Closure Report for CTCN Technical Assistance

1. Basic information

Title of response plan	**Tonga Circular Economy Project – Biogas Feasibility Study**
Technical assistance reference number	**2019000026**
Country / countries	**Tonga**
NDE organisation	Mr. Paula Pouvalu Ma'u, Chief Executive Officer, Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communication (MEIDECC)
NDE focal point	Nuku'alofa, Tonga
NDE contact information	paulm@mic.gov.to
Proponent focal point and organisation	Energy Division, Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communication (MEIDECC) Contact person: Dr. Tevita Tukunga, Director of Energy – ttukunga@gmail.com
Designer of the response plan	Energy Division, Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communication (MEIDECC) Contact person: Dr. Tevita Tukunga, Director of Energy – ttukunga@gmail.com
Implementer(s) of technical assistance	AD Solutions UG (haftungsbeschränkt), The Institute for Applied Material Flow Management, Ken Davey Consultant
Beneficiaries	▪ Tongan agricultural & fishing sectors ▪ Tonga's fledgling food processing/provision sector ▪ The Tongan business sectors ▪ Tongan society, especially Tongan youth ▪ The Tongan economy ▪ Tongans living and working abroad: Remittances from Tongans living and working abroad amount to 40% of GDP. However, as a result of Tonga's import dominant economy, led by imported energy and food, most of these remittances flow straight back out of Tonga in support of imports. ▪ NGO's engaged in Tonga. An agricultural and agri-industrial aligned circular economy strategy driven by Tonga's prolific and inexhaustible tropical photosynthesis resources and enabled by Anaerobic Digestion (biogas) will provide NGO's with a clear, nation-building strategy they can rally behind in support of substantive and meaningful socioeconomic development. ▪ The Tongan Government (support for strategic decision making)

Sector(s) addressed	✓ Renewable energy (all energy) ✓ Agriculture & fishing, ✓ Food and feed production, ✓ Food and feed processing, ✓ Fertiliser production & soil-based carbon sequestration, ✓ Industry, ✓ Land transport, ✓ Sea transport
Technologies supported	A modern, commercial biogas plant is a unique synergy of biological processes (Anaerobic Digestion) and a plethora technical systems. Beyond the direct technologies/systems that enable the production of the biogas and digestate, multiple layers of technologies and systems are enabled to be implemented within a Tongan circular economy linked to the utilisation of the biogas and digestate. These technologies and systems cover energy provision spanning all forms of energy: ✓ Baseload, dispatchable electricity generation, ✓ The provision of the full range of process energies (steam, hot-water, cooling, chilling, freezing, and drying), ✓ Fuel for land & sea transport. Applying the biogas and digestate to enable the development of a plethora of Tongan agricultural and agri-industrial aligned circular economy systems, with a particular initial focus on food and feed systems, will support the implementation of numerous, 'new-to-Tonga' technologies and systems.
Implementation start date	01/04/2020
Implementation end date	01/04/2021 – extended to 31/05/2022
Total budget for implementation	**149.470 USD**
Description of delivered outputs and products as well as the activities undertaken to achieve them. In doing so, review the log frame of the original response plan and refer to it as appropriate	▪ Detailed work plan based on the output of the kick-off meetings plus monitoring and evaluation plan ▪ Data collection about the local situation/ problems/ regulations/ tariffs, etc. ▪ Capacity building work to develop a higher level of circular economy and biogas understanding in Tonga and within Tonga's governmental institutions ▪ Focus on the Tongan youth during a video project supported by the Tongan National Youth Congress

