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ECOLOGICALLY RELEVANT CHARACTERISTICS OF FLOW-REGIME OF RUFJI BASIN IN TANZANIA

(AN ENSEMBLE OF ECOHYDROLOGICAL CLUES TO INFER ASSOCIATED
RAMIFICATIONS ON STREAM AND ECOSYSTEM)

By

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DEDICATION

This dissertation is lovingly dedicated to my beloved parents, who had been long long miles away from me during the preparation of this write-up; still spread their wings of best wishes and encouragement in each step of the way.

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RESUMO

Fenómeno ecohidrológico das necessidades de água para os ecossistemas aquáticos são hoje em dia uma preocupação de segurança ambiental que foi abordado através de diferentes formas de quantificação dos processos hidrológicos dinâmicos e ramificações associadas. Indicadores de fluxo de eco-relevantes disponíveis podem ser capazes de ditar o comportamento do fluxo necessário para serviços do ecossistema. Este estudo examinou como a variabilidade das características ecológicamente relevantes do fluxosignatário da bacia Rufiji na Tanzânia pode ser ligado de forma eficiente para traduzir as configurações de fluxo, e respostas do ecossistema. O fator-chave que está por trás a causar um tipo específico de impacto sobre ecossistema pode não ser sempre facilmente identificável; no entanto, saber o tipo ea extensão das ramificações, até mesmo devido ao desvio de comportamento do fluxo clássico de sua típica variabilidade e harmonia ou extensa variação nas métricas históricas de fluxo, são essenciais para a decisão de restauração e gestão de medidas e estratégias eficientes voltadas para a realização saudável de sistemas fluviais. Com este ponto de vista, este estudo teve como objetivo quantificar 47 características hidrológicas ecológicamente relevantes selecionados após a justificação de um conjunto de parâmetros disponíveis e explorar as probabilidades de ramificações dos ecossistemas associados. A quantificação do fluxo foi realizada com os dados de séries históricas de descarga por 18 estações de medição na bacia Rufiji na Tanzânia, que é um local de grande interesse devido a estar mais exposta incertezas hidrológicas recorrentes, do que qualquer outra região do mundo. Um problema aqui, que foi a irregularidade de dados e não ter informações específicas sobre o ano de referência de regulação de fluxo para dividir o período de registros em unidades comparáveis, foi criteriosamente gerido por um desenvolvimento de um método simples de processos de filtragem e agrupamento para os fazer uteis para cálculos específicos. Os resultados foram comparados com base de conhecimento cientificamente válido das suscetibilidades fluxo de comunidades da bacia existente para inferir o estado ecológico no local de interesse e eco-ramificações baseadas no fluxo foram discutidas. Assim, as características ecohidrológicas do regime de fluxo foram concluídas como eficientes, supondo as eco-ramificações da relação fluxo-ecologia; proporcionando, assim, uma forma conveniente para retratar a situação ecológica orientada do comportamento do fluxo da bacia do Rufiji de uma forma de causa e efeito. Tais explorações, juntamente com o zoneamento com base nas ramificações de fluxo críticas, pode ser muito útil para os gestores de bacias hidrográficas para decidir medidas e estratégias do sistema de gestão futuras de Rufiji. Estes tipos de informações podem orientar recomendações de fluxo ambiental subsequentes para atingir ecossistemas fluviais saudáveis na bacia Rufiji. Estas estatísticas podem ser incorporadas no plano de recuperação de bacias para elaborar ponto de partida eficiente que pode ser uma referência para afinar os parâmetros de modelagem hidrológica relevantes previstos para esta bacia. Conhecimento do estado ecológico bruto em determinados pontos do rio e cursos inferidas, a partir destas estatísticas pode ajudar a definir a priorização das necessidades de investigação na bacia. Os resultados deste estudo podem servir como um modelo útil para as outras bacias hidrográficas da região. Para enfrentar os desafios futuros de gestão da água em uma região de maior interesse da segurança hídrica como no Leste Africano da Tanzânia, essa investigação prévia das condições da corrente e dos ecossistemas, o que pode parecer ser um grande desafio inicialmente, para uma grande bacia como Rufiji, pode convenientemente e eficientemente ser feito pelo advento de pistas ecohidrológicas de indicadores de fluxo de eco-relevantes. Daí, a inferência do estado ecológico das relações fluxo-ecologia no presente estudo parece ser um marco na Rufijieco-hidrologia bacia.

Palavras-chave: Ecohidrologia; fluxo-métricas; segurança da água; influência dos ecossistemas; Bacia Rufiji; Tanzânia; África Oriental

ABSTRACT

Ecohydrological phenomenon of water requirements for aquatic ecosystems are now-a-days an essential environmental security concern which have been addressed through different ways of quantification of dynamic hydrological processes and associated ramifications (e.g. stress on biota, their removal or even extinction etc.). Readily available eco-relevant flow metrics can be able to dictate the flow behavior required for necessary ecosystem services. This study examined how variability in eco-relevant characteristics of signatory flow-regime of the Rufiji basin in Tanzania could efficiently be linked to translate stream configurations and ecosystem responses. The key driver acting behind the scene to cause a specific type of impact on ecosystem may not always be easily identifiable; nevertheless knowing the type and extent of the ramifications, even due to the deviation of classic flow behavior from its typical range of variability and harmony or extensive variation in historic flow metrics, are essential for deciding efficient restoration and management measures and strategies targeted to achieve healthy river systems. With this view point, this study was aimed to quantify 47 ecologically relevant hydrological characteristics selected after justification from a suit of available parameters and to explore the likelihoods of associated ecosystem ramifications. The quantification of flow-metrics was carried out with the historical time-series data of discharge for 18 gauging stations on Rufiji basin in Tanzania, which is a site of greater interest due to being more exposed to recurrent hydrological uncertainties than any other region of the world. The criticality here, which was regarding the data irregularity and about having no specific information on reference year of flow regulation to divide the period of records into comparable units, was judiciously managed by a simple methodological development of filtering and clustering processes to make those useful for targeted calculations. The results were compared with existing scientifically valid knowledge of the flow susceptibilities of basin communities to infer the ecological status in the site of interest and flow based eco-ramifications were discussed. Thus, the ecologically relevant characteristics of flow regime were concluded as efficient ecohydrological contrivance to surmise eco-ramifications from flow-ecology relationships; thus providing a convenient way to portray the flow behavior oriented ecological status of the Rufiji basin in a manner of cause and effect. Such explorations together with the zonation based on criticalness to flow oriented ramifications may be very useful to the river basin managers for deciding future management measures and strategies of the Rufiji system. These sorts of information may guide subsequent environmental flow recommendations for achieving healthy river ecosystems. These statistics may be incorporated in the basin restoration plan to devise efficient starting point rather than to play haphazardly which may be a reference for fine-tuning any relevant hydrological modelling parameters planned for this basin. Knowledge on gross ecological status at particular river points and courses inferred from these statistics may help to set spatial prioritization of research needs in the basin. The results of this study in total may serve as a useful model for the other river basins of the region. To face future water management challenges in a region of greater interest of water security like East African nation Tanzania, such a prior investigation of stream and ecosystem conditions, which may seem to be a big challenge initially for a large basin like Rufiji, can conveniently and efficiently be done by the advent of ecohydrological clues of eco-relevant flow metrics. Hence, the inference of ecological status from flow-ecology relationships in this current study appears to be a milestone in Rufiji basin ecohydrology.

Key words: Ecohydrology; flow-metrics; water security; ecosystem influence; Rufiji basin; Tanzania; East Africa

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1. INTRODUCTION

1.1. Background

Water resources management has always been a prime attention globally. Thousands of discrete river systems and watercourses have been identified across the world with their hydrologic signatures. Water related disasters and water security issues in all over the world provide a broad context for studying hydrology of river basins where environmental and ecosystem concerns are addition to these. Watershed hydrology in particular has presented its nature with lots of unpredictability and influence on resource elements due to its range and large coverage. Ecohydrological phenomenon of water requirements for aquatic ecosystems introduced in such watershed hydrology are now-a-days an essential environmental security concern which have been addressed through different ways of quantification of dynamic hydrological processes and associated ramifications.

Geomorphic and climatic variations have been the architecture of the signatory flow-regimes of the individual rivers and streams attributed by the magnitude, frequency, seasonal timing or predictability, duration, and rate of change of hydrologic conditions. Flows being a master variable chiefly modulate how their regimes translate into stream configurations and ecosystem responses (Arthington, 2012). In course of the development of hydrological science, researchers have identified universal characteristics and parameters of these flows to efficiently link to their translation process and outcome. All of these statistics have been studied well for their ecosystem influences (reviewed by Richter *et al.*, 1996); thus introduced as ecologically relevant hydrological indices.

Readily available eco-relevant flow metrics can be able to dictate the flow behavior required for necessary ecosystem services. Numerous scientific publications suggest that such methodologies have been implemented well on Australian and American river basin systems. While the African continent has been exposed more than any other region of the world to recurrent hydrological uncertainties (Rockstrom *et al.*, 2014), addressing these issues there with applying such methodologies can best be illustrated through representative ecohydrological researches on African river basins.

1.2. Motivation and significance

The site of interest for the current study, the Rufiji basin, lies entirely within the African nation of Tanzania and is the largest catchment basin of the country. The basin-use pattern includes agriculture, fisheries, forestry, livestock, mining and wildlife, navigation, tourism and transport, and human and industrial settlements (RBWB, 2014) which are the universal drivers to produce particular influence on its hydrology and dependent ecosystems, so as for Rufiji too. These anthropogenic activities which are dependent on basin water use are accompanied with environmental degradation potential. The responses of such degradations are expressed in deviations of natural flow regimes of the river basin from its typical range of variability and harmony, and subsequent changes in ecosystem services and resilience. Although the first most wave of these types of responses are initiated soon after regulating river water to meet human needs which constitutes the larger share of the ramification, but this may not be immediately responsive to its fullest; it is supposed to have a cumulative impact over the time where climate change is an addition to this. The key driver acting behind the scene to cause such a specific type of impact may not always be easily identifiable; nevertheless knowing the type and extent of the ramifications, even due to the deviation of classic flow behavior or extensive variation in historic flow metrics, are essential for deciding efficient restoration and management measures and strategies targeted to achieve healthy river systems. Such information can be incorporated in basin management plans to help policy makers and managers for prescribing ecohydrological solutions.

1.3. Research problem statement and justification

There are lots of ways to determine the ramifications on stream and ecosystem associated with flow behavior where complex hydrological modelling tools are advent to these. However, the problem is that the evolution of simple methodologies for such types of determinations has always been a true demand in ecohydrological research, especially where the historic flow data were not preserved regularly. Another problem is the absence of a particular cut point in the considered period of interest which distinguishes altered flow from the natural one. These problems were well justified for the current study on Rufiji basin in Tanzania since the time-series data of discharge were irregular in both spatial and temporal scale, and there were not any distinguishing year of flow regulation to divide the period of records into comparable units. Still irregular time-series data of river discharge can be of

great use if linkage between flow behavior and ecology can be established and incorporated in judicious processing and presentation of flow metrics. And comparative variations in historic flow metrics and comparative deviations of harmonic flow behavior can be taken into consideration to infer the associated ramifications.

