Int J Biometeorol (2007) 52:33–42
DOI 10.1007/s00484-007-0105-8

CLIMATE AND PERCEPTION

The Rufiji River flood: plague or blessing?

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Received: 8 June 2006 / Revised: 23 April 2007 / Accepted: 27 April 2007 / Published online: 12 June 2007

Abstract The building of a large multipurpose dam is planned at Stiegler's Gorge on the Rufiji River (Tanzania). Both national and local authorities have strongly emphasised the flood control aspect of the dam as they see the Rufiji floods as a major constraint to development. Though it is true that the Rufiji River has a high flow variability at various timescales, the flood perception in local communities differs from this view. The floods, essential for the sustenance of floodplain fertility, and therefore of the farming system, and vital to the productivity of most of the natural resources on which local communities depend, are perceived as a blessing, whilst droughts and the absence of regular flooding are perceived as the main threat. Historically, most of the food shortages in Rufiji District are associated with drought years and the myth of "the flood as a plague" emerged only in the late 1960s during the *Ujamaa* villagisation policy. The persistence of this myth is favoured by the inadequate assessment of the complexity of the local economies by the District technical staff. This difference in perception of the flood has major implications for development options. Under the current dam design, the alteration of the flooding pattern would have negative consequences for the downstream wetland and forest ecosystems and the flood-associated livelihoods of some 150,000 people. A cost-benefit analysis of flood control measures and a study of a dam design that would maintain the beneficial aspects of flooding should be accorded the highest priority.

Keywords Flood · Dam · Rufiji · Local livelihoods · Managed flood releases

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Introduction

The Rufiji River in Tanzania, with a mean annual flow of approximately 800 m^3/s is one of the largest rivers in Africa and drains 20% of mainland Tanzania through three major tributaries, the Great Ruaha, the Kilombero and the Luwegu, which respectively provide approximately 18%, 62% and 15% of the annual flow (Rubada 2001) (Fig. 1). The river has a strongly seasonal flow pattern, with a flood peak around April. Its fertile Lower Floodplain is up to 20 km wide and is traditionally planted with rice and maize. The river has constructed a vast delta, partially covered by some 500 km^2 of mangrove, the largest stand in East Africa (Fig. 2).

Scientific studies in the Lower Rufiji were initiated in the 1960s as part of a multidisciplinary study of the development constraints and prospects of Rufiji District, conducted by the Bureau of Resource Assessment and Land Use Planning Research (BRALUP) and reviewed in Havnevik (1993). During the 1970s, BRALUP became strongly involved in the assessment of the potential impacts of the Stiegler's Gorge Dam project, independently from the Rufiji Basin Development Authority (RUBADA), the government institution charged with its implementation.

At present, three dams have been constructed on the Rufiji's upstream tributaries, controlling some 20% of the flow. A large multi-purpose dam, that would control 95% of

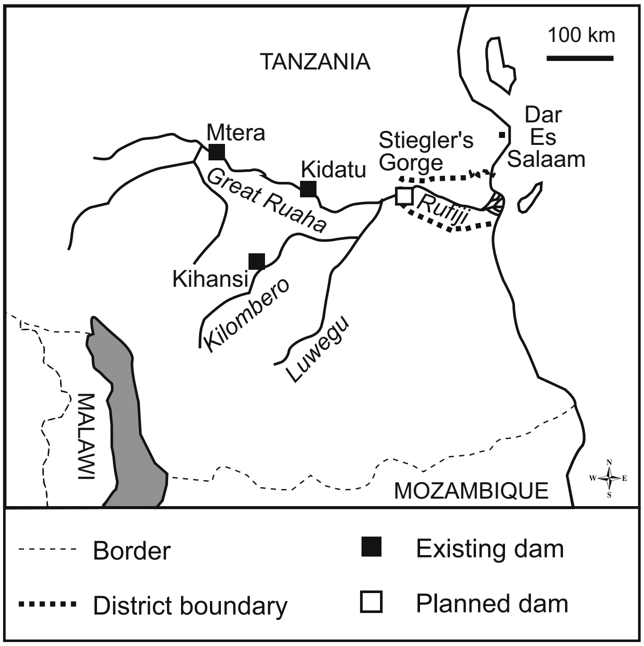

Fig. 1 The Rufiji River basin

the flow, is planned at Stiegler's Gorge, 150 km upstream from the Indian Ocean (Figs. 1, 2). The dam, designed in the 1970s, has three main objectives: hydropower production for the national grid and especially for export, irrigated agriculture on several hundred thousand hectares of the Lower Rufiji Floodplain, and flood control.

Both national and local authorities have strongly emphasised the flood control aspect of the dam, arguing that the flood is a major risk for the local population downstream of the dam. This point of view echoes the generally negative perception of floods by development agencies and international organisations (review in Ologunorisa and Abawua 2005). Logically, city dwellers, whose houses and possessions are under threat, tend to have a negative perception of floods (Brilly and Polic 2005) but floodplain farmers have adapted to the hydrological conditions and perceive some advantages of floods (Paul 1984).

