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Institutional Challenges to Robustness of Flood Plain Agricultural Systems[1]

by

Audun Sandberg

Bodo University College, Norway

Summary:

The farming of natural flood plains was in many parts of the world the cradle of civilization. The transformation of risky flood plain systems to socially controlled environments were the result of an intricate interplay between demography, religion, social organisation and technology of the time.
In our days there are few natural flood plains left to study in the warm regions of the world. One such flood plain is the Rufiji Flood Plain in Tanzania. Here an artificial irrigation culture has not evolved, but a robust risk minimising flood plain agricultural system based on rice, maize, cotton and peas. Through the Arab, German and British colonization, attempts were made to "modernise" this agricultural system, resulting in new crops and varieties incorporating into the system in a way that made it even more robust. This study also analyses challenges to this agricultural system during the last 30 years: the removal of the flood plain population to "safe ujamaa villages", infrastructure development plans and institutional challenges like individualized tenure, "land grabbing" and urban food marked expansion.

The study of "Robustness of Social-Ecological Systems" often requires lengthy observations. The processes of nature; the formation, the maintenance and the decay of eco-cycles, are slow processes that may take many generations to work their way through the system. Likewise the many processes of human society, constitutional change, the changes in inherited institutions and in cultural legacy, are usually incremental and invisible to the "one-shot" research project. However, the decisions on how to alter policies, incentive structures and basic institutions like property rights, are often based on such short-term observations. They are thus often threatening the long-term robustness of the interaction of the ecosystem and the social systems governing the human use of these. If for example one disaster flood prompts the removal of peasants from their dwellings in the flood plain, this can have long term repercussions on the robustness of agricultural systems as a whole and on the ability of peasants to exercise "Ecology Control" in relation to the wilderness. These balances between ecosystem processes and human modification

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of nature through social organisation have been recurrent issues in East-African history through centuries (Kjekshus 1977 & 1996).

The flood plains of the world have widely different stories to tell about the long term robustness of Social-Ecological Systems. The long enduring systems of the Nile Valley, the Mesopotamia and the Indus Valley were in most respects sustained "Cradles of Civilization", thus their basic Social-Ecological Systems must have been fairly robust. The explanations of the ecological success and failures of these systems are multiple; they range from the biblical narratives of the Lost Paradise on Earth, to the more cynical explanations of population pressure as a precondition for agricultural growth (Boserup 1965). Already Karl Marx classified the "Asiatic mode of production" as one based on state-controlled irrigation and a system of royal despotism and ownership of all land. But in contradiction to the whole Marxist programme for explaining the evolution of "western" modes of production, he offers hardly any explanation of the dynamics of genesis or change in this kind of class society: How did the transition from "natural" flood plain agriculture to controlled irrigation initially take place, how was the "surplus" that later formed the basis for "civilization" initially appropriated and what were the seeds of institutional change and decay of these great systems. To some theoreticians, a strong central power, an oriental despot who combined religious and political powers, has been seen as the crucial precondition for a transition from risk prone flood agriculture to a "hydraulic society" - a controlled irrigation farming system, (Wittfogel 1957). To other theoreticians, a despot might have been useful in organising defence against foreign invaders, but the transition itself is taken care of by the peasants themselves through continuous intensification and refinement of the farming system in response to a rising population (Geertz 1963).

It is not only in the past century that human influences on biophysical processes have led to environmental problems, it has been an integral part of human history throughout the last 5 millennia (Anderies, Janssen & Ostrom 2004). So has also been the human influence that has enhanced biophysical processes that benefited human life and sustained strong social systems. The "2nd Nature" of the Javanese paddy terraces, of the Buhaya banana groves and of the Chinese rice-pig-fish cycles are all examples of social-ecological systems (SES) that were "better than nature itself. What is it that made — and still makes - some of these systems robust when faced with external disturbances or internal stresses, while others collapsed or withered away? With the aid of modern theoretical tools from various brands of institutional analysis, we shall take a closer look at a particular group of social-ecological systems, the high-risk and high-potential unregulated flood-plains of the world (Campbell 2004)

The temptations to make sweeping generalisations about the evolutionary forces built into social-ecological systems will always be present. Therefore it is important to warn against overgeneralizations beyond time and space or beyond particular technologies and particular ecologies: The risk prone flood agriculture of the Nile Valley did in the millennia before the erection of the Aswan Dam produce a considerable surplus that was transformed into high cultures, religious belief systems, generous art and advanced science. On the other hand, the humanly controlled irrigation system of the Indus Valley decayed and produced a salinated and eroded environment that resembled the land given to Adam and Eve after expulsion from the Garden of Eden. But each of these farming systems, from the Nile Valley to the terraces of Java, has their distinct genesis. This means that the system; the planting cycles and planting strategies, the choice of crops and tilling methods have evolved as an intricate mix of geo-political

circumstances, power relations, belief systems, available technologies and market access. When certain ways of doing things have proved to be useful, this often becomes the "common way". It both saves time, minimise social transaction costs and reduce risk (or at least the social blame for failure) to adhere to this "common way". Thus working rules and organisations are often tailored to suit these ways and institutions like incentive structures and property right systems evolve and become codified as frozen images of the "ways we used to do things". The "path-dependency" of institutional development therefore explains a large portion of the inertia found in agricultural systems at the same time as it explains the preference for some predictability in a basically unpredictable ecology facing any natural resource based social system (North 1990). And the same path-dependency also explain why sweeping generalisations are risky, every social-ecological system, every European, Asiatic or African mode of production have their own genealogy and must be analysed on their own merits.