Methodologies applied to produce outputs and products	The title of this project - '**Tonga circular economy project** – biogas feasibility study' – defines the context and in-tern the context defines the required methodologies. ▪ Undertake studies and surveys within an optimised material flow management, circular economy context to identify the availability of current and future substrates in support of a world-best-practice commercial scale biogas plant. ▪ Work closely with the Tongan 'Ministry of Agriculture Food and Forestry' (MAFF) to identify existing and future substate supply chains. Given the limited supply of existing substates, the optimised material flow management / circular economy strategy underpinning these future substrate supply chain investigations were focussed on establishing a platform to enable the development of a plethora of multifaceted, multi-element, agricultural and agri-industrial aligned circular economy systems to be driven by Tonga's tropical photosynthesis and enabled by anaerobic digestion, biogas, and digestate. ▪ Such systems would concurrently address multiple socioeconomic issues across food and feed provision, food and feed processing, local organic fertiliser production, and provision of all forms of 100% local renewable energy. ▪ These investigations were also driven by the knowledge that more than 50% of Tonga's rich agricultural land lays fallow and the vast majority of agricultural land in production only supports subsistence farming. ▪ Conduct capacity building in support of general biogas technologies and deliverables and follow up analysis of specific biogas systems/technologies relevant to Tonga ▪ Identify a viable lead biogas project (Deliverable 3) that could address current energy challenges in a substantive manner whilst concurrently enabling the development and implementation of multiple agriculture and agri-industrial aligned circular economy systems. ▪ Prepare GCF proposals in support of the lead project captured in Deliverable 3 which was endorsed by all relevant Tongan stakeholders.

	▪ Filming a video with the Tongan youth in cooperation with the Tonga National Youth Congress ▪ Undertaking a workshop with the Department of Energy, Department of Climate Change, Department of Environment, and numerous representatives and stakeholders from the Joint National Action Plan (JNAP) taskforce. The main goal was to provide the multi- stakeholder group with the most comprehensive review of the feasibility study and to highlight the methodical further development processes for the project. ▪ Extensive investigations of the main island of Tongatapu to short list possible sites for the proposed commercial scale biogas plant captured in Deliverable's 3 and 5 to be further investigated during the conceptual planning phase. An additional purpose of these investigations was to capture a pictorial snapshot of Tonga's energy dense tropical landscape driven by tropical photosynthesis.
Reference to knowledge resources	n.a.
Deviations	The starting date of the Tonga Circular Economy Project – Biogas Feasibility Study coincided with the start of the COVID-19 global pandemic. The challenges that this presented were substantial and the less than cooperative approach adopted by the Tongan Department of Energy exasperated these problems exponentially. The volcanic eruption and tsunami of January 2022 further amplified these challenges. Given these challenges, we were required to think, act, and work laterally in cooperation with a range of other Tongan stakeholders to source the information required to complete this study. To address the 'Capacity Building' aim of Deliverable 4, it was our intention to accompany a small delegation to Europe to visit worlds-best-practice, agriculturally aligned biogas plants. Instead, Deliverable 4 focussed on work to be undertaken on the ground in Tonga. This capacity building work aimed to develop a higher level of circular economy and biogas understanding with relevant Tongan stakeholders. A particular focus of this work concentrated on the Tongan youth with this youth focused work to be supported by the Tongan National Youth Congress.