Historically, the Rufiji is known as a "land of plenty" (Elton 1879, cited in Hoag 2003) with "maize, rice, millet and peas largely cultivated, and heavy crops garnered every year, the periodical flood bringing fresh life to the soil" (*ibidem*). Currently there are some 150,000 inhabitants in the Lower Floodplain and Delta, whose livelihoods are strongly flood-dependent. Extensive contacts with local communities for village-based environmental management planning (Duvail et al. 2006) indicated that a positive perception of the floods seemed ubiquitous in the area.

In order to explore the roots of this paradox, hydrological data were collected, the role of the flood for local livelihoods was analysed and flood perception was described in detail. Furthermore, the different water management policies were assessed in historical sequence.

In spite of the largely negative assessment of the economic viability of the Stiegler's Gorge multipurpose dam, especially of its irrigated agriculture component, the project is still on the agenda of some agencies (RUBADA 2001). Also, its obsolete design does not cater for adequate managed flood releases and therefore it is expected to have negative environmental impacts downstream. Since the World Commission of Dams report (2000), it is essential to take local user perception of the impact of the changes in flood regime into account.

Materials and methods

Data collection started in 2001, first within the Rufiji Environmental Management Project (REMP), implemented by the District Government with financial support from the Dutch government and technical assistance from The World Conservation Union (IUCN). Since 2005 more detailed information (see below) has been collected within the framework of a joint research programme of the Institute of Research for Development (IRD), the French Institute of Research in Africa (IFRA), and the Institute of Resource Assessment (IRA) of the University of Dar Es Salaam (UDSM) which grew out of the BRALUP. The joint IRD–IFRA–IRA research programme, entitled "Water management and natural resource use in Eastern African lower floodplains and coastal wetlands", aims to estimate the value of river floods in several key sites in Kenya and Tanzania, both from a socio-economical point of view (for example, the value of the flood for agriculture and fisheries) and a cultural point of view (the representation of the flood by local communities). The research focuses on the relation-

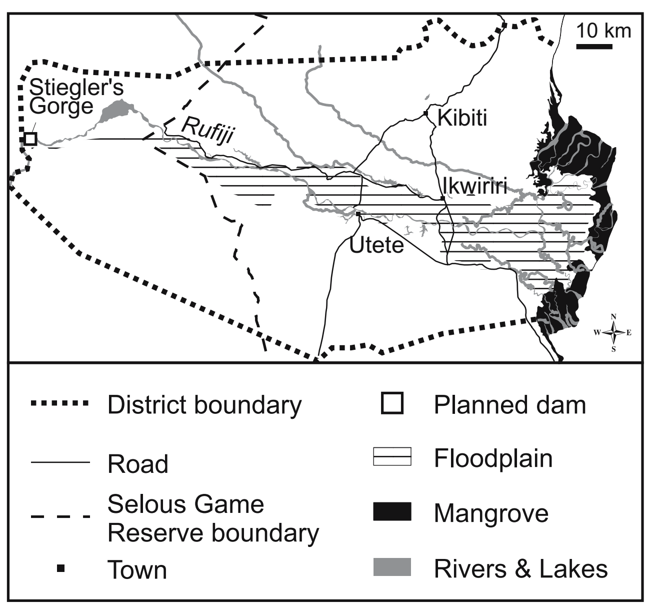

Fig. 2 The Rufiji district

ships between floodplain and coastal communities and their environment and local resource use, strategies and practices (Duvail 2004). One of the key sites is the Lower Rufiji Floodplain in Tanzania. Much of the research is still ongoing and only preliminary results can be reported here.

The research is based on the simultaneous and interactive application of hydrological, geographical and anthropological methods in order to be able to characterise the biophysical and socio-anthropological dynamics as well as their interactions. The analysis of the biophysical environment is done both from an external (hydrological and geographic variables, descriptions of resource use in space and time) and an internal viewpoint (comparison with the stakeholders' mental representation of the environment and especially the flood).

Collection and analysis of the historical hydrological data

Large amounts of data were collected by various agencies during the Stiegler's Gorge Dam design stage. These were reviewed for their pertinence and accuracy. In spite of the presence of a series of gauging stations in the Kilombero catchment (none in the Luwegu) and on the Rufiji itself, the data are scanty; there are very few reliable rating curves and some vital sections have especially poor data sets. For example, there have been no recordings at Stiegler's Gorge since 1984. Therefore, the reliable part of the historical dataset used runs from only 1957 to 1984. This dataset, plus the available rainfall information from the entire catchment (only 12 reliable time series for 200,000 km^2), was used by the University of Dar es Salaam for the development of a flood warning model for the Lower Rufiji (WREP 2003).

Hydrological and local rainfall monitoring

In order to assess the impact of modifications of the peak flow, the eight most important lakes in the Lower Floodplain were equipped with stageboards and the Rufiji itself with dataloggers, and monitoring was resumed as from 2001 within the framework of REMP in collaboration with UDSM's Water Resources Engineering Programme (WREP) and the Centre for Ecology and Hydrology (CEH) Wallingford, UK. A participatory monitoring system has been set up with a team of local village-based observers who received training and some backstopping from the Rufiji District Technical Departments. Additionally, rain gauges were installed in primary schools. The hydro-climatic data were analysed through feedback workshops bringing together the local observers, the District team and the research team. Through this collaborative approach, the information was shared between locals, managers and scientists.

