Contribution of UNU/GTP training to geothermal development in Africa

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Abstract

Seventy-five geothermal professionals from ten African countries have been trained in the UNU/GTP in Iceland since the programme started in 1979. Five of these UNU/GTP Fellows hold MSc degrees. This is about 25% of all the beneficiaries of this training world-wide. Kenya has benefited the most with 33 people, followed by Ethiopia with 20. About 32% of the trainees from Africa have left the industry. Kenya has retained the highest number of its professionals and has equally achieved the most in geothermal power generation. Over the 25-year period, Africa has benefited tremendously from the training. What is critically required now is to accelerate geothermal development in the continent by removing financial and political barriers so that the trained professionals can fully be utilised to achieve the intended growth. The Iceland training will still be required for some years to come, particularly in providing some assistance in formulation of a mechanism for involving the already trained professionals in training more Africans.

Keywords: *UNU/GTP training in Iceland, Africa, Kenya, Uganda, Ethiopia, Tunisia, Algeria, geothermal.*

1 Introduction

By 2000, geothermal resources had been identified in more than 80 countries and utilisation of the resource had been recorded in 58 countries in the world. The total installed geothermal electric power by 2000 was about 7,974 MW worldwide (Huttrer, 2000) and 53 TWh/a of heat energy was being used for direct heating (Lund and Freestone, 2000). Electricity generation using geothermal steam is currently in 21 countries spread over all continents. Among the African countries, Kenya has been generating electricity since 1981 and Ethiopia started in 1998. Exploration for high temperature resources (for electricity production) has also been conducted in Cape Verde, Djibouti, Eritrea, Tanzania, Uganda and Zambia (Fridleifsson, 2001).

Many African countries have made some direct uses of their geothermal resources. These countries are Algeria, Egypt, Ethiopia, Kenya, Tunisia, and Zambia. Hot springs have also been identified in Burundi, Cape Verde, Madagascar, Malawi, Mozambique, Uganda, and Zimbabwe (Fridleifsson, 2001).

In order to realise the above developments, Africa required trained manpower. The main institutions that have taken a leading role in geothermal technology training are the UNU/GTP in Iceland, the Geothermal Institute at the University of Auckland in New Zealand, the International Institute for Geothermal Research in Pisa, Italy, and Japan. By 1992, the school at Pisa had trained a total of 324 students from 68 countries in various courses. Of this total, there were 43 Africans, 119 Latin Americans, 113 Asians, and 49 Europeans (Dickson and Fanelli, 1995). On the other hand, the Geothermal Institute at Auckland University had trained 88 Africans (14%) out of a total of 638 by the year 2002. Similarly, 64 Africans (16%) out of a total of

393 had been trained in Japan by the year 2001. Except for the Iceland training, all the other three have now been discontinued.
During the 25-year period 1979-2003, 300 scientists and engineers from 39 countries have completed the six-month programme in Iceland (Fridleifsson, 2003). Of these, 43% are from Asia, 25% from Africa, 15% from Latin America, and 17% from Central and Eastern Europe.

2 Geothermal uses in Africa

Kenya and Ethiopia are the only two countries in Africa producing electricity from geothermal steam. Kenya commissioned its first geothermal power plant at Olkaria East in 1981. The 45 MWe plant has been producing electricity in the country with an availability factor of over 95%. An Independent Power Producer (IPP) commissioned an additional 12 MWe as a pilot plant for Olkaria III. Olkaria II (64 MWe) will be commissioned between August and October 2003, and the extension of Olkaria III up to 48 MWe is expected to start early 2004. The Kenyan government plans to have an installed geothermal capacity of 450 MWe within the next 16 years (Government of Kenya, 2003). This will be added to the Kenyan interconnected system of 1,162 MW, which includes import of 30 MW from Uganda.

Ethiopia commissioned its first 8.5 MWe geothermal plant in 1998 at Aluto in the Lakes District (Teklemariam et al., 2000). Unfortunately, the plant has had technical problems associated with well productivity, and the leaking of isopentane in the binary circuit. Presently, the plant is not working. This has created a negative impression on the reliability of geothermal power in Ethiopia primarily because Ethiopian Electric Power Corporation (EEPCo), which owns the plant, has few experienced staff in geothermal technology, and they did not integrate the already trained personnel from Ethiopia Geological Survey in the management of the reservoir and plant. Despite this problem, there are plans to increase the generation capacity to 30 MWe in the near future. In the long-term, Ethiopia plans to increase the geothermal capacity to 700 MWe as financing becomes available. Deep drilling in the Tendaho graben has shown temperatures of up to 260°C, and four (out of six) wells are productive. Production testing and a feasibility study are under way in Tendaho, aimed at the installation of a 5 MWe pilot plant. The present installed electric capacity in Ethiopia is about 380 MWe, mostly hydropower.

