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ESMAP
Energy Sector Management Assistance Program

Solar Resource Mapping in Zambia

PHASE 2 IMPLEMENTATION REPORT

NOVEMBER 2015

This report was prepared by Geomodel Solar, under contract to The World Bank.

It is one of several outputs from the solar resource mapping component of the activity "Renewable Energy Resource Mapping and Geospatial Planning – Zambia" [Project ID: P145271]. This activity is funded and supported by the Energy Sector Management Assistance Program (ESMAP), a multi-donor trust fund administered by The World Bank, under a global initiative on Renewable Energy Resource Mapping. Further details on the initiative can be obtained from the ESMAP website.

This document is an **interim output** from the above-mentioned project. Users are strongly advised to exercise caution when utilizing the information and data contained, as this has not been subject to full peer review. The final, validated, peer reviewed output from this project will be the Zambia Solar Atlas, which will be published once the project is completed.

ESMAP Solar Resource Mapping for Zambia

Phase 2 Implementation Plan − DRAFT

Renewable Energy Resource Mapping and Geospatial Planning – Zambia P145271

November 2015

Lead contractor: GeoModel Solar, Slovakia

Subcontractors: GeoSUN Africa, South Africa

SGS Inspection Services Ltd, Zambia

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1 INTRODUCTION

1.1 Background

This report is prepared within the project *Renewable Energy Mapping: Solar Zambia*. This project focuses on solar resource mapping and measurement services as part of a technical assistance in the renewable energy development implemented by the World Bank in Zambia. It is being undertaken in close coordination with the Department of Energy (DoE) of Zambia, the World Bank's primary country counterpart for this project, and Zambia Meteorological Department (ZMD).

This project is funded by the *Energy Sector Management Assistance Program* (ESMAP), administered by the World Bank and supported by bilateral donors.

1.2 Objectives and approach

Phase 2 has to deliver high quality solar resource measured data that are needed for **validation of solar resource and meteorological models**. Central in this effort is a focus on reducing uncertainty of the models and thus reducing financial and technical risk during implementation of photovoltaic solar power plants in Zambia.

Second objective is to **build a network of solar measuring stations** and to implement a **longterm and sustainable solar resource monitoring program** as one of support mechanisms for development and operation of solar power infrastructure in Zambia.

This report provides information on implementation of two-year solar measurement campaign including:

- Introduction (Chapter 1)
- Information on the consortium members (Chapter 2)
- Role of the project partners in Zambia (Chapter 3)
- Details of the solar measuring stations, such as position, equipment, layout, etc. (Chapter 4)
- Planned tasks to ensure sustainable quality of the measured data (Chapter 5)
- Proposed capacity building and training targeted to the local partners and sub-contractor (Chapter 6)
- Time table of Phase 2 (Chapter 7)
- Assessment of risks and appropriate mitigation measures (Chapter 8),
- Procedure for obtaining permits and local permission (Chapter 9).

This proposal for implementation of ESMAP Zambia Phase 2 follows the methodology described in the offer and elaborates on the details.

Assuming that this *Phase 2 Implementation Plan* will be approved in October 2015, the procurement of the solar radiation measurement stations can follow immediately, and we expect to complete the installation and commission all the 6 stations latest by mid December 2015. The first annual site resource report shall be delivered by end of December 2016, whereas the second annual site resource report will be delivered by end of December 2017. Recalibration and take over of the equipment by the host or other dedicated organisation is planned for January 2018.

1.3 Technical consultations

This Plan is a result of consultation based on the delivered *Site Selection Report* in November 2014, where we identified the most suitable host and sites for installing and long-term operation of one Tier 1 and five Tier 2 Solar Measuring Stations.

During and following the workshop, held in Lusaka on 9 to 12 December 2014, where representatives of all stakeholders were present, the decision about location of six meteo stations and hosts was made.

The host of Tier 1 station is UNZA School of Agricultural Sciences, the hosts of other five stations will be ZARI and ZMD. Alternatively, one of the five stations will be located at Lusaka South Multi-Facility Economic Zone (LS-MFEZ).

2 ROLES OF CONSORTIUM MEMBERS

The campaign will be managed in collaboration of three consortium members. The roles and responsibilities of the consortium members are distributed as follows:

GeoModel Solar, Slovakia (Project leader)

- Supervision of the project
- Control of tasks, time plan, finance, and deliveries
- Independent quality control of the data
- Delivery of Annual Solar Resource Reports and data for each of six sites
- Training and capacity building
- Transfer of the ownership to a new owner at the end of the project
- Visits according to the plan

GeoSUN Africa, South Africa (Responsible for Phase 2 measurements)

- Supervising tasks within Phase 2 and supervising local partner
- Procurement, import administration, calibration, testing
- Installation and commissioning of solar measuring stations and all the equipment
- Daily control of operation and quality control
- Regular visits and service of solar measuring stations over the period of two years
- Delivery of monthly and annual data and site reports
- Calibration verification after 12 months and calibration after 24 months
- Training and capacity building
- Transfer of the ownership to a new owner at the end of the project, or decommissioning

SGS Inspection Services, Zambia (Local partner)

- Import administration
- Support to the installation and routine maintenance
- Regular and ad-hoc visits, control and communication

3 PROJECT PARTNERS IN ZAMBIA

Zambia Meteorological Department (ZMD)

ZMD is natural project partner, as this is specialized meteorological agency in the country.

The main mission of ZMD is to monitor, predict and provide reliable, timely accurate and user-friendly weather and climate products and services for sustainable socio-economic development through collaboration with other stakeholders. In support of this mission statement, the goal of ZMD is "to improve its products and services to its clients by restoring its human resource base, observation network, communications infrastructure, data analysis and dissemination as well as its linkages with reputable regional and international climate centres.

In the ESMAP Solar project, ZMD will host three Tier 2 solar measurement stations in their premises and will take care of daily operation and cleaning of these stations.

Zambia Agriculture Research Institute (ZARI)

ZARI is the largest Agricultural research entity in the country. It has 10 research stations with Mt. Makulu Central Research Station being the institutes Headquarters. The Institutes overall objective is to develop and adapt crop, soil and plant protection technologies and to provide a high quality, appropriate and cost effective service to farmers.

ZARI operates several meteorological stations of ZMD on their research stations. As the potential public customer of solar and meteorological data, ZARI indicated their willingness to host solar measurement stations and to give support and own the station after two years.

The local ZMD staff operating meteorological stations at the ZARI sites expressed their support and willingness to participate in training and looking after the equipment. The existing meteorological stations are operated mostly in a manual mode, and the readings are taken every hour.

ZARI will host two Tier 2 solar measuring stations on their own and three Tier 2 stations in collaboration with ZMD (where ZMD sites are co-located with ZARI research stations).

School of Agricultural Sciences at University of Zambia (UNZA)

UNZA, located in Lusaka is an educational institution delivering the mandate of training in higher education since 1965.

At the present circumstances, UNZA has one meteorological station located in the school ground and performs measurements for the research and educational purposes. Installation of additional solar measurement instruments is highly appreciated by the university representatives, who assured the availability of staff for daily operation, maintenance and cleaning of instruments

UNZA will host one Tier 1 solar measuring station at the premises of School of Agricultural Services.

Notes

Staff of ZMD, ZARI and UNZA will receive regular training from GeoSUN Africa and GeoModel Solar to master the skills and routines for running these stations beyond time period of ESMAP project measurement mission (2 years).

Upon joint agreement between the World Bank and Department of Energy of Zambia, one of the Tier 2 stations will be moved to a new site: Lusaka South Multi-Facility Economic Zone (LS-MFEZ).

4 SOLAR MEASUREMENT STATIONS

As a result of discussion with representatives of Zambia Department of Energy (Client) and the World Bank at the end of Phase 1 workshop and during the following weeks, the final decision on measurement stations was taken.

In Zambia, **five Tier 2 and one Tier 1 solar measuring stations** will be installed at sites that are selected based on the preliminary Site Selection Report, elaborated by the Consultants, preferences of the Client, and strategic goals of the World Bank.

For a successful Phase 2 measuring campaign, the following factors are considered:

- The measurements are primarily used for validation of meteorological models and for detailed and accurate description of the solar climate. Therefore the measurements must be measured by high accuracy instruments.
- The equipment must be diligently controlled and maintained; regular cleaning of sensors must be applied. Data cleaning should be systematic and logged.
- Redundant sensors have to be used for rigorous quality control:
    - In case of Tier 2 configuration the installation of one secondary standard pyranometer to measure global horizontal irradiance and one Rotating Shadowband Radiometer (RSR) to measure global horizontal and diffuse horizontal irradiance.
    - In case of Tier 1 configuration the installation of two secondary standard pyranometers to measure global and diffuse horizontal irradiance and one pyrheliometer to measure direct normal irradiance.
- Data should be quality checked on a continuous basis and erroneous values should be flagged to avoid use of data, not passing through QC, in validation and/or calibration of models.
- Regular scheduled visits are planned to see each solar measuring station, every six months, to control the procedures and the state of the equipment. Common issues will be checked such as instrument misalignment, issues with PV power supply, battery failures or with data logger.
- Measurement instruments must be protected against damage or destruction. Premises of the ZMD, ZARI and UNZA have been selected as an optimum location to ensure high security and safety. Alternatively a secure location at LS-MFEZ will be identified.

The solar measuring stations will run autonomously with regular cleaning and will have a data capture recovery higher than 95%.

4.1 Position of solar measuring stations

Based on the delivered *Site Selection Report* and the following consultations, it was decided that six sites, suitable for installation of solar measuring stations will be located within the premises of the above-mentioned institutions (Table 2.1, Figure 2.1).