1.4. Purpose of the study

The main purpose of the current study is to identify the research problem for ecohydrological analyses of Rufiji basin in Tanzania in terms of available flow data type, to address those problems in terms of efficient clustering and comparative flow statistics, and to infer discharge related ramifications based on literature-oriented flow-ecology relationships.

1.5. Research questions and hypothesis setting

The research questions of the current study were phrased as follows:

- i) Can the clustering methodology based on concentrated discharge data across the considered period of interest provide an efficient platform for analyses and subsequent comparisons to determine or infer the flow behavior related ecological ramifications at Rufiji basin in Tanzania while there might not be regular series of discharge data available from hydro-meteorological stations?
- ii) Can the comparative studies of the variability of ecologically relevant flow-metrics at different hydro-meteorological stations or clustered stations or sub-basins of Rufiji basin in Tanzania provide signals of ecological ramifications while there is no distinguishing year of flow regulation to divide the period of records into comparable units?

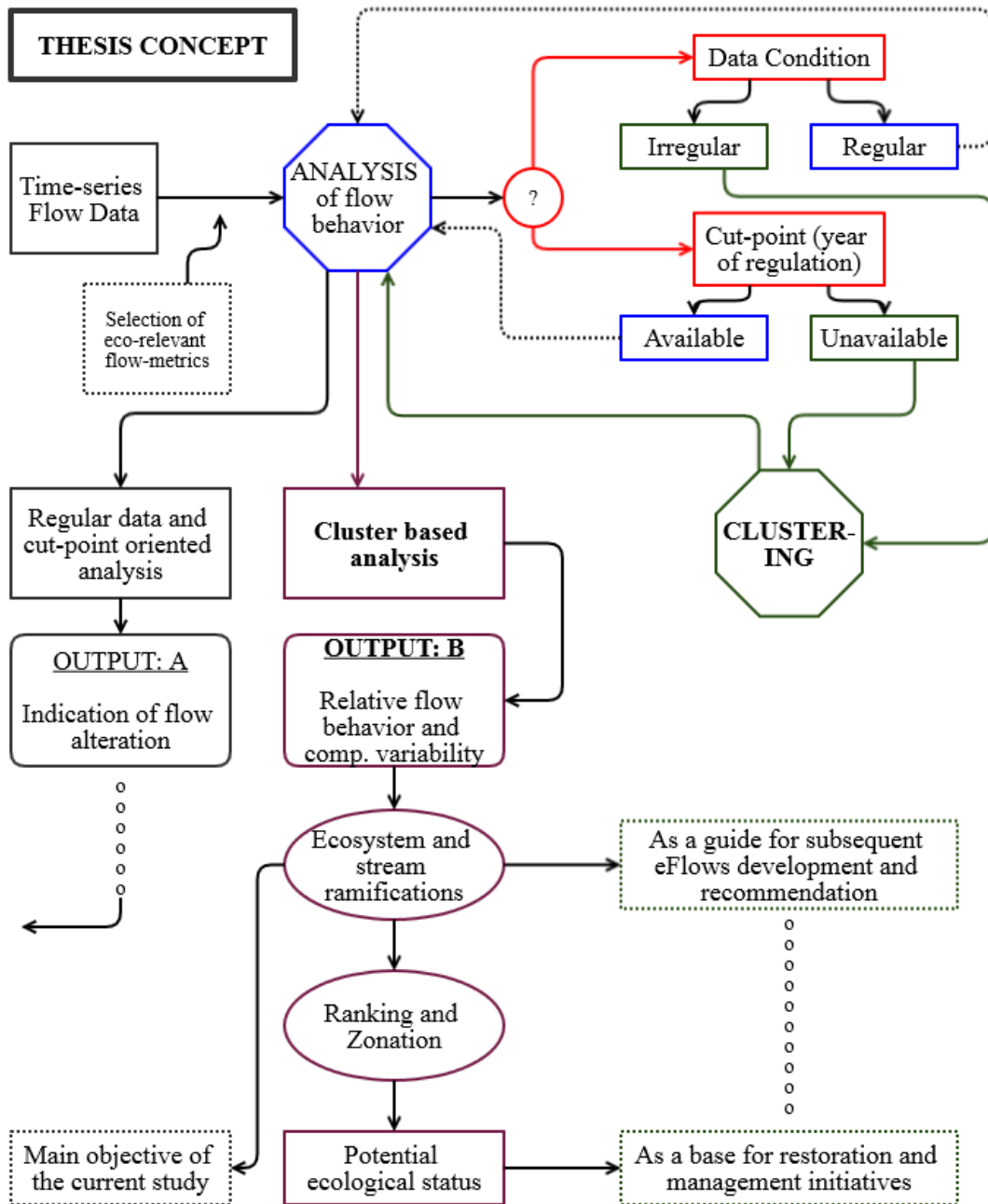
On the basis of these research questions, it was hypothesized that the idea of clustering hydro-meteorological stations based on concentrated flow data across the time-series could provide an efficient platform for analyses and subsequent comparisons to determine or infer the flow behavior related ecological ramifications at Rufiji basin in Tanzania. It was also hypothesized that the comparative inter-annual variability in flow metrics of selected ecologically relevant hydrological parameters at different hydro-meteorological stations or

clustered stations or sub-basins of Rufiji basin in Tanzania could provide signals of ramifications on stream and ecosystem, as well as ranking of stations, clusters and sub-basins and their zonation based on comparative ecological status or pressure. The results of testing these hypotheses were considered to be falsifiable. Please follow Figure 1.1 for the illustration of this concept.

1.6. Objectives of the study

The objectives of the current study were as follows:

- i) To deal with flow data for hydrological analyses while the data are irregular at both spatial and temporal scale.
- ii) To determine the ecologically relevant characteristics of flow-regime at Rufiji basin in Tanzania.
- iii) To infer ecological ramifications from the variability of the determined flow-metrics while there is no cut point to define pre-development status and post-development alterations.
- iv) To create a ranking-based zonation of the stations, clusters and sub-basins according to their susceptibility to those inferred ramifications on stream and ecosystem and to ascertain their potential ecological status or pressure.



1.1. Flowchart showing Thesis Concept

2. LITERATURE REVIEW

The natural regime defines the hydrological variability pattern and reflects the interaction between the climatic regime (precipitation and temperature) and the basin characteristics that regulate runoff (geomorphology, geology and vegetation) (Oscar *et al.*, 2010). The proper functioning of any healthy river system is strongly dependent on the natural flow variability to which the ecosystem components are adapted. Flow shapes physical habitat and biotic composition in rivers; life history strategies of aquatic species have evolved in response to natural flow variability (Bunn and Arthington, 2002). The components of natural flow regime which characterize its variability are defined as: magnitude, timing, frequency, duration, rate of change and predictability of flow events (Lytle & Poff, 2004). Any anthropogenic flow alteration caused from direct modification in the rivers or indirectly from land-use changes have significant impacts in nutrient and sediment dynamics and in the inter-connection between rivers and floodplains (Poff and Zimmerman, 2010). The general flow modification or alteration effect is the transformation of dynamic patterns into static, relatively stable patterns with reduced flows (Benejam *et al.*, 2010). On a global scale, flow modifications or alterations present a serious and extensive threat to the integrity of aquatic ecosystems and the persistence of freshwater species (Anderson *et al.*, 2011a). Over half of the world's major river systems are presently affected by flow regulation (Nilsson *et al.* 2005), and climate change is predicted to further modify historical flow patterns in many rivers (Anderson *et al.*, 2011a). Flow modifications or alterations imperil living aquatic inhabitants, more prominently migratory species (Bunn and Arthington, 2002), as well as spawning individuals and residents of local interest. It manifests its impact in the reduced ability of rivers to provide valued ecosystem services — sources of water and food, recreation, waste assimilation, flood control (Anderson *et al.*, 2011b) —upon which humans depend (Millennium Ecosystem Assessment, 2005).

Numbers of scientific literatures suggest that the flow modification or alteration of any river or stream are accompanied with any kind of flow regulation like water abstraction for agriculture or drinking water supply, flood control etc. or any kind of river engineering works like river dredging for navigation, embankment for flood protection, bridge construction for communication, damming for hydroelectricity, barrage for water control, river training structures, aqueducts, irrigation channels, diversions etc. and management and maintenance of these in-channel structures. All of these flow regulations and river engineering works

which are targeted to human needs and benefits can cause changes of the performance of rivers and streams. These universal drivers of flow modifications or alterations and subsequent ecosystem degradations in many cases are not mutually exclusive. In those situations, the key cause to influence a specific consequence may not always be easily identifiable. The current site of interest, the Rufiji basin in Tanzania, being the largest catchment in the country had been offering fuel to various kinds of economic activities and the associated ramifications on stream and ecosystem were evident here as well (discretely reported by Kangalawe and Liwenga, 2005; Mombo *et al.*, 2013; Mombo *et al.*, 2014; United Republic of Tanzania, 2007) where different drivers were responsible for these consequences.

In Tanzania, the river water dependent economic activities of the adjacent communities were found to effect degradation of basin resources and services; for example, in the Kilombero Valley, a Ramsar site and one of the sub-basins of Rufiji system (Kangalawe and Liwenga, 2005; Mombo *et al.*, 2014). Among plenty of natural resources there, well managed basin wetlands provide higher earning potential to the low-input rain-fed agriculture of Tanzania (United Republic of Tanzania, 2007) since the cropping activities were often found to be carried out in those wetland areas for exploiting the flow-borne soil fertility and soil moisture (United Republic of Tanzania, 1997). Varying degrees, methods and extents of wetland utilization in Tanzanian basins substantially affected its state at a range from minimal to profound (Mombo *et al.*, 2013). United Republic of Tanzania (2007) reported a conspicuous alteration of the ecosystem in parts of Rufiji basin, especially at the Panagani River of the Kilombero valley and the Usangu plains of the Upper Great Ruaha River, which were, according to Schuijt (2002), often associated with unsustainable use of the life support services and resources provided by those wetlands.

Impacts of flow modifications have recently been come up with a worldwide recognition of flow need of ecosystem which inspires to determine and maintain environmental flows (Naiman *et al.*, 2002; Tharme, 2003; Poff *et al.*, 2010). An environmental flow is a management concept that aims to establish the flow regime needed to sustain ecosystems and the amount of water available for off-channel human uses or storage in reservoirs at different times of the year (Anderson *et al.*, 2011a). Initially the idea was being used chiefly for temperate rivers, or in tropical regions where water policies recognized the significance of specific flow regimes to sustain ecosystems (Tharme, 2003). Recent water laws and policies in some tropical countries (e.g., East Africa) explicitly refer to maintain flows for sustaining

ecosystems. Environmental flows with variability as similar as natural are of vital importance for healthy ecological status. Specifically it must include the time distribution of maximum and minimum flows, flood and drought flows and the rates of flow change. Water laws of many nations are demanding the assessment and incorporation of environmental flow regime for every water bodies of ecological worth exclusively to their basin management plans. Environmental flow regime is necessary for reinstating the conservation of biophysical states with long-term sustainable functioning of the ecosystem (Oscar *et al.*, 2010). There is a clear distinction between the natural flow regime of a river that maintains ecosystem in a pristine state and an environmental flow that maintains a certain level of ecological integrity based on an appropriate management vision (Anderson *et al.*, 2011a). Environmental flow standards can be restrictive management thresholds—designed to limit water withdrawals—or active management thresholds—designed to control flow releases at downstream (Poff *et al.*, 2010).