Several other African countries, particularly in the East African Rift Valley region, have significant potential for geothermal electric generation. Some exploration has been conducted for high temperature resources in Burundi, Cape Verde, Djibouti, Eritrea, Tanzania, and Uganda. Deep drilling has only been conducted in Djibouti, where temperatures as high as 350°C have been measured in wells in the Lake Assal area. An Independent Power Producer (IPP) has already done a feasibility study for a 30 MW plant at Assal (BCSE, 2003).

Tunisia, which is one of the world leaders in the use of geothermal energy for greenhouse heating and irrigation, is currently leading in Africa with about 102 hectares of greenhouses being heated with geothermal. This development has mainly taken place in oases (Kebili, Tozeur and Gabes) in the Sahara desert (Said, 1997; Mohamed, 2003). Deep drilling (2-3 km) for irrigation water in the desert oases in Tunisia has produced a large quantity of water that is far too hot to be used for irrigating the crops directly. In the Kebili area south of Tunisia, 35 boreholes are being operated to irrigate 16,000 ha of oases (Mohamed, 2003; in prep). The hot water for irrigation of oases is initially cooled to below 45°C in multiple ponds, or by passing it through cascades before it is used. For greenhouses, the hot water is

initially circulated through the greenhouses to keep the temperatures high during the cold nights in the desert. This circulation cools the water before it is then used for irrigation. The geothermal heat is therefore a by-product of the irrigation water. The main products in the greenhouses are tomatoes and melons for export to Europe. For centuries, Tunisia has been using hot springs for bathing and treatment of skin diseases. These bathing springs are known as Hammams. Other uses have been for the treatment of soils in greenhouses, heating swimming pools in tourism areas, and also watering cattle.

In Kenya, a farmer who has been experimenting with the use of geothermal in growing flowers for export in greenhouses has recently commissioned a fully-fledged commercial system. The installed system will use steam from a 1.28 MW well to heat fresh water through heat exchangers. The heated fresh water will circulate through the greenhouses.

In addition to Tunisia and Kenya, many African countries make some direct use of their geothermal resources, e.g. Algeria, Egypt, Ethiopia, and Zambia. Hot springs have also been identified in Burundi, Cape Verde, Madagascar, Malawi, Morocco, Mozambique, Uganda, and Zimbabwe. The main recorded direct use of geothermal water is for bathing and swimming (e.g. Algeria, Ethiopia, Egypt and Tunisia) and for greenhouses (e.g. Algeria, Tunisia, Kenya). Kenya has, for decades, used geothermal heat to dry pyrethrum flowers and condense steam for drinking at Eburru.

There are numerous opportunities for the use of geothermal resources in many countries of Africa. The key issues at hand both for the exploration and the development of the geothermal resources, are financing and technology transfer.

Financial constraint has been recognised as the biggest barrier to realising geothermal development from exploration drilling to power station construction. A recent 2nd KenGen Conference in April 2003 in Nairobi, which was co-sponsored by the Global Environmental Facility (GEF) and KenGen (Kenya Electricity Generating Company), underscored this. This conference involved decision-makers from various East African countries and international financiers. The conference endorsed a resolution that GEF co-ordinate the establishment of a risk fund that could be used to accelerate geothermal development in the countries within the East African Rift system. A target of 1,000 MW development was set for the next 20 years.

Kenya and Tunisia certainly have the expertise to train people from other African countries in the development of geothermal energy for electricity production and direct use, respectively. This factor was also recognised in the 2003 2nd KenGen Conference. It was felt that it is an opportune time for experienced people in Africa to play a much bigger role in providing services and training to other Africans through the establishment of a geothermal resource centre which would co-ordinate the experts from various countries. The resource centre could be established in collaboration with other geothermal schools in Iceland, Japan and New Zealand. GEF and other donors would also co-fund the establishment of the centre.

