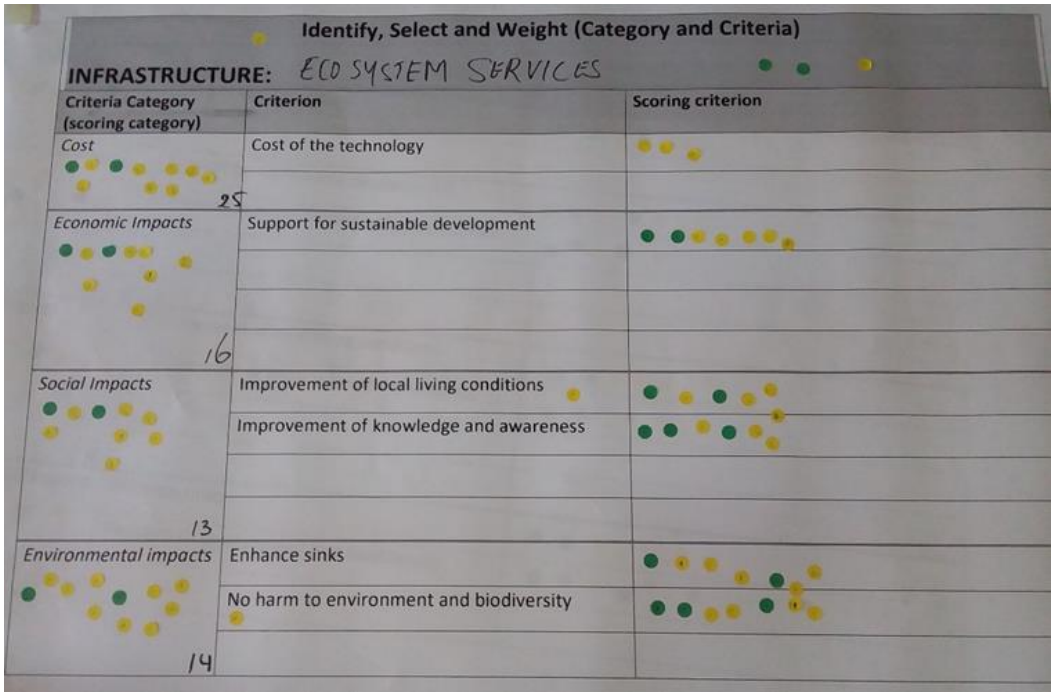


Figure 6: Brown paper work, (dot-voting exercise)[24], weighting and scoring of the technology

[24] Dot-voting: using a certain number of dots having the same value each, or two different sets of dots with different colours -each colour meaning different value- that can be used to vote the most relevant technology.

According to the guidebook for TNA assessments published in 2019 by UNEP-DTU[25], four criteria categories – cost, economic impacts, social impacts and environmental impacts – and a list of six (6) criteria for the Infrastructure sector as shown in table 15 was identified for the MCA.

Table 15: Sector Infrastructure, criteria category and corresponding criteria

INFRASTRUCTURE			
Criteria Category	**weight of criteria category**	**Criteria**	**Weight criteria**
Cost	13	Cost of the technology	13
Economic Impacts	27	Support for sustainable development	27
Social Impacts	30	Improvement of local living conditions	14
		Improvement of knowledge and awareness	16
Environmental impacts	30	Forest Carbon sink	15
		No harm to environment and biodiversity	15

The participants were asked to critically review the list of criteria, make changes where necessary or even add additional criteria if necessary. Weights were applied using the 'budget allocation' method, where, the sum of all weights equaled 100. The scale and value preference of the weights and scores applied were as follows:

Weight (4-scale, where 1 is the highest, thus most important			
1 = 20	2 = 15	3 = 10	4 = 5

Score (3-scale)		
High = 100	Medium = 50	Low = 0

Technologies were scored against each criterion using the information provided in the fact sheets, as well as, expert judgement. The fact sheets elaborated on each of the short-listed technologies, providing general information on the type of technology, cost (where available), scale of application, mitigation benefits and acceptability to stakeholders etc. Annex I includes the factsheets for the Infrastructure sector.

5.5 Results of technology prioritisation for the Infrastructure sector

After completing the MCA and selecting the technologies for the way forward, a sensitivity analysis was performed. This was done based on the outcome of the sticker-exercise where all participants had to sticker their preferences. In some cases there was some disagreements, but the sensitivity analysis changed the outcome as can be seen in table 3. Detailed results of technology prioritization for the sector both weighted score and sensitivity analysis score are given in table 3 and table 4 respectively, followed by a brief description of the prioritized technologies.

[25] James Haselip, Rasa Narkevičiūtė, Jorge Rogat and Sara Trærup (2019). TNA Step by Step: A guidebook for countries conducting a Technology Needs Assessment and Action Plan. Copenhagen, Denmark

TOTAL WEIGHTED SCORE

Table 16: Detailed results of technology prioritization for the sector Infrastructure. Total weighted score.