Besides the good geographical distribution, this choice also fits well to the population centres, where larger solar installations are potentially deployed. Having a solar measuring station there will be beneficial for financing the power plants nearby:

- The Tier 1 site is located in the Lusaka within the city. The strong interest of the University for the ESMAP work program, and motivation, highly qualifies this site for hosting Tier 1 station
- The Chilanga site is located in the Mount Makulu ZARI Head Quarters Research station will be exposed to visitors and used for educational purposes. The local meteo site is operated by ZMD. Alternatively, this Tier 2 station will be installed to LS-MFEZ site where a utility scale power plant is to be developed.
- Other four Tier 2 solar measuring stations will be distributed in the country at locations, which represent different geographical and meteorological conditions. The site selection respects the need for solar data validation:

- Longe and Mutanda sites are managed by ZARI Research Stations
- Mochipapa and Misamfu sites are located at ZARI Research Stations and managed by ZMD

The selected sites fulfil the criteria for the operation and maintenance of the solar measuring stations:

- Availability of free horizon,
- Availability of GSM networks,
- Availability of local work force for maintenance,
- Easy to access and high level of security.

Table 4.1: Proposed location of six solar measuring stations

ID	Site name	Rank	Nearest town	Host	Latitude	Longitude	Elevation
1	Lusaka	Tier 1	Lusaka	UNZA	-15.39461	28.33722	1262
2	Mount Makulu**	Tier 2	Chilanga	ZARI/ZMD	-15.5483	28.2482	1224
3	Mochipapa	Tier 2	Choma	ZARI/ZMD	-16.8382	27.0703	1282
4	Longe	Tier 2	Kaoma	ZARI	-14.8397	24.9319	1167
5	Misamfu	Tier 2	Kasama	ZARI/ZMD	-10.1726	31.2231	1382
6	Mutanda	Tier 2	Solwezi	ZARI/ZMD	-12.4236	26.2153	1317

** Upon agreement between the World Bank and Zambian Department of Energy, this solar measuring station may be installed at different site: Lusaka South Multi-Facility Economic Zone (LS-MFEZ).

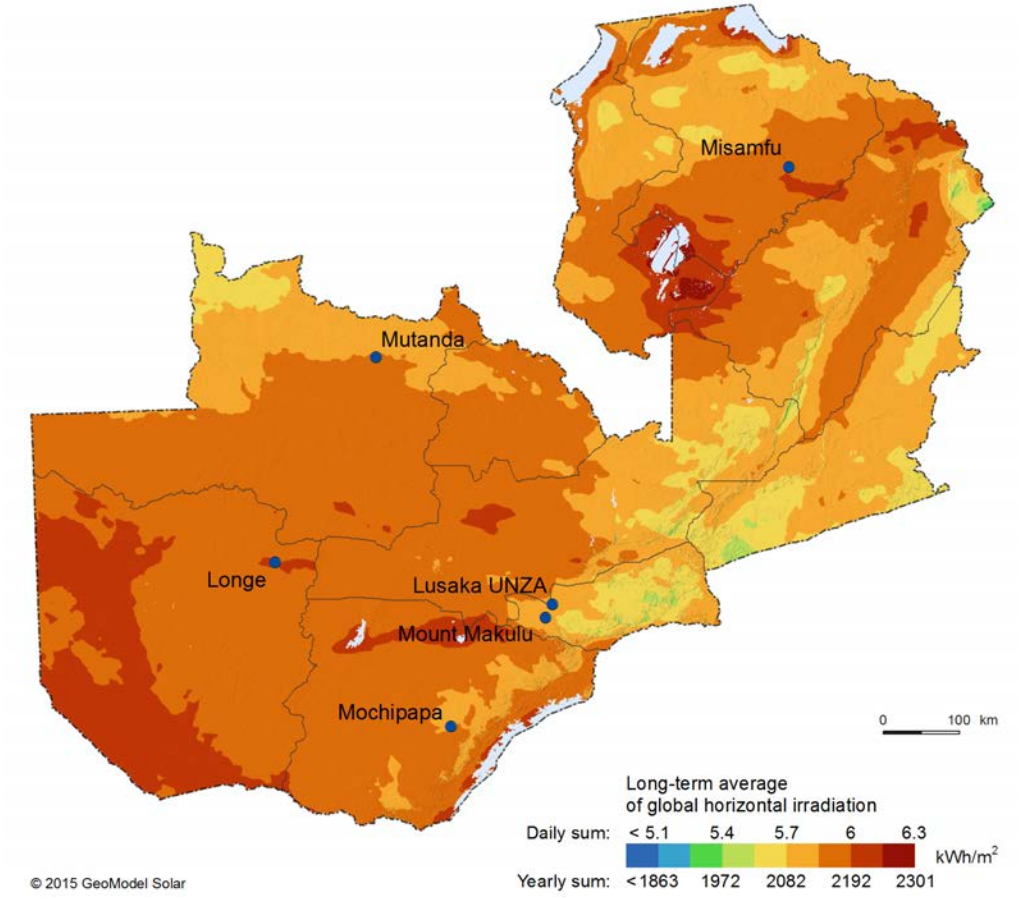

Figure 4.1: Position of six solar measuring stations in Zambia
in the context of global horizontal irradiation .

4.2 Solar and meteorological equipment

GeoSUN is responsible for procurement of the agreed equipment. The following are the planned activities:

- Equipment will be ordered, assembled and tested before shipping
- All measurement equipment will include factory calibrations. Documentation for each meteo station will be prepared, describing the technical details and the initial calibration protocols.
- Equipment will be packed and shipped to Zambia. Documentation will be prepared for successful custom clearance, which will be responsibility of GeoSUN and SGS Inspection Services
- Site preparation (foundations) will be started.
- Installation of solar measuring stations at the sites and creation of site installation reports.

After successful testing, the equipment will be shipped to a central storage place in Zambia. From there, all equipment will be sent to the sites and installed.

The station shall be designed in a way to work well under the tropical climate. Technical elements that are considered in the design of meteo stations to tackle harsh environmental conditions:

- High quality and proven measurement sensors
- High temperature: pyranometers and RSR equipped are with thermometers at the sensor heads to monitor and allow proper correction of temperature drifts.
- Heating of pyranometers to minimize dew on dome
- Use of weather proof electronic casings with high protection class
- Good maintenance by local staff: daily cleaning and check of levelling for thermopile instruments and at least three times a week cleaning of RSR.
- Lean and elevated installation of equipment on tripod to prevent damage from flooding,
- Shielding from radio frequency interference and protection from lightning strikes by grounding masts and tripods by single point groundings with a copper rod deep in the ground. Low voltage cables are using twisted pair technology and are physically isolated from the power cables.

Table 4.2: Equipment to be installed at solar measuring stations

Equipment	Meteo station	
	Tier 1	Tier 2
2-axis Solar Tracker SOLYS2, GPS controlled with sun sensor	x	-
Data logger with memory for storing at least 3 months of data	x	x
GPRS Modem	x	x
PV panel, battery, charge regulator	x	x
Weather proof cabinet	x	x
Lightning protection kit	x	x
Height of wind mast	10 m	3 m
Mounting material, casing, cabling & other accessories	x	x

Table 4.3: Technical parameters of instruments for Tier 1 solar measuring station

Instrument	Parameter	Technical specifications			
		Range	Accuracy	Response Time	Height
Thermopile Pyranometer (Secondary Std.)	Global Horizontal Irradiance (GHI)	0.3 - 2.8 µm, -40 to +80°C	<2% daily uncertainty	≤ 5s	-
Thermopile Pyranometer (Secondary Std.)	Diffuse Horizontal Irradiance (DIF)	0.3 - 2.8 µm, -40 to +80°C	<2% daily uncertainty	≤ 5s	-
Thermopile Pyrheliometer (First class)	Direct Normal Irradiance (DNI)	0.2 - 4 µm, -40 to +80°C	<1% daily uncertainty	≤ 5s	-
Ambient Temperature and Relative Humidity	Air Temperature	-40° to +60°C	±0.6°C	-	2 m
	Relative Humidity	0 – 100%	0° to +40°C: ±3% (0-90%) ±5% (90-100%)	-	2 m
Pressure Sensor	Barometric Pressure	500...1100 hPa	±0.3 mb @ +20°C (±0.6 mb @ 0° to 40°C)	500 ms	1 m
Anemometer	Wind Speed	0 – 100 m/s	±0.3 m/s	-	10 m
Wind Vane	Wind Direction	0 - 360°	±5°	-	10 m
Rain Gauge	Rain		1%		-

Table 4.4: Technical parameters of instruments for Tier 2 solar measuring station

Instrument	Parameter	Technical specifications			
		Range	Accuracy	Response Time	Height
Thermopile Pyranometer (Secondary Std.)	Global Horizontal Irradiance (GHI)	0.3 - 2.8 µm, -40 to +80°C	<2% daily uncertainty	≤ 5s	-
Thermopile Pyranometer (Secondary Std.)	Diffuse Horizontal Irradiance (DIF)	0.3 - 2.8 µm, -40 to +80°C	<2% daily uncertainty	≤ 5s	-
Thermopile Pyrheliometer (First class)	Direct Normal Irradiance (DNI)	0.2 - 4 µm, -40 to +80°C	<1% daily uncertainty	≤ 5s	-
Ambient Temperature and Relative Humidity	Air Temperature	-40° to +60°C	±0.6°C	-	2 m
	Relative Humidity	0 – 100%	0° to +40°C: ±3% (0-90%) ±5% (90-100%)	-	2 m
Pressure Sensor	Barometric Pressure	500...1100 hPa	±0.3 mb @ +20°C (±0.6 mb @ 0° to 40°C)	500 ms	1 m
Anemometer	Wind Speed	0 – 100 m/s	±0.3 m/s	-	10 m
Wind Vane	Wind Direction	0 - 360°	±5°	-	10 m
Rain Gauge	Rain		1%		-

Note:

- Wind direction measurement equipment was not requested in the TOR for Tier 2 stations, but included within the project budget
- Rain measurement equipment was not requested in the TOR but included within the project budget (automatic tipping bucket rain gauges)

4.3 Site layout at the measurement stations

For proper installation, operation and maintenance of the stations over a longer period the construction will be fixed to the ground by the help of concrete foundation. Due to the compact design of our Tier 1 stations, the actual area required are less than 10 x 10 metres. The final choice of the position will consider the actual situation of the existing meteo station and the best fit. The Tier 2 station requires an area of approx. 3 x 3 metres.

