CONSERVATION EFFORTS OF KIHANSI SPRAY TOAD *NECTOPHRYNOIDES ASPERGINIS*: ITS DISCOVERY, CAPTIVE BREEDING, EXTINCTION IN THE WILD AND RE-INTRODUCTION

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ABSTRACT

Species conservation depends on the initiatives to restore or retain and sustainably use the environment in which the species live. This paper highlights how development projects can affect biodiversity conservation and the challenges in achieving sustainable development. The paper discusses a case study of the Kihansi Spray Toad (KST) (Nectophrynoides asperginis) from its discovery, extinction in the wild, captive breeding and subsequent reintroduction to its native habitat; focusing on events, challenges, approaches in addressing issues, future prospects and achievements in the conservation of this endemic species. There has been considerable success in KST husbandry in captivity and reintroduction trials of the toad to the wild while concurrently the operations of the hydropower plant and the catchment ecosystem services have continued to provide electricity for domestic & industrial development and support human livelihoods respectively. The paper underscores the importance of interdisciplinary approach in addressing conservation problems and the need for serious commitment of participating parties, but also on the need to balance conservation with sustainable development.

Key words: *Kihansi spray toad, extinction, reintroduction,*

INTRODUCTION

In the year 1994, the Lower Kihansi Hydroelectric plant project was approved by the Government of Tanzania with funding from the World Bank (WB) (LKEMP 2004, Channing *et* al. 2006, LKEMP 2011, NEMC 2011, Rija et al. 2011). This was the Tanzania Power VI project which was approved in 1993 (credit 2489 - TA). The power project involved construction of a 180 MW hydroelectric facility on the Kihansi River at the Lower Kihansi Gorge. With the highest "head water value" 850m waterfall) the Lower Kihansi hydropower is irresistible and produces more electricity in the country than any of the three hydropower plants (Table 1) that will enable the country attain middle class economy by the year 2025; attain Sustainable Development Goals – 2030 and achieve Agenda 2063.

Table 1: Comparative head water value between Kihansi hydropower plant and other plants

Plant/Turbine type	Discharge at rated unit capacity m3/s	Head (m)	Rated unit output (MW)	Output per 1m3/s
Mtera (Francis)	47.0	92	40	0.80
Kidatu (Francis)	35.0	165	50	1.40
Pangani (Francis)	22.5	167	34	1.50
Kihansi (Pelton)	8.0	850	60	7.45

Source: TANESCO

The project also involved the construction of a dam which is located at the upper part of the Kihansi gorge along the Kihansi River in the southern part of the Udzungwa Mountains in Tanzania. An Environmental Impact Assessment (EIA) for the Project was prepared in 1992 and the government agreed to prepare and implement an Environmental Management Plan (EMP) that focused primarily on mitigating the upstream impacts on the area that would be covered by water and to the communities living in the vicinity of the project and downstream. This was in conformity with the National Environment Management Act (1983) and WB regulations.

The KST was discovered in 1996 during the monitoring of the gorge as part of the EMP proposed by the EIA (Poynton et al. 1998) (Fig. 1). Upon its discovery efforts to locate the species in similar waterfalls all over the country failed and it remains only in a small area covering 2 ha. in the Kihansi gorge in the Southern Udzungwa Mountains in Tanzania (Poynton et al. 1998). The natural slippery cliffs and the water's ferocity made the area relatively inaccessible to people, allowing the KST which gives birth to live toadlets (LKEMP 2004) to live undiscovered for many years (Krajick 2006). The waterfalls created mists that formed high relative humidity and low temperatures in the wetlands preventing the growth of forest trees so creating a unique wetland habitat dominated by moss vegetation (Channing et al. 2006).