3 Geothermal training in Iceland

The United Nations University Geothermal Training Programme (UNU/GTP) has operated in Iceland since 1979 with six months of courses for professionals from developing countries. Specialized training is offered in geological exploration, borehole geology, geophysical exploration, borehole geophysics, reservoir engineering, chemistry of thermal fluids, environmental studies, geothermal utilization, and drilling technology. More recently, MSc degree courses have been introduced.

The trainees specialise in their fields by working side by side with professionals from Orkustofnun, an agency actively working on most aspects of geothermal research, exploration, and development. The training is tailor-made for the individual and the needs of his institution/country. The outcome of this is that the graduates can produce reasonable amounts of work as soon as they return to their home countries. This is different from the New Zealand course which covers broad topics theoretically. Kenya has always found it necessary to send the graduates of the New Zealand course to Iceland in order to specialise. Since the priority is given to candidates from institutions where geothermal work is already under way, the graduates become useful immediately, and do not lose what they have learned.

Among the 300 graduates of the UNU/GTP, by 2003, seventy five (75) of the Fellows came from ten African countries (Table 1). They came from Algeria (3), Burundi (1), Djibouti (1), Egypt (3), Eritrea (1), Ethiopia (20), Kenya (33), Tanzania (1), Tunisia (6), and Uganda (6). In addition, this year two MSc students are from Africa. Two Kenyans have already completed their MSc degree (in Chemistry and Reservoir Engineering), and two more are currently undertaking MSc degrees in Environmental Studies and Geology. Most of the participants have been on fellowships from the UNU and the Government of Iceland, but some have studied on fellowships from UNDP and the International Atomic Energy Agency (IAEA).

Table 1: Fellows of UNU Geothermal Training from Africa.

Country	No. Trained	Retired or not in geothermal	Available
Algeria	3	3	0
Burundi	1	1	0
Djibouti	1	1	0
Egypt	3	0	3
Eritrea	1	1	0
Ethiopia	20	9	11
Kenya	33	5	28
Tanzania	1	1	0
Tunisia	6	0	6
Uganda	6	3	3
Totals	**75**	**24**	**51**

4 Activities of former UNU/GTP Fellows

4.1 Kenya

Out of the 33 Kenyans trained in Iceland, 27 came from KenGen, four from the Ministry of Energy, and two from the University of Nairobi.

KenGen has been at the forefront of geothermal exploration and development in Kenya, and this is reflected by the high number of staff trained at the UNU/GTP since the Olkaria I power plant was commissioned in 1981. The first group of UNU Fellows were trained in 1982. These are Joseph Ng'ang'a in Drilling, Martin Mwangi in Geophysics, and Zack Muna in Geochemistry. Mr Ng'ang'a became Chief Drilling Engineer, Geothermal Development Manager, and is now the Deputy Managing Director in charge of Business Development. He coordinates the geothermal activities through Business Development. Mr Mwangi became a senior geophysicist, then a chief geothermal scientist, and is currently Geothermal Development Manager

since 1996. Mr Muna became a senior geochemist, and is now Chief Geothermal Scientist in charge of all scientific work.

Since then, KenGen has trained a total of 4 geologists, 5 geochemists, 3 geophysicists, 6 reservoir engineers, 4 drilling engineers, and 5 environmental scientists. Out of these people, 1 reservoir engineer left the company and is at Berkeley University in the USA, 1 geochemist is teaching at Moi University, and 1 geologist is teaching at Egerton University. The rest are all working for KenGen.

External consultants carried out most of the geothermal work when the first three people were trained in Iceland. The drilling rate using consultants was very low and it took 6-10 months to drill a single 2,000 m well. By 1990, full-time consultants and experts were phased out, and the geothermal work is now managed and performed entirely by KenGen staff. The key people in this management were trained in Iceland. The fact that one of these people is now a Deputy Managing Director, and is in charge of business development has assisted the development of geothermal resources in Kenya. KenGen staff members have been involved in exploration work at Olkaria, Eburru, Suswa and Longonot fields. They have also drilled wells in Olkaria I, II, III and Olkaria Domes and undertaken various work-over jobs.