Hydrological characterization constitutes the first step of a new holistic framework intended to develop environmental flow criteria, where the unaltered hydrology of rivers and streams constitutes the basis for assessing the extents and effects of flow alteration, and estimating environmental flows (Belmar *et al.*, 2012). But the unaltered hydrology may not be always possible to differentiate or separate from the flow records of the period of interest, especially in cases where there is a cumulative impact of various drivers acting actively and concurrently on the basin hydrology to cause its flow modification and associated ecosystem ramifications. Most often assessment of environmental flow criteria (EFC) is based on statistical analysis of stream discharge data alone (Tharme, 2003). When environmental flow requirements are developed they are most often based on field data e.g. observed streamflow records (King *et al.*, 2008). Acreman and Dunbar (2004) reviewed various methods developed as of then to define environmental flows and concluded a simple categorization of the methods into four types: look-up tables, desktop analysis, functional analysis and hydraulic habitat modelling. According to him, no method is necessarily better than another; each may be suitable for different applications. Whilst look-up methods are easy and cheap to apply, they can be expensive to develop, are less accurate and more suitable for scoping studies; in contrast, although hydraulic habitat modelling is more expensive to apply, it is suitable for impact assessment at specific sites. Each method would need to be used within a wider decision-support framework. These are generally either objective-based to define a target flow regime for a specific desired river status, or scenario-based to indicate the relative merits of various flow regime options for the river environment. The current study had been

focused to the later one where scenario-based evaluation of the basin stations based on relative merits of various ecologically relevant characteristics of flow-regime were planned for aiding subsequent environmental flow assessment process by the policy makers and basin managers.

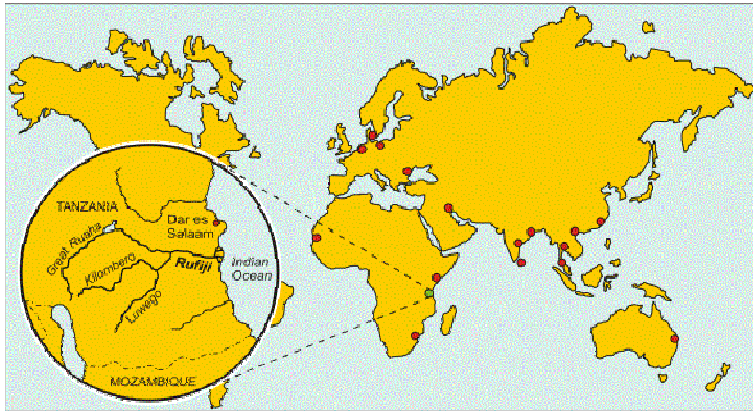
There are a lot of statistical parameters of ecohydrological importance to estimate ecologically relevant characteristics of flow-regime of any river or stream. The Nature Conservancy (2009) documented a well suit of such parameters to determine hydrological alterations and environmental flow components which provide a basis for inferring ramifications on stream and ecosystem. Laize *et al.* (2010) supplemented to various factors reported by Moss (2010) and Norris and Thoms (1999) for determining the health of a river ecosystem, which were light, temperature, nutrient levels, water discharge, channel structure, physical barriers to connectivity, species interactions and the level of management, such as macrophyte cutting and dredging, fishing and stocking etc. There are significant correlations between or among particular factors of such kind. Laize *et al.* (2010) gave an example of such inter-dependence of river health determining factors where they mentioned about an interaction among discharge, channel structure and macrophyte growth to determine water depth and velocity, which in turn influence food delivery, light penetration and oxygen levels. To say specifically about the discharge which is a dynamic key variable of any river system, scholars suggested that all the ecologically relevant components of flow-regime have particular influence on freshwater ecosystems (Junk *et al.*, 1989; Richter *et al.*, 1996; Poff *et al.*, 1997; Biggs *et al.*, 2005; Arthington *et al.*, 2006; Kennen *et al.*, 2007; Laize *et al.*, 2010).

Relative merits of eco-relevant flow metrics expressed in ecosystem ramifications can guide an efficient environmental flow assessment of any river basin under pressure of flow regulations, like the Rufiji basin in Tanzania. These types of discharge oriented ecosystem ramifications can also be sourced from deviation of typical harmonic flow behavior illustrated over a water year, thus causing a relatively higher or lower inter-annual variations of such kind. Year-to-year flow variability was predicted to have adverse effects on the biodiversity and ecological function of rivers and floodplain habitats and to be threatening to the ecological integrity of rivers, which in turn serve as a caution for careful consideration of water resource management options for rivers (Leigh and Sheldon, 2008). According to The Millennium Ecosystem Assessment (2005) and Nilsson *et al.*, (2005), many aquatic ecosystems all over the world were being degraded or lost or at least suffered from functional

unhealthiness particularly due to flow modifications. Thus, there is a pressing need to assess the degree of such modifications of discharge and associated ramifications on stream and ecosystem by the advent of ecologically significant hydrological statistics for guiding efficient management decisions and strategies (Leigh and Sheldon, 2008). A noticeable departure or deviation or lack of harmonization in these statistical measurements from their reference range of variability is the key element for the ramifications in associated ecosystem functionality and health. Environmental flows can doctor these situations due to which establishment of this prescription and its efficient execution is receiving increasing attention in ecohydrological science (Dyson *et al.*, 2003, Poff *et al.*, 2010). The current study was thus attempted, as a guide to develop such prescriptions, the exploration of the flow-behavior associated ramifications on stream and ecosystem of Rufiji basin in Tanzania.

3. STUDY AREA

The Rufiji Basin covers an area of 183,791 square kilometres (about 20% of Tanzania) which drains into the Indian Ocean. The basin is situated between Longitudes 33°55'E and 39°25'E and between Latitudes 5°35'S and 10°45'S. The altitude of the basin rises from 0 meter (above mean sea level) at the Indian Ocean to 2,960 meters (above mean sea level) in the



highlands (Kipengere ranges and Poroto Mountains) Iringa and Mbeya Regions. The Basin is divided into four sub basins which are Great Ruaha (46.5%), Kilombero (21.9%), Luwegu (13.8%) and Lower Rufiji (17.7%) (RBWB, 2013).

Figure 3.1. Showing Rufiji basin in the World Map (RBWB, 2013)

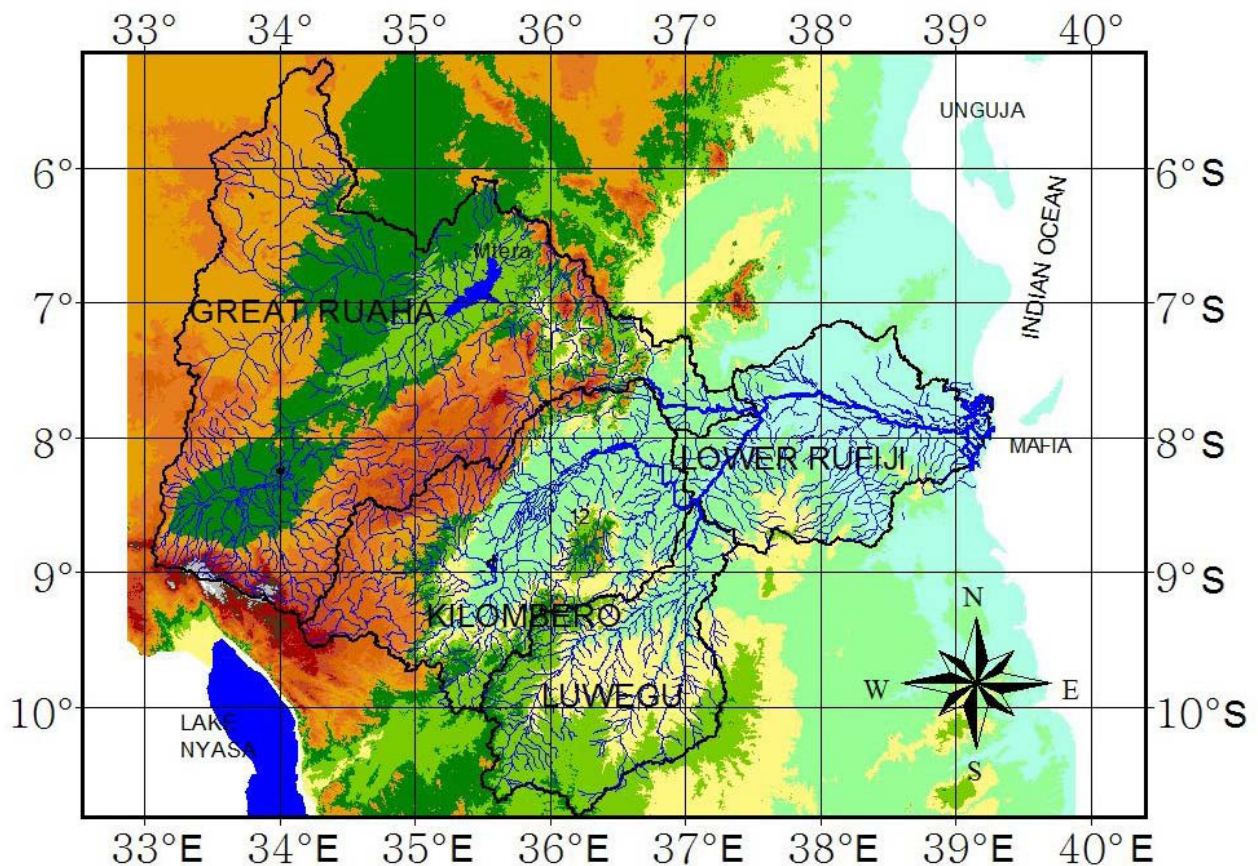


Figure 3.2. Showing Rufiji basin coordinates (RBWB, 2013)

The Rufiji basin is managed under the Rufiji Basin Water Board of the Water Councils unit of the Ministry of Water in Tanzania. Again The Rufiji Basin Development Authority (RUBADA) was established as a philanthropic Government organization of Tanzania to pursue multi-sectoral responsibilities for promoting, regulating, coordinating and facilitating sustainable and balanced development of ecological and socio-economics in the sector of energy, agriculture, fisheries, forestry, tourism, mining, industry, transport and environment in the basin (RUBADA, 2014). The basin was maintained by a network of 57 hydrometric stations among which 52 stations were fully operational, 2 were partially operated and 3 were non operational. From these we collect information on water level. 52 stations are fully operational, 2 are partially operated and 3 are non operational. Historical discharge (Q in m^3/s) data were collected for the current study from these stations on a selective basis.

The drainage patterns of the Rufiji basin were reported to be highly dependent on its geomorphology which was formed from a former erosion cycle due to earth's epeirogenic movements (RBWB, 2013). The basin is characterised by many wetlands both in the highlands and the lowlands, and the mangrove at the Rufiji river delta. Economic activities there in the Rufiji Basin are mainly agriculture, tourism, wildlife conservation, fisheries and mining. According to RBWB (2013), agriculture is the mostly practiced activity in the Usangu plain and Kilombero basin, tourism and wildlife conservation are practiced in the National Parks (Udzungwa, Mikumi, Kitulo and Ruaha) and the Game reserves (Selous, Mpanga/Kipengele and Rungwa), fisheries are practiced in the Kilombero, Great Ruaha and Rufiji rivers, and mining projects are developed in the Selous basin at Namtumbo district and in the Iringa district at Nyang'oro hills.