Flood plains are extreme cases of risky environments. In ecologies without human control over stored water, the absence of floods usually spells draught and disaster for large populations. Likewise, a peak flood that sweeps away everything that is planted in both low places and high places also lead to crop failure and famine. To ensure that nature delivers a "good" medium flood with nourishing silt every year has so far been beyond the control of any social system. The social solution is advanced micro-adaptation to the highly variable effects of the flood, both its variations across time (from one year to the next) and across place (between elevations). The opposite alternative to evolving adaptation is massive flood control works, i.e. the total removal of floods, the storage of water and silt, and the overall replacement of flood-plain agriculture with irrigated agriculture. Any in-between design seems less workable. For most large flood plains, massive flood control works seems unlikely to grow from peasant initiatives, they require the organising capacity and the resources of an "oriental despot", a strong state or a wealthy donor. Both a state and a donor can be benevolent or predatory, depending on a number of factors. For smaller flood plains on the other hand, peasant co-operation in harnessing the water and constructing a socially controlled ecological system seems feasible, although it will always depend on the existing property rights distribution, on the social capital in the communities involved and on the commitment to the local organisation.

Most flood-plains of the temperate or tropic world are already transformed into socially controlled ecological systems - or irrigation systems. This makes it difficult to answer some of the underlying questions: What does it take to make this transformation from a naturally flooded environment into a controlled environment? What are the social and technological preconditions that must be in place and what are the typical obstacles? And what are favourable institutional arrangements that can facilitate such a transformation? Does such transformations come about through internal social processes or through the spread of new thoughts from other systems, through copying or coercion (Campbell 2004). And are such transformations basically evolutionary, based on punctuated equilibria or are they revolutionary, where the collapse of one social-ecological system carries the seeds of a new and better system. Here it is important to bear in mind that these great transformations have happened in different millennia, with large differences in level of hydraulic and farming technology, with large differences in crop availability and crop genetics. Although this is often disputed, there have also been some advances in culture, organisational knowledge and organizational capacity during the last 5000 years. What it took to carry through a transformation in 2500 B.C. might be very different from what it takes to initiate such a transformation in 2005 A.D. And at the same time the past

transformations have to a large extent shaped the present so that the knowledge, the cultures and the institutions of the early hydraulic societies are very much part of the heritage of all of today's civilizations. The underlying question therefore becomes much more complex than a simple question of efficient social and ecological interrelations. It could thus be rephrased into two different questions:

- What were the driving forces behind the great transformations of precarious flood plain agricultural systems into managed irrigation systems?
- What does it take today to transform a flood plain agricultural system into an ecologically controlled system?

The first question is one of the grand puzzles that have occupied economic historians and sociologists for centuries. As mentioned above, several of the great theorists of classical social science have been intrigued by such revolutions in the basic mode of production and have tried to design grand theories that could explain all past — and future transformations. Not only Marx, Wittfogel and Geertz designed comprehensive theories, but also Max Weber and Douglass North have made attempts to explain the driving forces in such dramatic shifts as a strive for rationalization and reduced transaction costs (North 1990).

The second question indicates that such grand theories will always be futile, the driving forces in Mesopotamia, Indus Valley and Egypt must be understood in their own time and ecology and cannot be generalised across time and place. What it takes today to carry through a transformation might be very different from the time of the Mesopotamian rulers. In our globalized world it might more probably take a favourable foreign exchange situation and a favourable feasibility report to the World Bank rather than a conducive political and institutional framework on the ground.

All ecological systems are dynamic and in continuous change. A social system must therefore be able to show some of the same dynamics in order for the social-ecological system to survive. This means that the capacity for cooperation and the potential for collective action must be maintained within the social system and acknowledged by superior levels if the social system is nested into larger social systems. One of the strengths of institutional analysis is that the mechanisms for collective action in a particular setting can be analysed with a certain degree of accuracy. One of the weaknesses is that it is not easy to generalise from the analysis of one social-ecological system to driving forces affecting changes in a whole class of similar systems.