	CRITERIA						
Short listed Techologies	**Cost of technology**	**Support for sustainable development**	**Improvement of local living conditions**	**Improvement of knowledge and awareness**	**Forest Carbon sink**	**Extent of harm to environment and biodiversity**	**Total Weighted Score**
STRATEGIC ENVIRONMENT ASSESSMENT (SEA).	0	100	100	100	50	50	
Score	0	27	14	16	7,5	7,5	**72**
FOREST SPECIFIC LAND USE PLANNING	50	100	100	100	0	50	
Score	6	27	14	16	0	7,5	**70,5**
ECOSYSTEM SERVICES FRAMEWORK	50	100	50	0	50	50	
Score	6	27	7	0	7,5	7,5	**55**
Criterion weight	12	27	14	16	15	15	

SENSITIVITY ANALYSIS SCORE

Table 17: Detailed results of technology prioritization for the sector Infrastructure. Sensitivity Aalysis Score

	CRITERIA						
Short listed Techologies	**Cost of technology**	**Support for sustainable development**	**Improvement of local living conditions**	**Improvement of knowledge and awareness**	**Forest Carbon sink**	**Extent of harm to environment and biodiversity**	**Sensitivity Analysis Score**
STRATEGIC ENVIRONMENT ASSESSMENT (SEA).	20	80	80	90	60	50	
Score	2,4	21,6	11,2	14,4	9	7,5	**66,1**
FOREST SPECIFIC LAND USE PLANNING	50	100	80	80	30	50	
Score	6	27	11,2	12,8	4,5	7,5	**69**
ECOSYSTEM SERVICES FRAMEWORK	50	80	50	20	40	50	
Score	6	21,6	7	3,2	6	7,5	**51,3**
Criterion weight	12	27	14	16	15	15	

All three shortlisted technologies are more or less known in Suriname, but still in a scoping phase. The technologies have frequently been addressed in a number of policy and national documents as measures to address specific climate change concerns. For instance, (Forest specific) Land Used Planning is mentioned as a measure in both the NCCPSAP and the NAP. And SEA, as a strategic development instrument, has been introduced by NIMOS, but not implemented.

Boxes 3, 4 and 5 give a brief description of the technologies.

STRATEGIC ENVIRONMENT ASSESSMENT (SEA)
The OECD has defined SEA as 'a range of analytical and participatory approaches that aim to integrate environmental considerations into policies, plans, and programmes and evaluate the interlinkages with economic and social considerations'. In the case of long-lived infrastructure or networks, (e.g. large-scale dams, road of railroad networks) this will include assessing the likely impact of climate change as well as reducing the impact on deforestation within the planned useful life of the infrastructure facilities. The SEA approach allows the planning of infrastructure projects to be integrated in a participatory way with land and environment planning at an early stage. The weakest groups in society and biodiversity receive the extra attention they require, preferably accompanied by pro-poor and pro-environment investment options.

Box 3: Brief description of technology 'Strategic Environment Assessment'

FOREST SPECIFIC LAND USE PLANNING
Lack of upfront planning to anticipate and address social and environmental impacts, usually around local community's access to natural resources, can be a major driver of infrastructure related conflict, often resulting in substantial delays and costs. Upstream spatial and landscape-scale planning is essential to optimize the deployment of physical and natural capital. Appropriate Land Use planning is needed to address the issues around large scale infrastructure, both for the coastal areas and the interior. Upstream planning can de-risk infrastructure investments and increase project value- while improving outcomes for preservation of natural capital and ecosystem services. In addition, planning can identify opportunities for natural infrastructure to take the place of traditional built solutions. For instance, natural infrastructure, or hybrid solutions that combine natural and "gray" infrastructure (such as seawalls, dams).

Box 4: Brief description of technology 'Forest Specific Lad Use Planning'

ECOSYSTEM SERVICES FRAMEWORK
Incorporating ecosystem services information throughout the design and implementation of road projects can help minimize risks and maximize benefits while also enhancing social benefits. Ecosystem service models and decision support tools can help identify key areas that provide erosion control or flood mitigation services to infrastructure and local communities that rely on that infrastructure. Mapping and quantifying the value of the benefits of ecosystem services, and incorporating this information in project design and execution, can improve road project feasibility and outcomes. Applying an ecosystem services approach to planning, preparation, and Implementation of road projects can improve returns on investment by producing more reliable and durable roads that contribute to sustainable and equitable economic benefits

Box 5: Brief description of technology 'Ecosystem Services Framework'

5.6 Criteria and process of technology prioritisation for the Housing sector

During the same stakeholder workshop on the 13th of September, the technology prioritization for Housing was conducted after the technology prioritization of the Infrastructure sector took place. The process was similar and included presenting an overview of the shortlisted technologies by the consultant, discussion about the possible mitigation impact of these technologies and brown paper work. That is, that the participants had the opportunity to sticker their preferences on the technologies based on the criteria and their expert judgment. The technologies were prioritized through the process as recommended in the Technology Need Assessment Handbook (UNDP and UNFCCC, 2011) and MCA, specifically technology categorization and prioritization with the Multi-Criteria Analysis, scoring and assessment of the results by conducting sensitivity analysis.

Out of a long list of a total of 4 technologies, a short list of two was composed during a stakeholder dialogue meeting in august 2019. The consultant facilitated the discussion where the short listed technologies were identified and selected based on the country's priorities, the impacts in the sector, the type of technology and its application to the local context. For the sector Housing two technologies were short-listed. The next stage in the TNA assessment was the preparation of fact sheets and completion of the Multi Criteria Analysis (MCA).

The MCA was used to prioritize technologies through a participatory process involving a number of stakeholders. A workshop for criteria weighting and technology prioritization was held at the office of NIMOS on 13th of September 2019 where 12 key-stakeholders comprising government, academia and technical experts participated. The list of participants is given in Annex III. The consultant gave an overview of the housing sector with emphasis on the impact of climate change and the short list of targeted and market specific technologies. Furthermore, according to the UNEP-DTU guidelines for TNA assessments, four criteria categories – cost, economic impacts, social impacts and environmental impacts, and a list of six (6) criteria for the Housing sector as shown in table 1 was identified for the MCA.