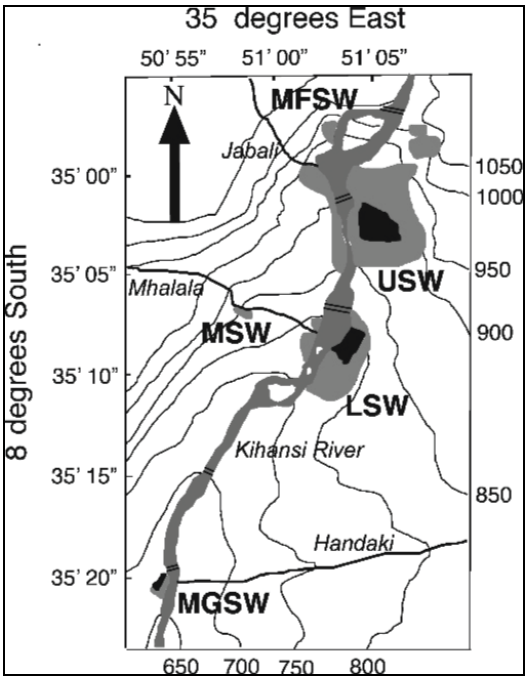

Figure 1: Location of Kihansi gorge and spray wetlands in the Kihansi River. MFSW = Main Falls Spray Wetland, USW = Upper Spray Wetland, LSW = Lower Spray Wetland, MGSW = Midgorge Spray Wetland and MSW = Mhalala Spray Wetland (Source: Channing et al., 2006).

The production of hydroelectric power begun in 2000 and shortly, it was realized that the generation of hydropower reduced the volume of water needed to maintain the natural sprays in the wetlands from $16m^3$ to $2m^3$ following the diversion of the Kihansi River into tunnels running into the hydropower plant and returning the water to the river over 6 km downstream (LKEMP 2011). Such a situation drastically affected the habitat where the KST inhabited as the wetlands became considerably drier in early 2000 and beyond (Rija et al. 2011).

A series of emergency mitigation measures were initiated in 2000 under the Immediate Rescue and Emergency Measures Project (IREMP) to conserve the spray wetland habitat and the KST *in-situ* (IUCN 2002). The IREM was established to implement the EMP and it also involved the installation of artificial sprinklers and sending some 500 toads to the United States of America (USA) for captive breeding before the KST went extinct in the wild (Channing et al. 2006, LKEMP 2011). International Union for Conservation of Nature IUCN requires all "Critically Endangered and Extinct in the Wild taxa be subjected to *ex-situ* management to ensure the recovery of the wild populations" (IUCN 2002).

Regardless of the installation of artificial sprinklers, wild populations plummeted from tens of thousands to a few in a couple months (Hirji and Davis 2009, LKEMP 2011, Rija et al. 2011) possibly due to chytrid fungus attack. Although an *ex-situ* assurance population of 500 animals was established in Bronx and Toledo zoos (in USA) in the year 2000, numbers in captivity fell steadily for 4 years reaching 15% of the original size (IUCN-CBSG 2007) due to husbandry challenges. Successive periodic monitoring in the gorge confirmed the wild extinction of the KST and by 2009 the IUCN declared the species "extinct in the wild" (Channing *et al*. 2009) and The Convention on International Trade in Endangered Species of Wild Flora and Fauna CITES placed the toad in its Appendix I.

Other factors that are assumed to have contributed to the extinction of the toad in the wild include the flushing of the dam by releasing sediment contaminated with pesticides from upstream farms (Rija et al. 2011, Rija et al. 2014). Also safari ants *Dorylus* spp. that invaded the wetlands and became predators of the toads (NORPLAN 2002). Thus the desire to tap hydropower for economic development created an environmental and ecological problems that threatened species and the Kihansi gorge ecosystem. Appropriate measures had to be taken to ensure a win-win situation is realized. This study therefore intended to investigate how development projects like hydropower production can affect species conservation and determine approaches which are used to mitigate the arising ecological and environmental problems in order to ensure that economic development and species conservation goals are both achieved.