4.4 Detailed description of solar measurement stations

General description of all sites: The sites are located within premises of the existing meteorological measurement stations with restricted movement of unauthorized personnel, which ensures higher level of security. All meteorological stations have permanent presence of local ZARI, ZMD or UNZA staff.

4.4.1 UNZA, School of Agricultural Sciences

Short name	Description	Latitude	Longitude	Elevation
UNZA Lusaka	Campus of UNZA, existing meteo station in the test field close to university buildings	-15.39461	28.33722	1262

Description of the site:

- The site is located in the Lusaka campus of the University of Zambia (UNZA), which is located in the neighbourhood of the city.
- At the site there is a meteorological station, which is owned and operated by the School Agricultural Sciences. It is located at the test fields of the University about 150 m from the office buildings.
- The site is considered suitable for the installation of a Tier 1 solar and meteorological measurement station
- There is availability of local support and good access (within 20 minutes of international airport)
- UNZA demonstrated strong interest and motivation for the solar measurement work program, and this site qualifies for hosting Tier 1 station.

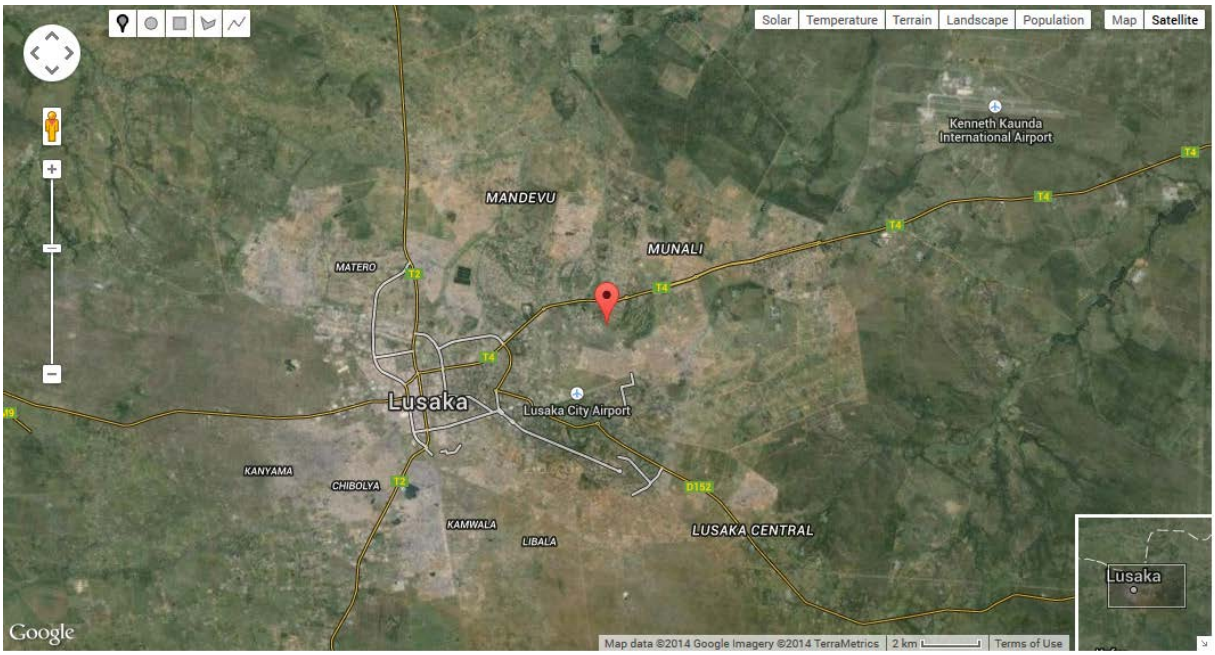

Figure 4.4: Location of UNZA site relative to the extent of Lusaka

Figure 4.5: Existing meteorological station at UNZA, School Agricultural Sciences

Like with all sites in Zambia the East and West horizons are the most critical in terms of shading due to the relative low latitude (the sun sits relatively high in the sky during winter). No nearby obstructions are at this site and the horizon is clear.

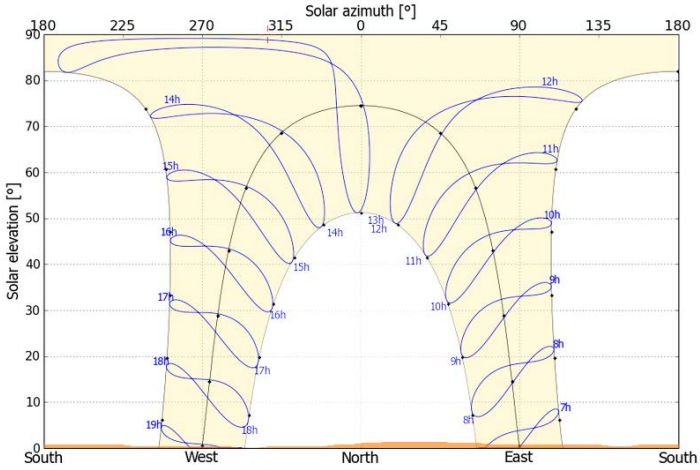

Figure 4.6: Sunpath and shading at the site

Figure 4.7: Sunpath at the site

4.4.2 Mount Makulu, ZARI Headquarters

Short name	Description	Latitude	Longitude	Elevation
ZARI Mount Makulu (Chilanga)	Premises of ZARI research station, existing operational meteo station ZMD at the site	-15.5483	28.2482	1224

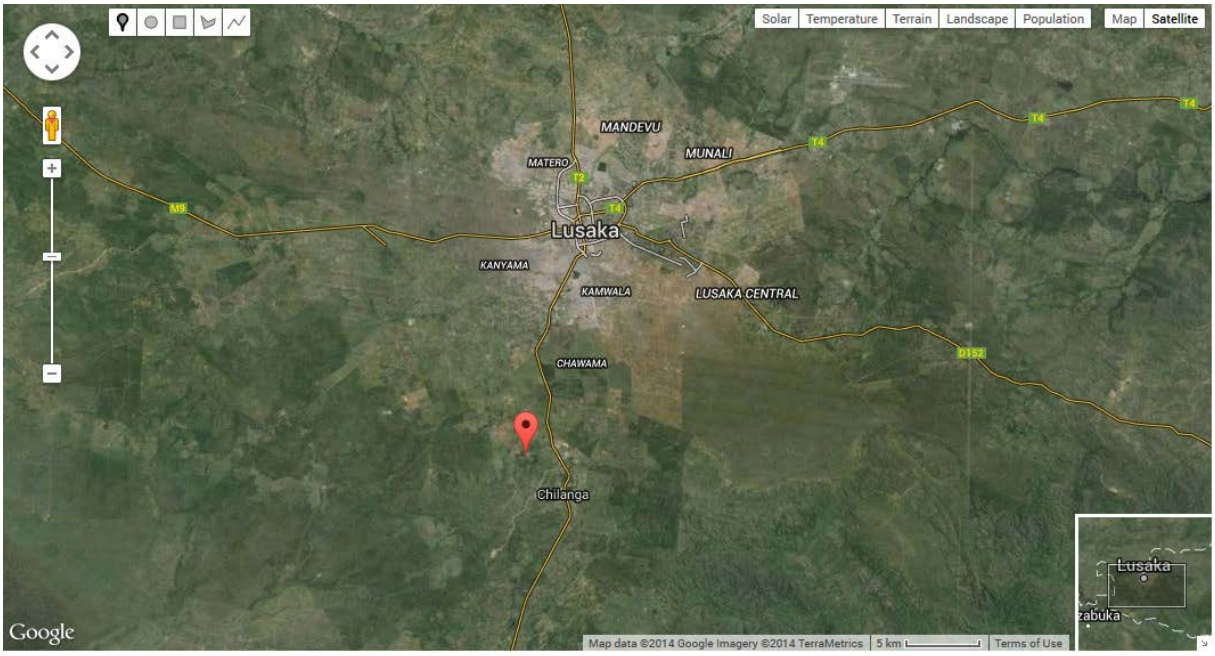

Figure 4.8: Location of Mount Makulu (Chilanga) site, relative to Lusaka

Figure 4.9: Existing meteorological station

Description of the site:

- Site is located in the Mount Makulu Research station, close to Chilanga town
- There is a meteorological station, at the site, operated by Zambia Meteorological Department (ZMD)
- The site located on the outskirts of Lusaka on the road connecting Lusaka with Livingston in the South
- The site is suitable for the installation of a solar and meteorological measurement station of Tier 2
- ZARI is willing to host the station and to give support and own the station after two years. They also indicated the usefulness and their need for the data.
- The ZMD representative expressed his support and willingness to participate in training and looking after the equipment.

The site slopes at 1° in the NE direction, which causes a slightly early sunset. Few trees on the East and West and thin power cable are the only obstructions at this site.

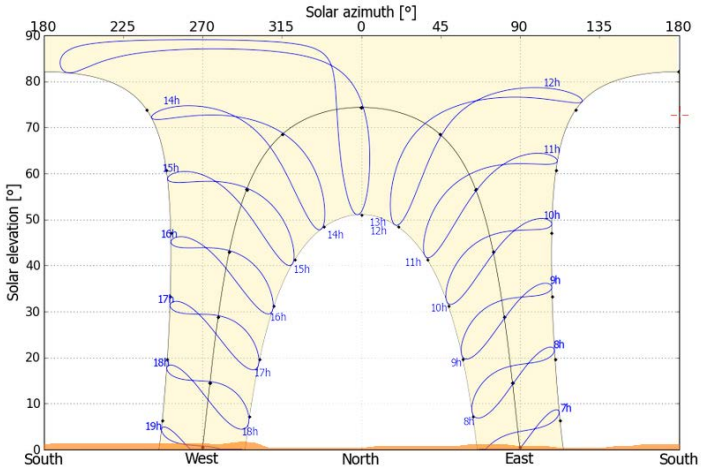

Figure 4.10: Sunpath and shading at the site

Figure 4.11: Sunpath at the site

Important note: Alternatively, other site will be considered as a substitute to Mount Makulu. Due to the latest development LS-MFEZ site will be preferably chosen for installing the Tier 2 equipment.