Weathering of the parent rocks in the area characterized the soil types of the basin which are mostly dominated by coarse to medium grained sand, reddish-brown fine slits and clay volcanic types. The flood plains in Lower Rufiji, Great Ruaha and Kilombero Catchments are dominated with the black clay soil and scarcely distributed sand and silt soils. According to RBWB (2013), the Rufiji River Basin varies greatly in climatic and hydrological conditions. The basin has a tropical dry, humid and hot climate which differs from the coast to the highlands or mountainous regions in the upper parts of the catchments. The lower parts of the basin experience two rainy seasons while the most part is characterized by unimodal rainfall. The annual rainfall ranges from 400 mm to 1800 mm with a high along the mountain chain and uneven falling across the year. The four principal sub-basins of the Rufiji are characterized by numerous river systems which experience with wide range of flow

variations (on an average, 50 to 14,000 m³/sec). The largest part of the basin experiences longer dry seasons and shorter wet seasons. Economic activities have increased in the basin areas hence decreases the flows in most of the rivers which consequently lead to insufficient flow to downstream users.

The Rufiji basin drains through a number of tributaries including Great Ruaha, Mlombiji, kimani, Mbarali, Chimala, Kioga, Halali, Ndembera, Little Ruaha, Mswiswi, Kisigo, Bubu, Fufu, Lunwa, Mwega, Lukosi, Yovi, Umrobo, Ipatagwa, Mlowo, Ruhiji, Kigogo, Lidete, Mnyera, Mpanga, Furua, Sofi, Mchilipa, Luri, Kihansi, Mgeta, Ruipa, Lumemo, Msolwa, Luhombero, Hagafiro, Mbarangandu, Luwegu etc. There are three major reservoirs in the basin which are Mtera and Kidatu in the Great Ruaha and Lower Kihansi in the Kilombero. The basin is running important water resources management interventions including Studies for Construction of Ndembera dam and Preparation of the Integrated Water Resources Management Plan which are expected to be the solution of many water related challenges within the basin (RBWB, 2013).

According to 12 years old national census results, about 1,400,000 people were living in the Rufiji basin. The greater significance of this basin lies under four National Parks (Kitulo, Ruaha, Mikumi and Udzungwa), big game reserves (Selous, Rungwa, Usangu, Mpanga/Kipengere, Lunda etc), forest reserves (23,200 km²), mining of Uranium and Copper (Mbeya, Iringa and Morogoro regions), livestock keeping, eco-tourism attractions, the Rufiji Delta, the coast lines and the Mafia Island (RBWB, 2014).

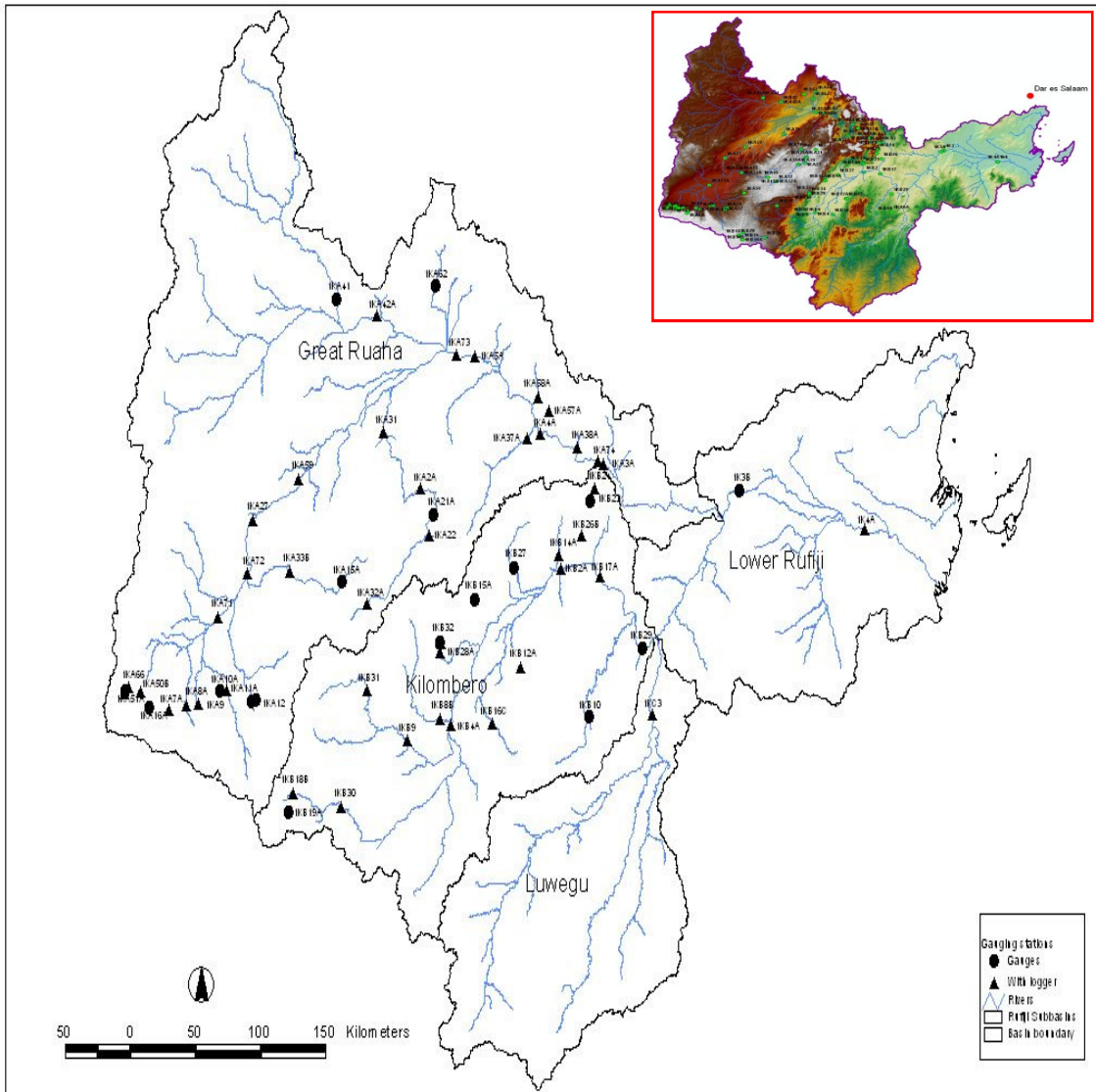


Figure 3.3. Map showing boundary, sub-basins, gauging stations and rivers of Rufiji basin in Tanzania (RBWB, 2013; RBWB, 2014)

4. METHODOLOGY

4.1. Data collection, tabulation and plotting hydrographs

Historical discharge (Q in m^3/s) data of 29 stations under 3 sub-basins of Rufiji River Basin System were collected from Rufiji Basin Water Board (RBWB), Tanzania and tabulated according to time-series format (Year: 1957-2014) where a double column database having date and Q fields for each station was prepared. Hydrographs based on these datasets were plotted for each station (Annex I) to visually determine the data quality.

Table 4.1.1 reveals the basic information of the stations of the Rufiji River Basin System under rivers, locations and positions headings. Shaded numbers of stations were selected for final analyses which were chosen by data filtering and data clustering method (section 4.2 and 4.3) and therefore, the complete information in Table 4.4.1 were provided only for these selected stations.

Table 4.1.1. Basic information of the gauge stations of Rufiji Basin (based on RBWB, 2013)

Sub-basin	Serial No.	Station Code	River	Location	Latitude	Longitude
Ruaha	1	-	Little Ruaha	Iringa Nduka	-	-
	2	1KA5A	Great Ruaha	Trace	7.12722	36.08333
	3	-	Chimala	Chitekelo	-	-
	4	1KA8A	Gre Ruaha	Salimwani	8.9	37.11666
	5	1KA9	Kimani	Great North Road	9.85	34.18333
	6	1KA11A	Mbarali	Igawa	8.78333	34.36666
	7	1KA15A	Ndembera	Ilongo	8.28333	35.21111
	8	1KA21A	Little Ruaha	Ihimbu	7.88333	35.8
	9	1KA22	Mtitu	Mtitu	8.01666	35.78333
	10	-	Ruaha	Malangali	-	-
	11	1KA31	Little Ruaha	Mawande	7.5	35.5
	12	1KA32A	Little Ruaha	Makalala	8.33333	35.33333
	13	1KA37A	Lukosi	Mtandika	7.56666	36.43333
	14	-	Kizigo	Ilangali	-	-
	15	-	Kizigo	Chinugulu	-	-
	16	-	Mswiswi	Wilima	-	-
	17	1KA51A	Urobo	Great North Road	8.81666	33.66666

Sub-basin	Serial No.	Station Code	River	Location	Latitude	Longitude
	18	1KA52A	Little Ruaha	Iwawa	8.93333	34.00111
	19	-	Gre Ruaha	Gorge	-	-
	20	1KA33B	Ndembera	Madibira	8.23333	34.8
Kilombero	21	1KB14A	Lumemo	Kiburubutu	8.01222	36.65722
	22	-	Ruhudji	Kifunga's Falls	-	-
	23	1KB19A	Hagafiro	Hagafiro	9.39583	34.81666
	24	1KB8B	Mpanga	Mpanga Mission	8.93777	35.81277
	25	1KB9	Mnyera	U/S Taveta Mission	9.01666	35.51666
	26	1KB15A	Mngeta	U/S Bridge	8.33611	36.08611
	27	-	Kilombero	Swero	-	-
Lower Rufiji	28	-	Pangani	-	-	-
	29	-	Utete	-	-	-

Note.