Table 18: Sector Housing, criteria category and corresponding criteria

HOUSING			
Criteria Category	**Weight of criteria category**	**Criteria**	**Weight criteria**
Cost	40	Cost of the technology	40
Economic Impacts	28	Reduced fuel consumption	15
		Energy Security	13
Social Impacts	10	Reduced consumers spending	4
		Improvement of knowledge and awareness	6
Environmental impacts	22	GHG emission reducion	22

The participants were asked to critically review the list of criteria, make changes where necessary or even add additional criteria if necessary. Weights were applied using the 'budget allocation' method, where, the sum of all weights equaled 100. The scale and value preference of the weights and scores applied were as follows below:

Table 19: scale and value preference of the weights and scores

Weight (4-scale, where 1 is the highest, thus most important			
1 = 20	2 = 15	3 = 10	4 = 5

Score (3-scale)		
High = 100	Medium = 50	Low = 0

The discussion started and brown paper work, comprising the weighting of the criteria and scoring the technologies for both sectors. Each participant was given the opportunity to sticker their preferences regarding the weighting and scoring of each technology against the criteria. Technologies were scored against each criterion using the information provided in the fact sheets, as well as, expert judgement. The fact sheets elaborated on each of the short-listed technologies, providing general information on the type of technology, cost (where available), scale of application, adaptation benefits and acceptability to stakeholders etc. Annex II includes the factsheets for the Housing sector.

It must be noted that at some moment several stakeholders left early for other obligations, making the discussion and listing round very brief. Because not all exercises could be done in an elaborated manner, the consultant made sure that the participants were given the opportunity to email their score and listing in the following weeks to the consultant.

5.7 Results of technology prioritization for sector Housing

The same process followed for the sector Infrastructure was used for the sector Housing. After completing the MCDA and scoring the short listed technologies, a sensitivity analysis was performed. The sticker-exercise helped in performing the sensitivity analysis as some participants had other opinions in prioritizing the technologies. Based on their preferences the score were slightly changed as seen in table 4. Table 4 gives the detailed results of technology prioritization for the sector Housing.

TOTAL WEIGHTED SCORE

Table 20: Detailed results of technology prioritization for the sector Housing. Total weighted score.

	Criteria						
Short listed Technologies	**Cost of technology**	**Reduced fuel consumption**	**Energy Security**	**Reduced consumers spending**	**Improvement of knowledge and awareness**	**GHG emission reducion**	**Total Weighted Score**
ENERGY EFFICIENT BUILDING DESIGNS	100	100	100	50	50	100	
score	40	15	13	2	3	22	**95**
ENERGY EFFICIENT HOUSEHOLD APPLIANCES AND ENERGY CONSERVATION	50	50	100	50	50	100	
Score	20	7,5	13	2	3	22	**67,5**
Criterion weight	40	15	13	4	6	22	

SENSITIVITY ANALYSIS SCORE

Table 21: Detailed results of technology prioritization for the sector Housing. Sensitivity Analysis Score.

	Criteria						
Criteria	**Cost of technology**	**Reduced fuel consumption**	**Energy Security**	**Reduced consumers spending**	**Improvement of knowledge and awareness**	**GHG emission reducion**	**Sensitivity Analysis Score**
ENERGY EFFICIENT BUILDING DESIGNS	100	80	80	70	70	90	
score	40	12	10,4	2,8	4,2	19,8	**89,2**
ENERGY EFFICIENT HOUSEHOLD APPLIANCES AND ENERGY CONSERVATION	50	50	80	70	50	70	
score	20	7,5	10,4	2,8	3	15,4	**59,1**
Criterion weight	40	15	13	4	6	22	

Suriname is currently in the process of enhancing its nationally Determined Contribution in which 'Energy' is one of the sectors where measures are proposed. Both shortlisted technologies are also proposed as a measure within the NDC-assessment.

Boxes 6 and 7 give a brief description of the technologies for the Housing sector.

ENERGY EFFICIENT BUILDING DESIGN

The Government of Suriname wants to pursue an increased use of energy efficiency (EE) technologies and measures in Suriname. Under the new legal and regulatory regime established by the Electricity Act of 2016, energy efficiency (EE) measures and guidelines are included in the Energy Sector Plan which will be finalized end of 2019. This ensures that EE is included as part of the country's energy sector reform. The two important elements to be considered are the cooling technology and the electrical appliances (including the lighting system). Energy efficient design and build can improve the quality of residential buildings; make them more safe, comfortable and economical.

Currently the National Building Code is being revised. This could be an opportunity to streamline standards for building design, and include energy efficiency, for both domestic housing and commercial buildings. The building code revision should take into account the retro-fitting of existing buildings. If the code were to be aligned with Energy Efficiency standards and labelling requirements, they can be jointly implemented.

Box 6: Brief description of technology 'Energy Efficient Building Design'

ENERGY EFFICIENT HOUSEHOLD APPLIANCES AND ENERGY CONSERVATION

Measures for Energy Efficiency are associated with household appliances, lighting, air conditioners, boilers, insulation and glazing. Energy conservation refers to changes in consumer's behavior or habitual lifestyle that are intended to reduce energy use. The objective is to reduce energy consumption in buildings and associated GHG emissions in the housing sector in Suriname by stimulating the use of energy efficient household appliances. For example, replacement of incandescent lamps with energy saving lamps, which use less power to provide the same amount of light, reduces the amount of energy demand and also have a longer life (e.g.: replace 25W incandescent with 7W fluorescent). The beneficiaries will be the individual households through the use of energy efficient appliances which will result in energy savings and lower expenditures, and contribute to national objectives to reduce poverty.