4.4.3 Mochipapa, ZARI Research Station

Short name	Description	Latitude	Longitude	Elevation
Mochipapa	Premises of ZARI research station, existing operational ZMD meteo station at the site	-16.8382	27.0703	1282

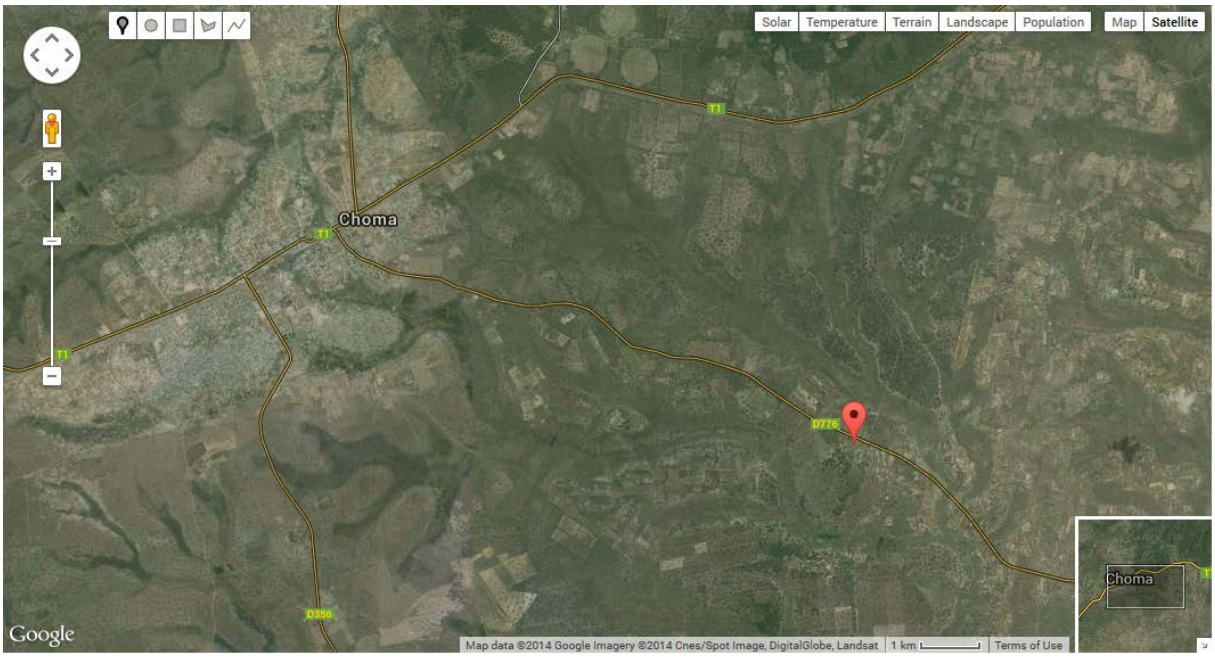

Figure 4.12: Location of Mochipapa site relative to the closest town

Figure 4.13: Existing Automatic Weather Station

Description of the site:

- At the site there is a meteorological station operated by Zambia Meteorological Department (ZMD)
- The site is located about 320 km South of Lusaka on the way to Livingston. The site is about 15 km from the town of Choma and near the Kafue River.
- The site is suitable for the installation of a solar and meteorological measurement station of Tier 2.
- The site is flat with no or few obstructions. There is ample space to locate the station elsewhere near the existing meteorological station.

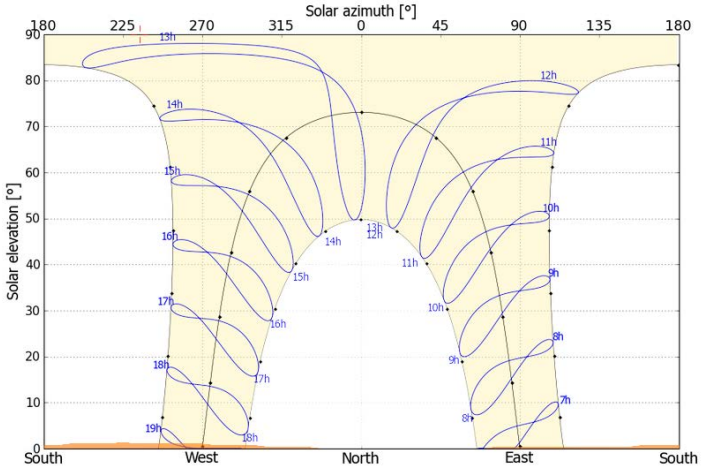

Figure 4.14: Sunpath and shading at the site

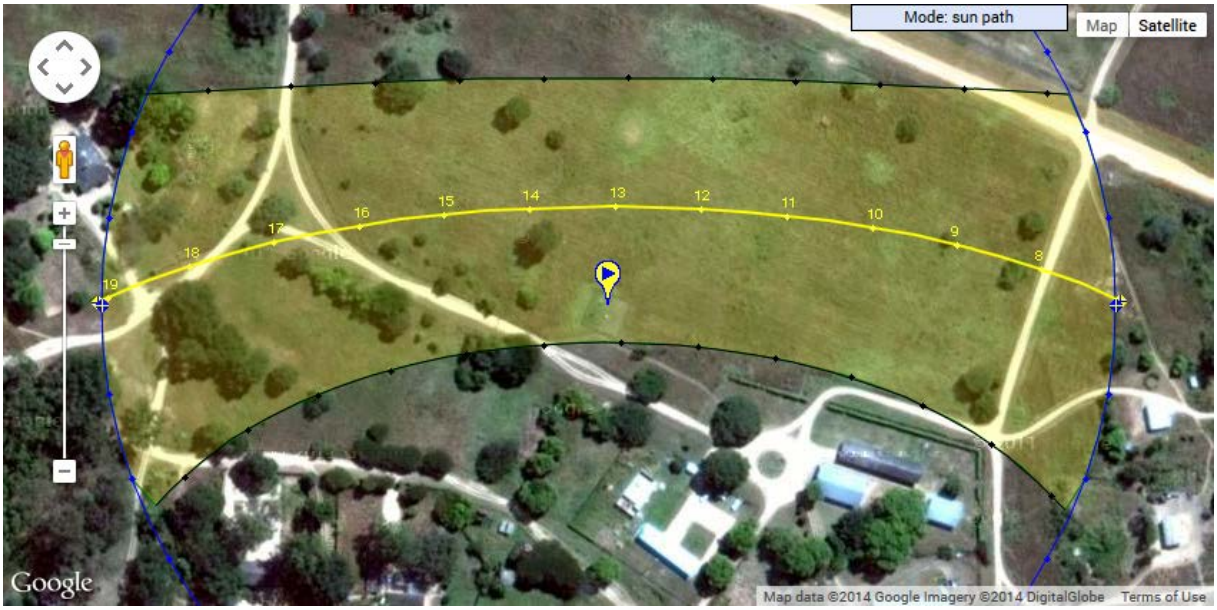

Figure 4.15: Sunpath at the site

4.4.4 Longe, ZARI Research Station

Short name	Description	Latitude	Longitude	Elevation
Longe	Premises of ZARI research station	-14.8397	24.9319	1167

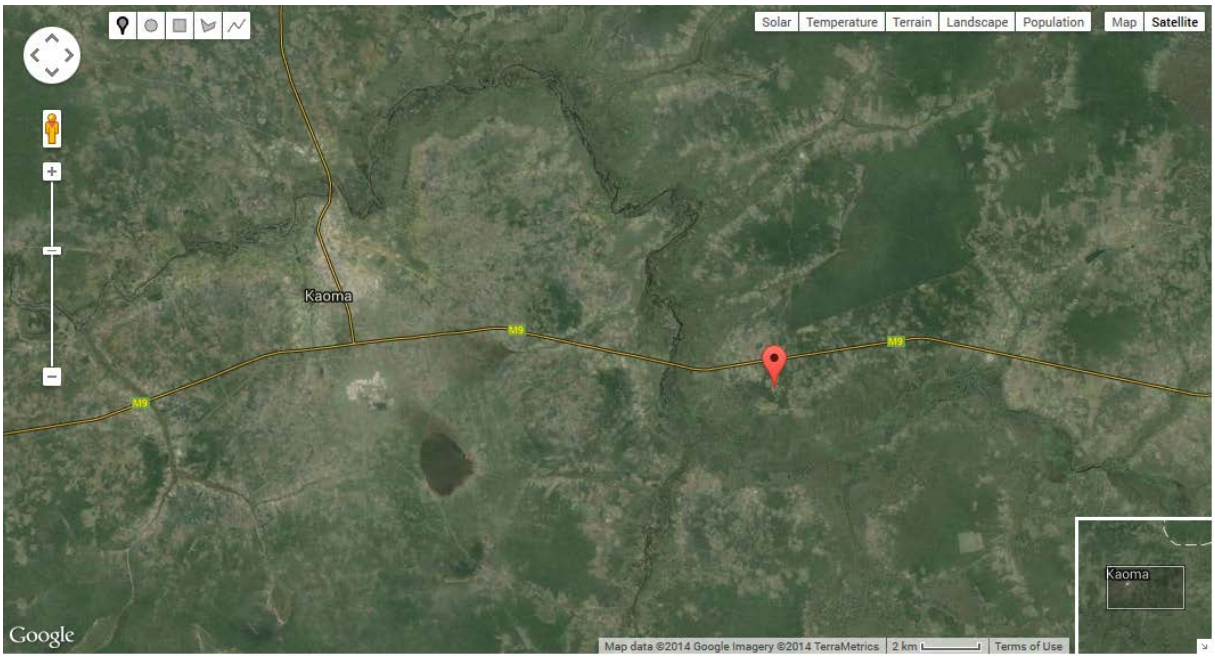

Figure 4.16: Location of Longe site relative to the closest town, Kaoma

Figure 4.17: Location of Longe relative to other infrastructure

Description of the site:

- The site is located about 15 km East of Kaoma on the road M9 road from Lusaka in a Western direction
- The site is suitable for the installation of a solar and meteorological measurement station of Tier 2
- No presence of permanent ZMD staff and the very basic station is operated by permanent ZARI staff
- ZARI is willing to host the station and to give support and own the station after two years. They also indicated the usefulness and their need for the data.
- The site is flat with no obstruction or shading sources.