Data for total 29 no. of stations were collected primarily; subsequently filtered and clustered at 18

4.2. Data filtering

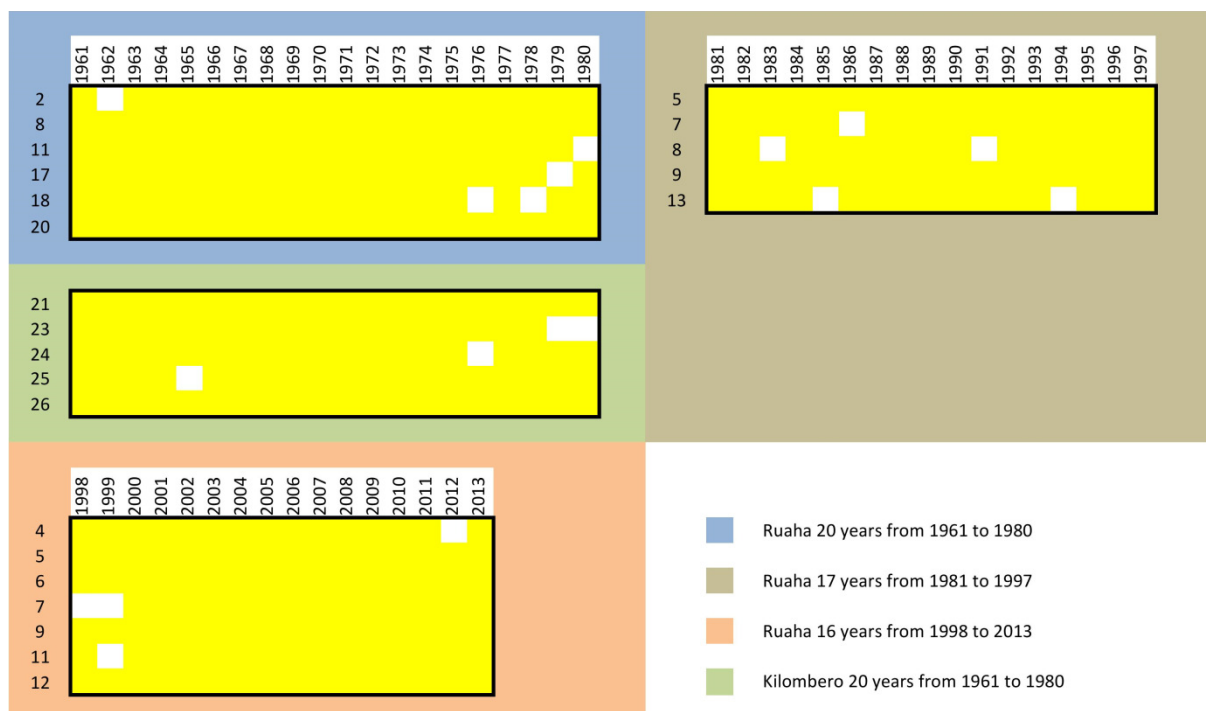
For each station, discharge (Q in m^3/s) data were filtered according to dual conditions where there were at least 26 daily values in a month and afterwards, 08 monthly values in a year. Missing value statistics were calculated and based on that, the thresholds for this filtering were decided along with keeping consideration of a balance so that a large portion of data points might not be excluded by this filtering process. Thus the thresholds for this filtering were arbitrarily chosen with flexibility of that limit. This gave an estimation that a month was considered to be representative for subsequent analyses if it consisted no more than 10%, 12%, 15%, and 18% daily missing values for 28, 29, 30, and 31-day months respectively, and a year was considered to be representative for subsequent analyses if it consisted no more than 40% monthly missing values in the time-series.

4.3. Data completeness chart, clustering and plotting:

Based on the dual conditions set at data filtering stage a completeness chart was prepared which showed both the complete data years and missing data years across each station of the Rufiji Basin (Table 4.3.1). A bird's eye view on the chart gave a visual signal of the concerted data which provided a clustering idea over the basin database. A total of four bases were set

for this clustering process: i) length of time-series must not be less than 15 years, ii) number of stations per cluster must not go below 5, iii) sub-basins must not overlap with one another, and iv) missingness must not cross a maximum limit of 14.5%. These thresholds were set by trial-and-error process. After several work outs of placing those boundaries, four final clusters were developed which met all the four conditions set (Table 4.3.2). Hydrographs based on these filtered and clustered discharge data were plotted for each station (Annex II) to visually determine the quality of the processed data.

Table 4.3.2. Clustering of discharge data (numbers at left side indicates stations of Rufiji basin which were taken from Table 4.1.1 and Table 4.3.1)



4.4. Flow statistics, data cleaning and completeness

Filtered and clustered flow data were arranged for a couple of significant statistical measurements. Minimum, maximum, range, mean, range-by-mean (R/M), standard deviation (SD), and coefficient of variation (CV) were computed and plotted to visualize the flow variability. Subsequently, extremely variable data points (above 0.98 percentile) and visually determined suspicious data points were identified and removed from the series as outliers (Annex III). Finally, completeness of each station in terms of having suspicious and outlier free discharge data (termed as 'cleaned data') was determined for each series and cluster (Table Ann-III.5 in Annex III).

4.5. Estimation and plotting of mean-monthly discharge and flow duration curve

Cleaned discharge data were arranged month-wise for all the years in each cluster for each station and month-year-wise means were calculated from all the series. Subsequently month-wise means and their percentages to mean-annual discharge were computed for each period of record to normalize the data. Finally, mean-monthly (%) graphs were plotted to observe the long-term flow behavior and the annual cycle across months and stations within each cluster. Flow-duration curves from clean data were plotted for each station to visualize percent time flow exceeded during the considered period of record.

4.6. Computation of ERCs of flow-regime

A total of 47 ecologically relevant characteristics (ERCs) of flow-regime to be computed were selected (Table 4.6.1) from a list of 67 statistical hydrological parameters introduced and documented by The Nature Conservancy (2009). This selection was based on judgmental decision. Timing of annual extreme water conditions (6 parameters: Julian date of 1-day maximum, 1-day minimum, peak extreme low flow, peak high flow pulse, peak small flood, and peak large flood) were delisted since a similar type of information could be possible to extract from an earlier measurement viz., mean-monthly plots. Frequency and duration of annual water extremes (4 parameters: number and duration of low and high flows) were delisted since similar statistical measurement were carried out more extendedly under extremely low flows, high flow pulses, small floods, and large floods categories. Rise and fall rates from high flow pulses, small floods, and large floods groups (6 parameters) were delisted since similar type of information could be possible to extract in simpler format from measurements of rate and frequency of water condition changes. Annual extremes of 90-day means (2 parameters) were delisted since these seemed to be redundant with annual extremes of 1, 3, 7, 30-day means. Number of zero-flow days and base flow index (2 parameters) were delisted since these might be less meaningful according to objectives of this study. Thus, the number of ecologically relevant characteristics were thinned down from 67 to 47 and selected for analyses of the current study which are mentioned in the following sub-sections.

Table 4.6.1. Ecologically relevant characteristics of flow-regime (based on The Nature Conservancy, 2009)

ERCs	Hydrologic parameters	Ecosystem influences on/in
Monthly water conditions	Mean value of each calendar month <hr/> <i>Subtotal 12 parameters</i>	Availability of habitat, soil moisture, food, water etc. and dynamics of physico-chemical parameters in water
Annual water extremes	Annual minima and maxima of 1-, 3-, 7-, and 30-day means <hr/> <i>Subtotal 08 parameters</i>	Stress balance, sites for colonization, ecosystem structure, channel morphology, habitat condition, nutrient dynamics, community distribution, waste disposal, sediment dynamics, spawning facilities etc.
Monthly low flows	Mean values of low flows during each calendar month <hr/> <i>Subtotal 12 parameters</i>	Habitat, water temperature, DO, water table levels, soil moisture, drinking water supply to dependent terrestrial animals, egg suspension, mobility, hyporheic organisms etc.
Extremely low flows	Frequency, mean peak flow (minimum flow during the event), and mean duration of extremely low flow events during each water year <hr/> <i>Subtotal 03 parameters</i>	Prey concentration, certain recruitments, removal of invasives, riparian structure along depth etc.
High flow pulses	Frequency, mean peak flow (maximum flow during the event), and mean duration of high flow events during each water year <hr/> <i>Subtotal 03 parameters</i>	Shaping channel pools, riffles and bed substrates (sand, gravel, cobble), limiting riparian structure, water quality, flushing wastes and pollutants, oxygenation, preventing siltation, mixing and transporting nutrients etc.
Small floods	Frequency, mean peak flow (maximum flow during the event), and mean duration of small flood events during each water year <hr/> <i>Subtotal 03 parameters</i>	Migration, spawning and nursing, floodplain connection and recharge, distribution and abundance of biodiversity, nutrient exchange, introducing waterbirds and their habitats etc.
Large floods	Frequency, mean peak flow (maximum flow during the event), and mean duration of large flood events during each water year <hr/> <i>Subtotal 03 parameters</i>	Shaping floodplain habitats, disburse riparian seeds and fruits, flushing foods and debris, creation of new habitats as secondary channels, prolonging soil moisture, helping colonization, balancing species of aquatic and riparian communities etc.

Table 4.6.1. Ecologically relevant characteristics of flow-regime (based on The Nature Conservancy, 2009)

ERCs	Hydrologic parameters	Ecosystem influences on/in
Reversals of water conditions	Rise and fall rates, and number of reversals	Wet-dry dynamics and related stress on biota, entrapment due to floodplain disconnection, mobility and coverage of aquatic organisms etc.
	<i>Subtotal 03 parameters</i>	
Total 47 parameters		

4.6.1. Monthly water conditions

Inter-month variations of a given period of record in mean-monthly discharge were determined for all the stations and presented for within-cluster and among-clusters comparison to reveal monthly water conditions.

4.6.2. Annual water extremes

The 1-, 3-, 7-, and 30-day minima and maxima were computed from moving averages of the appropriate length calculated for every period for all the stations under investigation.

4.6.3. Monthly low flows

Mean values of low flows for each calendar month were determined for all the years in a given period of record for each station and presented cluster-wise for comparison. Low-flow threshold was set at 50th percentile of daily flows (according to The Nature Conservancy, 2009). All flows less than or equal to this threshold were classified as low flow events.

4.6.4. Extremely low flows

Frequency, mean peak flow (minimum flow during the event), and mean duration of extremely low flow events for each water year in a given period of record were determined for each station and presented cluster-wise for comparison. Extremely low-flow threshold was set at 10th percentile of daily low flows (according to The Nature Conservancy, 2009). All flows less than or equal to this threshold were classified as extremely low flow events.

4.6.5. High flow pulses

Frequency, mean peak flow (maximum flow during the event), and mean duration of high flow events for each water year in a given period of record were determined for each station and presented cluster-wise for comparison. High-flow threshold was set at 75th percentile of daily flows before small flood (according to The Nature Conservancy, 2009). All flows greater than this threshold and less than small-flood threshold were classified as high flow pulses.

4.6.6. Small floods

Frequency, mean peak flow (maximum flow during the event), and mean duration of small flood events for each water year in a given period of record were determined for each station and presented cluster-wise for comparison. Small-flood threshold was set at 50th percentile of the peaks of high flow events before large flood (according to The Nature Conservancy, 2009). All high flows greater than or equal to this threshold and less than large flood threshold were classified as small floods.

4.6.7. Large floods

Frequency, mean peak flow (maximum flow during the event), and mean duration of large flood events for each water year in a given period of record were determined for each station and presented cluster-wise for comparison. Large-flood threshold was set at 90th percentile of the peaks of high flow events (according to The Nature Conservancy, 2009). All high flows greater than or equal to this threshold were classified as large floods.

4.6.8. Rate and frequency of water condition changes

Rate and frequency of water condition changes were calculated by dividing the hydrologic record into "rising" and "falling" periods, which correspond to periods in which daily changes in flows were either positive or negative, respectively. The number of hydrologic reversals was determined as the number of times that flow switches from rising to falling or vice-versa. Reversals were analyzed on a water year by water year basis, so the first change in flow of the water year could not be counted as a reversal, since no rising or falling trend existed before then.

4.7. Programming language / tool used

All the computations of the aforementioned ecologically relevant hydrological statistics were carried out using R programming language. Direct use of the 'Indicators of Hydrologic Alteration' (IHA) software of The Nature Conservancy for such computations was not possible because of irregular data type and not having any pre-post alteration cut point in the current study. Manual estimation by R programming language coding, although took huge computing works and hours, did not impact the result quality of the measurements, rather paved the way to deal with such type of data series for ecohydrological analyses similar to IHA.