Box 7: Brief description of technology ´Energy Efficient Household Appliances and Energy Conservation´

The technologies selected for the Infrastructure and Housing sector are:

1. **Infrastructure: Forest Specific Land use planning**
2. **Housing: Energy Efficient Building Design**

Box 8: Two selected priority technologies for Infrastructure and Housing

Chapter 6 Summary and Conclusions

Wrapping up the identification and prioritization of technologies for the prioritized sectors for Suriname, the following can be concluded:

1. The Technology Needs Assessment requires certainly a participatory approach, since there is a wide range of technologies that can be beneficial to the country. However, if priorities need to be established broad consultation of stakeholders is utterly needed, to create support for the final list of prioritized technologies.

2. Scoring and reviewing of possible technologies is a meticulous process, in which multiple score systems are applied. This is needed to make absolutely sure that the outcomes of the scoring system, and thus of the prioritized technologies, are accurate.

3. The TNA team is confident that the prioritized technologies, if selected for future funding, give opportunities to Suriname to introduce the necessary technologies to make the prioritized sectors more resilient to climate change.

The active support of the TNA Coordinator, the TNA liaison officer, the Working Groups and all the stakeholders was indispensable in fulfilling this assignment.

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Annex I: Technology Factsheets for selected technologies

Factsheets Water management

Water resource mapping

Technology name	Water resource mapping
Short description of the technology	Climate change has serious harmful implications on the availability of fresh water resources, with in turn has adverse consequences on the living conditions of large populations, on the availability of drinking water, on food production and on the economy as a whole. Water resource mapping provides information on the availability of water on earth, the use of these water resources, the quality of water, etc. This information is fundamental to the effective management of the national water resources. Every assessment of the impact of climate change on the water sector starts with the question: where is the water? The presence of water can be on the surface (in rivers, streams, lakes), in the ground (subsurface water, aquifers) or in the sky (precipitation). Nowadays water resource mapping software makes use of technologies such as Remote Sensing and Geographic Information Systems (GIS). Satellite data is obtained and combined with on-the-ground hydrological, geological and other water-related data. With current technologies such data can even become real-time available on smart phones and other devices. Water resource mapping technologies produce maps with geographical water data such as the annual rainfall map and the water balance map. A water atlas can tell you at a glance how much rainfall a region gets annually, where the rivers, streams and dams are located, what watershed region an area belongs to, which direction the water flows, how much groundwater is available, where the soil conditions are suitable for well drilling for drinking water purposes, and much more. Most water resource mapping tools have water quality portals, which can help to asses if, for instance, there is a risk of pollution of the surface water or the groundwater. Water resource mapping is nowadays crucial in assessing trends in the availability and quality of water on both global and local level.
Objective	To assess the quantity and quality of available water resources, including groundwater, surface water and subsurface water, to observe trends and to support long term planning and strategy development in relation to climate change.
Beneficiaries	Water technicians, farmers, fishermen, private businesses, policy makers, researchers, climate change advocates.
Ease of implementation of the technology	Water resource mapping is already being done for many years by the Hydraulics Department of the Ministry of Public Works (WLA). As such there is an existing network of water level meters in the main rivers, streams and swamps through which the hydrological characteristics are monitored. This department also calculates the water balance, based on data on precipitation, evaporation, runoff and storage.

	With this experience the ease of implementation is considered fairly high. Critical success factor is the availability of trained human resources to be able to implement the technology.
Coherence with national policies, strategies and plans	Water resource mapping is mentioned in the Suriname Water Supply Master Plan, in national drinking water strategies, as well as in policy papers of the ministry of Public Works.
Institutional aspects	Implementation of the water resource mapping technology requires institutional strengthening of the Hydraulics Department of the Ministry of Public Works. The availability of a sufficient number of trained technical persons is a critical requirement. Therefore the implementation of the water resource mapping technology must be accompanied by a training program for human resources.
Social benefits	The timely information on the availability and quality of water resources in the country supports adequate national water policies and plans. This will lead to better planning of the use of water for drinking purposes and for food production. As a result on the long term there will be more drinking water and more food available, leading to a healthier and more prosperous population.
Economic benefits	Information on water availability will lead to better planning of drinking water and food production, attracting more investments from the private sector with higher profitability. Implementing the water resource mapping tool on a national scale will require more laborers to manage the hydraulic stations, leading to more jobs throughout the country. Improved economic performance and more investments will also increase job opportunities.
Environmental benefits	Knowing where the water resources are and being able to observe and analyze trends in the behavior of these water resources will contribute to strengthen the resilience of the country in its adaptation to the adverse effects of climate change, such as sea level rise, salinization, inundation, droughts and floods. Knowing the quality of the water resources will have a positive impact on the protection of biodiversity and ecosystems.
Cost	The investment cost of the water resource mapping technology is estimated to be around USD 250,000. Breakdown of the investment cost: - Purchase of software and hardware: USD 100,000 - Modification to local conditions by consultant: USD 50,000 - Training of local counterparts: USD 25,000 - Local costs (data stations, transport, personnel): USD 50,000 - Unforeseen: USD 25,000 Beside the investment cost the annual cost of operation should be taken into consideration as well (equipment costs, labor costs, maintenance costs etc).
Time frame	The water resource mapping technology can be implemented in the short to medium term (1-2 years).