	Additionally, with the direct support of MAFF, over 40 circular economy and biogas related community consultations were undertaken in 2019. These community consultations spanned the agricultural sector, the business sector, NGO's and the donor sector, the finance sector, and the broader Tongan society. The revised capacity building strategy will focus on revisiting these 40 plus community consultations armed with more, highly developed information and the detail of the specific Tongan project captured in Deliverables 3.
Anticipated follow-up activities and next steps	**The development path forward** The title of this project - '**Tonga circular economy project** – biogas feasibility study' – defines the context and in-tern the context defines the required development path. The commercial biogas plant captured in Deliverable 3 is to be the principle enabling element of a plethora of multifaceted, multi-element, agricultural and agri-industrial aligned circular economy systems to be designed, developed, and implemented in Tonga. As such, this biogas plant cannot be developed in isolation. In adherence with the principles of the circular economy, this biogas plant will enable these agricultural and agri-industrial aligned circular economy systems to exist, and in-turn these agricultural and agri-industrial aligned circular economy systems will enable this biogas plant to exist. The agricultural and agri-industrial aligned circular economy systems and the biogas plant are completely interdependent. Given this interdependence, the further development of the agricultural and agri-industrial aligned circular economy systems and this biogas plant must proceed concurrently as a single, integrated, and contiguous body of work based on the principles and dictates of the circular economy. Adherence to this fundamental point is essential to the success of both the circular economy systems and the biogas plant. Succinctly stated, there is no effective pathway to go from this feasibility study to a tender for a commercial biogas plant to be implemented in Tonga in support of the circular economy systems it will be intrinsically connected to and enabled by. Therefore, the further development of this biogas plant and the circular economy systems must transition concurrently through 3 phases. 1. Conceptual planning 2. Detailed planning, engineering, and consent authority approvals 3. Construction and commissioning

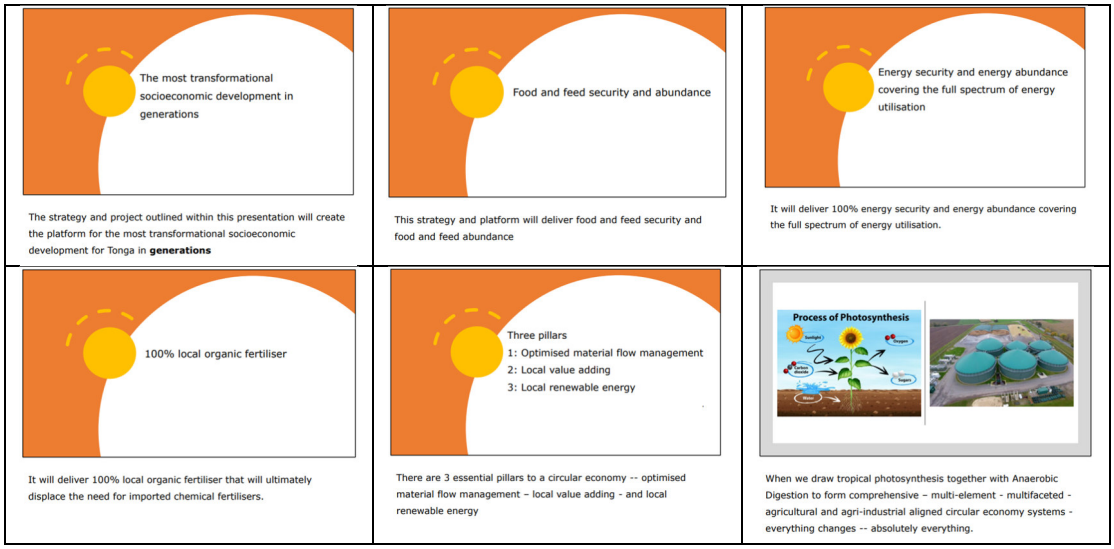
	The next and most important phase is the conceptual planning phase. Whatever is done or not done during the critically important and project defining conceptual planning phase will have whole-of-life implications on the circular economy systems and the biogas plant.