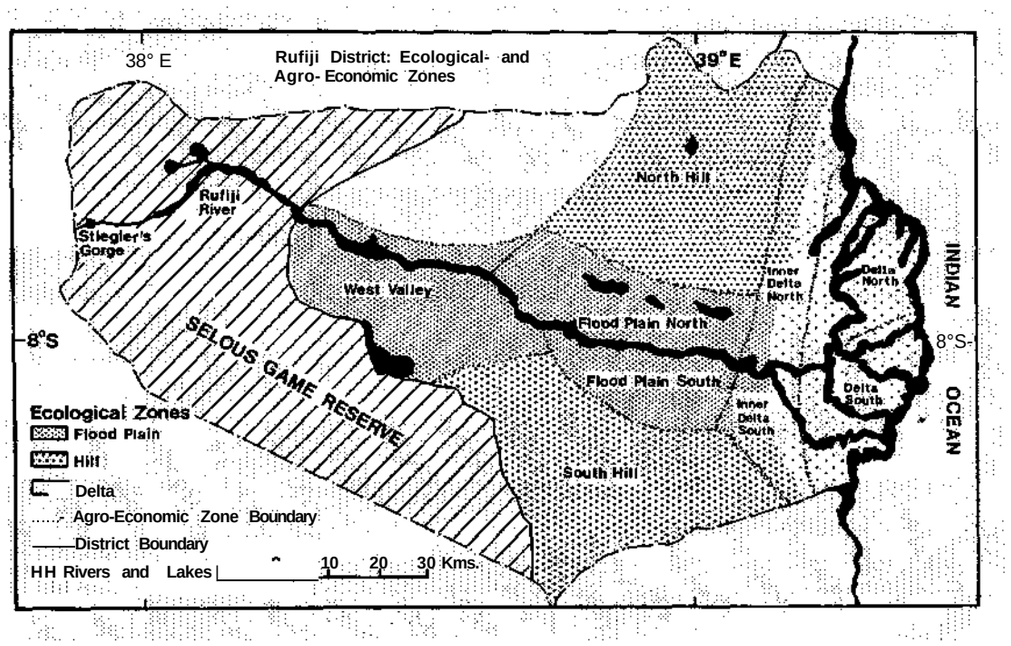
In this article we shall therefore aim for no more than testing "middle range theories" in answering the underlying question of what it would take today to transform a risk prone flood plain agricultural system into a socially controlled ecosystem? One such middle range theory is that "robustness" - either evolved or purposely designed - always will be a trade-off between the ability to survive external disturbance and internal stress and the system's maximum economic performance (Anderies, Janssen & Ostrom 2004). And that this compromise in a modern globalized world can undermine not only the social-ecological system, but also the productivity of the ecosystem itself. Further we shall see what we can learn from such probes in terms of relationships between the ecological properties of the resource, the official governance system for the resource and the associated government infrastructure.

One of the few remaining large natural flood plains in the world is the Rufiji River Flood Plain in Tanzania. While most large flood plains of the temperate and tropical zones have been harnessed and turned into irrigation schemes, the flood plain and delta of this largest of the East African rivers remains naturally inundated by yearly floods and fertilized by annual deposits of silt. A number of potential candidates offer themselves as explanations of the absence of a transformation of this un-harnessed ecological system. Most of these are related to the way of farming and living in the flood plain as individual and collective solutions to the risks of a flood environment. As such they constitute a social system for managing ecological uncertainty and reaping possible, but unpredictable benefits.

The Rufiji Delta Agriculture as a Risk Management System.

In the Rufiji Delta and Flood Plain a considerable rural population is still dependent on the generous gifts and the fatal risks of the river. They have through the centuries developed an intricate farming system that attempts to reap the benefits at the same time as it guards against the obvious risks. This system has been described through the last 4 centuries and has shown a versatile capacity to incorporate new crops and new farming technologies (Bernadino [1606], 1962), (Marsland 1938), (Sandberg 1974, Havnevik 1993). Approximately 150.000 people, mostly peasants, inhabit and farm the flooded plains and adjacent hills. This Ecological system can be divided into 9 agro-economic zones, each with its own peculiarities: The West Valley, The Flood Plain North, The Flood Plain South, The Inner delta North, The Inner Delta South, The Delta North, The Delta South - together with the upland ecologies of The North Hill and The South Hill (See Figure 1.)

Fig. 1. Agro-Economic Zones of the Rufiji District, Tanzania



In addition to the "agro-economic zones" at a particular time in the continuous formation of a flood plain, this is also a dynamic social-ecological system with both short term and long term dynamics. Most floods will be most severe in the narrow entrance to the flood plain: The West Valley, then spread out and calm down throughout the flood plain proper and the inner delta. When a flood meets the tidal effects in the delta, its effects are largely absorbed by this. Even a high volume flood will in most years be offset by the combined system of distributaries and tidal effect of the delta, while an early high peak flash flood can cause considerable damage also here. On the other hand a flood has to be of a considerable height and volume in order to inundate the heavy alluvial soils of the flood plain and to flush out and keep at bay the salinity resulting from the tidal action. Here there are very visible short term system dynamics at work: Only with yearly flushing of fresh water can cultivation of the delta continue, otherwise the mangrove forest will expand inwards towards the inner delta. The rainfall also varies considerably, from 1000 mm/ year in the delta to 600 mm/ year in the West Valley, thus offering the best opportunities for rain fed farming in areas where the floods make the least damage. This could also be easily observed in considerably higher population densities and greater wealth in the inner delta areas than in the West Valley.