MATERIALS AND METHODS

Data were collected at Kihansi gorge, University of Dar es Salaam (UDSM), Sokoine University of Agriculture (SUA), USA zoos keeping KSTs, National Environment Management Council (NEMC), Tanzania Wildlife Research Institute (TAWIRI) and included literature search and interview of various people. KST captive breeding program was established in the year 2000 in the USA zoos. For a long time, the Toledo Zoo in Ohio was the only place in the world where the KST was on display to the public. The Bronx Zoo in New York City opened a small exhibit in February 2010. In Tanzania, captive breeding facility was established in August 2010, with 100 toads from the Toledo and Bronx Zoos in USA. The Kihansi captive breeding facility (KCBF) was established in

June 2011.The second colony of 200 KSTs from USA arrived in February 2011 to top up the breeding colony brought in 2010 but this second batch was purposely for experimental purposes. The third batch of 500 toads came in May 2012 and was distributed to both facilities (UDSM and Kihansi) for captive breeding and was also for experimental purposes. The considerable success of the breeding program of the KSTs in captivity both in the USA and Tanzania paved the way to eventual reintroduction of the toads in the wild a process which begun in October 2012 by reintroducing 2,433 toads, 2,000 at the Upper spray wetland (USW) and 433 at Mhalala spray wetland (MSW) which are two of the five wetlands the Kihansi toad inhabited before its wild extinction. Activities in the facilities include cleanliness of the cages, feeding of the KSTs, attending the feeder insects, water quality monitoring and microclimate monitoring inside the facilities [using indoor Onset Hobo data loggers (temperature and humidity) and AXIOM thermometers (temperature)]. In-door temperature is regulated using air conditioners. Strict bio-secure protocols are enforced whenever one is in the facility. The KSTs in captivity are fed with a variety of feeder insects which include fruit flies, Cricket Pin-heads, Bean beetles, Isopods and Springtail. Like in Tanzania, the KST in the USA are fed with Springtail, Fruitflies, House Crickets, Bean beetles and Isopods. In the USA zoos, the food is bought from dealers while in Tanzania the KST food is reared within the facilities.

The KSTs in the facilities are under intensive medical care that includes the determination of diseases, parasites and worms that require undertaking of pathological and fecal tests involving swabbing of the toad bellies and feet. Once the toads show abnormal conditions or die detailed medical examinations are conducted by qualified veterinary doctors to establish the problems and determine the right medication for the toads. Toads were also observed to assess their physical fitness, external parasites and signs for fungal infection. Microscopes are used to test the samples collected to determine diseases and parasites.

Terraria are lighted to supply the KSTs and the vegetation with Ultra violet (UV) light. Cages are also furnished with different plant species for controlling primary production and gaseous exchange in the cages and provision of perching platform to KSTs. Facility rooms are air conditioned to control microclimate and are also installed with extractor fans for air exchange.

Total count method was used during KST census in all captive breeding facilities in Tanzania and USA zoos where all toads in each terrarium were counted. Records were made on age, sex and whether an adult female was gravid or not.

The re-introduction of the KST incorporated several pre-release scientific experiments including *ex-situ* pilot experiments that were conducted at UDSM and Kihansi captive breeding facilities. Following the successes of these experiments an international workshop of amphibian experts was convened in Dar es Salaam in February 2010 which ended up drafting the "Kihansi Spray Toad Reintroduction Guidelines" which were prepared under the IUCN guidance. Soon after in the same year soft release experiments were started, followed by hard release trials. Some experiments conducted prior to the KST reintroduction included disease challenging experiments conducted at SUA and *ex-situ* pilot experiments including exposing the toads to untreated substrates presumed to contain chytrid fungus. The substrates were obtained from the Kihansi gorge spray wetlands and were mixed with the captive toads with their surrogate species from the wild. The results

from these experiments suggested that KSTs could be successfully reintroduced back to the Kihansi spray wetlands as its substrate appeared not to harbor infectious agents that could threaten the survival of the KST, and soft release experiments in Kihansi gorge.