2. Lessons learned

	Lessons learned	**Recommendations**
Lessons learned from the CTCN TA process	*Describe lessons learned from following the steps of the TA process and interacting with the CTCN Secretariat. What were the challenges and essential factors contributing to successful implementation*	*Recommendations include* • *Steps which could be taken to improve the CTCN TA process* • *Considerations for increased success of similar efforts (i.e., regulatory, legal, stakeholders, communication, etc.)*
Lessons learned related to climate technology transfer	Biogas is often falsely portrayed as just a renewable energy system. Anaerobic Digestion, the passive biological process at the heart of a biogas plant, supports and delivers so much more than just renewable energy. This is eloquently and insightfully captured in the following phase taken from the IEA global benchmark document entitled: **'THE ROLE OF ANAEROBIC DIGESTION AND BIOGAS IN THE CIRCULAR ECONOMY':** "Biogas from anaerobic digestion is not merely a concept of production of renewable energy; it cannot be compared to a wind turbine or a photovoltaic array. Nor can anaerobic digestion be bracketed as just a means of waste treatment or as a tool to reduce greenhouse gases in agriculture and in energy. It cannot be pigeonholed as a means of producing biofertilizer through mineralisation of the nutrients in slurry to optimise availability, or as a means of protecting water quality in streams and aquifers. It is all these and more. The multifunctionality of this concept is its clearest strength.	The essential lesson that all parties should learn is that pursuing the development of modern, commercial scale biogas as merely a means of providing renewable energy is a flawed proposition. The promotion of modern, commercial scale biogas in developing countries must always be pursued with a comprehensive, country/situation specific, multifaceted, multi element circular economy context.

	Sustainable biogas systems include processes for treatment of waste, for protection of environment, for conversion of low-value material to higher-value material, for the production of electricity, heat and of advanced gaseous biofuel (biomethane).	

3. Illustration of the TA and photos



Selected slides of the presentations

JNAP meeting 26th of May 2022

Tongan youths involved in the video production

Tongan youths involved in the video production

Tongan youths involved in the video production

Indoor element of the workshop with Tongan youths

4. Impact Statement

Challenge	Due to its geographical location and topography, Tonga is one of the most vulnerable countries to climate change. However, Tonga's socioeconomic reality means it's one of the least capable countries to deal with the effects of climate change. This project captured within the feasibility study seeks to substantially change Tonga's current reality and set in motion a transition to an equitable, prosperous, fully sustainable, and largely self-determined circular economy.
CTCN Assistance	▪ Explore the feasibility of generating base load energy at an industrial scale of 0.5 MW from the biogas to diversify the energy source and accelerating the renewable energy transition. ▪ Support for GCF proposal development and apply for implementation of the biogas project under other international funding mechanisms.
Anticipated impact	▪ Increase of economic, health, well-being, infrastructure and built environment, and ecosystems resilience to climate change impacts as a result of TA (CI-2) ▪ Job creation through biomass production, waste management mechanisms and industrial scale biogas plant ▪ Develop energy security within the community, reduce fossil fuel dependability and reduce CO_{2e} emissions
Co-benefits: Achieved or anticipated co-benefits from the TA	▪ Resource availability and sustainability ▪ Review of optimum biogas technologies suitable for the study area ▪ Capacity development ▪ Procure services and technology to implement biogas-based plant
Gender aspects of the TA	▪ The feasibility study will look at the ways in which men, women, children, and disadvantaged parties can contribute to and benefit from the project (A 3.1 and 3.2 for Output 3) ▪ The consulting meeting and training workshops planned under the TA will address the gender aspects of the project
Anticipated contribution to NDC	▪ The NDC of Tonga has emphasized on energy generation from renewable sources to reduce the GHG emission from fossil fuel-based electricity sector which has high share of GHG emission about 23% ▪ The energy efficiency is also emphasized under other various national plans in Tonga Strategic Development Framework, National Climate Change Policy and Tonga Energy Roadmap
The narrative story	Due to its geographical location and topography, Tonga is one of the most vulnerable countries to climate change. However, Tonga's socioeconomic reality means it's one of the least capable countries to deal with the effects of climate change. This project seeks to substantially change Tonga's current reality and set in motion a transition to an equitable, prosperous, fully sustainable, and largely self-determined circular economy. Tonga's reliance on imported energy, in the form of fossil fuels, along with imported food, feed, and chemical fertilisers in ever increasing amounts dominates the Tongan economy. Compounding this entrenched unsustainability is the continual, debilitating loss of human capital. Driven by economic necessity, more Tongans live and work abroad than live and work in Tonga and this drains Tonga of its essential human capital.