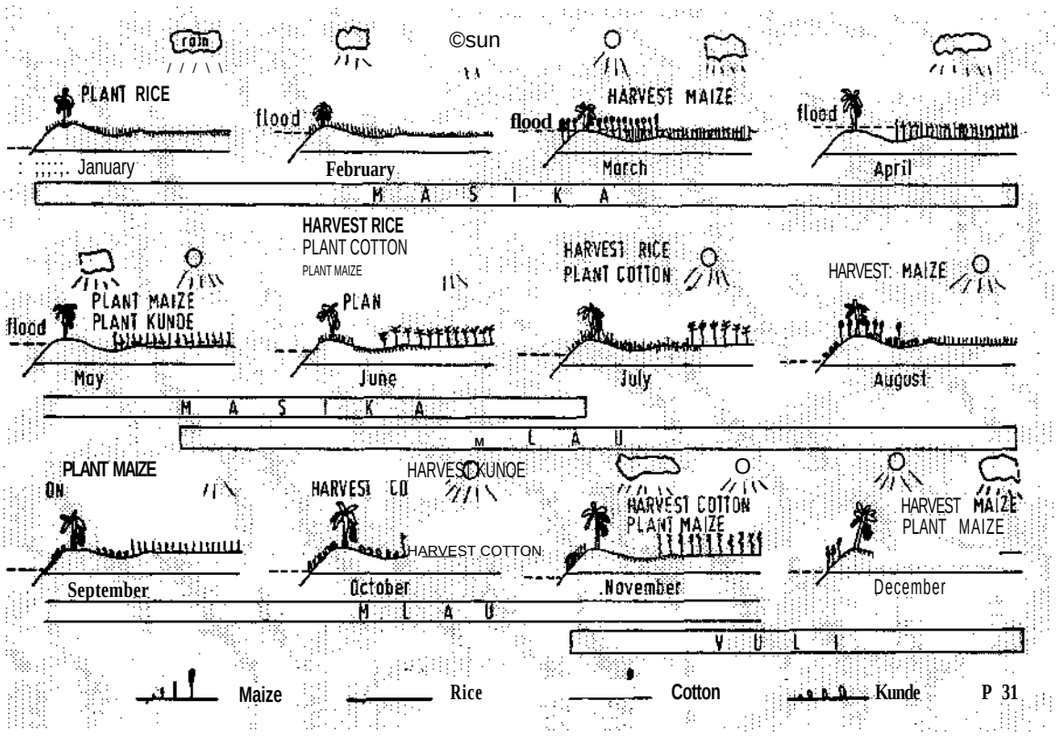
The third factor affecting risk management in the agricultural system here are the varied soil conditions and micro-differences in elevations in the flood plain. These are largely a result of thousands of years of flood and tide action and of differential silting as the meandering changes the course of the river. These are long term dynamic alluvial processes that lead to a very complex micro-ecology with layers of soil types sandwiched in different ways all through the flood plain. River courses change continuously while old river levees and ox-bow lakes are left behind. Even old storm beaches in the delta are part of this complexity. The lowest parts of the flood plain have largely clay soils, *Kitope,* which have high soil moisture retention capacity, poor drainage and are hard to work with hand tools. The most preferred soils, the *Mbaragilwa* soils,

are found at medium elevations in the flood plain, on old river levees and other areas that are normally lightly flooded. These are mixed clay and sandy soils. They usually have good water retention capacity, good drainage and are easy to work with hand tools. The *Gongo* soils are found on the highest river levees not flooded during a "normal" flood. These are mostly sandy soils, they have a poor water retention capacity, good drainage and they are easy to work with hand tools. But in addition to these 3 major ecosystem properties, farmers also view the ecosystem in a 3-dimensional and dynamic perspective. They distinguish between uniform alluvial clay and clay overlying *mbaragilwa* or sand, as well as between uniform *mbaragilwa* and *mbaragilwa* overlying sand or clay. In a dynamic perspective, the users of the preferred *mbaragilwa* soils "need" a substantial flood with considerable silt deposit every third year. If this does not happen, the yield will drop to about one half without the application of artificial fertilizers (Sandberg 1974, Havnevik 1993).

In this risky and generous environment, there has through the centuries evolved among the peasants of Rufiji an intricate agricultural system that seems to minimise risks and maximise benefits as far as this is possible. The system has evolved from below, not only as response to all the ecological factors mentioned above, but also as a response to various colonial and state interventions in rural production, and to new technological and marketing possibilities. It thus represents a true social-ecological system characterised in a few cases by punctuated equilibrium, but in most cases by continuous change. There is a long discussion whether the system has once been at "its peak equilibrium" and then decayed due to external disturbance and the influence of modernity (Marsland 1938), (Kjekshus 1977/96), (Sandberg 1974), (Havnevik 1993). To most peasants, however, the "system" as such means little; it is the farming strategies open to them that produce their individual and collective choices and thus reproduce what can at a given time be observed as a flood plain agricultural system. Therefore the evolutionary history of the agricultural system as such is not so relevant in this perspective, apart from the path-dependency that particular ways of doing things in the past create for future generations. The question is rather, with 9 agro-economic zones, 8-10 different crops, 3x3 soil variations and multitudes of micro-elevations, should there not in principle be sufficient strategies available for any peasant to meet any flood scenario? If so, should not this flood plain agricultural system constitute a "robust" social-ecological system with no need for transformation into an irrigated ecological system? Or are there internal stress factors that challenge the robustness of the system? To answer these questions, it is necessary to look more in detail at the agricultural system with crops and farm labour input, here as it was practiced in the second half of the 20th century.