Carrying KST surveys in the gorge involved surveying the upper and Mhalala spray wetlands during the night where flashlights were used. Timed-constrained audio-visual surveys according to Howell (2002) were used to survey the wetlands in which the toads have been reintroduced and systematic walks along transects were employed to count all the detected KSTs and other amphibians (Harper et al. 2010, Channing and Howell 2006). Survey and monitoring at the Upper spray wetland were conducted systematically during day and night hours while the Mhalala spray wetland was surveyed only during the day to avoid deadly slides due to its slippery and steep nature. Careful walks along sprinkler lines were encouraged to avoid extensive disturbance to the wetland vegetation and the possibility of stepping on toads. Crabs and other potential predators detected during the surveys were also recorded and identified according to Spawls et al. (2004), Gabriel and Gerber (2002) and Picker et al. (2002). Snakes that were commonly seen were the house snakes. Sex and age classes of the toads were identified whenever possible. The information on the activity of the toads once spotted (whether vocalizing, amplexing, moving, sitting on vegetation etc.) was recorded. Footwear and equipment were sterilized to prevent the possible spread of chytrid fungi from equipment and clothing into the gorge, and from one site to another. Footwear and equipment were first rinsed in water and then bathed/immersed in a sodium hypochlorite solution (100 mg/L) for at least 2 minutes (Weldon 2006).

Amphibian husbandry challenges in captive facilities were noted, as well the challenges encountered in the process of reintroducing the toads to the wild. Achievements attained in both husbandry and reintroduction process were also noted and recorded. These included the efforts employed to ensure the toad does not go extinct, maintenance of the catchment ecosystem health and integrity for species survival, sustained hydropower production and support of community livelihoods. Also international collaboration of scientists and stakeholders in the project planning, implementation, monitoring and evaluation were observed.

RESULTS AND DISCUSSION

KSTs in captive breeding facilities

Captive breeding program at the Bronx zoo began with 500 toads flown from the Kihansi gorge in Tanzania after the establishment of the Immediate Rescue and Emergency Measures (IREM) project (Channing et al. 2006, LKEMP 2011). This was a necessary measure since it was obvious the wild toad population was facing imminent danger due to water diversion for hydropower production. The Toledo Zoo established the breeding colony of KSTs with toads from the Detroit Zoo. The KST population increased to more than 5,000 toads in 2009 in the two zoos, the Toledo zoo in Ohio being the zoo that holds a big population of the KSTs in USA. In October 2015, the estimated population size both at the Toledo and Bronx Zoos were 6,000 KSTs despite of several shipments of the toads to Tanzania for captive breeding and reintroduction to the Kihansi gorge.

The success attained at the UDSM captive breeding facility came after a series of challenges in the management of the toads in captivity. Some of the reasons were deaths caused by some husbandry difficulties, which included high temperature due to air condition malfunctioning and relative humidity variation becoming extremely intolerable for the KSTs to survive especially when there was power cuts and

operational failure of the backup generator. At normal circumstances the temperature in the toad rooms is supposed to be at the range of 16–20°C and 53–86% relative humidity (Rija et al. 2014) above which mass deaths must occur. Normal frequent deaths of adult KSTs and low birth rate also contributed to the gradual fall and rise of the KST numbers. The trend began improving in October 2013 when the population size was 497 and continued to increase until when it reached 3,005 in February 2016.