	Agriculture is at the core of the Tongan economy. However, over 50% of Tonga's rich agricultural land lays fallow and the vast majority of land that is in service is used for subsistence agriculture adding little value to the country's economic output or food security. Additionally, Tonga's manufacturing sector is minimal and accounts for less than 3% of GDP. In 2019 total imports (USD$267million) were 13 times greater than exports (USD20.3million) and dominating these imports are energy and food. As a percentage of GDP, Tonga relies more on remittances than any other country with remittances making up approx. 40% of the Tongan economy. What is particularly disabling about Tonga's unsustainable, import dominant, linear economy is that most of the remittances sent home in support of family and friends flow straight back out again in support of imported energy, food, feed, chemical fertilisers, and other products. To reduce its dependency on imported fossil fuels and reduce GHG emissions, Tonga set a target to generate 70% of its electricity from renewable sources by 2030. Currently, Tonga's renewable electricity generation is achieved via Solar PV and Wind. However, these intermittent generation sources cannot provide the baseload, dispatchable electricity and grid support services required to support Tonga's small, Islanded electricity grids. Additionally, these fully imported, intermittent electricity generation systems offer minimal local employment opportunities. A further shortcoming of intermittent PV and Wind is their inability to effectively address the critically important issue of access to commercial quantities of affordable and reliable process energies. In a country that cannot feed itself because it has no capacity to process food or feed, access to commercial quantities of sustainable, affordable, and reliable thermally based process energies is as important as renewable electricity. In 2017/18, at the request of the Tonga Government, the 'Climate Technology Centre and Network' worked closely with the Tongan Energy Department to develop a 'Tonga Energy Efficiency Master Plan' (TEEMP). The TEEMP report showed that in 2017 imported fossil fuels dominated the Tongan energy sector and therefore dominated the Tongan economy. What the TEEMP report also showed is that after achieving a 70% renewable electricity target by 2030 through the continued rollout of PV and Wind, along with the adoption of every energy efficiency measure recommended in the TEEMP report, the post 2030 Tongan economy will still be dominated by imported fossil fuels. Therefore, something far more substantial and socioeconomically engaging, enabling, and empowering is required to shift the Tongan economy and society onto a sustainable development footing that concurrently and comprehensively addresses multiple socioeconomic development challenges. This is the essence of an agricultural and agri-industrial aligned circular economy strategy that is driven by tropical photosynthesis and enabled by commercial scale, best-practice, Anaerobic Digestion.

Contribution to SDGs	**GOAL 5: Gender Equality** ▪ Achieve gender equality and empower all women and girls. - TA will generate equal opportunities in farming and processing **GOAL 6: Clean Water and Sanitation** ▪ Ensure availability and sustainable management of water and sanitation for all - Circular economy approach ensures the optimum use of resources with least wastage **GOAL 7: Affordable and Clean Energy** ▪ 7.1- By 2030 ensure universal access to affordable, reliable, and modern energy services - Biogas based generation will increase the access to affordable, reliable, and modern energy services **GOAL 12: Responsible Consumption and Production** ▪ Ensure sustainable consumption and production patterns - Circular economy approach will enable the sustainable consumption and production patterns **GOAL 13: Climate Action** ▪ 13.b - Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth, and local and marginalized communities - Promote capacity development in Tonga, which is a SIDS, including focusing on women, youth, and local and marginalized communities

CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

Annex 1 Technical assistance data collection

Please add quantitative and qualitative values for the indicators selected in the M&E plan and monitored throughout the technical assistance in the tables below. Indicators which have been monitored in addition to the proposed indicators below may be added at the end of table A. Non-relevant indicators should be left blank.