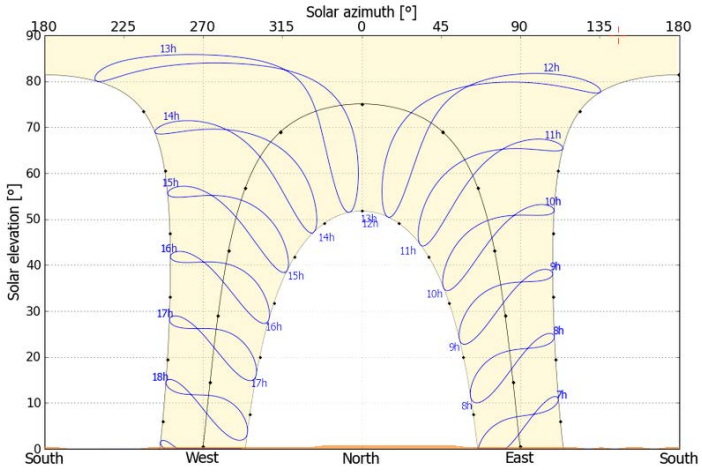

Figure 4.18: Sunpath and shading at the site

Figure 4.19: Sunpath at the site

4.4.5 Misamfu, ZARI Research Station

Short name	Description	Latitude	Longitude	Elevation
Misamfu	Premises of ZARI research station, existing operational meteo station ZMD at the site	-10.1726	31.2231	1382

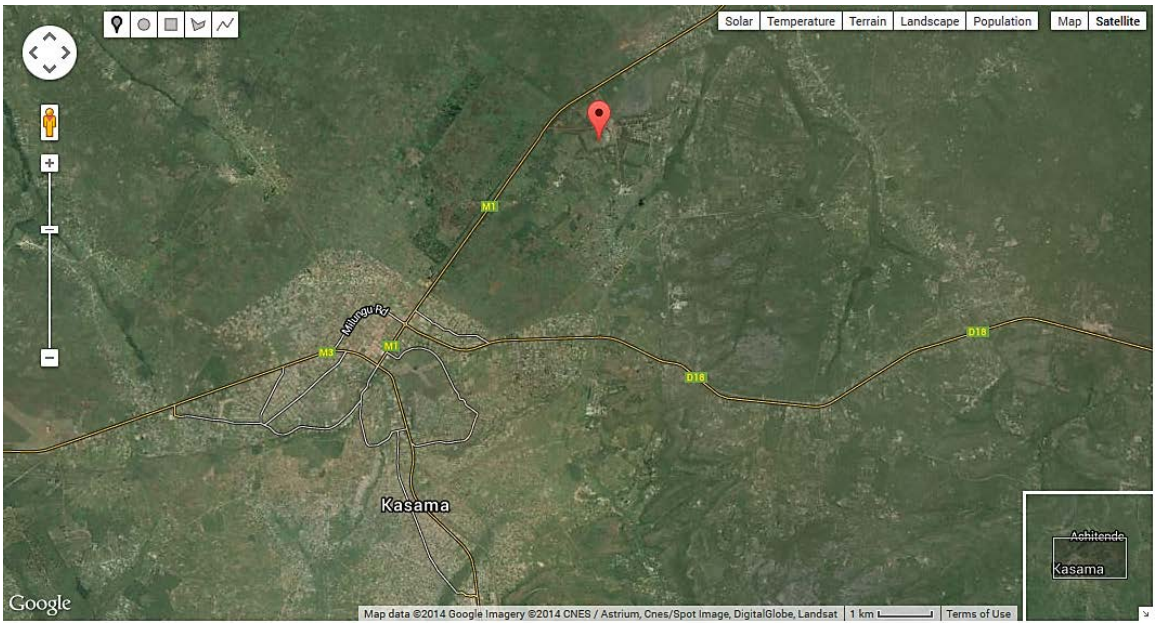

Figure 4.20: Location of Misamfu site relative to the closest town

Figure 4.21: Location of Misamfu relative to other infrastructure

Description of the site:

- The site is located about 5 km North of Kasama on the road M1 road from Kasama to Mbala
- The site is suitable for the installation of a solar and meteorological measurement station of Tier 2
- The site will be representative of the North Western parts of Zambia
- Existing ZMD meteo station is obstructed by trees: as a result alternative site was chosen for solar meteo station positioning
- ZARI is willing to host the station and to give support and own the station after two years. They also indicated the usefulness and their need for the data
- The ZMD representative is open to participate in training and looking after the equipment.

Note: position of the site may be changed during the installation.

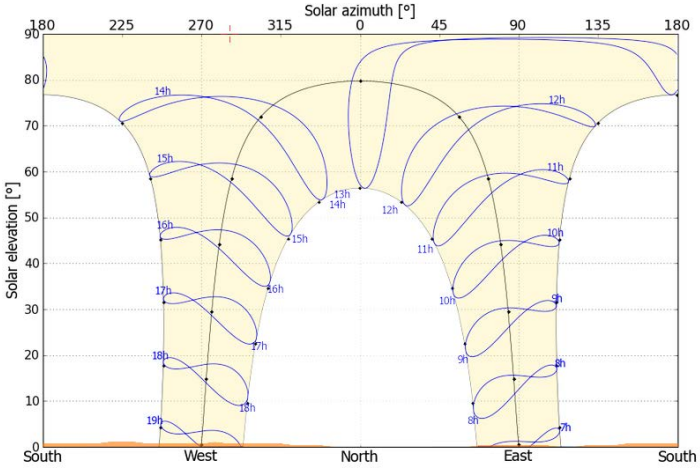

Figure 4.22: Sunpath and shading at the alternative site

Figure 4.23: Sunpath at the site

4.4.6 Mutanda, ZARI Research Station

Short name	Description	Latitude	Longitude	Elevation
Mutanda	Premises of ZARI research station, existing operational meteo station ZMD at the site	-12.4236	26.2153	1317

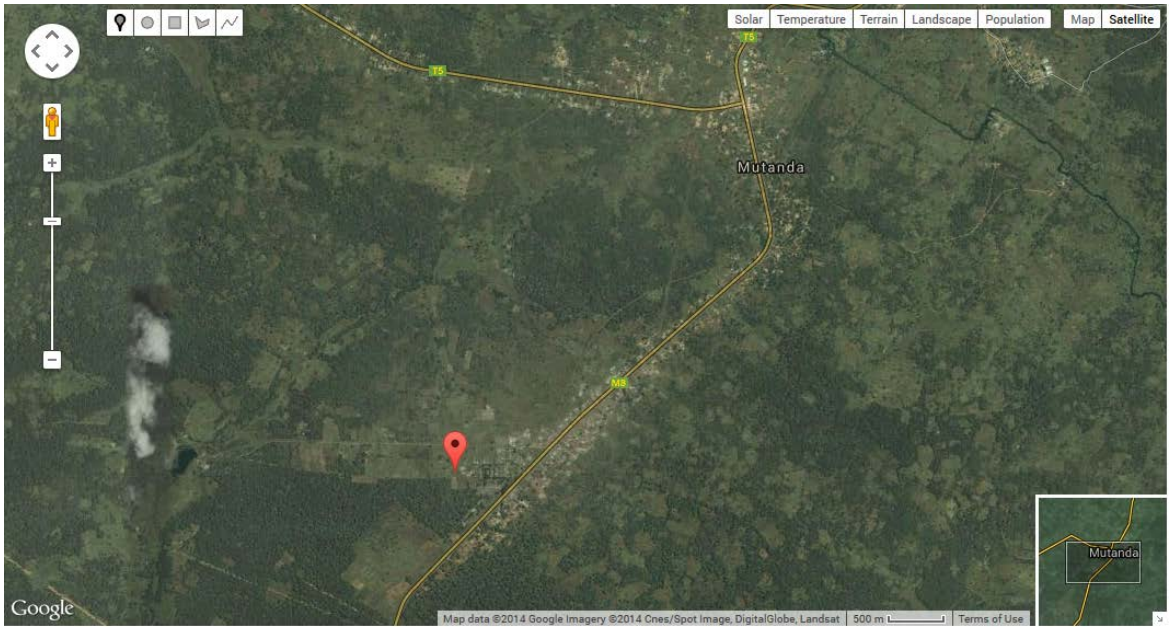

Figure 4.24: Location of Mutanda site relative to the closest town

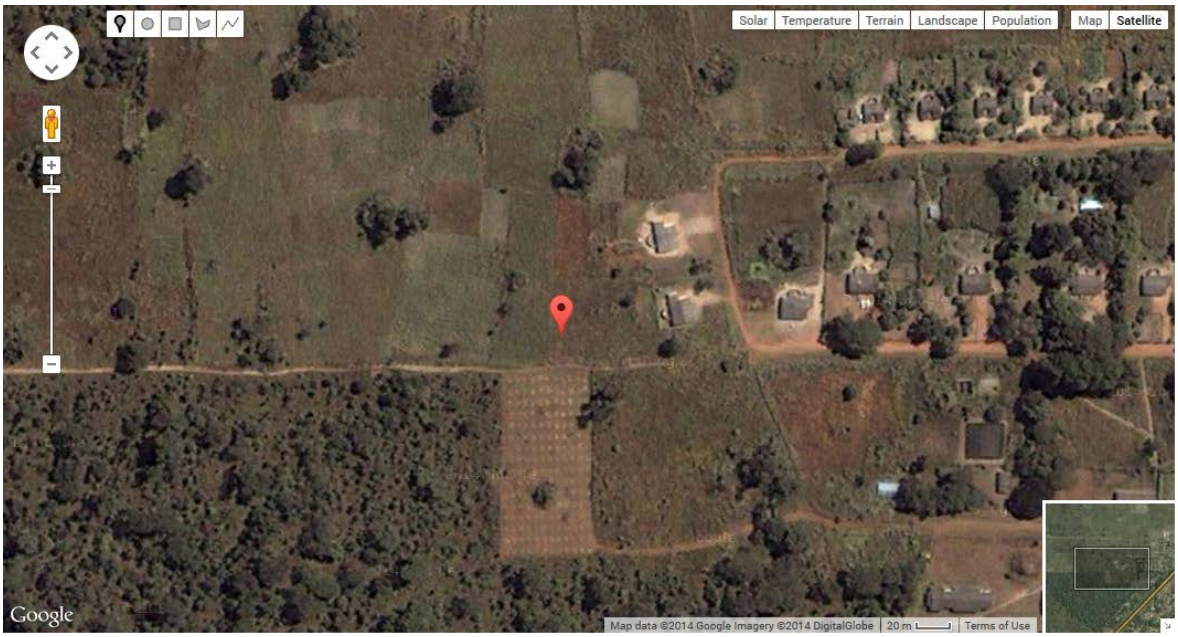

Figure 4.25: Existing meteorological station

Description of the site:

- The site is located about 33 km South-West of Solwezi on the T5 road.
- The site is suitable for the installation of a solar and meteorological measurement station of Tier 2
- The site will be representative of the North Eastern parts of Zambia
- The site is owned and managed by ZARI
- Permanent ZMD staff operates an agro-meteorological station that is taken care of by a permanent ZMD staff member. Station is shaded by local sources, therefore an alternative site for solar meteo station have ben chosen
- ZARI indicated their willingness to host the station and to give support and own the station after two years. They also indicated the usefulness and their need for the data.
- The ZMD representative expressed his support and willingness to participate in training and looking after the equipment. The existing meteorological station is a manual station and readings are taken every hour.
- The chosen alternative site is flat with no or few obstruction.

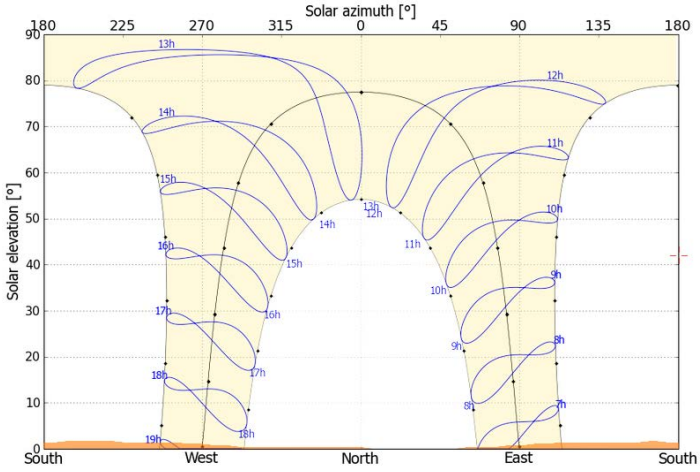

Figure 4.26: Sunpath and shading at the site

Figure 4.27: Sunpath at the site

5 TASKS AND DELIVERABLES

Table 5.1: Tasks to be carried in Phase 2
(Task ID is compatible with original Technical proposal)

ID	Task	Deliverables	Chapter
2.1.1	Site selection and Phase 2 Implementation Plan	D2.1	5.1
2.1.2	Procurement, testing and calibration of equipment	D2.2	5.1
2.1.3	Installation and commissioning of meteo stations	D2.3, D2.4	5.1
2.2.1	Operation and maintenance of meteo stations	D2.5, D2.7	5.2
2.3.1	Data download and quality control	D2.10, D2.11	5.3
2.3.2	Annual solar resource reports after 12 and 24 months	D2.12, D2.13	5.3
2.4.1	Verification of the calibration status after 12 months and re-calibration after 24 months	D2.6, D2.14	5.4
2.2.2	Training and capacity building	D2.8	6

5.1 Site selection, procurement, installation and commissioning

The selection of sites has been concluded in September 2015. The equipment has been procured and shipped to Zambia, Lusaka. Next, GeoSUN Africa will manage the local tasks with SGS Inspection Services Ltd, Zambia, the headquarters being based in Lusaka:

- The equipment has been procured and shipped to Zambia and has been cleared in Zambia and stored at the SGS premises.
- Local SIM cards will be procured and tested in the modems before departing from Lusaka
- One person from GeoSUN, one person from Local Partner and one, preferably two members of the local staff (station keepers) will install equipment at each site. During installation the GeoSUN Africa staff member will train the local engineers and local station keepers. Representatives from the Zambia Government and from the World Bank are welcome to attend the installation works.
- Commissioning tests for each meteo stations will be carried out by GeoSUN Africa to certify that stations are installed properly, following the best practices.
- Site Installation Reports with detailed station descriptions and photos will be prepared for each meteo station, according to specifications by The World Bank.

Maintenance equipment such as tools or cleaning tissues and wear parts, such as silica gel, will be provided for the first 2 years of operations at each site. One set of spare parts for all instruments will be given through providing a complete spare station.

GeoSUN Africa will prepare the **Station Operation and Maintenance Plan**, with guidelines, the aim of which is to guarantee operation at high quality and low failure rates.

Milestones

- Equipment deployed from the cleared central storage at SGS Inspection Services
- Site space allocated, fencing and foundations prepared.
- Equipment installed, tested and commissioned at each site.

Deliverables

D2.1 This Implementation Plan

D2.2 Documentation for each station, with calibration documents for all sensors, including the RSR instruments and pre-commissioning test protocols.

D2.3 Site Installation Report for each meteo site (including photos, design, and individual documentation of calibration). Sample data recorded from the station.

D2.4 Meteo station maintenance manual

5.2 Operation and maintenance

GeoSUN Africa, in collaboration with SGS Inspection Services (SGS) and local staff members, including the station keepers will be responsible for managing the in-country maintenance of the equipment. GeoModel Solar will be participating at these activities and coordinating the tasks. The following tasks are planned:

- Daily cleaning of thermopile pyranometer and once in two days of the RSR – to be performed routinely by local station keepers
- Field verification (optionally re-calibration) every 12 months by GeoSUN Africa and SGS
- In addition unscheduled site visits if issues appear as a result of the regular data control.

Cleaning button will be installed at each station, and it should be pressed after each cleaning event. The station keepers will be trained on cleaning and small maintenance works. Daily cleaning of the sensors will be monitored remotely by GeoSUN Africa and GeoModel Solar from the electronic cleaning logs obtained from the meteo station. In case of no cleaning event, SGS will be immediately informed so that remedial measures can be taken.

Maintenance visits will be carried out according to the *Meteo Station Maintenance Manual*. Parts that are either non-functional or need replacement, such as silica gel to prevent condensation in instruments will be replaced during these visits. Small maintenance will be part of routine operations.

In case of failure or malfunction, the fault will be immediately detected through remote monitoring of stations by GeoSUN Africa. In such cases, GeoSUN Africa will initiate remedial measures and inform SGS, who will send their personnel on the site to solve the problem. GeoSUN Africa will keep the spare parts and instruments at the offices of SGS so that the missing or failing components can be replaced in a short time. In case of defective instrument, the instruments would be replaced from the spare kit and would be shipped to OEM for replacement. This will ensure high station availability.

After 12 and 24 months a Summary report for each station will be issued including info about all scheduled and unscheduled events and measures taken. For this purpose all station keepers must keep a Station Logbook. During the station keeper training they will be advised on the details of daily routines. The yearly summary report will include also verification results of sensor calibration.

In Month 12 and 24 GeoSUN Africa and GeoModel Solar will visit Zambia for station operation and maintenance and will deliver further training (see Chapter 6).

At the end of Phase 2 we will execute transferring the equipment to the legal entity, designated by the World Bank and Zambia Government.

Milestones

- Daily cleaning of thermopile pyranometers and once in 2 days sensor of the RSR
- Scheduled site visits and field verification/calibration as set out above
- Unscheduled site visits on as-needed basis

Deliverables

D2.5 Meteo station summary operation report delivered after each 12 months for each meteo station.

D2.6 Recalibration reports if recalibration of instruments required

D2.7 Report after each unscheduled site visit

5.3 Delivery of solar and meteo measurements and reports

Data from all the stations will be downloaded and checked on a (work) daily basis by GeoSUN Africa. The planned stations for Zambia will be added to the existing data download and quality check system. In parallel the data will be sent to the server of GeoModel Solar and analysed. This will insure high robustness of data acquisition and monitoring system.

Automated value/limit checks that send automatic emails are setup. This system displays data live on large screens. The quality control tests will be applied in two runs: (i) first, the automatic tests are run to identify the obvious issues; next (ii) by the visual inspection we identify and flag inconsistencies, which are of more complex nature. Visual inspection is an iterative and time-consuming process.

The **automatic quality control tests** include:

- Identification of missing values
- Correction of time shifts
- Evaluation of measurements against sun position (Sun below and above horizon)
- Comparing the data with possible minimum and maximum irradiance limits
- Evaluation of consistency of GHI, DIF and DNI by comparing the redundant measurements
- Extreme (minimum and maximum) physical values test
- Clear-sky exceedance test
- Diffuse component exceedance test
- Cleaning frequency test

The **visual quality control** aims to identify and flag the following erroneous patterns:

- Shading from nearby objects (near shading) or mountains (far shading)
- Regular data error patterns
- Irregular anomalies.

In quality control GeoSUN collaborates with GeoModel Solar using near real time satellite-derived data for cross-validation. Data from meteo stations will be regularly transmitted to the repository established by ESMAP.

Monthly reports will be delivered to the World Bank summarizing the situation at all measuring stations, mainly issues encountered and irregularities in data flow. The reports will include the following information:

- Site info
- Summary of technical parameters of the instrumentation and sensor calibration status
- Technical maintenance summary, list of issues and irregularities encountered at the site
- Data coverage summary and quality statistics (following the best practices)
- Validation statistics, soiling control

After completion of the first year of the measurement campaign, **Site Solar Resource Reports after 12 months** will be delivered. After completion of the second year of the measurement campaign, **Site Solar Resource Reports after 24 months** will be delivered using the same methodology. The reports will be prepared along with quality-controlled measured datasets and site-adapted modelled data.