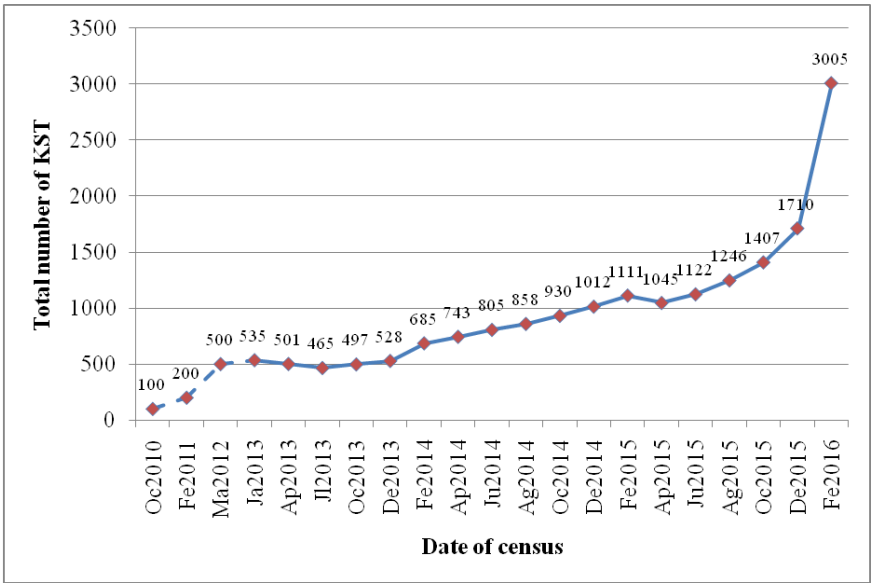

Figure 2: KST trend at UDSM captive breeding facility from October 2010 to February 2016

The increase of the KST population was also due to the increase in the number of adult females able to give birth to an average of 13 toadlets per female. Increase of food production (fruit flies, springtails, Isopods and Crickets pinheads) also had a significant contribution to the rise of the KST population size. The data based on daily collection of toadlets show there is extremely higher birth rate than before ranging from 50 to 100 toadlets born per day especially for the period between December 2015 and March 2016 unlike in 2011 to 2014 where birth rate ranged between 5 to 20 weeks. From December 2015 to March 2016, the new born were produced from a population size of 1,145 adult toads of which 542 were males and 603 were females. The population increase based on the trend from December 2014, indicates the annual total count of the toads was almost twice the annual number in the previous year.

KCBF was initiated in June 2011 with 60 individuals from the captive breeding facility at the UDSM. Other stocks of 250, 566 and 2,000 toads were brought in 2012 and 400 toads were brought in 2013 from the USA respectively. At KCBF there are five insect feeders. The main feeder insects include fruit flies, Crickets pinheads, bean beetles, Isopods and springtail. The bean beetles and isopods are not used on regular basis due to complexity in handling them. All insects are fed on daily basis with

vegetables, fruits and poultry food. The containers are cleaned and water is provided to the feeder insects. Each insect species is treated differently depending on its biological and ecological requirements.

The KST population at the KCBF since 2011 has not been stable with few instances of increase and mass declines. The reasons associated with this population trend include the facility not being able to maintain the ecological and biological requirements of the KST. The highest number of KSTs at KCBF was 858 toads in June 2012 whereas the smallest was 15 toads in April 2012 (Fig. 3).

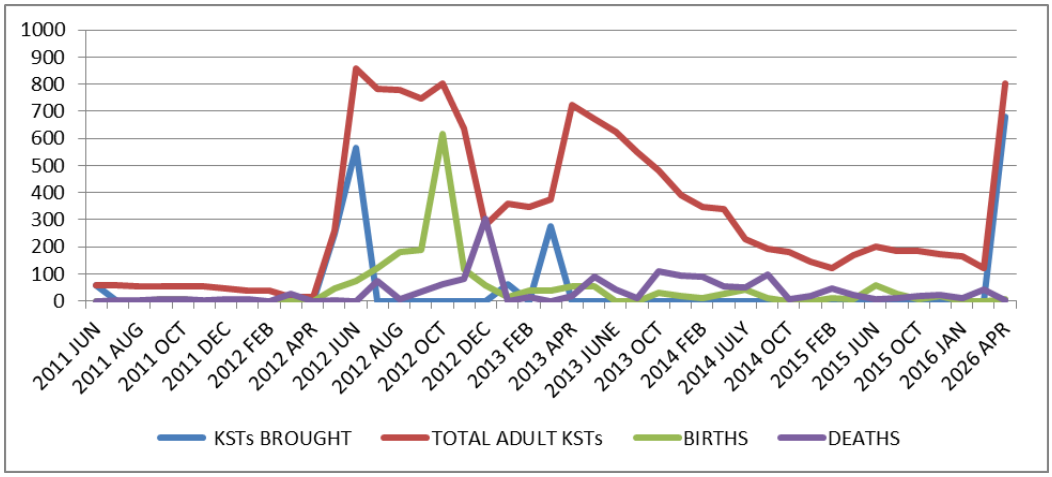

Figure 3: KST population at the Kihansi captive breeding facility from 2011 to April 2016

