

UNITED REPUBLIC OF TANZANIA

INTRODUCTION

The Light and Life in African Environments (LLAE) Project was conceived as a project aimed at studying the visible and ultra-violet solar radiation and its effects in the African equatorial regions, involving researchers from Norway, Gambia, Uganda and Tanzania. This would encompass measurements on land as well as in water on the coasts of the Atlantic and Indian Oceans, and Lake Victoria. The project lasted for only one phase, spanning the years 2002 to 2006. NUFU, the Norwegian funding agency, did not support it for the next phase, spanning the years 2007 to 2011, because it shifted its attention to other research areas. As a result, it became necessary to redefine the project on the Tanzanian side, and efforts have continued to seek funding but these have yet to materialize. In spite of this, data collection is still going on at the stations established at the Department of Physics of the University of Dar es Salaam, and on the slopes of Kilimanjaro Mountain. This report provides a short summary of the accomplishments of the project since its establishment, and future plans if funding is obtained.

GOALS AND OBJECTIVES

The goal of the project was to establish climatology of PAR and UV radiation as well as long-term trends of total ozone abundance, cloudiness, PAR and UV radiation levels in the equatorial belt of Central Africa.

The attendant objectives were:

- To establish a network of PAR and UV surface-based measurement stations, including one station in Gambia, one in Kampala, one in Dar-es-Salaam and five in the Kilimanjaro area.
- To use the network of surface-based measurement stations to evaluate and validate studies of the ozone resolving sensors on ESA's Environmental Satellite (ENVISAT).
- To use the network of surface-based measurement stations and the satellite sensors to establish the climatology mentioned above.
- To carry out surface-based PAR and UV radiation measurements in Lake Victoria, and later in coastal waters in countries on the Eastern (Indian Ocean near Dar es Salaam) and the Western (Atlantic Ocean) coasts of Africa.
- To use the water-based instruments and satellite-based sensors to establish the floating water plant coverage, algae distribution, and primary production in the mentioned water bodies,
- To transfer the science and technology of monitoring environmental parameters and assessing national resources to the collaborating African institutions.

Following the requirement to address the interests of Tanzania in a more focused way, and foreseeing that it might only be possible to obtain funding for the research component on the Tanzania side, the project component in Tanzania has been revised to bear the title *Light and Life in Tanzanian Environments* (LLTE). Its goal is to establish the climatology of PAR and UV radiation, and long-term trends of total ozone abundance, cloudiness, PAR and UV radiation levels in Tanzania. The attendant objectives are then:

- To extend the network of PAR and UV surface-based measurement stations over that already established at Dar-es-Salaam and Kilimanjaro.
- To extend the area of measurement using satellite-derived data with the ground measurements for validation.
- To use the network of surface-based measurement stations and the satellite sensors to establish the climatology mentioned above.
- To extend the surface-based measurements to include Lake Victoria and the Indian Ocean.
- To use the water-based instruments and satellite-based sensors to establish floating water

- plant coverage, algae distribution, and primary production in the mentioned water bodies.
- To advance the already obtained science and technology of monitoring environmental parameters and assessing national resources.

Since the LLTE project is still taking shape, and noting that funds are still being sought to operationalize it, the activities reported in this report are those carried out under the LLAE project.

ORGANISATION AND OPERATION

The LLAE project was part of a much larger project titled ***Research in Basic Sciences at Makerere and Collaborating Universities to Promote Technological Development in Mathematics, Chemistry, Physics, and Biology***. Most of the activities in this large project were based at Makerere University, with the LLAE sub-project involving collaborators from Norway, Uganda, Gambia and Tanzania. As such, the LLAE project was initiated from Uganda, and the Tanzanian involvement came in at a later stage. On the Tanzanian side, the project is based at the University of Dar es Salaam.

The main and crucial activities in the project include instrument calibration and data collection. The instrument in Dar es Salaam is calibrated each week, and it serves as a reference for the other instruments. Data is downloaded from the instruments in Kilimanjaro four (4) times a year, and that is when the instruments are calibrated. The calibration and downloading of data is done by a team of researchers, who have to visit all the stations in Kilimanjaro. In addition, a local technician takes care of the instruments in Kilimanjaro, especially cleaning to ensure that dust does not degrade the quality of the light going to the sensors within the instruments.