A separate report will be delivered for each site and it will include the following **Table of Contents**:

Executive summary

Glossary and abbreviations

Site info

- Position (map) of the site

Instruments

- Summary of technical parameters of the instrumentation and sensor calibration status
- Technical maintenance summary, list of issues and irregularities encountered at to the site

Data Quality Control

- QC following best practices of BSRN and SERI QC
- Note on calibration or field testing
- Data coverage summary and quality statistics
- Validation statistics, soiling control

Correlation with satellite data (SolarGIS 22 or 23 years of time series)

- Site adaptation of SolarGIS Time Series
- Uncertainty info

Solar resource and meteo statistics

- Long term summary statistics for each parameter
- Comparison of actual year to long-term average (map and site view)
- Seasonal and diurnal statistics
- 1-minute ramp-rates for ground measured sola resource data
- Comments and suggestions

Interannual variability and uncertainty

- Variability on 1 year and in 20 years
- Uncertainty of estimate
- Combined uncertainty (of estimate and variability)

Conclusions

Time series data will be delivered in the SolarGIS CSV data format:

- 12-months data with quality controlled measurements (corrected as applicable) in primary (1-min) and aggregated time resolutions
- Multiyear site-adapted satellite data in hourly and 30-minute data resolution.

TMY data will prepared from the site-adapted time series in SolarGIS CSV, TMY3 and PVSYST data formats.

The data sets will include the following parameters:

- Direct Normal Irradiation, DNI [Wh/m^2]
- Global Horizontal Irradiation, GHI [Wh/m^2]
- Diffuse Horizontal Irradiation, DIF [Wh/m^2]
- Azimuth and solar angle, SA and SE [°]
- Air temperature at 2 metres, TEMP [°C]
- Relative air humidity, RH [%]
- Wet bulb temperature, WBT [°C]
- Wind speed converted to standard height of 10 metres, WS [m/s]
- Wind direction at 10 metres (3 metres), WD [°]
- Atmospheric pressure, AP [hPa]

Milestones

- Continued data download and quality control by GeoSUN Africa and GeoModel Solar
- Quality procedures and measurements systematically controlled through monthly reports
- Site reports + clean and site-adapted time series data after 12 months
- Site reports + clean and site-adapted time series data after 24 months

In Month 12 and 24 GeoSUN Africa and GeoModel Solar will visit Zambia for station operation and maintenance and will deliver further training.

Deliverables

D2.10 Data in 1-minute and time aggregations delivered every month, to ESMAP server

D2.11 Monthly reports and Yearly reports (individual delivery for each measurement station)

D2.12 Site Resource Report on completion of 12 months of the measurement campaign (one for each site) with time series of locally measured and satellite-based data

D2.13 Site Resource Report on completion of 24 months of the measurement campaign (one for each site) with time series of locally measured and satellite-based data

5.4 Verification and calibration

In Month 12 GeoSUN Africa will visit the stations and verify the calibration status of the instruments. In case that the deviation of the calibration exceeds the limits the instrument will be re-calibrated.

In Month 24, at the end of Phase 2, GeoSUN Africa will calibrate the instruments and only afterwards the ownership of the meteorological stations will be transferred to the new owner.

Milestones

- Verification of the calibration status after 12 months
- Calibration of the instruments after 24 months

Deliverables

D2.6 Verification report after 12 months. Recalibration reports if recalibration of instruments required

D2.14 Calibration report after 24 months

6 CAPACITY BUILDING AND TRAINING

The training and capacity building will be dedicated to the staff members of UNZA, ZMD and ZARI and will include also our local partner SGS Zambia. The informative workshops will be dedicated

We propose to hold the three training campaigns:

1. At the start of Phase 2 (November 2015)
2. After 12 months of monitoring (December 2016)
3. After 24 months of monitoring (December 2017)

During each of the above-mentioned three stages, it is proposed to hold one informative workshop and technical trainings, to efficiently target different stakeholders:

1. **Informative workshop:**
    a. Governmental representatives
    b. Representatives of ZESCO and other institutions
    c. Dedicated technical personnel from ZMD, ZARI and UNZA
    d. World Bank and other invited persons
    e. Consultant team and SGS Zambia
2. **Technical training:**
    a. Technical personnel from ZMD, ZARI and UNZA
    b. Technical experts from SGS Zambia
    c. Government representatives, World Bank and other invited persons
3. **On-site training related to the daily operations:**
    a. Station keepers at each solar measuring station.

6.1 Workshop and training at the start of Phase 2

6.1.1 Informative workshop at start of Phase 2

The objective of this workshop is to provide the latest information about the project and its main components and to show the relevance of the solar monitoring activities in a broader context of developing and operation of solar photovoltaic power plants. The topics will include:

- Value of solar resource monitoring for development of solar energy in Zambia
    - Solar monitoring system: benefits of combining measurements with data from models
    - How data is applied in planning, monitoring and forecasting of solar power plants
- Work plan of Phase 2 of the ESMAP Solar Monitoring
    - Sites and equipment
    - Responsibilities of involved partners: Consultants, ZMD, ZARI, UNZA and SGS
    - Time schedule and reporting
    - Phase 2 deliverables, data availability and benefits
- Moving toward Phase 3 of the project and beyond
    - Development of utility-scale solar parks and smaller-size systems
    - Grid integration and grid stability issues
    - Systematic monitoring and solar power forecast
- Discussion and next steps

It is proposed to hold this informative workshop at the premises of the World Bank or Department of Energy in Lusaka, during the installation campaign. Time needed for this workshop: 2.5 hours.

6.1.2 Technical training during the installation

The training is designed to include a mixture of theory and hands on practice. The training will be focused on the technical staff from each involved institution that will be involved. The topics will include:

- Basics of solar radiation
- Measuring instruments and related uncertainties
- Data loggers and modems, data formats, data retrieval
- Installation and operation of meteo stations
- Procedures for daily cleaning and maintenance, safety and security
- Documentation, operation, servicing
- Verification and calibration of solar instruments
- Data quality control
- Troubleshooting, maintaining long term quality
- Review of first measuring results

It is proposed that this training will be held at UNZA in Lusaka. The training will be provided in the field and also in the meeting room; thus it will be split into several blocks. It will be performed during the installation at UNZA, and afterwards.

6.1.3 Training of the local staff during the installation

This training will be held during the installation of the meteo equipment and continued/re-evaluated at the occasion of each yearly visit. The topics include:

- Basics on solar and meteorological monitoring
- Overview of measuring instruments
- Procedures for daily cleaning and maintenance
- Simple servicing and troubleshooting of instruments
- Safety and security measures.

6.2 Workshop and training in Month 12 of Phase 2 campaign

6.2.1 Informative workshop after 12 months

The objective of this workshop is to provide the update of the project and its results. The topics will include:

- Review of the results achieved at the end of Month 12 of the measuring campaign
- Status of meteo stations, instruments, measurement statistics
- Summary report on site resource assessment delivered on completion of 12 months of the measurement campaign with time series of locally measured and satellite-based data
- Report on reduced modelled data uncertainty and implications for solar energy development
- Related issues (development of solar parks and other renewable energy strategies)
- Lessons learned, discussion and nest steps

It is proposed to hold this informative workshop at the premises of the World Bank or Department of Energy in Lusaka. Time needed for this workshop: approx. 2 hours.

6.2.2 Technical training

The training will be focused on the technical staff from each involved institution to ensure that all necessary skills are acquired and maintained. The topics will include:

- Review of procedures related to equipment and data monitoring
- Status of cleaning and calibration verification
- Status of data analysis and interpretation, data quality checks and reporting
- Typical issues and lessons learned
- Organisational issues
- Next steps towards maintaining long term quality
- Hands-on re-confirmation on specific maintenance tasks

It is proposed that this training is held at the premises of UNZA.

6.2.3 Training of the local staff at each site

The objective of this training is to re-confirm the acquired skills and procedures and provide further more detailed information.

6.3 Workshop and training in Month 24 of Phase 2 campaign

6.3.1 Informative workshop after 12 months

The objective of this workshop is to provide the update of the project and its results. The topics will include:

- Review of the results achieved at the end of Phase 2 measuring campaign
- Status of meteo stations, instruments, measurement statistics
- Report on re-calibration
- Summary report on site resource assessment delivered on completion of 24 months of the measurement campaign with time series of locally measured and satellite-based data
- Report on reduced modelled data uncertainty and implications for solar energy development
- Transfer of ownership
- Demonstration of preparedness for sustainable continuation of the measurement program
- Related issues (development of solar parks, electrical grid, minigrids, and other renewable energy strategies)
- Lessons learned and discussion

It is proposed to hold this informative workshop at the premises of the World Bank or Department of Energy in Lusaka. Time needed for this workshop: approx. 2.5 hours.

6.3.2 Technical training

The training will be focused on the technical staff from each involved institution to ensure that all necessary skills are acquired and maintained. The topics will include:

- Review of procedures related to equipment and data monitoring

- Status of cleaning and re-calibration
- Data quality checks and reporting
- Review of extended maintenance and servicing
- Review of the data, uncertainties and reports
- Transfer of ownership and documentation
- Next steps towards maintaining long term quality
- Hands-on re-confirmation on specific tasks

It is proposed that this training is held at the premises of UNZA during the site visit and control.

6.3.3 Training of the local staff at each site

The objective of this training is to re-confirm the acquired skills and procedures and provide further more detailed information.

Milestones

Three training campaigns (each consisting of an informative workshop and technical training)

- At the installation
- In Month 12 to review the results and to confirm the calibration status
- In Month 24 to review the results and to focus on training and capacity building of the staff at ZMD, ZARI, UNZA and SGS at the end of measurement campaign
- Transfer of the solar measuring stations to a local entity identified by the World Bank and Zambia Government.