KCBF experienced an outbreak of Chytridiomycosis that at one time wiped about 304 toads in one room. Except for the December 2012 population crash due to chtridiomycosis (Makange et al. 2014) no other confirmed reasons have been ruled out as among the causes of KST population drop. The facility has experienced different population declines in different periods since 2012 to date. Several reasons were associated with such declines including failure of the water treatment unit, air conditioners malfunction and lack of nutrient supplements. Monitoring of health condition has enabled the understanding of the various disease conditions in KSTs at KCBF and other facilities. For example, KSTs can show a state of swellings on their bodies associated with the failure of proper functioning of either liver, kidney or heart. Reddish colour on some parts of the skin for the KST suggests the toads to suffer from bacteria attack. Loss of weight for the KST suggests fighting among animals especially between males, food scarcity, presence of bacteria, parasites and worms whose eggs can be observed through fecal tests. Some gravid toads have been facing most of the problems above at the time of giving birth while some toads break their legs usually during a fight between males. In captivity the primary diseases of adult KSTs have been lungworm infection, caused by Rhabditiform nematodes, and Gram-negative septicaemia (Lee et al. 2006). On several occasions gravid females suffer from oedema and die. If oedema is diagnosed early the toads are treated with a topical application of enrofloxacin (Baytril) (Lee et al. 2006).

Medical treatments for the KST can be applied in various ways including applying medical drops on an individual toad**,** dipping the toads in a solution placed in a dish 3/4 inches deep mixed of water and medicine and, applying medical powder on food before feeding and socking a towel in medicated water and fold the toads gently in a towel

KCBF has four trained staff out of which three were trained twice in the USA in amphibian husbandry. KCBF occasionally contributes KSTs for release in the Kihansi Gorge for example the facility provided 250 toads for hard release in 2012. The centre is also used for practical training and about 70 university students have undertaken field training at Kihansi at different times and levels from 2011 to 2015. The facility provides awareness and conservation education to local communities and the Tanzanian public at large who visit the facility at different times since 2011.

Reintroduction and monitoring of the KSTs in the Kihansi gorge

In 1995, the long term environmental monitoring program for flora and fauna of the Kihansi gorge was initiated. It was established to investigate the long-term impact of the hydropower project on animals, plants and the environment. Among the parameters chosen for monitoring were amphibians (LKEMP 2006). A total of 5,416 Kihansi spray toads have been released in the spray wetlands of the Kihansi gorge since the beginning of the reintroduction in October 2012. Out of the reintroduced 5,416 KSTs, the number that still survives in the gorge is estimated to be 54 individuals as of December 2015 (Ngalason et al 2015). This is probably a conservative figure as it is anticipated that there are more toads surviving in the area. During monitoring, the data showed that there is a high population of toads at the night of release and for the next two days following each hard release and thereafter the number begins a sharp decline. The reasons for the decline of the toads after every release are scientifically not yet established. However, it may probably be related to the adaptation failure in the wild because of having stayed in captivity for more than a decade where they were predators' free, received medication and got easy food. With an average life span of 2 – 3 years the toads being returned to the wild are about the 6^{th} to 7^{th} generation. In the wild the KST are probably not able to locate food and avoid potential predators like crabs (*Potomonautes* sp.) and snakes. So far there is no evidence that weather conditions and chytrid fungus are a problem for toads released back into the wild.