Water harvesting and storage

Technology name	Water harvesting and storage
Short description of the technology	Water harvesting and storage technologies are water-related interventions with the potential to contribute to rapid improvements in the yields of crops during dry seasons. Water harvesting enables to store water when it is plentiful and make it available for later use when it is scarce. Water harvesting and storage technologies can help provide water for domestic use, farming, livestock, fish ponds, etc. Rainwater runoff can be harvested from roofs and ground surfaces (rainwater harvesting) as well as from open water sources (flood water harvesting). Some water harvesting techniques collect runoff to encourage infiltration to increase groundwater storage, and others store water at the surface in natural or man-made ponds or tanks. Water is later withdrawn for irrigation or other productive uses. On a small scale, usually at farm level, water storage tanks, both above-ground and in the ground, can store water. Structures and dams, both small and large, and their associated reservoirs, can store water on a larger scale. In many cases, water storage simultaneously serves multiple purposes, such as irrigation and flood control.
Objective	To use natural reservoirs, such as swamps, and manmade water reservoirs for harvesting and storage of excess rainwater and surface water, in order to be able to use this collected water in periods of water shortages.
Beneficiaries	Farmers, food production businesses, policy planners, villages in the interior, society as a whole.
Ease of implementation of the technology	Water harvesting and storage is not considered a particularly high- tech technology. Rainfall water harvesting techniques have been practiced by farmers for a long time in Suriname. For instance rice cultivating areas in Nickerie have vast experiences with harvesting surface water for irrigation purposes. Some private agribusiness companies have large reservoirs to store rain water for future use. The Ministry of Agriculture gives advice to farmers on how to harvest and store rainfall water and surface water to increase agricultural production. In the interior people are already familiar with collecting and storing rainwater and fresh surface water for domestic and irrigation use. With these experiences the ease of implementation is considered high. Critical success factor is the training of farmers, people living in villages in the interior and other users of harvested and stored water.
Coherence with national policies, strategies and plans	Rainwater harvest and storage are part of the strategies of the ministry of Agriculture and the ministry of Regional Development.
Institutional aspects	Implementation of water harvesting and storage technologies requires cooperation between government agencies such as the Ministry of Agriculture with farmers organizations, such as water boards in Nickerie and other areas. Training of farmers in water harvesting and in efficient use of stored water will improve the success rate of this technology.
Social benefits	With additional water becoming available farm lands will become less vulnerable to periods of water shortages. The resulting higher crop yields will contribute to poverty reduction among famers, usually a marginalized group.

	Longer seasons of farming will reduce food shortages and will lower food prices (for instance vegetables, tomatoes etc.) in the dry season. This will benefit all consumers, in particular households living on a small budget.
Economic benefits	The ability to harvest and store rainwater and surface water will improve the productivity of farms and agribusinesses, resulting in higher profitability and higher investments. Better economic performance of the agricultural sector will lead to more job opportunities. Construction of structures and dams in water catchment areas will also require additional manual workers.
Environmental benefits	Water harvesting and storage technologies will not have a particular large impact on the reduction of greenhouse gas, however, increased storage of runoff water will reduce the need for additional pumping of subsurface water, reducing the fuel amount needed. On the other hand, establishment of large-scale natural water reservoirs may have an adverse effect on greenhouse gases. The net balance should be calculated in more details.
Cost	The investment costs of water harvesting and storage programs throughout the country are relatively high, and are estimated to be around USD 1,000,000. Breakdown of the investment costs: - Technical consultancy design and construction: USD 100,000 - Identification of storage and harvesting locations: USD 50,000 - Construction of storage and harvesting facilities: USD 700,000 - Training of local farmers and households: USD 50,000 - Unforeseen: USD 100,000 Beside the investment cost the annual cost of operation and maintenance should be taken into consideration as well.
Time frame	The water harvesting technology can be implemented nationwide in the short to medium term (2-5 years).

Water modelling

Technology name	**Water modelling**
Short description of the technology	In the past decade there have been remarkable advances in technology and computing power, which have exponentially changed the ability to collect, process, analyze and present vast amounts of data. In the water sector, the number of catastrophic events that can be related to climate change, such as long-duration droughts and floods, have been significant drivers for using these new computing technologies. There is an obvious need to better understand and manage the effects of climate change on the water sector. The advanced computing power and new software development support the modelling of the whole water cycle in a single model.

	Essentially the architecture of a water modelling platform is to place a hydraulic model at the center of a system which pulls together a wide range of real-time information, runs hydraulic simulations and then interprets the results and make future predictions. Water models serve as an early warning system, which includes a series of alerts and alarms to key stakeholders, such as farmers, drinking water companies, and the society as a whole.
Objective	To develop and implement a real-time water model which can function as an early warning system, based on climate forecasting and hydro modeling to be able to predict seasonal periods of flooding and/or severe droughts.
Beneficiaries	Farmers, people living in low-lying areas, people living in the interior, the society as a whole.
Ease of implementation of the technology	Water models are already being used on an initial scale in Suriname. The Hydraulics Department of the Ministry of Public Works has a network of water level meters in the main rivers through which the hydrological characteristics of the rivers are monitored. This department also calculates the water balance, based on data on precipitation, evaporation, runoff and storage. The Meteorological Services has a climate model based on a series of weather stations spread over the country that is used for weather forecasting. With this experience the ease of implementation is considered fairly high. Critical success factor is the availability of trained human resources to be able to implement the technology.
Coherence with national policies, strategies and plans	Early warning systems are stipulated in the National Climate Change Policy, Strategy and Action Plan for Suriname 2014-2021, as part of Disaster Risk Management. The EWS is to be implemented in the coastal zone by the Ministry of Public Works and in the interior by the National Coordination Commission on Disasters (NCCR).
Institutional aspects	Implementation of the water modelling technology requires close cooperation between the Ministry of Public Works and the Meteorological Services. Other ministries, such as Agriculture, Regional Development, Public Health, etc., as well as the NCCR, also have important roles to play in the dissemination of the outcomes of the early warning system. The availability of a sufficient number of trained technical persons is a critical requirement. Therefore the implementation of the water model must be accompanied by a training program for human resources.