Conveniently the Rufiji agricultural system could at that time be seen as consisting of two subsystems: the century old *Mian-system.* - or the dry season farming system (June — September), and the newer Mvuli - system - the flood season farming system (February to June). The Mlau system is a low-risk system, a flood recession planting strategy where the roots of the growing plants follow the sinking moisture level and all parameters (flood hights, duration and soil properties) are known at the time of planting. The Mvuli system is a high-risk system facilitated by the marketing openings created by the Zanzibar Sultanate. Here the properties of the coming flood are unknown and the farmers had to prepare for alternative flood scenarios by planting at different elevations. The typical farmers' calendar would thus look like this for a farmer who tries to implement the entire system:

Fig. 2. Farmer's Calendar 1974 - Rufiji Flood Plain



In detail, the farmers' calendar consists of a number of choices at regular intervals through the year. The choice of every month will to a large extent depend on the prospects for the harvest of the crops planted a few months earlier. Figure 3 below list all the alternatives open to a typical flood plain farmer and the main considerations that enters the farmers' choice:

Fig 3. Details of Farmer's Calendar:

November	Low water	Plant maize on high river banks	Good crop if low flood
		Start preparing rice fields	Avoid labour bottlenecks
		Harvest and market cotton	Mlau- system
		Harvest and market mango fruits	
December	Low water	Harvest maize from low clays	Mlau system
		Preparing rice fields continue	Avoid labour bottlenecks
		Plant maize on high river banks	Good crop if low flood
		Harvest and market mango fruits	
January	Low water	Plant rice, fast/slow > high/low	Right variety in right place
February	Rising water	Rice is growing	
March	Rising water	Rice is growing	Good crop if medium flood
		Harvest maize from river banks	Needs dry spells to ripen

April	Flood peaks	Rice grows	Tolerates medium floods
May	Flood recedes	Rice ripens	
		Plant maize on highest places	As flood recedes
		Plant cowpeas on highest places	As flood recedes
June	Flood recedes	Plant maize on *mbaragilwa*	As flood recedes
		Plant cotton on *kitope*	As flood recedes
		Harvest rice	Labour peaks
July	Flood recedes	Harvest and market rice	
		Plant cotton on lowest clays	
August	Low water	Harvest maize from high places	
September	Low water	Plant maize on lowest clays	
October	Low water	Harvest cow-peas	
		Start harvesting cotton	

Within the given ecological system, this constitutes a sophisticated system of allocation of human resources throughout the year. Although it is virtually impossible for every peasant to use the whole system within one year, it is important to think of the system as a set of collective strategies at their disposal, in short it is part of the Rufiji peasant culture. Although probably not an optimal system in terms of output per man-hour spent in farming, the system is robust in face of the risks involved in flood farming. This robustness also comes from the flexibility of the system and its transparent feed-back mechanisms. If the system is disturbed by absence of rain or a devastating flood, it is self-correcting within the same agricultural year. If a high and voluminous flood drowns all the rice in April, there are no labour peaks in June, but large areas of moist and fertile soils that can be planted with cotton, maize and cow-peas. Such large floods have on average happened every 6th year during the last century, e.g. in 1930, 1936,1940,1942, 1944,1945, 1952,1956, 1962,1968,1974, 1979 etc. (Havnevik 1993). If the flood is medium or small, the rice yield is usually good provided that the right rice variety had been planted in the right micro-environments (Sandberg 1974). In such cases there are neither vast areas, nor many free hands available to plant large quantities of cotton and maize.

As explained above, the Rufiji flood plain agricultural system of the 20th century could be seen as a fully evolved risk-minimizing system in which the farmers absorb all the risk themselves. As such it is a robust social-ecological system capable of accommodating most environmental uncertainties. The farmers of Rufiji have also shown a rare capacity to include new crops and new technologies into their strategic repertoire: rice during the Zanzibar Sultanate, maize from South America, cotton during the German Colonial Period, cashew-nuts during the Ujamaa period, together with oranges and mangos. All these crops were incorporated into the agricultural system in a way that strengthened the system and contributed to make it gradually more robust as a self-contained risk management system. Most of this incorporation took place as individual adoption of new planting and labour strategies, often after collective resistance to the forced introduction of a new "cash-crop". But as it takes a lot of human concern and effort to prepare for several possible, but unknown future flood situations, the return to labour will always be low in such a system. It takes a lot of extra work to have more than one egg in your basket. Low labour productivity is therefore the price the Rufiji peasants have to pay for their complicated risk

insurance system. As mentioned above, a maximum economic efficiency is also not to be expected from a robust social-ecological system. However, faced with modern market forces, both in crop markets, in capital markets, and eventually also in labour markets and property markets, this low labour productivity represents a new kind of exogenous risk which has become more pronounced towards the end of the 20th century and the beginning of the 21st century. If such risks are likely to be absorbed by others than the peasants themselves, e.g. by financial markets, new farming strategies with higher labour productivity will most probably take precedence over traditional risk management strategies. This will in a profound way affect he nature of the robustness of the Rufiji as a social-ecological system.

This is because the sustained robustness of the traditional agricultural system itself depends on a number of conditions that have to be fulfilled. They are mostly related to the micro-environmental knowledge among the peasant population and especially the dynamic aspects of this.

- Shared knowledge of diversity of flood heights and onset times in various fields
- Shared knowledge of drainage and fertility properties of the various soils
- Shared knowledge of place and timing of vermin attacks
- Shared knowledge of the flood resistance properties of seed varieties, especially of rice
- Shared knowledge about the importance of traditional land tenure mechanisms which allow most farmers to make the right strategic choice in relation to time and place for planting and use of human energy.