ACTIVITIES UNDERTAKEN AND THEIR ASSESSMENT

Establishing the Network

The initial objective of the project was to establish the network with six NILU-UV stations, one in Dar es Salaam and five in Kilimanjaro. Due to financial constraints, this number was reduced to four, with one instrument being installed in Dar es Salaam and three in Kilimanjaro. It was envisaged that the results from the four instruments could be evaluated to form the basis for the future architecture of the network.

Unfortunately, some factors have militated against the proper establishment of the network, especially in Kilimanjaro. First, although four instruments were installed initially, one of them failed to operate, and it was taken to the manufacturer for repairs. It has since been repaired and is awaiting installation. Secondly, after examination of the initial data from Kilimanjaro, it was discovered that the instruments needed to be mounted higher than originally planned. The parts for the two stations in Kilimanjaro were modified, and were installed in the July-September 2007 phase. The parts for the third station have already been fabricated, and are awaiting installation. Thirdly, the power supply in one of the instruments in Kilimanjaro operated erratically. This problem contributed to unreliable data, and it took quite some time to tackle. Currently, all stations are being monitored carefully to avoid the repetition of the anomaly. The latter two problems described above made it necessary to postpone the re-installation of the third station in Kilimanjaro. Its location is not easily accessed, and its installation must therefore be done very carefully to avoid recurrent mal-performance.

The achievement on the LLAE network is the experience that has been gained as far as establishing, managing and operating a network of measurement stations is concerned. This experience will therefore be very useful in the envisaged LLTE project and any similar work in future.

Data Collection and Analysis

Data has been collected from the instrument in Dar es Salaam since 2000 and analyzed. Data has also been collected from the instruments installed at Marangu and Horombo stations since 2003.

The achievements in data analysis are the reliable scientific results that have been obtained so far from the instrument installed in Dar es Salaam, which have also been compared with the ones from Serrekunda, Gambia and Kampala, Uganda. The results show that the atmosphere at Kampala has less ozone compared to that at either Dar es Salaam or Serrekunda because of the higher altitude of Kampala. The results also show that the satellite sensors over-estimate the erythemal UV falling on the earth's surface and also that clouds have a much reducing effect on the incoming UV radiation. These results seem to suggest that there will be less ozone in the atmosphere at Kilimanjaro than at Dar es Salaam because of the higher altitude of Kilimanjaro and the presence of less cloud. This, however, will be tested when reliable data from Kilimanjaro is obtained and analyzed. The results also seem to suggest that accurate results are best obtained by using ground-based measurements. The results further show that Dar es Salaam is slightly more affected by aerosols than Kampala because of the air-borne salt from the Indian Ocean, whereas Gambia is more affected (4 to 5 times) by aerosols than either Tanzania or Uganda because of the dust from the Sahara desert.

Some of the results mentioned above have appeared in several papers. While data collected at the Dar es Salaam station is very reliable, there have been a number of problems hindering the smooth collection of data in Kilimanjaro. First, as explained before, only two stations have been fully operational in Kilimanjaro. Therefore, data has never been collected from one of the stations. Secondly, the problem with the power supply in one of the stations as mentioned before made it impossible to obtain data that could be analyzed to draw good conclusions. Thirdly, all the instruments in this project exhibit some drift which lead to wrong interpretation of the data. Part of this problem has been tackled by instituting regular calibrations on the instruments, and these are synchronized to the times of collecting data. In addition to the frequent calibrations, software has been developed to correct for the drift. It is expected that the two measures will lead to reliable interpretation of the collected data. Fourthly, it has been quite a challenge for the researchers to reach the instrument at Gilman's Point, especially when the weather is not conducive. For this reason, part of the work in the LLTE project will be to design the electronics that will enable the remote collection of data from stations that are not easily accessible. Finally, the M.Sc. student in the project declined to proceed with the studies, and as a result, no reliable results could be obtained from his work.