Social benefits	With the water model, timely warnings can be given regarding expected flooding or periods of droughts. As a result there will be less damage, leading to less hazard costs, especially for the more vulnerable population, as such, contributing to poverty reduction. Less flooding of urban areas will limit water borne diseases, which will lead to less health problems.
Economic benefits	Timely information on extreme weather forecast and on excess or shortage of water will lead to better preparedness of farmers, food processors, etc., leading to less production losses. Private investments will increase, because damages due to extreme weather will be reduced, and profitability of business will increase. Implementing the water model on a national scale will require more laborers to manage the weather stations and the hydraulic stations, leading to more jobs throughout the country. Improved economic performance and more investments will also increase job opportunities.
Environmental benefits	The water model in itself will not significantly mitigate greenhouse gasses. However, the early warnings on an upcoming flooding or an extreme water stress is more of an adaptation measure, improving climate resilience, and reducing the vulnerability on climate change.
Cost	The investments cost of the water modelling technology are estimated to be around USD 500,000. Breakdown of the investment cost: - Purchase of software and hardware: USD 200,000 - Modification to local conditions by consultant: USD 100,000 - Training of local counterparts: USD 25,000 - Local costs (data stations, transport, personnel): USD 100,000 - Unforeseen: USD 75,000 Beside the investment cost the annual cost of operation should be taken into consideration as well (labor costs, transportation costs, maintenance costs etc.).
Time frame	The water modelling technology can be implemented nationwide in the short to medium term (1-2 years).

Factsheets Agriculture

Integrated Farming systems

Sector	**Agriculture**
Sub-sector/ category	Crop and livestock management
Technology	Integrated farming systems
Scale of application	National
Availability	Integrated farming has immense potential to make farmers climate smart through the cultivation of different crops and livestock on the same land and using farm resources sustainably. Till now integrated farming is only practiced on a small scale in Suriname. The few farmers who apply integrated farming can still improve their farming systems to make these more efficient
Technology characteristics	
Introduction	The integrated farming system is a combined approach aimed at efficient sustainable resource management for increased productivity in the cropping system. It involves different components like trees, crops and livestock arranged spatially and temporarily over the same unit of land for the best utilization of available resources. Various types of plants, livestock, mushroom, aquaculture and other aquatic flora and fauna are managed for maximum productivity in such a way that one complements the other. The waste generated from one component is recycled and used as a resource for the other. It is system to protect and conserve land and water resources from depletion. Integrated farming has immense potential to make farmers climate smart through the cultivation of different crops on the same land and using farm resources sustainably: •Climate smart agriculture (CSA) involves integrated resource management for maximum productivity •It involves best utilization of the growing space through the integrated farming approach •Nutritional and economic security is ensured for better health of the farm family as they get different fruits, cereals, vegetables, livestock products and cash crops from their own land. It boosts food security through local production and consumption and checks migration •This improves soil's physical and chemical properties, its nutrient status and biological components. Such interactive systems affect the microclimate and provide a strong base to good agricultural practices for increased productivity. In an integrated system, maximum use is made of resources, making the system highly interdependent. Little is wasted in such a system. The water that is used to clean the ponds where fish are raised is recycled and used to irrigate crops. After harvest and/or processing of food crops, vegetable, and perennial crops, the residues, which are commonly thought of as waste, are reinvested back into the production. Similarly, the by-products generated by livestock (litter and droppings) are composted for use in the place of chemical fertilizers to improve the soil on which

organic food and feed crops are grown or they are used to produce bio-gas. This can be used for cooking, lighting, and heating.
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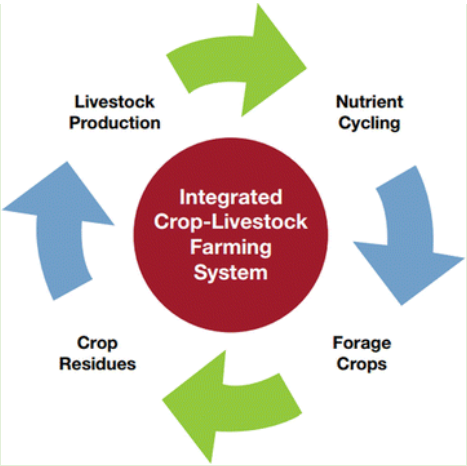
Loss of assets is a possible major cause and consequence of vulnerability that can be triggered very rapidly through the whole production system. Although each farming system has different limiting resources, labor is often the only asset of resource-poor farmers. Integrated systems can play a critical role in mitigating greenhouse gases from agriculture, as their emission intensities are typically lower than the sum of those from specialized systems.
Emissions from manure storage can also be reduced if the manure is properly applied to crop fields. Planting trees can also sequester carbon sequestration in biomass and the soil, which can also partially or entirely offset greenhouse gas emissions from ruminants. The rate of increase in soil carbon stocks after adoption of improved management practices follows a sigmoid curve: it attains a maximum level of sequestration rates in 5 - 20 years and continues at decreasing rates until soil organic carbon stocks reach a new equilibrium. Therefore, in the short term an exponential relationship between application and accumulation of soil organic matter can be expected, until a saturation point, which is mainly determined by soil texture and the chemical composition of soil organic matter, is reached. In the long term, the ratio of the current soil organic carbon level to the steady-state level is more important than agronomic management. This means that gains can be made in soil carbon stocks where initial soils are eroded and degraded, and there is the opportunity to increase soil carbon through planting trees (FAO, 2012a).