Identification of social groups, their historical constructs and characterisation of their social reproduction strategies in conjunction with their natural resource use strategies, agriculture and flood perception

Fifty local stakeholders from different villages, socio-professional categories, tribal origin, gender and level of market integration were interviewed with regard to their natural resource use strategies and their flood perception. In addition, focus groups were conducted with the village-based water level and rainfall recorders (36 individuals) and village elders (8 individuals). Effectively, the local communities are composed of distinct social groups whose interests are not necessarily converging and may even be incompatible. Various authors (Lockwood 1998; Sunseri 2002) have emphasised the importance of generic factors in the economic strategies of actors in East Africa. In addition, the make-up of different social groups with distinct strategies cannot be explained solely on the basis of a synchronous analysis. Therefore, a prospective analysis with the elaboration of different scenarios needs to be approached from a historical perspective. Natural resource use strategies can be understood only within the framework of the wider social reproduction strategies (Bourdieu and Passeron 1990) of each of the groups and, in order to better integrate economical and cultural aspects, both strategies need to be analysed in conjunction.

Analysis of local perception of biophysical dynamics and rhythms

The biophysical environment defines a framework of potentials and constraints to the economic activities of the social groups. The perceived flood risk does not necessarily correspond to the 'objective' hydrological statistics.

Description of natural resource use practices and formulation of hypotheses on resource use strategies under several scenarios

The natural resource use practices were documented and the impact of the various extant use strategies analysed beyond the discourse that the users hold about them by confronting these with the reality of practice. The analysis is therefore based on the collection of economic, social and spatial data.

Cartography of natural resource use practices

Maps are a means toward the formulation of hypotheses on natural resource use practices: spatial representation of resource use practices permits analysis of the coherence (ecological, economic, cultural) of resource use strategies.

With a base map derived from a combination of satellite imagery and aerial photography, information was collected in a participatory manner on vegetation structure, land use and some cultural and spiritual values and incorporated into a GIS (Duvail et al. 2006).

Fish catch assessment

Fisheries in Rufiji District have been irregularly monitored 2000 (May–August 2000, May–September 2002, March–August 2003, and since November 2005 to present) with varying spatial coverage but with special emphasis on freshwater lakes.

Results

Analysis of the hydrological data

From the available reliable flow data (1957–1984), the average annual discharge of the Rufiji River at Stiegler's Gorge can be estimated at some 800 m^3/s. The flow is highly seasonal and average monthly discharge varies between 200 m^3/s in October–November to over 2,000 m^3/s in April. These averages, however, obscure the high variability of the flow at various timescales.

For example, in April, the month in which the river usually experiences its highest floods, the monthly average discharge can vary between 1,000 m^3/s and 5,000 m^3/s. Peak flows during El Nino (as recorded in mid-February 1998) have been estimated at about 10,300 m^3/s (JBG Gauff Ingenieure 2000; Erftemeijer and Hamerlynck 2005). At such extreme flows, the water level at Stiegler's Gorge is thought to be about 14 m above the dry season level (the height of the water column itself will probably be between 20 and 30 m as at such flows all sandy deposits in the Gorge have been washed away and the river is scouring the bedrock, e.g. 23 m on 25 April 1979, 8.25 on stageboard). In the central floodplain area such flood peaks result in a water level 5–6 m above the dry season level. Bank full flow is estimated at 2,500 m^3/s. When this flow is exceeded, the river spills over its banks and leaves its 300 m wide dry season bed to cover the floodplain (maximum width around 20 km).

Flows over bank occur on average in 6 years out of 10, flows of over 3,000 m^3/s occur on average 4 years out of 10. Therefore, floods with an impact on floodplain agriculture occur on average 1 year in 2. However, again this average obscures the fact that there are series of years where no flood occurs, e.g. 3 consecutive years (1975–1977) and even 5 consecutive years (1980–1984) (Fig. 3). The period 2003–2006 is also a dry one: there has been no significant flood since 2002 and local rainfall has been below average for the past 10 years (Fig. 4). Such series of drought years have had considerable impact on the productivity of the floodplain and therefore on human livelihoods (in 2005 and 2006 hundreds of households, especially in the western part of the floodplain, received food aid).

What is often described as the capricious nature of the Lower Rufiji has various causes. Its main tributary, the Kilombero, although it accounts for only about 18% (33,000 km^2) of the total surface area of the Rufiji River Basin, provides an estimated 62% of the flow. The Kilombero drains the still relatively well-forested highlands along the western escarpment and flows through a substantial floodplain with braided channels. This means there is an opportunity for the flood peaks to become attenuated before the Kilombero enters a much narrower bed at Shuguli falls.