Kihansi catchment conservation and sustainable development

In all its phases since the year 2000 to date the Kihansi project in collaboration with stakeholders have indulged in an effort to conserve the Kihansi catchment for the purpose of conserving the ecosystem but also protect the KST habitat. This initiative has involved the central government, local government, village communities, NGOs and parastatal institutions. The major goal has been to ensure that the catchment, which is an important water source for hydropower production and rivers providing water for irrigation, fishing, flooding lowland plains used for agriculture and protecting the habitat for the toads, is effectively conserved. All these serve the purpose of sustainable development where people's livelihoods are maintained and improved, and economic development and environmental conservation are achieved.

Role of captive facilities in research and education

The UDSM breeding facility has played a significant role in the conservation of the KST. It had contributed 100 toads for the first hard release in the gorge in 2012. Students studying Wildlife Conservation and

Marine Science at the University of Dar es Salaam use the facility to learn about *ex-situ* conservation and amphibian husbandry. Awareness creation on wildlife and environmental impact is another role played by the facility in educating primary and secondary school pupils and students and to whoever visits the facility. The facility has been a center for some graduate students to conduct their field studies and allow volunteers to work and broaden their knowledge on *ex-situ* species conservation. All staff, visitors, field students and volunteers must observe bio-secure protocols at all times while at the facility. Most importantly, the facility undertakes research work on various aspects of which some are published in international journals like the "Research Article on Activity Patterns and Fine Scale Resource Partitioning in the Gregarious Kihansi Spray Toad *Nectophrynoides asperginis* in Captivity" published on Zoo Biology 9999: 1–8 in 2014. Another paper on "Recruitment and survivorship of the Kihansi Spray Toad (*Nectophrynoides asperginis*) in captivity" was presented at the 10th TAWIRI Scientific Conference in December 2015. Three research works on the diet and food habits of KST in captivity and on KST genetic viability are underway.

Institutional roles and participation in the project

The UDSM is the technical adviser to the NEMC, which runs this ongoing project through funding from the World Bank and now Global Environment Facility (GEF) to restore and conserve the Kihansi catchment ecosystem. Conservation of the species within the Kihansi gorge is a component in which the Kihansi spray toad is included and of which the University of Dar es Salaam particularly the Department of Zoology and Wildlife Conservation and other units are involved.

The University of Dar es Salaam has thus been involved in the history of the KST since its discovery. The baseline survey team which in 1996 discovered the toad comprised a member of staff from UDSM, in the Department of Zoology and Wildlife Conservation.

UDSM is involved in conducting research, monitoring, and provision of professional consultations. The University units which have been involved in research and monitoring include the Institute of Resource Assessment (land use/land cover), Department of Zoology and Wildlife Conservation (amphibian, avifauna, primates monitoring), Department of Botany (woodland and wetland vegetation monitoring), Department of Water Resources Engineering (water flow), and the Department of Aquatic Sciences and Fisheries Technology (DASFT) (macro invertebrates, water quality, limnology). These units have been monitoring parameters like KST population dynamics & other amphibians, landscape and land use changes, primate populations, avifauna, aquatic invertebrates, spray wetlands vegetation, woody vegetation, limnology and water resources/flow.

The UDSM has also been providing staff and technical support in the KST reintroduction process. Two University employees have trained in the USA in amphibian husbandry and are actively taking the lead in looking after toads in the captive breeding facility. The University has provided land for the facility and its Estates Department has provided professional guidance in the facility construction process. Estates department are also continuing to provide technical advice in the rehabilitation of the captive facility at Kihansi.

UDSM has benefited from the project in terms of capacity building. The LKEMP project has provided various teaching

materials and equipment for the teaching of conservation biology, which include books, DVDs, computers, a vehicle and other teaching accessories. LKEMP has also supported the establishment of the Master of Science in Biodiversity Conservation programme which started to be offered in the 2009/2010 academic year with 9 students enrolled in the first batch. The project has also trained in the field of conservation biology 2 University staff in Doctor of Philosophy and 2 in Master of Science programme.