The key principles of integrated farming are:

- The farming system is essentially cyclic. Therefor management decisions related to one component may affect the others
- For resource poor farmers, the correct management of crop residues, together with an optimal allocation of scarce resources , leads to sustainable production

Figure 1:Schematic overview of integrated farming

	
Institutional/ organizational	The Department of Agriculture of the Anton de Kom University of Suriname, the Center for Agricultural Research in Suriname (CELOS) and the National Rice Research Center (ADRON) are the leading institutions for technology generation while technology transfer is done in collaboration of these institutes with de extension division of the Ministry of Agriculture.
Adequacy for current climate	The agricultural sector in Suriname is extremely vulnerable to the negative impacts of climate change particularly from drought, salt water intrusion and flooding.
Size of potential beneficiary	This technology is likely to have benefits to the small and medium size farms
Disadvantages	Higher labor input Slow adoption of the technology by the farmers
Capital costs	The total costs for the set-up of 5 demonstration farms (each 10 ha) and an investment fund for farmers who want to set up an integrated farm after training in integrated are estimated to be US$30,000,000
Costs to implement/ operate/ maintain	US$2,000,000/ year
Development impacts-direct/ indirect benefits	Farmers will learn how to establish an integrated farm and see what the advantages are from an integrated farm
Status of technology	Mixed farming is well known and applied but efficient integrated farming is not applied yet
Market potential	Good
Acceptability to stakeholders	After demonstration of the advances advantages of integrated farming farmers stepwise will become interested in establishing their own integrated farm
Opportunities and barriers	Farming will become more cost effective and less risky The higher labor input might become a barrier since many farmers are part-time farmers
Time frame	3-5 years

Improved irrigation efficiency

Sector	Agriculture
Technology	Improving irrigation efficiency
Scale of application	National
Availability	Efficient irrigation systems are only on a small scale applied in Suriname till now.
Technology characteristics	Improving irrigation efficiency aims at minimizing water use within the agricultural sector while continuing to obtain optimal crop productivity. Water efficient irrigation also provides a number of environmental and socio-economic benefits. High irrigation efficiency will become important in the near future due to the expected decrease in available irrigation water For wetland rice production land leveling of rice fields by application of laser land leveling can result in a significant more efficient use of irrigation water.
Capital costs	Technologies for the implementation of improved irrigation efficiency include irrigation systems where water release can be controlled (e.g. .drip irrigation). Irrigation efficiency can also be improved through suitable farming practices such as crop rotation, conservation tillage, mulching. Costs for purchase of a complete laser controlled land leveling system are estimated to be about US$20,000
Implementation	The first step is to evaluate the current levels and costs of water and energy use related to irrigation and find out where water and energy can be saved. Soil type, target crop types and water availability should then be assessed to calculate minimum water requirements and establish where the water can be obtained. Making farmers aware of the benefits and goals of efficient use of irrigation water is an important step in the development of plan for improvement of irrigation efficiency. Changes in irrigation methods may require changes to legislation. Implementing the changes is the next step and these may include installation of a new irrigation system and equipment, equipment maintenance and repair, land leveling, water conservation techniques and on-site water recycling facilities. Finally a plan to monitor, maintain and evaluate the changes should be implemented to ensure high efficiency is sustained regarding irrigation water use.
Environmental benefits	-Reduces the amount of water extracted for irrigation purposes, and the amount of water lost (in surface runoff in the fields and evapotranspiration). Energy needed for pumping and conveying of water are subsequently reduced, minimizing the carbon footprint. -Minimizes nutrient leaching and pollution of local watersheds due to decreased agricultural runoff.
Socio-economic benefits	-reduced costs related to extraction and transport of water for irrigation -contribution to food security and income generation due to high crop productivity
Opportunities and barriers	
Opportunities	-agricultural production van be improved during the long dry season and / or in case of unexpected longer dry periods -extended environmental and economic benefits, including cost savings and reduced risks of water source degradation
opportunities	-Climate change adaptation and mitigation benefits, including increased community resilience to changing water availability

	-awareness of the importance of water conservation in farming is likely to increase the chance of improving water efficiency in other sectors
Barriers	- Technology maturity: medium - Initial investments: medium - Operational costs: low - Implementation timeframe: 3-5 years

Climate resilient crop varieties and livestock breeds

Sector: Agriculture	
Subsector / category: sustainable crop and livestock management	
Technology name	Climate resilient crop varieties and livestock breeds
Technology characteristics	
Introduction	The introduction of new cultivated species and improved varieties of crop is a technology aimed at enhancing plant productivity, quality, health and nutritional value and/or building crop resilience to diseases, pest organisms and environmental stresses. Development and / or use of climate resilient livestock breeds and crossbreeds is a technology aimed at enhancing animal productivity, health and / or building livestock resilience to diseases. Use of breeds which are heat stress tolerant is a very useful adaptation strategy.
How this technology contributes to adaptation	The development and use of improved crop varieties enhances the resistance of plants to a variety of stresses that could result from climate change. For crops these potential stresses include water and heat stress, water salinity, water stress and the emergence of new pests. Crop varieties that are developed to resist these conditions will help to ensure that agricultural production can continue and even improve despite uncertainties about future impacts of climate change. Varieties with improved nutritional content can provide benefits for animals and humans alike, reducing vulnerability to illness and improving overall health. Use of livestock breeds and cross-breeds with a high level of heat stress tolerance will make livestock production less vulnerable to the future impacts of climate change The process of farmer experimentation and the subsequent introduction of adapted and accepted crop varieties and livestock breeds can potentially strengthen farmers' cropping systems and livestock production by increasing yields, improving drought resilience, boosting resistance to pests and diseases, reducing mortality and morbidity of livestock and also by capturing new market opportunities
	.