One of the major tasks achieved by KenGen has been to demonstrate that geothermal is an important source of energy for Kenya's power generation mix, and that it needs to be included in the National Power Development Plan. This was done in 1986, and geothermal is now an important source in the plan. KenGen was also involved in the development of a new geothermal policy that is meant to accelerate geothermal development. The environmental friendliness of geothermal resources compared to other fossil fuel sources is well demonstrated by the development of the Olkaria field inside a National Park.

The training received from Iceland, in various disciplines, has been very useful in the management of Olkaria I reservoir in order to guarantee adequate and quality steam to the station. This experience has been extended in the design of Olkaria II which has incorporated a complete re-injection programme tested in Olkaria I. Some of the personnel are currently involved in the supervision of Olkaria II steam field contracts.

The environmental staff members of the project, who were all trained in Iceland, have been KenGen's forerunners in raising awareness in environmental matters not only within KenGen, but also in the country as a whole. They have also been instrumental in the development of KenGen's corporate environmental management policy statement. One of them, Mr Joshua Were, was involved in the development of the software-based Integrated Environmental Management System (EMS), for pilot implementation in Olkaria geothermal and Kipevu thermal power stations.

KenGen staff members have also provided consultancy services to an IPP who was licensed to develop the Olkaria III power station in 1997. With this experience, KenGen is marketing its expertise in the East African region and it is confident that it can greatly contribute in the development of geothermal resources in the African Rift system region by providing training and consultancy services. Since 2002, KenGen has organised annual conferences in Nairobi with the aim of bringing Africans together to share ideas and experiences. This year's conference was particularly successful as it had a session that focused on how geothermal development can be accelerated in the region.

The Ministry of Energy has sent four scientists for training in Iceland. Two of these retired in 2001. Two geophysicists are still with the Ministry of Energy. The personnel working with the Ministry provided counter-part personnel to Geothermica Italiana which was contracted by UNDP to carry out exploratory work in Longonot,

Suswa and Menengai prospects between 1988 and 1992. They were also involved in geological and geochemical exploration carried out by the British Geological Survey, which covered a large area of the Rift Valley from Longonot to Lake Turkana. The British Geological Survey undertook this work in three phases from 1985 to 1992, and it was funded by the British government (Clarke et al, 1990; Dunkley et al, 1993). After these two sets of exploratory work, the Ministry staff has not been directly involved in geothermal work because of lack of funds. These people have now been involved in the exploration for coal in the coastal region of Kenya for the last two years.

Professors Tole and Singh came from the Faculty of Science, University of Nairobi with the aim of establishing training in geothermal technology at the university. Professor Singh has not been active in geothermal, and is no longer teaching since December 2002. However, Professor Tole has been very active. In 1989, he became Associate Professor and moved to Moi University. Between 1990 and 1995, he was Dean of Post-Graduate Studies, and from 1995-1996, the Dean of the School of Environmental Studies. He has co-authored about sixteen referred papers and has supervised seven post-graduate students in the field of geothermal resources. He is currently Professor of Environmental Geochemistry at the School of Environmental Studies at Moi University.

4.2 Uganda

Six people have been trained from Uganda - three geologists, two geochemists and one geophysicist. Godfrey Bahati is currently a principal geochemist, based at the Uganda Geological Survey in the Ministry of Energy and Minerals, which undertakes geothermal exploration. He is the coordinator of the geothermal programme. Mr Vincent Kato is a chemist and Edward Isabirye a geologist under the geothermal programme in the same department. Amos Bazaale-Dolo and David Kyagulanyi are also geologists but are no longer directly active in geothermal work. Fred Alex Tugume trained as a geophysicist. He initially worked in geothermal exploration as a senior geophysicist, but left to become Project Manager at Uganda National Seismology Network. He is currently the manager for the Global Seismic Station established jointly by the University of California at San Diego and the Government of Uganda as an auxiliary station for the Nuclear Test Ban Treaty Organisation (CTBO). Therefore only three former UNU/GTP Fellows are currently directly involved in geothermal work in Uganda and have published several reports and papers (Mugadu et al, 1999; Mugadu, 2000).