Apart from the UDSM other institutions that have actively taken part in the whole process include Vice Presidents' Office through NEMC (Project management and coordination), World Bank, GEF and Government of Tanzania through the Ministry of Natural Resources and Tourism (funding), Wildlife Conservation Society – WCS (funding and management of KSTs in US zoos), Bronx, Toledo and Detroit zoos in the USA (KST husbandry), SUA (amphibian diseases and pathology research and monitoring), Tanzania Pesticides Research Institute – TPRI (pesticides residues research in Kihansi river system and dam), IUCN (technical advice in KST reintroduction process), Tanzania Electric Supply Company – TANESCO (installation and maintenance of artificial sprinkler system in the gorge), TAWIRI (weather monitoring, management of Kihansi research centre facility), Rufiji Basin Water office (water user rights, water flow and quality), Kilolo, Mufindi and Kilombero districts (community sensitization, awareness and mobilization in Kihansi catchment conservation).

Project successes

Over almost 20 years at which the project has been in place since the discovery of the toad it can be said that it has been quite successful in the rescuing the species from extinction, conserving the species, protecting the Kihansi ecosystem, the environment and supporting livelihoods. The Kihansi Spray Toad should be viewed as a "Flagship Species" which alerted humans on the environmental problem affecting the Kihansi catchment due to the hydropower development project. Through this flagship species the Kihansi ecosystem has received its due attention and efforts are continuing to ensure its protection. From these initiatives the environment has been conserved, water flows maintained for the production of hydropower, river flows have continued to maintain the livelihoods of fishermen and farming communities in the Kilombero valley, rainfall has been maintained in the catchment and impliedly the habitat of the toad has been protected. The capacity which Tanzanians have built in amphibian husbandry makes them key global resource persons in amphibian conservation because it is commonly agreed among experts that no other amphibian species threatened with extinction has given the global community of scientists and big challenge like the KST.

Challenges in amphibian husbandry and reintroduction

Regardless of strict protocols in the KST facilities, the toads are occasionally attacked by Chytrid fungus resulting into mass deaths at the Kihansi facility. Also failures in the facility infrastructure such as air conditioning system and water filtration system both at UDSM captive breeding facility and KCBF have sometimes caused toads' mortality. On the other hand the reintroduction of the KST in the wild might take time because the toads are adapting slowly in the environment where they have to find food, evade predators and overcome diseases unlike in captivity where they had free meals, predator free environment and received medical treatment. The reintroduction of the toads is a process that has to happen in stages from surviving of the reintroduced toads in the wild, breeding,

population increase to re-establishment of the toads in their native habitat.

CONCLUSION AND RECOMMENDATIONS

Given the complexity of the project in terms of *ex-situ* conservation of the KST population, planning and implementation of the hard release of the toads to the wild and their eventual surviving in the wild it should be considered that the project is a considerable success though there is still more to be done especially in the reintroduction of the toad to the wild. The fact that Tanzania can now proudly boast of its ability to successfully care for the species both in captivity and in the wild does not need to be underscored. Further planned and ongoing research should focus on diseases like Chytrid fungus, endo and ectoparasites that may probably affect the KSTs released in the wild. The lack of adaptation of the released toads to the wild environment after the absence of over a decade and other survival skills such as ant predator behavior need to be studied to understand how the toads can cope with the natural environment. The suitability of microclimate in the gorge is another area that needs to be considered to ascertain the survival of the KST in the wild. Researchers should also design a more accurate sampling technique for the released toads, which will take into account the detection probability of the toads to allow accurate estimation of the toads surviving in the wild. However, the cost of the project in all its phases so far approximates USD 12 million. This is an enormous amount of funding which calls for serious commitment and political will among the host nation and the global community to ensure that the intended goal is ultimately achieved. For Tanzania, plans to streamline activities and obligations of the participating institutions in post project funding period should be speeded up for sustainability of the activities and eventual success of this unique species and ecosystem conservation initiative.

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