5. RESULTS

The ecologically relevant characteristics of flow-regime were calculated for Rufiji basin in Tanzania. The list of these hydrological parameters was chosen from The Nature Conservancy (2009) and selections from that list for the analysis for this study were made with proper justifications and ecosystem influences. All the results from those analyses are presented here.

5.1. Mean-monthly discharge

Mean-monthly discharge at Figure 5.1.1 shows the long-term flow behavior and the annual cycle of discharge within each cluster.

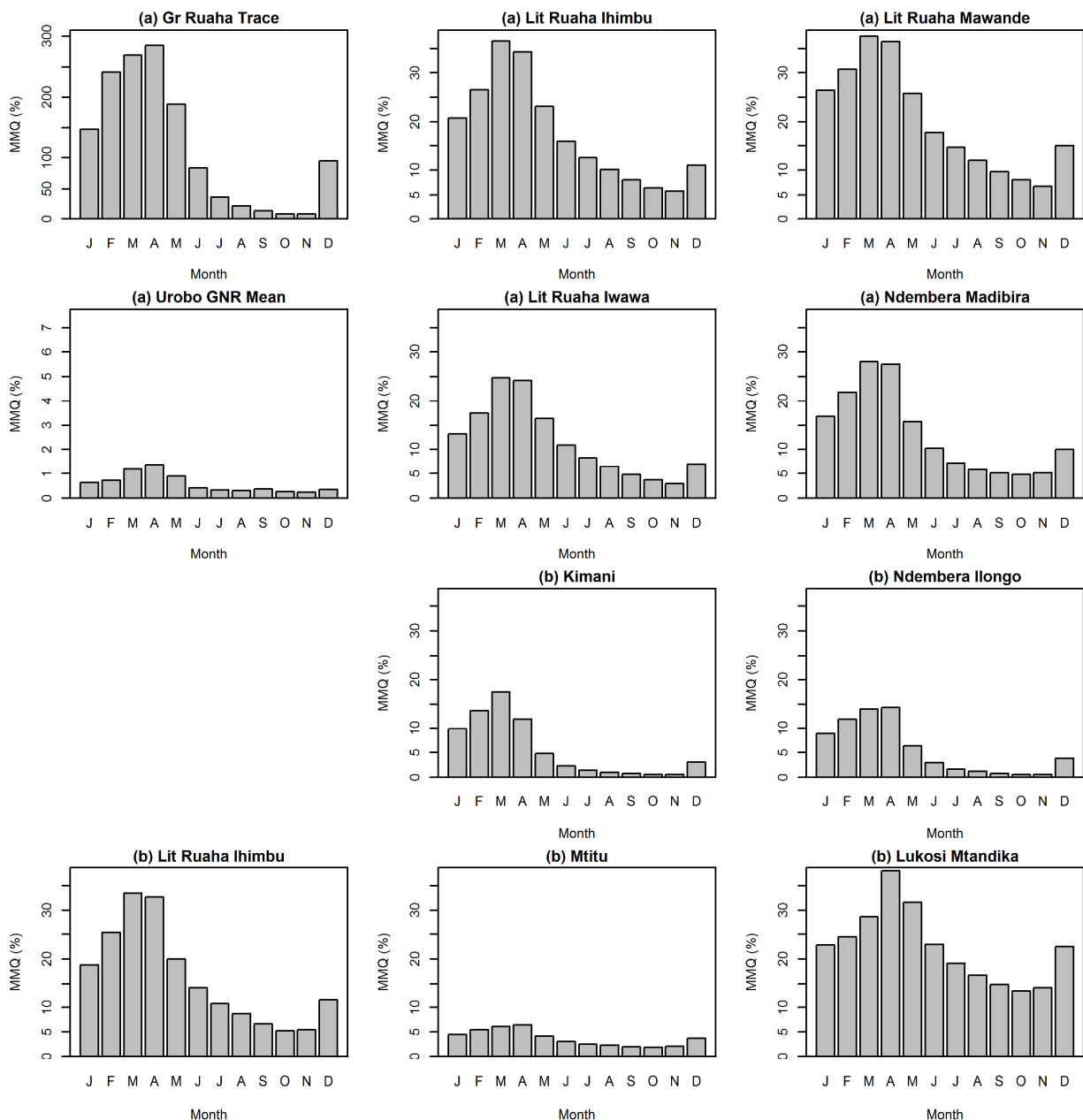


Fig 5.1.1. Mean-monthly discharge (a = Ruaha sub-basin in 1961-1980, b = Ruaha sub-basin in 1981-1997)

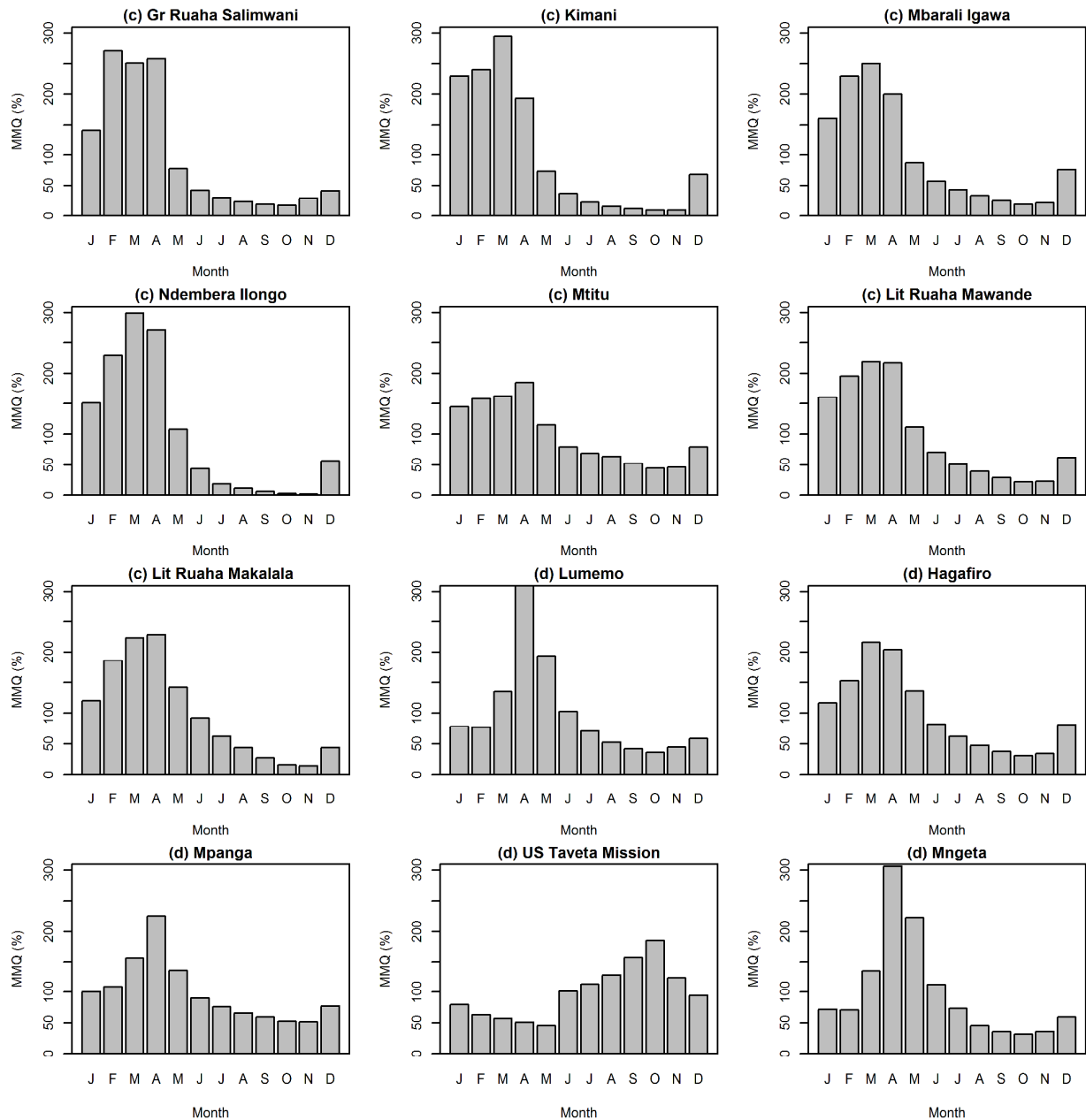


Fig 5.1.1. Mean-monthly discharge (c = Ruaha sub-basin in 1998-2013, d = Kilombero sub-basin in 1961-1980)

The patterns are clearly visible and there were peaks around the month of Mar-Apr and drops around Oct-Nov at annual cycles for almost all stations of the Rufiji basin in Tanzania. The exception of this pattern was noticed for the station at US Taveta Mission at Kilombero sub-basin where the average peak shifted to Oct and the drop to May. The magnitude of the peaks and drops at the stations were varied in extent where two exceptional variations were noticed in the time series '1961-1980' at Ruaha sub-basin and even the flows at these stations were lower than the stations of Kilombero sub-basin in the same time series. Flows at Great Ruaha (Trace) were found to be much higher and the flows at Urobo (Great North Road - GNR) were found to be much lower comparative to other station of the Ruaha sub-basin in the same

time series '1961-1980'. General observations showed that the flows at the stations of Ruaha sub-basin were higher in the time series '1998-2013' than '1981-1997' and '1961-1980'.

5.2. Flow-duration curve

Flow-duration curves at Figure 5.2.1 visualize the percent time flow equalled or exceeded during the considered period of record. High and low flow thresholds from Figure 5.2.1 were compiled in Table 5.2.1 and the values were normalized for comparison. It was possible to follow the ranking of inter-station moistness and dryness within each cluster as well as each sub-basin.