Active participation of former UNU/GTP Fellows in Uganda has been affected by the lack of funds to proceed with geological and geochemical exploratory work done in Katwe, Buranga and Kibiro since the UNDP funded the initial programme carried out between 1992 and 1994 (Gislason, 1994). Since then, some funds were provided by the International Atomic Energy Agency (IAEA) to carry out hydrological studies using isotopes in the three prospects. In 2000, isotope studies were integrated into the Uganda Alternative Energy Resource Assessment and Utilisation Study (UAERAUS) funded by the African Development Bank (AfDB) and the Ugandan Government. In this project, some geophysical work will be done this year at Katwe and Buranga prospects using a private company. This company will involve to some extent the Uganda Geological Survey staff. The Iceland International Development Agency (ICEIDA) will fund Geophysical work at the Kibiro prospect. The ICEIDA project will further evaluate the findings of all three prospects, and propose a strategy for exploratory drilling by the end of 2003 (BCSE, 2003).

4.3 Ethiopia

Twenty people have been trained from Ethiopia since 1983 when the first two people attended the UNU/GTP. Only eleven of them are currently actively involved in geothermal. Most of the remaining nine is now living in other countries. Most of the active people work for the Geological Survey of Ethiopia (GSE) and have the responsibility for exploration and drilling. Berhanu Gizaw and Kibret Beyene are senior geochemists; Meseret Teklemarian has a PhD and is a senior geologist; Yiheyis Amdeberhan is a senior reservoir engineer and geophysicist; and Yiheyis Kebede and Yohannes Demissie are also senior geophysicists.

Three of the trained Ethiopians have come from the Ethiopian Electric Power Company (EEPCo), which is responsible for the running of the Aluto-Langano power plant. Merga Tassew is an engineer, trained in 2001, and has been engaged in the project on solving the problems with the power plant, and two more engineers were trained in control systems and maintenance of geothermal power plants in 2002.

Over the years, the UNU/GTP Fellows in Ethiopia have been involved in the Aluto-Langano field, and later Tendaho where wells have been drilled and a pilot station constructed in the former location. Two rigs owned and manned by GSE were used. In Tendaho, they worked with an Italian company. The personnel is still monitoring the two reservoirs. Other exploration areas that they have been involved in are Tulu-Moye, which they explored in 1998, Corbetti and Lake Abaya, Dofan, and Fantale. Tthe staff was involved in isotope studies organised through a technical cooperation program by the Ethiopian Science and Technology Commission and the International Atomic Energy Agency (IAEA) in 1993.

The poor performance of the Aluto-Langano plant has to some extent affected the impetus of geothermal development in Ethiopia, even though GSE continues to carry out some exploration work. This, coupled with war with Eritrea may have caused many trained personnel to look for better employment outside the country. However, Ethiopia is realising that even though it has huge potential of hydropower, it is necessary to develop geothermal resources in order to protect itself from lack of power during the dry periods.

4.4 Eritrea

Mohammed Berhan Abdulkadir is a geophysicist and attended the UNU/GTP in 1984. Since then, he has been involved in geophysical surveys on Aluto-Langano, Corbetti, Tendaho, Fentale, Tulu, Moye, Gedemsa and Dofan prospects in Ethiopia before Eritrea became independent. In the first three prospects, he was team leader of geophysical crews and in the last four years, he was the counter-part geophysicist with Electroconsult (ELC), an Italian company. He later became Senior Geophysicist. After 1993, when Eritrea became independent, he joined the Department of Energy dealing in hydrocarbons and geothermal in Eritrea. He worked on geothermal until 1997 when the geothermal section was moved to the Department of Mines. He was left to work for hydrocarbons specialising in seismic data for which he has obtained an MSc degree.

4.5 Tunisia

Six Tunisians have so far been trained in Iceland between 1997 and 2000. Mr. Mouldi Ben Mohamed and Mr. Mondher Said have been working in the Ministry of Agriculture, Environment and Water Resources, and have been instrumental in the development of greenhouse heating using hot water in Kebili. Mr. Ben Mohamed has

been working for the Commission of Agricultural Development (CRDA) at Kebili, assisting farmers in the use of geothermal energy in greenhouse heating, and in the utilisation of geothermal in bathing and swimming pools. He is the lead person for national and international consultants working in Tunisia on geothermal energy. He has authored about five papers and a postgraduate thesis. One paper is included in this publication.