There it is joined by Luwegu River, which drains about 14% of the basin area. Virtually nothing is known about this substantial tributary, as there are neither rain gauges nor stageboards in its basin. It is purported to contribute an estimated 15% of the flow but this is in fact no more than an 'educated guess'. It is 'calculated' from the estimated flow at Stiegler's Gorge, minus the known flows of the Kilombero at Ifakara and the known releases from Mtera. Unfortunately, Stiegler's Gorge is one of the least reliable stations because

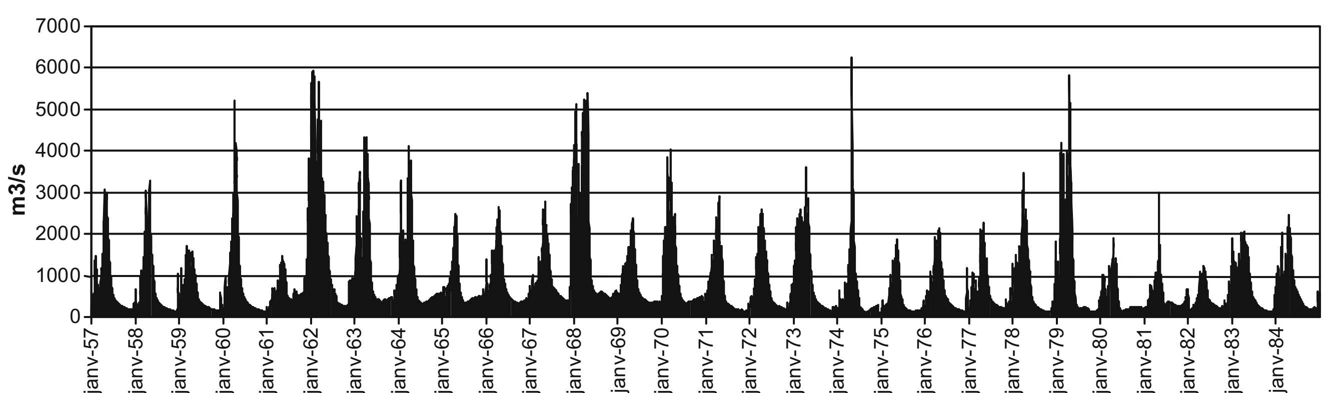

Fig. 3 Daily discharge at Stiegler's Gorge in m^3/s (1957–1984)

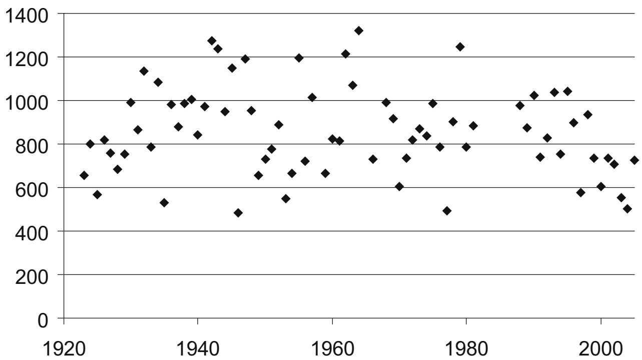

Fig. 4 Local rainfall 1923–2005 (in mm per agricultural year: from 1 August to 31 July of the next year)

of the difficulties of performing flow measurements in its highly turbulent waters, its highly unstable section, and the unknown depth of the erodable part of its bed at different flow levels. Some minor catchments, most likely with highly variable rainfall and flows, e.g. the ungaged Madaba and Mawera rivers, also contribute to the Rufiji flow before it is joined by the Great Ruaha just before Stiegler's Gorge. To the known flood releases from Mtera Dam one has to add the rather less well understood, but highly variable, flows that originate in the small but relatively high rainfall catchment between Mtera and Kidatu and below Kidatu. All these separate flood peaks from the various catchments are contained in a narrow channel and can add up to extremely impressive floods that tumble down from Stiegler's Gorge into the Lower Floodplain.

Analysis of qualitative data: discrepancy between local representation of flood benefits and the official vision

Perception by Government authorities: 'the flood as a plague'

Since 1984, Tanzania has been involved in a decentralisation process, which devolves natural resource management to Local Government at District and Village level (though without adequate budget allocation or sufficient human capacity development support). The District Council (composed of elected members), under the supervision of the District Commissioner, charges the District Executive Director and the Technical staff with the implementation of environmental policy. In Rufiji District the decentralisation process was supported by REMP and, during the formulation phase, one of the highest priorities of the District was the development of a flood-warning model, which would allow the authorities to evacuate the floodplain to prevent loss of life and allow limitation of damage to infrastructure and crops during floods. The District authorities clearly perceive the floods a major constraint on the development potential of the District as the main vision for the future is to develop an irrigation scheme on 80,000 ha that would "help to protect the lower valley from flooding and increase agricultural production through an introduction of an efficient agricultural system" (Rufiji District Council 1997). The order to evacuate the floodplain is given out rather frequently, even in the absence of a functional flood-warning model, the most recent evacuation being in 2002.

At the National level, RUBADA, the implementation agency of the Stiegler's Gorge Project, initially commissioned a single purpose hydropower dam (Norconsult 1972). The World Bank let it be known that a single purpose project would not be funded, and, not without some difficulty (Havnevik 1993), the project was turned into a multipurpose dam with a strong emphasis on flood control (Norad/VHL 1978) combined with large-scale irrigated agriculture. It was subsequently shown that the agricultural scheme was not economically viable (Agrar- und Hydrotechnik 1982) and that the ecological impacts would be severe (Euroconsult and Delft Hydraulics Laboratory 1980). The 2,000 MW dam was therefore not funded but is still strongly promoted by RUBADA (RUBADA 2001 and http://www.rubada.org) and figures amongst the investment opportunities in Tanzania of UNIDO (http://www.unido.org) and the Nile Basin Initiative's Strategic/Sectoral Social and Environmental Assessment of Power Development Options in The Nile Equatorial Lakes Region (http://www.nilebasin.org).