The work that is going on now on data analysis is the preparation of a report to incorporate the data from Kilimanjaro. Due to the problems mentioned above, that data consists of portions when data was not collected and portions when the data collected was not reliable. The report is being prepared in collaboration with the counterpart researchers from Norway.

Training

Only one M.Sc. student was under training for this project, but explained above, that student already dropped from studies. Two technicians have been trained on the calibration and data collection procedures within the project.

The setback on the postgraduate training side was due to two factors. First, Tanzania was late in entering the LLAE project, which was a sub-project of the main project based at Makerere University, Uganda, and which had been running for more than 10 years. There was not much time therefore in recruiting postgraduate students. Secondly, the project was new, and prospective postgraduate students were precarious to join it.

Even though the first M.Sc. student in the project dropped out of studies, there is much research work for future postgraduate students in the project. Therefore, much emphasis will be put on attracting postgraduate students to the envisaged LLTE project.

Interaction with the Tanzania National Park Sector

The National Park Sector, that is TANAPA, TAWIRI and KINAPA has been very cooperative and helpful throughout the project. KINAPA specifically, has been very instrumental in offering whatever assistance was needed by the project personnel going up the Kilimanjaro throughout the instrument installation and data collection expeditions. It is hoped that this will continue in the envisaged LLTE project.

Following the work in Kilimanjaro, KINAPA had requested for 3 weather stations, but due to budget constraints only 3 temperature loggers were supplied. The expectation was to enable the purchase of the weather stations if NUFU had continued to support the project, but this was not possible. Since monitoring of the weather is very important all along the mountain climbing route in Kilimanjaro, efforts will be made to include the weather stations in the envisaged LLTE project. Also, an important aspect that can be added to the research within LLTE is climate change, which has become important with the possibility of the ice on Mountain Kilimanjaro disappearing. This is not only important ecologically, but also to the tourism industry.

Significance of the research to cancer research in Tanzania

The role of UV in cancer has been highlighted in many reports. Excess exposure to UV accelerates skin cancer. In efforts to find out more on this, a visit was made to the Ocean Road Cancer Institute (ORCI), in Tanzania. First, it was learned that increased skin cancer has been a problem of major concern to the institute. Second, it was learned that the most affected group in the population are albinos. The skin cancer and complications arising from them lead to a great reduction in the life span of albinos, to around 40 years. The second group so affected by this problem are children, especially young infants. Thirdly, there has been an increase in cases of skin cancer patients from among the general population, so far assumed least unaffected. Thus, while previously dark skinned people have been less affected by exposure to UV, there is an increase in the number of dark skinned people having skin cancer. Four, quite a number of tourists from Europe have sought treatment at the cancer institute after overexposure to sunlight, with some being hospitalized for days. The incidence of skin cancer is therefore a very important problem to the Ocean Road Cancer Institute.

The increased incidence of skin cancer and overexposure to UV as explained above led the institute to install instruments for measuring the amount of UV reaching the ground as far back as the 80's. Unfortunately, the instruments broke down, and attempts to have them repaired failed. Thereafter, no more attempts were made to re-start the measurements. It is envisaged that part of the ground-based data in the LLTE project will be of assistance to the institute.

FUTURE PLANS

Future progress in the research will be based on the goal of establishing the climatology of PAR and UV radiation, and long-term trends of total ozone abundance, cloudiness, PAR and UV radiation levels in Tanzania. Capitalising on the gained experience which will enable us chart out how we can proceed with the research, the intention is to establish LLTE as a successor to the LLAE project, and take on the challenge of making it sustainable. That, however, will need the involvement of all the relevant stakeholders.

Therefore, in addition to research on UV, PAR and ozone, the future project will focus on a number of issues:

- a) Strengthening and expand the established network of measurement stations.
- b) Extending its work to study life in Tanzanian water masses.
- c) Including research on climate change, which will be of interest to the Kilimanjaro National Park.
- d) Including research on the effects of UV on cancer, this will be of interest to cancer research in Tanzania.
- e) Training more postgraduate students.
- f) Increasing participation of other researchers and stakeholders.
- g) Expanding the science and technology of monitoring environmental parameters.