If these preconditions are not fulfilled -i.e. actively maintained and supported, this will affect the long term robustness - or sustainability - of the traditional system. Among he conditions from which such robustness is likely to be negatively affected is e.g. a breakdown of effective transmission of knowledge between generations, state intervention in rural production and marketing, and in the case of land tenure changes initiated without the participation of the peasants. Recent developments in Tanzania show a number of examples of cases which have a deep impact on the robustness of intricate traditional risk management systems like the Rufiji flood plain agriculture. We shall briefly deal with some of these below.

Ecology Control Initiatives

The first State effort to modify the social-ecologial system of the Rufiji flood plain was the forced cultivation of cotton introduced by the German Colonial Government in 1902. It threatened and interfered with the traditional rice and maize system evolved during the Zanzibar Sultanate and led to the largest peasant uprising in Colonial Africa, the *Mqji Mqji* rebellion (1905-1907) where altogether 75.000 Africans were killed. However, after the rebellion, the Rufiji peasants individually adopted the cotton as a cash crop and planted large areas with cotton under their own control, especially when the Germans established ginneries and efficient market outlets for the crop (Havnevik 1993). But new crops were not always the result of unilateral state initiatives. Apart from a massive cashew nut campaign during the *ujamaa* period, most new crops, like Mango and Oranges were adopted gradually without any campaigns and incorporated

into the agricultural system explained above so as to transform this into an even more intricate social-ecological system.

After a devastating flood in 1968, the Tanzanian Government decided to alter the social-ecological system of the Rufiji dramatically. The objective of future disaster prevention and the ideological aim of "living and working together" were blended to produce the first *ujamaa*-campaign in Tanzania 1968-1972. The process was carried out without real participation by the inhabitants of the flood plain and some force or heavy persuasion was applied. This campaign removed the majority of the peasants from their dwellings in the flood plain and relocated them in "secure panned villages" on higher ground. By 1973, 75 % of the population in Rufiji were living in 25 *ujamaa* villages, the remaining 25% were either not affected by the operation (the Delta North and Delta South) or refused to move because the proposed villages were too far from their fields (Inner Delta South). In the West Valley the peasants lost most of the ecological control over their fields, as the new villages were established on the north side of the Rufiji River while their fields in the valley remained on the south side of the river, now bordering directly on the Seleous Game Reserve. Without any human settlement as a barrier against wild animals, the attacks on crops by elephants and wild pigs added new risks to the difficulties of farming in this part of the flood plain (Sandberg 1974), Ndunguru & Hahn 1998). In the Flood plain North the distance to the flood plain fields were short, here the peasants in the new villages could continue the agricultural system explained above more or less uninterrupted after 1973. Here, other social mechanisms started to work as a result of the massive resettlement. On the one hand a gradual urbanization of these villages, has increased the demand for and the value of good adjacent flood plain land. On the other hand, the growth of these *ujamaa* villages, especially Ikwiriri, now a town of 40.000 inhabitants, has facilitated specialized occupation and a growth in local food markets. This has altered the strategic options for farmers; staples and cereals for sale to the State Marketing Board are no longer the only options. A wide range of different grains, fruits and vegetables are now demanded by an increasing number of more sophisticated consumers within the Rufji District itself..

In 2003 there was also completed a new major bridge across the flood plain and river from Ikwiriri. This has dramatically increases the marketing possibilities for all crops from the whole of the Rufiji Flood plain. Following the resettlement programme, the reluctant villagers in the Flood Plain South and in some other parts of Rufiji were reported to maintain the traditional flood plain system somewhat throughout the 1980s and 90s by establishing peripheral houses in their old fields, thus commuting between the new villages and the flood plain (Havnevik 1993). With the exemption of the villagers of the West Valley, who have had to receive famine relief, the total effect of the resettlement of farmers from the flood plain to higher ground villages have over time not destroyed the social-ecological system evolved in the Rufiji. But it has led to some major changes in the choice of crops and planting strategies, especially in the Flood Plain North and has in a dramatic way brought the farmers more into the mainstream of national development.

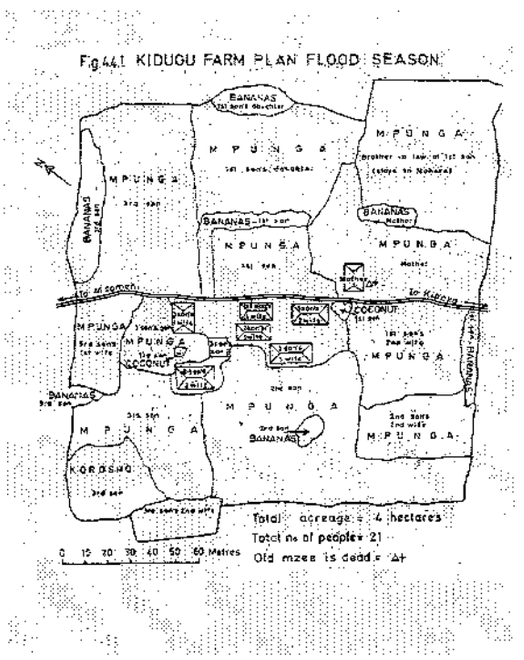
Attempts have also been made to change the fundamentals of the ecological system of Rufiji itself by introducing flood control. This would be done in the shape of plans for a large dam at Stiegler's Gorge for the combined purpose of hydro-electric power production and flood control. Already in 1907 the Germans (Stiegler) surveyed the Rufiji Basin for the potential for irrigated agriculture and hydropower generation. Surveys both in 1928, 1952 and 1961 (FAO) were based