Perception by local population: 'the flood as a blessing'

Flood perception in local communities differs categorically from the "flood as a plague" view. Far from being a negative element, the river is part of the identity of the Warufiji. There is no "Warufiji" tribe as such, as the designation covers a mixture of several lineages and ethnic groups around the eponymous Rufiji River. These define themselves as floodplain farmers in contrast to the hill tribes that practice shifting cultivation in the coastal forests and with whom they have a "joking relationship" (Radcliffe-Brown 1940, 1949). In both focus groups and farmer interviews, all participants expressed the view that the vast majority of the Rufiji River floods are a blessing whilst droughts and the absence of regular flooding are the main threat to their livelihoods. Floods are perceived as being essential for the sustenance of floodplain fertility, and therefore of the farming system, and as vital for the productivity of most of the natural resources on which these communities depend: forestry, fisheries, wildlife and, more recently, grazing. These subjective claims will need to be quantified for objective assessment but preliminary findings indicate that floodplain fisheries and honey collection have been highly negatively affected by the recent drought.

The farming system is well adapted to variations in hydrological conditions, and is rather sophisticated though this has been recognised by only a minority of authors (e.g. Telford 1929; Marsland 1938; Bantje 1980)—mainly those who have spent prolonged time periods in Rufiji and interacted substantially with the local population. In this system, the value of the floods is perhaps best summarised by the words of Mrs. Habibi Omari, one of the respected elders of Utete (Doody et al. 2003): '...she preferred the famine caused by floods to the famine caused by drought. There is more suffering in a drought year because, after a big flood, the recession agriculture (*Mlao*) harvests are good and the fishing is good'. She also made reference to the short and the long rains (*Jacha* cultivation) and the recession (*Mlao*) complement or alternative by stating '...the Rufiji Floodplain has so many seasons', and in conclusion: '...the people of Rufiji have adapted to the floods'.

From the agriculture profiles and sociological interviews, it appears that the Rufiji Floodplain farmers have come to grips with the interplay between short rains crops, long rains crops, floods and recession agriculture and the subtle use of the topographical variability, which determines the nature of the soils and their flooding frequency (Fig. 5). On the higher non-floodable levees, the sites of the pre-*Ujamaa* villages, farmers plant perennial crops (mango, cashew, banana) and some annual rainfed crops (maize, sorgho, sesame). In the floodable area, the preferred farmland is on the *Mbawila* soils of the levees, consisting of loam and fine sand, relatively easy to work, well drained and suitable for a variety of crops but in general dominated by maize. These soils are most commonly interspersed with the lower-lying depressions with *Finyanzi* (dark heavy clay), which are suitable for rice. By cultivating a number of small plots (about 0.4 ha each) with different soil types and at different topographical levels, often at dispersed locations, each household harvests from about 1.5 ha of cleared floodplain land each year with double crops in years of good rainfall and/or adequate floods. Inside each plot, by making judicious use of their knowledge of the land, they also plant according to a risk avoidance strategy, intercropping maize with rice on the slopes of the depressions and using different varieties planted at different times (broadly categorised as "early" and "late" but in fact planted after each major downpour until adequate cover is achieved). Thus, under a wide range of rainfall and flood behaviour, they are likely to achieve sustenance and, in favourable years, produce considerable surplus. Under such favourable circumstances the staple food crops (rice and maize) are also the main cash crops in Rufiji.

For any given year, the success of these two staple foods is dependent on a subtle balance between rainfall and flood characteristics. More precisely, from our interviews, we can describe four main agricultural situations, depending on the timing of rainfall and flood (Fig. 6). The best agricultural scenario for a farmer is when there is conjunction between a good rainy season and a flood (Fig. 6, scenarios 2 and 3). Under the other two scenarios (Fig. 6, scenarios 1 and 4), the major difference between the drought (scenario 1) and excessive flood (scenario 4) is the fact that most of the "safety nets" (fisheries, hunting, gathering of wild fruits and honey) are also favourably influenced by the flood. Even though virtually all floodplain users identify themselves as farmers, agriculture accounts for only about 37% of average household income, which is supplemented by fishing,