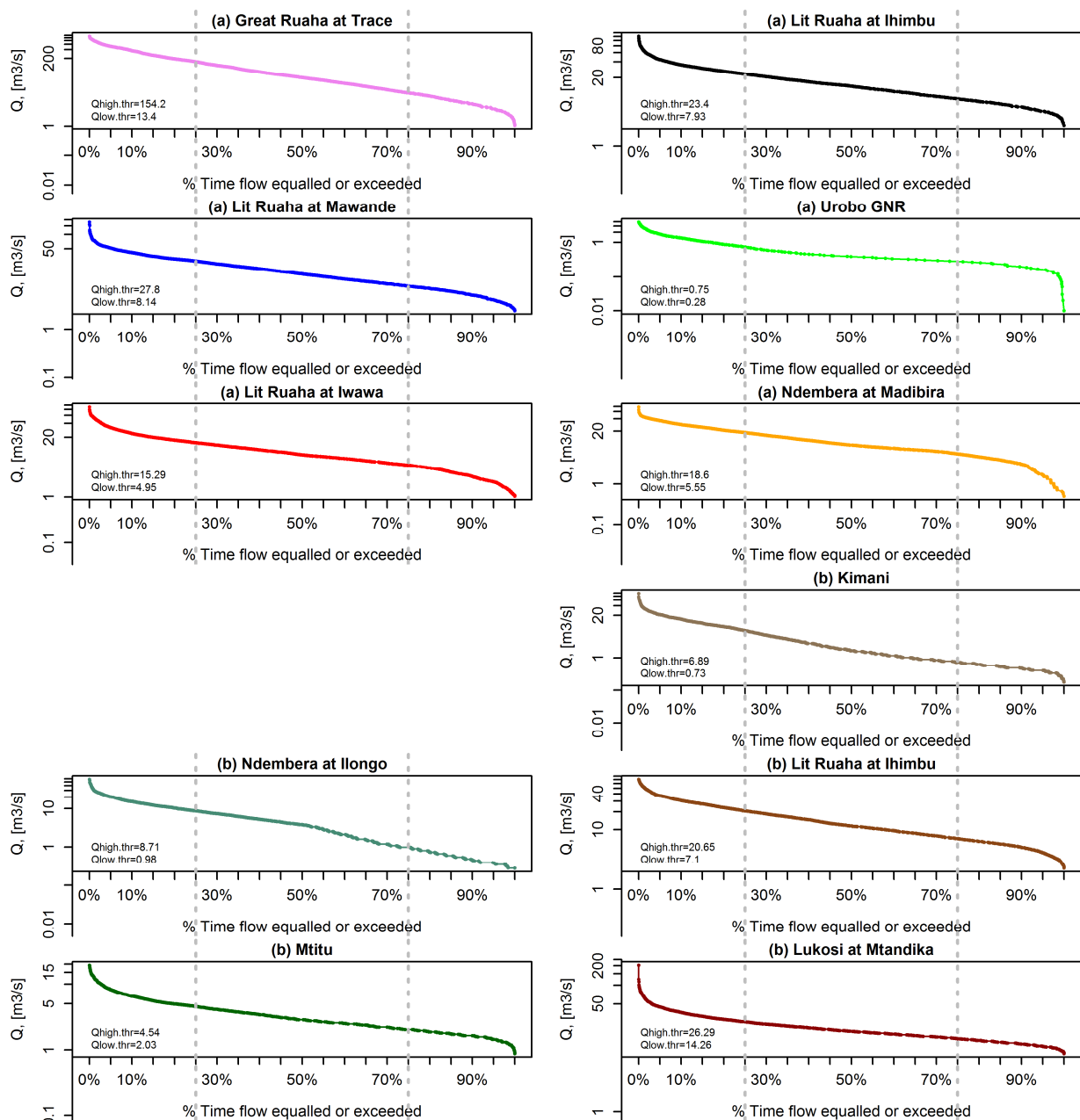


Fig 5.2.1. Flow-duration curves (a = Ruaha sub-basin in 1961-1980, b = Ruaha sub-basin in 1981-1997)

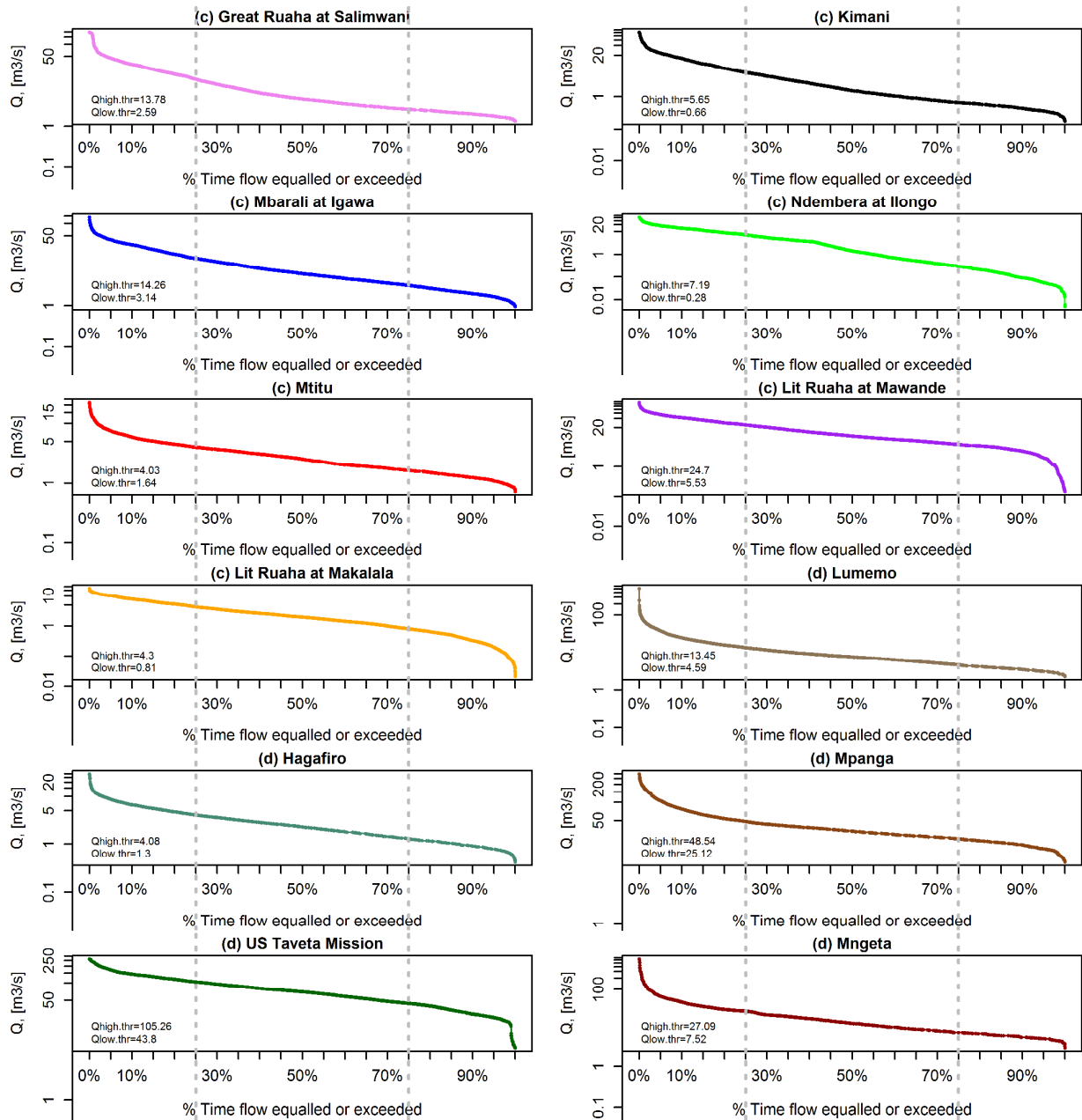


Fig 5.2.1. Flow-duration curves (c = Ruaha sub-basin in 1998-2013, d = Kilombero sub-basin in 1961-1980)

Flows at high flow threshold or 25% flows equalled or exceeded 18.60 m³/s, 8.71 m³/s, 7.19 m³/s, and 105.26 m³/s at Ndembera (Madibira), Ndembera (Ilongo), again Ndembera (Ilongo), and Mnyera (US Taveta Mission) stations within Ruaha '1961-1980', Ruaha '1981-1997', Ruaha '1998-2013', and Kilombero '1961-1980' clusters respectively which were the highest variations of flows to the respective means within respective clusters (according to the normalized values of high flow threshold). On the contrary, flows at low flow threshold or 75% flows equalled or exceeded 0.28 m³/s, 14.26 m³/s, 1.64 m³/s, and 25.12 m³/s at Urobo (GNR), Lukosi (Mtandika), Mtitu, and Mpanga stations within Ruaha '1961-1980', Ruaha '1981-1997', Ruaha '1998-2013', and Kilombero '1961-1980' clusters respectively which were

the highest variations of flows to the respective means within respective clusters (according to the normalized values of low flow threshold). Cluster mean reveals that, among all the four clusters, Ruaha '1961-1980' and Kilombero '1961-1980' had the highest variations to the means at high and low flow thresholds respectively. Between sub-basins, on an average, Ruaha showed higher variations at high flow threshold and Kilombero showed higher variations at low flow threshold.

Table 5.2.1. Flow durations in Rufiji Basin

Cluster	Station	Series	HFT *	LFT *	MF *	nHFT *	nLFT *
1	Gr. Ruaha at Trace	1961-1980	154.20	13.40	121.30	127.12	11.05
	Lit. Ruaha at Ihimbu	1961-1980	23.40	7.93	17.71	132.13	44.78
	Lit. Ruaha at Mawande	1961-1980	27.80	8.14	20.03	138.79	40.64
	Urobo at GNR	1961-1980	0.75	0.28	0.60	125.00	46.67
	Lit. Ruaha at Iwawa	1961-1980	15.29	4.95	11.80	129.58	41.95
	Ndembera at Madibira	1961-1980	18.60	5.55	13.16	141.34	42.17
<i>Cluster Mean</i>						132.33	37.88
2	Kimani	1981-1997	6.89	0.73	5.32	129.51	13.72
	Ndembera at Ilongo	1981-1997	8.71	0.98	6.07	143.49	16.14
	Lit. Ruaha at Ihimbu	1981-1997	20.65	7.10	15.38	134.27	46.16
	Mtitu	1981-1997	4.54	2.03	3.64	124.73	55.77
	Lukosi at Mtandika	1981-1997	26.29	14.26	22.16	118.64	64.35
<i>Cluster Mean</i>						130.13	39.23
3	Gr. Ruaha at Salimwani	1998-2013	13.78	2.59	12.58	109.54	20.59
	Kimani	1998-2013	5.65	0.66	5.46	103.48	12.09
	Mbarali at Igawa	1998-2013	14.26	3.14	11.70	121.88	26.84
	Ndembera at Ilongo	1998-2013	7.19	0.28	4.72	152.33	5.93
	Mtitu	1998-2013	4.03	1.64	3.21	125.55	51.09
	Lit. Ruaha at Mawande	1998-2013	24.70	5.53	17.64	140.02	31.35
	Lit. Ruaha at Makalala	1998-2013	4.30	0.81	3.10	138.71	26.13
<i>Cluster Mean</i>						127.36	24.86
Sub-basin Mean (Ruaha)						129.94	33.99
4	Lumemo	1961-1980	13.45	4.59	12.11	111.07	37.90
	Hagafiro	1961-1980	4.08	1.30	3.18	128.30	40.88
	Mpanga	1961-1980	48.54	25.12	43.32	112.05	57.99
	US Taveta Mission	1961-1980	105.26	43.80	79.84	131.84	54.86
	Mngeta	1961-1980	27.09	7.52	22.95	118.04	32.77
<i>Cluster Mean</i>						120.26	44.88
Sub-basin Mean (Kilombero)						120.26	44.88

Table 5.2.1. Flow durations in Rufiji Basin

Cluster	Station	Series	HFT *	LFT *	MF *	nHFT *	nLFT *
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* HFT is the high flow threshold where 25% flows equalled or exceeded the value, LFT is the low flow threshold where 75% flows equalled or exceeded the value, MF is the mean flow, nHFT is the normalized HFT (percentage of HFT to MF), and nLFT is the normalized LFT (percentage of LFT to MF)

5.3. Ecologically relevant characteristics of flow-regime

5.3.1. Monthly water conditions

Station-wise statistics of series average of mean-monthly flows for all the stations of Rufiji basin are presented in Table 5.3.1.1 to explore the variations of monthly water conditions within and among clusters (please find the complete computations in Appendix). Urobo (GNR), Ndembera (Ilongo), Mtitu and Mpanga were found to have the lowest inter-month flow variability, and Little Ruaha (Iwawa), Little Ruaha (Ihimbu), Great Ruaha (Salimwani) and Hagafiro were found to have the highest inter-month flow variability at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.1.1).