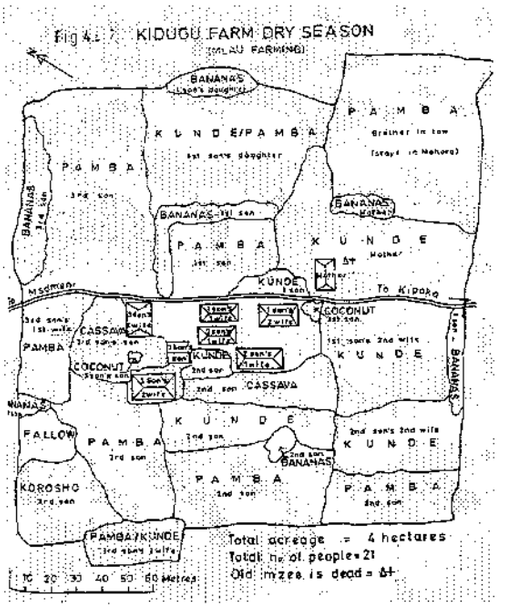
on a "multipurpose" idea of replacing the flood agriculture of Rufiji with an artificial irrigated agriculture combined with absolute flood control and hydro-power production. However, the FAO report concluded that the cost to each acre of net irrigable land (flood control and irrigation) would be rather high, and that more than half of the costs therefore should be charged to hydropower generation. Subsequent surveys in 1967 (USAID), 1968 (JETRO), 1972 (NORAD/Norconsult), 1980 (NORAD/Hafslund) therefore put most emphasis on the hydropower generation potential. Gradually the criticism against this single purpose planning strategy grew and a multipurpose approach was reintroduced. But contrary to the early German ideas of a massive transition from flood cultivation to artificial channel irrigation, this approach was a modified flood release design, which aimed at not loosing too much electricity, while releasing sufficient floods through low level outlets to allow the flood plain agriculture to continue during a lengthy transition period towards fully irrigated agriculture of an undisclosed nature. This transition was however not part of the project and there was only minimal participation of the Rufiji peasants in the design of the planned mega-project. The multipurpose compromise was therefore a poor one, so that the feasibility of both the hydropower objectives and of the agricultural objectives was only marginal. In the end, the World Bank turned down the project; only a proper plan for a comprehensive multipurpose project would stand a chance at the World Bank. All these planning efforts during a period of 100 years resulted in nothing and left both the Flood Plain Ecosystem and its robustness intact. There might be many explanations offered for this distinct non-transition to irrigated agriculture during the whole of the 20th century. Among such explanations are the particularities of this flood plain ecology, the internal politics of Tanzania, the role of donors, of consultants and of sector bureaucrats. The farmers of Rufiji have, however, largely been absent in the 100 year discussion and planning of hydropower development and of a possible total change of their Social-Ecological system. If the issue of flood control, power generation and irrigated agriculture should appear again in the 21st century, it is important that farmers are an integrated part of the planning and implementation process. But as we shall see below, these farmers are most likely to be quite different from the typical risk-managing peasant of the 20th century.

Land tenure changes and modernization of the Social System

The struggle of the Warufiji during colonial times taught them the lesson that their land in the flood plain was valuable and worth fighting for. The potential for collective action was traditionally tied to the traditional settlement pattern. Here the fields were organised around the homestead, with individual family members, including wives and in-laws being allocated their own plot for the growing season by the family head. These patterns we could still find in the inner delta in the 1970s. A typical homestead here (see Fig 4.) consisted of 21 people farming about 4 hectares continuously. The micro-ecology of the area decided to a large extent which crops could be grown in what place, and the working ability of the individual decided to a large extent the size of a particular plot (Sandberg 1974).

Fig. 4. Traditional Rufiji Homestead





During the *ujamaa* programme, the state launched a campaign for collective farming on larger fields. However, the peasants had bad experience with the co-operative farms of the corrupt and defunct Co-operative Society and did not see collective farming as a novelty. The solution devised by the new village collectives was that communal farms were demarcated on the infertile and sandy higher grounds close to the new villages, while the land tenure of the fertile flood plain was left undisturbed. As no annual crops would succeed on the higher ground, they were planted with cassava and cashew-nut trees, which, if tended properly, can give considerable cash income after a number of years. Thus the effects of the period of collectivisation in Tanzanian agriculture were hardly noticeable in this flood plain agriculture.

However, the effects of the physical relocation of people to *ujamaa* villages have gradually become more noticeable. As the demographic processes of aging, marriages and birth of new generations worked their way into land use, the land tenure of the flood plain did in practice gradually become more and more fragmented in relation to the new settlement pattern. One person can now have different plots through different family affiliations in widely different places. The advantage of this is that risks are still low if these plots are in different micro-environments. The disadvantage is that labour productivity in tilling, planting and harvesting is even lower than before, due to the need for extensive commuting between the village and the various plots. Also the institutions for allocation of plots to new members of villages (youngsters, married or migrants) come under pressure when fragmentation becomes too intricate and the Customary Village land property rights start to erode from within. Some effects of more cumbersome land tenure arrangements can bee seen in the increasing number of young men engaging in cash-generating "bizzniss", like charcoal trade, hardwood logging and fruit sales (mango and oranges) to urban markets in Dar es Salaam. Most probably these give higher and more immediate return to labour than continued cumbersome farming of staples in the flood plain. However, there was in principle no hindrance for a continuous

adjustment of land tenure through a local land consolidation process through local land tribunals at the district level -with active involvement of the local collectives in Rufiji villages. But such processes did not take place, mostly because the central government during the last two decades of the 20th century gave no active support to such local level land tenure processes. In a nested system of land tenure processes, a national deadlock on national land tenure policies has severely hampered the necessary local adjustments of land tenure to changing demographic circumstances.