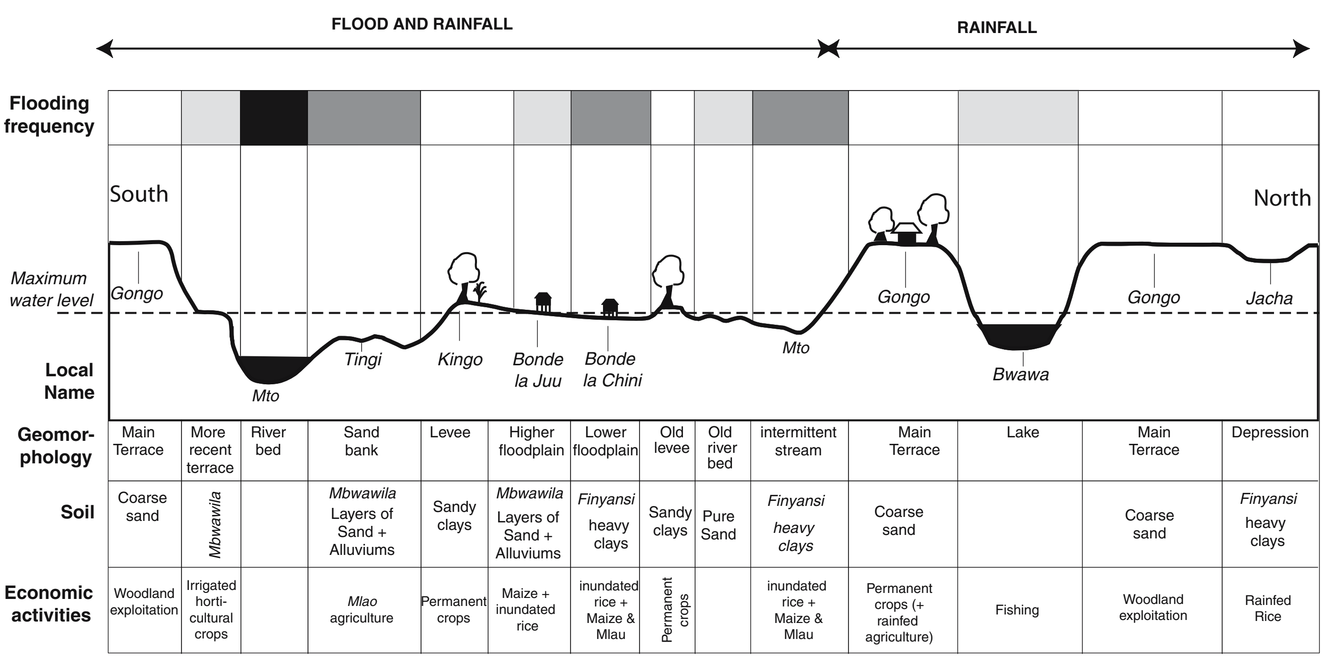

Fig. 5 Characteristics and uses of the floodplain topography (profile South–North)