Key messages from the technical training will be communicated within Phase 3 workshop.

Deliverables

D2.11 Training programme overview for each format in all three stages

D2.12 Reports from each event

7 TIME TABLE

Table 7.1 shows time plan and deliverables of Phases 2 and 3 of the Project. Tables 7.2 and 7.3 show summary of deliverables and plan of scheduled visits. Each visit will include also training and capacity building component.

Table 7.1: Time schedule for Phase

Task	Activity	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
		2015						2016											
2.1.1	Site selection and Phase 2 Implementation Plan				D2.1														
2.1.2	Procurement, testing and calibration of equipment				D2.2														
2.1.3	Installation and commissioning of meteo stations					D2.3	D2.4												
2.2.1	Operation and maintanence of meteo stations																D2.5		
2.2.2	Training and capacity building					D2.8	D2.9											D2.8	D2.9
2.3.1	Data download and quality control					D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10
						D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11
2.3.2	Annual solar resource reports																	D2.12	
2.4.1	Verification and re-calibration																		D2.14
3.1	Regional adaptation of SolarGIS data and maps																		
3.2	Delivery of bankable site-specific TMY data																		
3.3	Validated Solar Resource Atlas																		
3.4	Phase 3 workshop																		
	Management																		

Task	Activity	1	2	3	4	5	6	7	8	9	10	11	12	1
		2017												2018
2.1.1	Site selection and Phase 2 Implementation Plan													
2.1.2	Procurement, testing and calibration of equipment													
2.1.3	Installation and commissioning of meteo stations													
2.2.1	Operation and maintanence of meteo stations									D2.6	D2.5			
2.2.2	Training and capacity building											D2.8	D2.9	
2.3.1	Data download and quality control	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10	D.2.10		
		D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11	D2.11		
2.3.2	Annual solar resource reports											D2.13		
2.4.1	Verification and re-calibration												D2.14	
3.1	Regional adaptation of SolarGIS data and maps											D3.1	D3.2	D3.3
3.2	Delivery of bankable site-specific TMY data												D3.4	D3.5
3.3	Validated Solar Resource Atlas													D3.6
3.4	Phase 3 workshop													D3.7
	Management													

Table 7.2: Tasks and deliverables of Phase 2

Phase	Tasks and subtasks		Deliverables	
2	**2.1**	**Planning and implementation of the solar measurement campaign**		
	2.1.1	Site selection and Phase 2 Implementation Plan	D2.1	Updated and approved Phase 2 Implementation Plan
	2.1.2	Procurement, pre-installation testing and calibration of equipment	D2.2	Documentation for each station, with calibration documents for all sensors, including the RSR instruments and pre-commissioning test protocols
	2.1.3	Installation and commissioning of meteo stations	D2.3	Site Installation Report for each meteo site (including photos, design, and individual documentation of calibration). Sample data recorded from the station.
			D2.4	Meteo station maintenance manual
	2.2	**Operation and maintenance, capacity building**		
	2.2.1	Operation and maintenance of meteo stations	D2.5	Meteo station summary operation report delivered after each 12 months for each meteo station
			D2.6	Re-calibration reports if such action required
			D2.7	Report after each unscheduled site visit
	2.2.2	Training and capacity building	D2.8	Training programme overview for each format
			D2.9	Brief reports from each training event
	2.3	**Delivery of solar and meteo measurements and reports**		
	2.3.1	Data download and quality check	D2.10	Data in 1-minute and time aggregations delivered every month, to ESMAP server
			D2.11	Monthly report (individual delivery for each measurement station)
	2.3.2	Annual Site Resource Reports	D2.12	Site Resource Report #1 on completion of 12 months of the measurement campaign (one for each site) with time series of locally measured and satellite-based data
			D2.13	Site Resource Report #2 on completion of 24 months of the measurement campaign (one for each site) with time series of locally measured and satellite-based data
	2.4	**Recalibration**		
	2.4.1	Recalibration of the instruments	D2.14	Delivery of the Recalibration report

Table 7.3: Scheduled visit to the sites

Task	Date	GeoModel Solar	GeoSUN Africa	SGS Zambia
Installation and commissioning	November 2015	X	X	X
Visit of sites after 6 months	June 2016		X	X
Visit of sites and calibration verification after 12 months	December 2016	X	X	X
Visit of sites after 18 months	June 2017		X	X
Visit of sites and re-calibration after 24 months	December 2017	X	X	X

8 ASSESSMENT OF RISKS

Environmental and social risks were assessed to prevent or minimize harm during the implementation of the project.

Potential sites for installations meet requirements such as availability of personnel for maintenance and cleaning, security and sustainability of running the measurement campaign in a long term. The sites obtained also the acceptance from the Government (Department of Energy) and the present landowners: UNZA, ZARI and ZMD (alternatively one site will be operated at Lusaka South Multi-Facility Economic Zone).

The solar measuring stations will be located further away from the buildings and source of shading. The selected sites are not located in any restriction zones, such as natural habitats − they will be located at in agricultural research fields or directly in already existing meteorological sites. The equipment will be located in a flood-safe area and not too close to sources of pollution. The meteo stations will have their own fencing and independent power supply (photovoltaic panel + battery). Solid foundations will have to be built, and this will include civil and construction works. No significant quantities of emissions or effluents nor hazardous materials or processes are generated during the installation and operation of the solar measuring stations. Emissions caused by transport vehicles are within standards of the Republic Zambia, as the cars used are registered in the country. Water quality will not be influenced, as there is no use of water during the operation. No long-term effects on the environment are expected from installation and operation of the solar measurement stations. After the initial assessment of World Bank Groups Safeguards, the likely impact of the project on the environment is expected to be Category C, having minimal or no adverse impacts.

Risks related to the installation, operation and maintenance could occur from the use, storage or handling of any quantity of hazardous materials. The equipment includes data loggers and batteries (12V with at 15Ah capacity). The meteorological stations are equipped with encapsulated batteries, that are resistant to shocks and vibration, as well as against moisture, solvents, and corrosive agents. Encapsulation is also used to aid electrical insulation, flame resistance and heat dissipation. All batteries will be made safe for handling, prior to packing for shipment. The waste management (collection, temporary storage, recycling and disposal) will conform to the Universal Waste Management Guideline and the EHS Guidelines of the World Bank Group. The quantities of generated waste will be reduced to minimum. The meteorological stations are designed to run in a longterm (longer than this project) and decommissioning and waste management is not considered in this Implementation Plan. At the end of lifetime, the electronic equipment (e.g. data logger) should be treated as ordinary electronic waste, batteries as other typical batteries on the market.

Preventive and protective measures will be carried out to protect health and safety of staff involved in installation and operational of the solar measuring stations. The involved staff has technical capabilities and experience to manage the occupational health and safety. All staff contributing will be trained before installation and periodically during the maintenance and operation of the stations by staff from GeoSUN Africa. The safety during the operation will be ensured by a fence built around each station. The sites are located within premises of the ZARI, ZMD and UNZA, which ensures reasonable level of security. No relevant issues are expected concerning community health and safety.

9 PERMITS AND IMPORT PROCEDURE

Permits for the installation of the solar meteorological stations have been obtained Department of Energy (DoE) of Zambia as well as all stakeholders. World Bank and DoE have been instrumental in arranging the necessary support documents for import of the equipment. The equipment is stored in the storage managed by SGS.

10 ACRONYMS

ESMAP	Energy Sector Management Assistance Program of the World Bank Group
SGS	SGS Inspection Services in Zambia - local partner to the Consultants
UNZA	University of Zambia in Lusaka
ZARI	Zambia Agricultural Research Institute
ZMD	Zambia Meteorological Department

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13 ESMAP SOLAR ZAMBIA CONSULTANTS

13.1 Lead contractor: GeoModel Solar

Primary business of GeoModel Solar is in providing support to the site qualification, planning, financing and operation of solar energy systems. We are committed to increase efficiency and reliability of solar technology by expert consultancy and access to our databases and customer-oriented services.

The Company builds on more than 25 years of expertise in geoinformatics and environmental modelling, and more than 15 years in solar energy and photovoltaics. We strive for development and operation of new generation high-resolution quality-assessed global databases with focus on solar resource and energy-related weather parameters. We are developing simulation, management and control tools, map products, and services for fast access to high quality information needed for system planning, performance assessment, forecasting and management of distributed power generation.

Members of the team have long-term experience in R&D and are active in the activities of International Energy Agency, Solar Heating and Cooling Program, Task 46 Solar Resource Assessment and Forecasting.

GeoModel Solar operates a set of online services, integrated within SolarGIS® information system, which includes data, maps, software, and geoinformation services for solar energy.

See more at http://geomodelsolar.eu and http://solargis.info

ISO 9001
LL-C (Certification)

GeoModel Solar is ISO 9001:2008 certified company for quality management since 2011.

13.2 Subcontractor: GeoSUN Africa

GeoSUN Africa (located in South Africa) is a spin-off company from the Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University in South Africa. GeoSUN Africa was formed in 2012.

GeoSUN Africa has extensive experience in the installation and up-keep of high accuracy solar measurement stations. This experience dates back to 2009 when the current GeoSUN Africa employees were working for CRSES. After GeoSUN Africa was formed all the CRSES solar measurement projects were seeded to GeoSUN Africa.

Apart from South Africa, GeoSUN Africa has performed installations in other African countries, including Botswana and Lesotho and with projects lined up in Namibia and Rwanda. GeoSUN Africa has strong and formal working relationship with Campbell Scientific Africa (CS Africa).

http://geosun.co.za/

13.3 Local partner: SGS Inspection Services

SGS is a company operating in the inspection, verification, testing and certification. It is recognized as a global benchmark for quality and integrity operating in 1250 offices and laboratories around the world.

SGS Inspection Services is an independent supplier of services in agriculture, mining and other sectors in Zambia. In agriculture it offers service in precision farming, soil classification, crop inspection, yield data management and soil fertility management. Having experience in meteorology and measurements, SGS assists with the preparation, installation and operation of meteo stations.

http://www.sgs.com/