Under pressure from the World Bank for accelerated "structural adjustments", Tanzania embarked during the 80's on a road "from *ujamaa* to economic liberalization". As part of this, a New Agricultural Policy was formulated, which opened up for "institutionalising a market for land" - also in rural areas. A long struggle took place during the 1990s over the question whether Village Land property rights should be codified in new legislation (The National Land Policy 1995), or whether it should only be protected administratively without any title, but with freedom to enter into land transactions also for villagers (Draft Bill for the Land Act 1996),(Izumi 1998). Finally, and still under pressure form the World Bank, a Land Act which established a sort of market for agricultural land was passed. This enable villagers to buy land and get a title, in line with some of the new land policies in a number of African countries which has been inspired by recent work by Hernando de Soto (de Soto 2001). But these policy changes will also enable foreign investors and political dignitaries to buy large tracts of land for more efficient commercial agricultural production than the customary peasant agriculture (Ikdal 2000), (Lindstrom 2001). So-called "land-grabbing", i.e. the conversion of political capital into individual land property, will now be legally possible under the new act. The exchange of political favours towards special villages against subsequent individualization of village land is only one way of making such conversions.

The Rufiji Flood Plain is a very attractive tropical agricultural area, and both rich villagers in Rufiji, foreign food companies and national industrial and political leaders will be interested in acquiring individual property rights in this area. An increasing number of villagers from the most urbanized villages maintain two houses, one in the village and one in one of Dar es Salaam's suburban areas. Thus the village collectives of the 70s and the older social capital homesteads and kin are gradually eroded and the potential for collective action is decreased. However, the first cases of land purchases in the Flood Plain have not yet (2003) been observed, but are likely to happen in the near future. The new bridge across the Rufiji river has also "opened up" the vast area of flood plain south of the river for non-subsistence agricultural development and brought the whole district much closer to the market. In addition has the market itself expanded extremely rapidly. The national capital Dar es Salaam has grown from a population of 0,75 mill in 1974 to 3,5 million in 2003. This market now works as an enormous stimulus for accelerated commercialisation of agriculture in the Rufiji Flood Plain in the coming decades. Especially in fruits and vegetables there is an insatiable market in the whole metropolitan area of Dar es Salaam. Fruit trees, like Mango, thrive in the flood plain and are robust against floods and draughts at the same time as the labour input is minimal. While labour intensive pump irrigated vegetables has a high potential profit in the urban market provided that the logistics of rapid transport and efficient marketing is in place. The social processes in the Rufiji agricultural communities resulting from these new market openings will take several decades to have full impact, but will most probably strengthen further the importance of individualized property rights to flood plain land.

Implications for the Robustness of the Social-Ecological System

Changes in land tenure do not alone affect the robustness of a social-ecological system. A change in land tenure with a maintenance of robustness is quite feasible. But changes in agricultural practices resulting from new and more profitable marketing openings combined with land tenure changes can influence dramatically on the robustness of a system. A peasant risk management system can as we have seen above, be robust against external disturbances. for a long period, incorporating new crops and expanding the array of peasant strategies. But this often happened at the price of hard toil and labour bottlenecks. It is also possible that this traditional robustness could have been strengthened and prolonged by introducing micro-credit schemes especially for women cultivators to overcome the financial bottlenecks that lower the efficiency of the system and to prevent short term famines. With the present policy environment in Tanzania, this is not likely to happen.

With the development towards increased individualized tenure and increased commercial agriculture in Rufiji, the social-ecological system is likely to go through a qualitative change. When the balance of risk-taking tilts from the local peasant community to the national banking system or to multinational corporations, the social-ecological system has changed and the criteria for robustness have to be changed correspondingly. Now a single after-flood contract crop *(Mlau)* with high market potential can catch a high value. And combined with perennial flood resistant Mango-fruit trees and pump irrigated intensive vegetable cultivation these strategies can be elements in a new type of robust social-ecological system. This would have a higher degree of specialization and a much more unequal social fabric than then typical Tanzanian peasant communities of the 20th century. With a larger portion of the risk located outside the flood plain, it would represent a stage in the transition to a different system, although in the final analysis the famine relief to the Rufiji peasants also has shown some external risk taking in the traditional system.

With the potential of growing commercial agriculture sector in the Rufiji Flood Plain, the question of transition from flood prone agriculture to large scale artificial irrigation will be quite different from than it was in the 20th century. This is because the balance of power between the State and its foreign donors on the one hand and the farmers on the other hand will shift in the favour of the commercial farmers. In the future they will therefore demand a greater say in how the Social control over the Ecological System shall be designed than the case was in the 20th century. The future of the Rufiji social-ecological system is therefore more open than ever and only the 21st century can show in what way its inherent robustness will manifest itself..

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