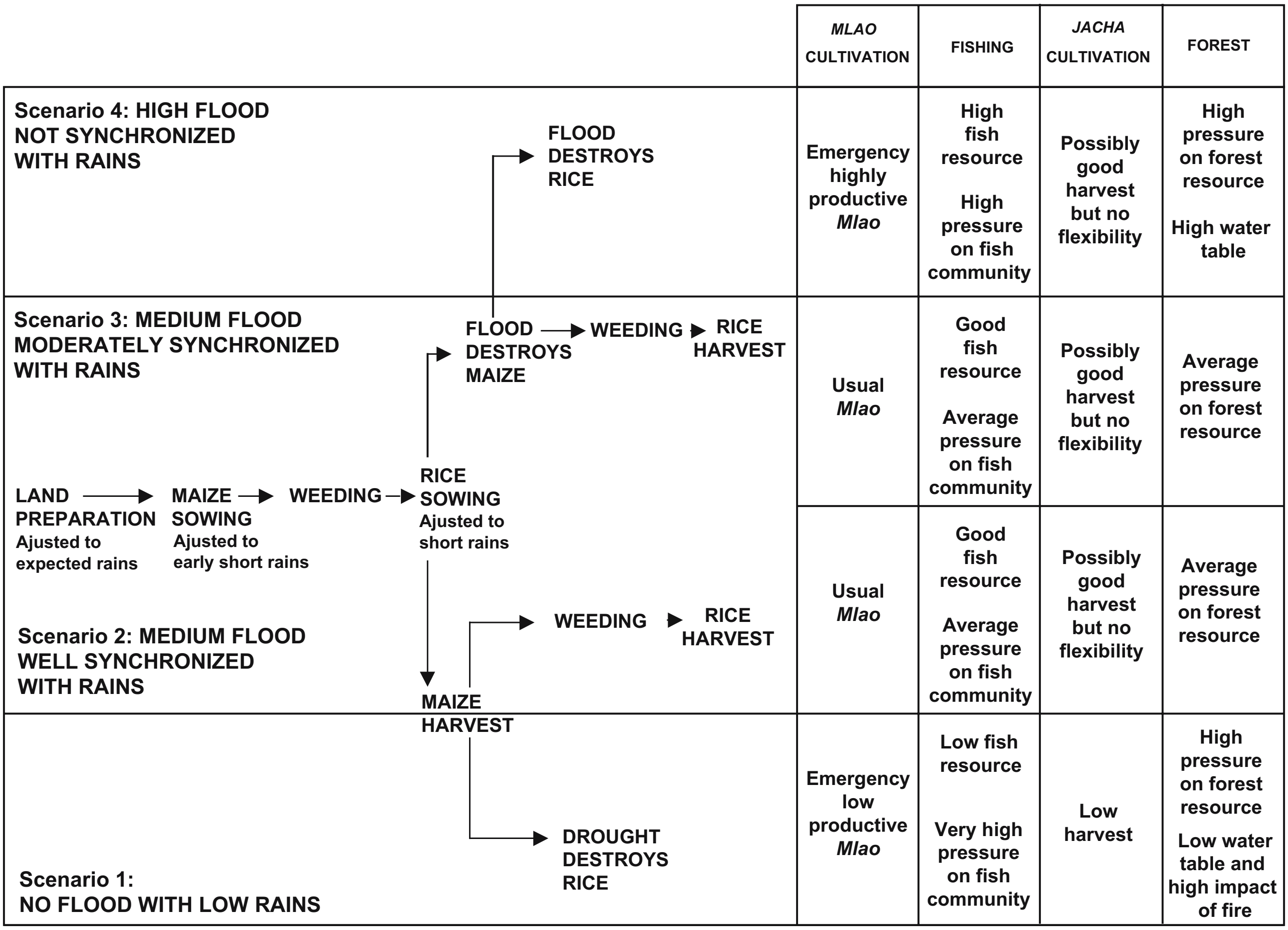

Fig. 6 Flood scenarios and farmers strategies

forestry (especially in drought years) and a host of other activities (Turpie 2000).

Prolonged droughts, such as the one from 2003 to 2006, have particularly strong negative impacts, both on livelihoods and on the natural resource base. There was a spectacular intensification of the exploitation of hardwood, mainly exported illegally to China (Milledge and Kaale 2003) and charcoal production soared. A rather effective total ban on roundwood export was implemented in August 2004 (creating a spectacular increase in the number of sawmills operating in Rufiji District to turn the roundwood into planks) and charcoal use in cities was (rather unsuccessfully) prohibited in early 2006. The floodplain lake fisheries declined strongly in terms of the diversity of species harvested, average fish size and catch per unit effort. This has had the effect of pushing fishermen into going on high risk fishing trips into the Selous Game Reserve. Illegal harvesting of ivory has also been taken up again. Possibly, the increase in deaths from attacks on farmers by lions (Baldus 2004) is, at least partially, correlated with the drought—low ungulate densities in the Selous Game Reserve inciting more lions to move to the adjacent floodplain.

Discussion

Historically, the flood as a plague is a myth

As stated above, the traditional farming system, though well adapted to highly variable hydrological conditions encounters its limit when a prolonged drought leads to the failure of both agricultural and non-agricultural activities. Extreme or late floods can also negatively affect agricultural activities but, historically, most food shortages and famines in Rufiji District are associated with drought years. Indeed, through a review of the existing literature and especially a thorough reading of the colonial reports of the English and German administrations and a synthesis of the famine records from 1880 to 1980, Bantje (1979, 1980) described a high occurrence of famines in the Rufiji, especially in the upstream part, where there is less rainfall and flooding requires higher peak flows. From his analysis of 20 famine events since 1881 he concludes that “in spite of the damage done by high floods, food production is more endangered by drought, wars and misconceived policies than by flood” (Bantje 1979, 1980). He insists on the fact that *Mlao* cultivation would be impossible without flood and that “the suppression of the floods would put an end to their beneficial effect on soil fertility, fish production and vermin control and would totally change the ecological conditions in the delta” (Bantje 1979). Though the occasional early flood peak, as was the case in December–January 1968, can lead to the destruction of the “short rains” maize crop, and the even more exceptional late flood peak, such as the one of May 1974 can destroy the rice crop, these events are rare and are, in general, compensated by excellent conditions for flood recession farming and also by a very productive fishing season.

Factors of emergence and persistence of the myth of “the flood as a plague”

Lack of communication between local users and district technical staff

For decades, postcolonial Tanzania was characterised by a top-down approach to development (Havnevik 1993). Since structural adjustment and decentralisation, a more bottom-up approach is publicly advocated but has largely failed to take off, especially so in Rufiji District, one of the poorest in the country and which has the lowest school attendance and graduation statistics. Therefore, almost none of the District technical staff are Warufiji. The technicians have their roots in the mountainous areas in northern and southern Tanzania with very different eco- and agricultural systems. By ignorance or disdain, the quality of traditional knowledge, as well as the capacity of the local communities in resource management and the sophistication of their recession agricultural practices are not appreciated. Very few District officers perceive the integrated nature of the various local resource uses (agriculture, fisheries, gathering, forestry) and stick to a sectoral view of economic activities. They do not perceive the importance of the flood for the sustainability of agriculture nor do they appreciate its vital role in the sustenance of non-agricultural activities. One of the main objectives of the Rufiji Environmental Management Project was to try and reduce the communication gap by actively involving District staff in village-based activities. Thus, the production of village maps provided a useful basis for dialogue within the village, between villages and between villagers and local government, leading to better communication and improved information sharing (Duvail et al. 2006).

Political origins and persistence of the myth

The flood risk, as perceived by the Government, was used in the late 1960s and early 1970s to pilot the *Ujamaa* villagisation policy. The floods of 1968 and 1974 were the pretext for the forced relocation of tens of thousands of inhabitants from, respectively, the floodplain and the delta towards the river terraces. Not only would they be safe from the floods there but they would also benefit from social services such as education, health, piped water, etc. and have access to transport facilities and therefore markets. Forest and woodland were cleared to create collective farms where they would practise “modern” agriculture, which would contrast with their traditional supposedly “unreliable” mix of rainfed and flood recession farming. The failure of *Ujamaa*, especially in Rufiji where it led to widespread famine, highly destructive charcoaling and logging and massive migration of able-bodied men to the urban areas, is still largely a taboo subject. An objective analysis of the causes of its failure, not in the least the myth of a permanent threat to floodplain dwellers of “killer” floods would require a substantial evolution of political culture. Even during the 2002 flood, an evacuation order was given and panicky articles appeared in the national newspapers stating crops were destroyed and the locals forced to eat hippos. In reality, the stilt houses on the floodplain were still at least 0.5 m above the water level and the Warufiji in them were patiently waiting for the waters to recede to start planting for a fantastic *Mlao* crop and to prepare nets for a great fishing season.