A. Output and outcome indicators

Indicator Please note indicators below highlighted as **anticipated**	**Quantitative value** *Numerals only; disaggregates must sum to the total*	**Qualitative description** *List the various elements corresponding to the quantitative value as well as timelines and responsible institutions*
Total number of events organized by proponents and implementing partners	*13*	
Number of participants in events organized by proponents and implementing partners	*72*	
a) Number of men	*26*	
b) Number of women	*34*	
Number of climate technology RD&D related events		
Number of participants in climate technology RD&D events	*List total number here*	
a) Number of men		
b) Number of women		
Number of trainings organized by proponents and implementing partners	*List total number here*	*List the title of the training sessions and capacity strengthening activities*
Number of participants in trainings organized by proponents and implementing partners	*1*	
a) Number of men	**10**	
b) Number of women	**7**	
Total number of institutions trained	*4*	
a) Governmental (national or subnational)	**4**	*Department of Energy, Department of Climate Change, Department of Environment, representatives and stakeholders from the Joint National Action Plan (JNAP) taskforce*
b) Private sector (bank, corporation, etc.)		*List the name of organisations trained here*
c) Nongovernmental (NGO, University, etc.)		*List the name of organisations trained here*
Percentage of participants reporting satisfaction with CTCN training (from CTCN training feedback form)		*Satisfied= 4+ on 5-pt scale*
Percentage of participants reporting increased knowledge, capacity and/or understanding as a result of CTCN training (from CTCN training feedback form)		*Increased knowledge, capacity and/or understanding= 4+ on 5-pt scale*

a) Percentage of men		
b) Percentage of women		
Total number of deliverables produced during the assistance (excluding mission, progress and internal reports)	*2*	
a) Number of communication materials, including news releases, newsletters, articles, presentations, social media postings, etc.		*List the name of the documents*
b) Number of tools and technical documents strengthened, revised or developed		*List the name of the documents*
c) Number of other information materials strengthened, revised or created (For example training and workshop reports, Power Points, exercise docs etc.)	**2**	*"Tonga biogas and CE part 1 and part 2" (Attachment B and C)*
Total number of policies, strategies, plans, laws, agreements or regulations supported by the assistance	*List total number here*	
a) Adaptation related		*List the type and name of documents supported*
b) Mitigation related		*List the type and name of documents supported*
c) Both adaptation- and mitigation related		*List the type and name of documents supported*
Anticipated number of policies, strategies, plans, laws, agreements or regulations proposed, adopted or implemented as a result of the TA	*List total number here*	
a) Adaptation related		*List the type of documents anticipated to be proposed, adopted or implemented*
b) Mitigation related		*List the type of documents anticipated to be proposed, adopted or implemented*
c) Both adaptation- and mitigation related		*List the type of documents anticipated to be proposed, adopted or implemented*
Anticipated number of technologies transferred or deployed as a result of CTCN support	7	Renewable energy resource mapping Grid integration for renewables Switch from fossil fuel to biomass Biogas for heating Biomass for heating Energy supply from waste Biogas power
Anticipated number of collaborations facilitated or enabled as a result of technical assistance	*List total number here*	
a) Number of South-South collaborations		*List the names of the organisations (excluding the CTCN or TA implementers)*
b) Number of RD&D collaborations		*List the names of the organisations (excluding the CTCN or TA implementers)*
c) Number of private sector collaborations		*List the names of the organisations (excluding the CTCN or TA implementers)*

Number of countries with strengthened National System of Innovation as a result of CTCN support		*List names of countries*
Insert any additional indicators here		

B. Core impact indicators

Please fill in the tables for anticipated impacts of the CTCN assistance. Every technical assistance should contribute to at least one of the indicators below. For guidance on how to report on core indicators see the '[M&E Guidance Document for TA Implementers']'.