CRDA is responsible for drilling of deep-water wells used for irrigation and heating in greenhouses. Mr. Mohamed A. Gandouzi is the head of the Soil Division of CRDA, Kebili, and is also working in the development of greenhouse heating. Mr. Mongi Elguedri is an engineer in rural equipment in CRDA, Kebili. He attended a course for one year in Japan on irrigation, drainage and rural development. Mr. Aissa Agoun is the head of the Water Resources Department in CRDA, Tataouine. Dr. Lasaad Sbita teaches in the National School of Engineering in Gabes (ENIG) in the use of computers in automation, including control systems in geothermal greenhouses.

4.6 Algeria

Three Algerians were trained between 1989 and 1994. Mr. M. Abouriche passed away last year. Mr. Talal Karouaz went for a diploma course at the Geothermal Institute of the University of Auckland soon after leaving the UNU/GTP in Iceland, and has not returned to Algeria yet. Mrs. Malika Rachedi teaches at the University. However, she is not actively involved in the geothermal industry, but still keeps some interest in it.

5 Proposal for improvement

The UNU has played a major role in geothermal manpower development for third-world countries. Some of these countries like Kenya and Ethiopia now have the capacity to carry out surface geothermal exploration, drilling and reservoir monitoring, and environmental impact assessments (Kenya). In these areas, a requirement is envisaged for specialisation in certain aspects, for example in directional and air drilling, and reservoir simulation studies. The specialised courses may be suited to be offered through the MSc training programme that the UNU has started.

Kenya is very keen to have its people trained in various aspects of power plant design and selection; economics and financial analyses; and contract documentation and implementation. This course could be offered as an MSc degree. Although the desire is not to design power plants, this knowledge is very necessary in the critiquing process of consulting engineers' work to get the most benefit from power station projects. In this respect, Kenya has already started training people in pipeline design, contract documentation and supervision for make-up well connections. The development of expertise in information technology in digital control systems (DCS), which have now become the industry standard in power station operations, is now critical.

Considering the high level of global environmental awareness, the UNU/GTP specialization in environmental studies should be broadened to include other disciplines such as toxicology and environmental health; environmental engineering; environmental management systems such as GIS; environmental laws and regulations and their implications on geothermal development; and socio-economic issues among others.

There are other countries for instance Uganda, Eritrea, and Tanzania who have not attained the capacity to carry out exploratory work. Recently, there have been signs of

interest from these countries to explore and develop indigenous geothermal resources, which are expected to be inspired by the establishment of the risk fund mentioned earlier. The UNU would therefore continue to play a major role in assisting such countries attain the necessary capacity. This means that the UNU would continue with the type of training that it has been giving, but at the same time offering specialized training for those countries that are already ahead.

There have been suggestions of starting regional geothermal resources facilities such as the East African Geothermal Resources Centre. The proposed centre would be used for training people from the region, archiving important documents/data, and acting as a coordination centre for geothermal activities in the region. It is suggested that this sort of centre can be started as part of the UNU under the UNU/GTP curriculum, and with Iceland's support, to cut down on the travel costs. This can be done by the UNU providing the expertise, with additional assistance of available experts in the region. This would help in developing further the expertise in the region, and would provide training to the locals in their surrounding environment. This has the advantage of developing home-based solutions to problems.

6 Conclusions

Although Africa will have had only 129 MWe of electric power generation and an unknown amount of direct uses from geothermal resources by the end of 2003, this achievement has been realised by efforts made under very difficult circumstances by some former UNU/GTP graduates. In some countries, former UNU/GTP Fellows could not be fully utilised because there was either war or a poor economic environment; and these experts have been lost to the developed countries. In several other countries, the UNU/GTP Fellows have been fully utilised and are planning to extend their expertise to assist other African countries develop their resources. As barriers of geothermal development are removed and more countries with geothermal potential realise that it is important to have a power generation mix to overcome the severe price and weather changes, this group of trained personnel will become critically useful in the future.

UNU/GTP training has been very useful and will continue to be useful as more countries diversify their power generation mix to include geothermal as an indigenous and environmentally friendly source of energy. Some countries are already ahead of others in manpower development but will still require UNU funded training in specialised areas. This will include an expansion into areas like power station cost analysis, design, and contract management. By applying innovative ideas, the UNU/GTP could assist the African countries better utilise their trained human resources in geothermal technology to train other countries, and to develop homegrown solutions to their geothermal development problems.

Acknowledgements

The author thanks the entire KenGen staff and various people from African countries and the UNU/GTP for providing me with some useful information used in this paper.

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