Risks associated with the persistence of the myth

This difference in perception of the flood between local communities and the administration has major implications for development options. If the flood is a plague, its elimination is a “good” thing. Measures to control the floods, ideally dam construction, are high on the agenda, also because it would replace a perceived obsolete agricultural system by modern large-scale irrigation. If the flood is a blessing, its elimination will negatively affect traditional farming and ecosystem productivity, which is also strongly flood-dependent, and threaten traditional multi-resource livelihoods.

The current dam design has some major and contradictory constraints. Under the multi-purpose scenario the dam would need to produce hydropower, be effective as a flood control device and support downstream agriculture and ecosystems.

The hydropower output is not our main concern here but suffice it to state that, when fully operational, Stiegler’s Gorge Dam would more than triple current power production capacity in Tanzania, which is far beyond projected demand for several decades. Because of the drought, current hydropower production from existing dams is well below its potential and the government has decided to diversify into power production from natural gas and coal. The main use of Stiegler’s Gorge power would therefore be for export.

Flood control

The calculations of the original design were based on the hydrological data of 1956–1978 and did not include the major 1979 flood or the 1998 El Niño flood and therefore underestimated the peak flows and the investments needed for 1:100 year flood protection. Unfortunately, with structural adjustment and decreased donor support to RUBADA, the hydrological dataset has not been expanded very much from what was available in the 1980s and is probably insufficient for improved dam design, especially in the light of climate change and the associated increased probability of extreme events. As a matter of fact, the bridge over the Rufiji River, built between 1998 and 2003 was designed on the basis of the available hydrological knowledge and clearly underestimated peak flows. During the large, but not exceptional, 2002 flood the bridge functioned as an obstacle and created a back-surge that destroyed road infrastructure upstream. The main riverbed also moved south over several hundred metres and threatens to circumvent the southern limit of the bridge. Major costly additional reinforcements were required and their effectiveness during a large flood still needs to be assessed. Moreover, dangerous and destructive floods, such as the 1975 late peak, originate in the virtually unstudied Luwegu catchment where, potentially, flood control measures could be implemented at much lower cost.

Agriculture

The Agrar- und Hydrotechnik study concluded that the irrigated agriculture option was not economically viable (mainly because of the high cost of flood protection infrastructure). With the loss of traditional floodplain farming and flood-dependent livelihoods, it would also be unlikely to be a socially acceptable or environmentally sustainable option. Managed flood releases would therefore need to be able to support and, by providing optimal floods each year, probably improve on the traditional farming system. Flood releases would also need to be sufficient to sustain the ecosystem functions and services of the floodplain, delta and coastal ecosystems, e.g. the US$ 15 million per year shrimp fishery (Duvail and Hamerlynck 2006). The original design catered for maximum flood releases of only 2,500 m^3/s, corresponding to bank full conditions but insufficient for extensive flooding of the main agricultural areas. Flooding of the latter would require at least 4,000 m^3/s but, even if the low level dam outlets could be redesigned to produce such large floods, the erosion of the river bed below the dam would very soon result in the need for much higher flows to achieve the same flood extent.

Sediment

Another unresolved issue is sediment. The dataset on sediments in the Rufiji is even worse than the hydrological dataset. Only very rough approximations exist, insufficient to assess e.g. coastal erosion figures, which would need to be re-evaluated anyway in the light of projected sea-level rise and increased frequency of extreme weather events.

Conclusion

After several decades of a functional moratorium on the construction of large dams in Africa, most notably through the refusal of the World Bank to fund such projects, there is renewed interest since the publication of the World Commission on Dams Report (2000). Amongst the guidelines for the design of new dams, the need for managed flood releases to support downstream ecosystems and livelihoods is emphasised. However, in reality, very little is known on the water needs of these systems and quantitative data exist only in a negative sense, i.e. the losses of productivity recorded after the construction of dams that did not provide adequate managed flood releases (Bergkamp et al. 2000; Acreman 2003).

In Eastern and Southern Africa, there is a projected demand for electricity that largely exceeds current production and, considering the links between climate change and CO_2 production, there is an emphasis on non-fossil fuel sources. The projected 2,000 MW that a high dam at Stiegler's Gorge could potentially produce makes it one of the prime dam sites on the continent. However, the dam design does permit the sustainable performance of managed flood releases that are adequate to sustain traditional livelihoods and downstream ecosystem functioning floods.

The preliminary assessment of the perception of the value of the floods by local users of the floodplain reported here highlights the subjective positive impact of the floods for a variety of livelihood support systems, most notably farming and fisheries. These subjective assessments will need to be confirmed by quantitative analysis where possible.

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