Advantages of the technology	Crop - and livestock production under a changing climate will become more climate resilient
Disadvantages of the technology	Farmer experimentation using only native varieties can limit the range of benefits and responses that may be found amongst the materials being tested, although local adaptation and acceptance are ensured. At the same time, problems can with the introduction of exotic species (from other origin centers) that after being introduced turning into pests. There are several examples of introduced species that have escaped control becoming pests or agricultural weeds (Ojasti, 2001; Hall, 2003). A limitation of heat stress tolerant livestock breeds can be lower milk yields, carcass characteristics and growth which are lower than these for the breeds developed in the temperate regions.

Factsheets for Infrastructure and Housing

Forest Specific Land Use Planning

Technology name	FOREST SPECIFIC LAND USE PLANNING
Background Notes	Suriname does not have a sound, credible, and integrated policy and institutional framework for sustainable infrastructure. Lack of upfront planning to anticipate and address social and environmental impacts, usually around local community's access to natural resources, can be a major driver of infrastructure related conflict, often resulting in substantial delays and costs. Upstream spatial and landscape-scale planning is essential to optimize the deployment of physical and natural capital.
Short description of the Technology	Appropriate Land Use planning is needed to address the issues around large scale infrastructure, both for the coastal areas and the interior.
Objective	Minimize deforestation and reduce impacts on biodiversity through developing a specific forest land use plan.
Applicability **Need, barriers, acceptability, status of technology, scale, time horizon**	Infrastructure investments are long-term and require huge investment. Spatial and landscape-scale planning is essential to optimize the deployment of physical and natural capital. Planning will establish strategies and investment plans, which integrate sustainable development objectives, and will coordinate them with other national strategies and policies.
Benefits	Upstream planning can de-risk infrastructure investments and increase project value- while improving outcomes for preservation of natural capital and ecosystem services. In addition, planning can identify opportunities for natural infrastructure to take the place of traditional built solutions. For instance, natural infrastructure, or hybrid solutions that combine natural and "gray" infrastructure (such as seawalls, dams).
Social level	The habitat of vulnerable communities in forest is taken into consideration an treated with respect in upstream planning
Economic level	Planning can de-risk infrastructure investments and increase project value, thus saving time and money.
Environmental level	Planning can minimize deforestation risks and impacts on biodiversity
GHG emission	Project pipelines or guidelines for the appraisal of infrastructure projects are missing in many infrastructure plans. Procurement policies only partially address sustainability criteria, and many governments face challenges to implement sustainable procurement policies such as the perception that green products and services are more expensive than non-green ones, public officials' lack of technical knowledge; and the absence of legislation and

	monitoring mechanisms to evaluate the performances of green procurement system.
Cost	N/a. Includes intensive knowledge and awareness campaigns. Capacity building for all key stakeholders. Institutional strengthening.

Energy Efficient Building Designs

Technology Name	**ENERGY EFFICIENT BUILDING DESIGNS**
GHG emissions	GHG emissions in the residential sector in 2008 (Second National Communication, 2016) accounted for 38 Gg eq CO2 (2008GHG emissions of Suriname). With the proposed measure, an estimated reduction of 20% can be established
Background Notes	The Government of Suriname wants to pursue an increased use of energy efficiency (EE) technologies and measures in Suriname. Under the new legal and regulatory regime established by the Electricity Act of 2016, energy efficiency (EE) measures and guidelines shall be included in the Energy Sector Plan which will be finalized end of 2019. This ensures that EE is included as part of the country's energy sector reform.
Short description of the Technology	An energy efficient house is a house which achieves comfortable condition by including natural ventilation, shading devices, thermal insulation (to minimize direct solar gain), zoning to avoid cooling and ceiling fans where possible with minimal dependency on heating-cooling devices. It ensures reduced maintenance costs through energy efficient design.
Objective	Reduce energy consumption and associated GHG emissions in the housing sector in Suriname by introducing and stimulating energy efficient building design.
Benefits	Energy efficient design and build can improve the quality of residential buildings; make them more safe, comfortable and economical. Energy saving in energy efficient buildings will improve energy security on consumer and country level.
Social level	Reduce consumers spending e.g. on air conditioning systems

Economic level	Reduce fuel consumption. Potential energy savings about 30%.
Environmental level	Reduce GHG emissions with 20-30%
Beneficiaries	• Architects, designers, Infra-students acquire practical knowledge of integrated design principles and practices • Social energy efficient housing can provide decent living conditions and reduced energy bills to vulnerable families. • Efficient material and construction technology providers – by promoting their product and services • Developers and housing customers through increased awareness and possibility for improving their future energy performance
Implementation assumption	A nationwide knowledge and awareness raising campaign on the benefits of EE design and EE building materials. Using energy efficient friendly materials will lead to market boost.
Cost	App. 1,000,000.- USD

Annex II: List of stakeholders involved and their contacts

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Annex III Technology Needs Assessment – Sector Water Management

Brainstorming session on possible technologies in the water sector September 26, 2019

Drinking water

- Smart water meters to address the issue of Non Revenue Water
- Small scale water installations
- Purification of drinking water from open water sources

Rain water

- Rain water collection from rooftops
- Rain water treatment and safe storage

Surface water & Hydrology

- Hydrological models
- Water resources mapping

Flooding

- Early Warning Systems
- Flood hazard mapping

Irrigation & agriculture

- Land leveling of rice fields with laser technology
- Drip irrigation
- Water harvesting

Waste water

- Waste water treatment

Meteorology

- Weather and precipitation forecast

Water and Energy

- Small and medium scale hydropower plants

Water data

- Water data collection and monitoring system
- Water data sharing platform

Water Management Systems (soft technologies)

- National Water Policy Plan
- Strengthening water institutions and improve coordination
- Capacity building in integrated water resource management
- Water knowledge