Core indicator 1	**Anticipated metric tons of CO_2 equivalent (CO_2e) emissions reduced or avoided as a result of CTCN TA** *Please add your calculations in word or excel format as an Annex to this Closure Report, where applicable.*	
	Anticipated metric tons of CO_2e reduced or avoided as a result of the TA **on annual basis**	Anticipated metric tons of CO_2e reduced or avoided as a result of the TA **in total**
Quantitative value *(emissions reductions)*	*Total number (numerals only, no rounding or abbreviations)*	*Total number (numerals only, no rounding or abbreviations)*
Unit	tCO_2e	tCO_2e
GHG assessment boundary (project emissions) Identify expected post-TA activities, associated effects and assess boundary for quantification of GHG emission reductions	133.250 (energy production) 6.734 (replacing LPG) Total: **139.984**	**2.799.682**
Baseline emissions Describe baseline scenario, baseline candidates, emission factors and emissions calculated		
Methodology Explain the method or process of verifying the indicator and how data was gathered	Using Tonga's specific CO_2 emission factor of 533 g CO_2e/kWh for firm energy, the total number of CO_2e was calculated. While generating 25 million kWh in a 3.2 MW biogas plant, 133.250 tCO_2e can be avoided. Annual emissions of the transport sector can be reduced by replacing 2.500 t imported LPG with generated biogas. Therefore, 6.734 tCO_2e can be avoided.	Based on the biogas plant's estimated lifetime of 20 years, the biogas plant will produce enough energy whilst 2.779.682 t CO_2e can be avoided during this time.
Assumptions		

Describe assumptions made during calculation and quantification of GHG reductions		

Core indicator 2	**Anticipated increased economic, health, well-being, infrastructure and built environment, and ecosystems resilience to climate change impacts as a result of TA** *Please provide a **qualitative** description of the anticipated impacts on the categories below*
Infrastructure and built environment Anticipated increased infrastructure resilience (avoided/mitigated climate induced damages and strengthened physical assets)	
Ecosystems and biodiversity Anticipated increased ecosystem resilience (areas with increased resistance to climate-induced disturbances and with improved recovery rates)	
Economic Anticipated increased economic resilience (e.g., less reliance on vulnerable economic sectors or diversification of livelihood)	
Health and wellbeing Anticipated increased health and wellbeing of target group (e.g., improved basic health, water, and food security)	

Core indicator 3	**Anticipated number of direct and indirect beneficiaries as a result of the TA**	
	Quantitative value	**Means of verification**
Total beneficiaries	Total population of Tonga (100,000 people)	The globally mature biogas sector and its inherent and enabling connections to multi-faceted, multi-element agricultural and agri-industrial aligned circular economy systems is well understood and well documented against many decades of project implementations on a global basis. Through adherence to a comprehensive circular economy strategy, the proposed Tongan project has been purposely designed to concurrently address a plethora of renewable energy, socioeconomic, environmental, and mitigation benefits. These benefits will in-tern positively impact every member of Tongan society.
Number of adaptation beneficiaries	Total population of Tonga	
Number of mitigation beneficiaries	Total population of Tonga	
Number of adaptation-and mitigation beneficiaries	Total population of Tonga	

Core indicator 4	**Anticipated amount of funding/investment leveraged (USD) as a result of TA (disaggregated by public, private, national, and international sources, as well as between anticipated/confirmed funding)**			
	Quantitative value confirmed *in USD*	**Quantitative value anticipated** *in USD*	**Qualitative description** *List the institutions, timelines, and description or title of the investment*	**Methods** *Describe methods used for quantification of funds leveraged*
Total funding	*Total number in USD (numerals only, no rounding or abbreviations)*	*Total number in USD (numerals only, no rounding or abbreviations)*		
Anticipated amount of public funding mobilised from national/domestic sources				
Anticipated amount of public funding mobilised from international/ regional sources		32.840.000	GCF (Green Climate Fund), Asian Development Bank	The amount of required funding was estimated in regards of the conducted feasibility study as well as invited offers for technical equipment.
Anticipated amount of private funding mobilised from national/domestic sources				
Anticipated amount of private funds mobilised from international/regional sources				