Table 5.3.1.1. Statistics of monthly water conditions of Rufiji basin

Cluster	Station	Max ¹	Min ¹	Range ¹	Mean ¹	Variability ²
1 Series: 1961 - 1980	Gr. Ruaha at Trace	38.33	4.42	33.91	12.38	274
	Lit. Ruaha at Ihimbu	6.90	0.97	5.93	3.19	186
	Lit. Ruaha at Mawande	100.61	23.02	77.59	44.61	174
	Urobo at GNR	149.99	37.13	112.86	81.21	^{lv} 139
	Lit. Ruaha at Iwawa	71.27	7.30	63.97	23.28	^{hv} 275
	Ndembera at Madibira	285.01	7.94	277.08	116.52	238
Cluster Mean						214
2 Series: 1981 - 1997	Kimani	36.51	5.82	30.70	17.59	175
	Ndembera at Ilongo	37.47	6.74	30.73	20.06	^{lv} 153
	Lit. Ruaha at Ihimbu	1.37	0.25	1.12	0.59	^{hv} 189
	Mtitu	24.72	2.96	21.76	11.67	187
	Lukosi at Mtandika	28.01	4.78	23.22	13.19	176
Cluster Mean						176
3 Series: 1998 - 2013	Gr. Ruaha at Salimwani	17.50	0.61	16.89	5.64	^{hv} 300
	Kimani	14.28	0.53	13.75	5.58	246
	Mbarali at Igawa	33.51	5.23	28.28	16.08	176
	Ndembera at Ilongo	6.47	1.85	4.62	3.68	125

Table 5.3.1.1. Statistics of monthly water conditions of Rufiji basin

Cluster	Station	Max ¹	Min ¹	Range ¹	Mean ¹	Variability ²
	Mtitu	38.00	13.55	24.45	22.43	^{lv} 109
	Lit. Ruaha at Mawande	34.51	2.16	32.35	12.74	254
	Lit. Ruaha at Makalala	16.54	0.51	16.03	5.61	286
Cluster Mean						214
Sub-basin Mean						201
4 Series: 1961 - 1980	Lumemo	28.95	2.15	26.80	11.56	232
	Hagafiro	13.71	0.09	13.62	4.58	^{hv} 298
	Mpanga	5.93	1.43	4.50	3.21	^{lv} 140
	US Taveta Mission	37.38	3.74	33.64	17.07	197
	Mngeta	7.11	0.45	6.67	3.11	214
Cluster Mean						216
Sub-basin Mean						216

1 = Station-wise statistics of series average of mean-monthly flows, 2 = (Range/Mean)*100, hv = within-cluster highest variability, lv = within-cluster lowest variability

Cluster mean reveals that the Ruaha sub-basin at '1981-1997' had the lowest and the Kilombero at '1961-1980' had the highest inter-month flow variability on an average. Sub-basin scale observation reveals that the Kilombero had the higher inter-month flow variability than the Ruaha sub-basin.

5.3.2. Annual water extremes

Annual water extremes of Rufiji basin in the form of annual minima and maxima of 1, 3, 7, and 30-day means are presented in Figure 5.3.2.1 and Table 5.3.2.1 to explore the variations of their influences within and among clusters and to follow the trend in the considered period of record (please find the complete computations in Appendix). Little Ruaha (Mawande), Lukosi (Mtandika), again Little Ruaha (Mawande), and Mnyera (US Taveta Mission) were found to have the lowest inter-type (annual minima of 1, 3, 7, and 30-day means) flow-minima variability, and Urobo (GNR), Kimani, again Kimani and Mngeta were found to have the highest inter-type (annual minima of 1, 3, 7, and 30-day means) flow-minima variability at within- cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.2.1). Cluster mean reveals that the Ruaha sub-basin at '1981-1997' had the lowest and the Ruaha at '1998-2013'

had the highest inter-type (annual minima of 1, 3, 7, and 30-day means) flow-minima variability on an average. Sub-basin scale observation reveals that the Kilombero had the higher inter-type (annual minima of 1, 3, 7, and 30-day means) flow-minima variability than the Ruaha sub-basin.

Table 5.3.2.1. Average annual minima of 1, 3, 7, and 30-day means

Cluster	Station	min_1d	min_3d	min_7d	min_30d	SACVs
1 <u>Series:</u> 1961 - 1980	Gr. Ruaha at Trace	5.34	5.40	5.52	6.04	6.64
	Lit. Ruaha at Ihimbu	4.52	4.70	4.86	5.35	7.25
	Lit. Ruaha at Mawande	6.12	6.19	6.31	6.69	^{lv} 5.01
	Urobo at GNR	0.15	0.15	0.17	0.19	^{hv} 14.19
	Lit. Ruaha at Iwawa	2.42	2.45	2.53	2.74	6.48
	Ndembera at Madibira	3.96	3.99	4.05	4.34	5.18
Cluster Mean						7.46
2 <u>Series:</u> 1981 - 1997	Kimani	0.42	0.43	0.45	0.51	^{hv} 9.73
	Ndembera at Ilongo	0.33	0.33	0.34	0.37	4.97
	Lit. Ruaha at Ihimbu	4.25	4.30	4.40	4.79	6.26
	Mtitu	1.36	1.39	1.44	1.62	8.18
	Lukosi at Mtandika	11.10	11.24	11.45	12.19	^{lv} 4.55
Cluster Mean						6.74
3 <u>Series:</u> 1998 - 2013	Gr. Ruaha at Salimwani	1.76	1.78	1.81	2.00	6.11
	Kimani	0.29	0.30	0.32	0.40	^{hv} 16.25
	Mbarali at Igawa	1.54	1.56	1.59	1.78	6.52
	Ndembera at Ilongo	0.04	0.04	0.05	0.06	15.13
	Mtitu	1.08	1.10	1.11	1.23	5.85
	Lit. Ruaha at Mawande	2.79	2.81	2.85	3.10	^{lv} 5.16
	Lit. Ruaha at Makalala	0.23	0.24	0.25	0.29	16.18
Cluster Mean						10.17
Sub-basin Mean						6.09
4 <u>Series:</u> 1961 - 1980	Lumemo	3.28	3.34	3.44	3.86	8.13
	Hagafiro	0.69	0.70	0.72	0.82	8.50
	Mpanga	17.10	17.75	18.07	19.66	6.27
	US Taveta Mission	28.64	29.05	29.60	31.69	^{lv} 5.15
	Mngeta	4.55	4.94	5.08	5.85	^{hv} 12.29
Cluster Mean						8.07
Sub-basin Mean						8.07

hv = within-cluster highest variability, lv = within-cluster lowest variability,

$$SACVs = \sum_{i=1}^n ((SD_{amin13730}/Mean_{amin13730}) * 100)/n$$

where SACVs is the series average of coefficient of variations, SD is the standard deviation, amin13730 is the annual minima of 1, 3, 7, and 30-day means and n is the length of the series.

On the other hand, Ndembera (Madibira), Little Ruaha (Ihimbu), Little Ruaha (Makalala), and Mnyera (US Taveta Mission) were found to have the lowest inter-type (annual maxima of 1, 3, 7, and 30-day means) flow-maxima variability, and Great Ruaha (Trace), Kimani, again Kimani and Lumemo were found to have the highest inter-type (annual maxima of 1, 3, 7, and 30-day means) flow-maxima variability at within- cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.2.2). Cluster mean reveals that the Ruaha sub-basin at '1961-1980' had the lowest and the Ruaha at '1998-2013' had the highest inter-type (annual maxima of 1, 3, 7, and 30-day means) flow-maxima variability on an average.

Table 5.3.2.2. Average annual maxima of 1, 3, 7, and 30-day means

Cluster	Station	max_1d	max_3d	max_7d	max_30d	SACVs
1 <u>Series:</u> 1961 - 1980	Gr. Ruaha at Trace	634.74	606.63	555.00	410.92	^{hv} 20.48
	Lit. Ruaha at Ihimbu	59.46	54.42	49.90	40.98	15.06
	Lit. Ruaha at Mawande	74.37	63.81	57.72	45.67	18.41
	Urobo at GNR	2.52	2.21	2.06	1.68	17.75
	Lit. Ruaha at Iwawa	44.54	40.20	36.36	29.78	17.36
	Ndembera at Madibira	39.48	35.98	33.93	29.62	^{lv} 12.46
Cluster Mean						16.92
2 <u>Series:</u> 1981 - 1997	Kimani	49.32	37.29	30.86	22.90	^{hv} 30.31
	Ndembera at Ilongo	28.77	27.50	25.29	18.17	17.51
	Lit. Ruaha at Ihimbu	51.02	48.07	44.84	38.70	^{lv} 11.23
	Mtitu	15.63	13.37	11.59	8.55	25.04
	Lukosi at Mtandika	81.47	67.73	57.86	48.93	21.56
Cluster Mean						21.13
3 <u>Series:</u> 1998 - 2013	Gr. Ruaha at Salimwani	83.50	73.12	64.09	49.76	22.09
	Kimani	57.54	43.12	35.22	23.44	^{hv} 39.57
	Mbarali at Igawa	83.78	61.48	51.78	36.38	34.74
	Ndembera at Ilongo	26.72	25.68	23.32	17.39	17.91
	Mtitu	12.84	11.11	9.72	7.45	22.60
	Lit. Ruaha at Mawande	77.49	64.44	58.41	45.50	20.70
	Lit. Ruaha at Makalala	11.01	10.23	9.64	8.34	^{lv} 12.01
Cluster Mean						24.23
Sub-basin Mean						15.57
4 <u>Series:</u> 1961 - 1980	Lumemo	122.71	88.67	68.26	48.75	^{hv} 37.51
	Hagafiro	12.92	11.99	11.07	8.40	16.62
	Mpanga	185.10	163.65	144.06	113.57	20.01
	US Taveta Mission	229.93	225.84	213.34	175.92	^{lv} 11.53
	Mngeta	171.99	132.60	105.42	76.98	26.18
Cluster Mean						22.37
Sub-basin Mean						22.37

hv = within-cluster highest variability, lv = within-cluster lowest variability,

$$SACVs = \sum_{i=1}^n ((SD_{amax13730}/Mean_{amax13730}) * 100)/n$$

where SACVs is the series average of coefficient of variations, SD is the standard deviation, amax13730 is the annual maxima of 1, 3, 7, and 30-day means and n is the length of the series.

Sub-basin scale observation reveals that the Kilombero had the higher inter-type (annual maxima of 1, 3, 7, and 30-day means) flow-maxima variability than the Ruaha sub-basin.

Figure 5.3.2.1 shows the trends of the minimum flows in the considered period of record at all the stations of the Rufiji basin in Tanzania, and the inter-type variability at flow-minima which are described at earlier section are also visible in these figures. All the stations except Ndembera (Madibira) at Ruaha sub-basin in '1961-1980' were found to have different magnitudes of decreasing trends of their annual minima, where Ndembera (Madibira) was found to have an increasing trend of annual minima. No station at Ruaha sub-basin in '1981-1997' was found to have increasing trends of annual minima. Great Ruaha (Salimwani) and Little Ruaha (Makalala) at Ruaha sub-basin in '1998-2013' were found to have increasing trends of their annual minima, whereas Little Ruaha (Mawande) showed no trend and the rest of this cluster had different magnitudes of decreasing trends of their annual minima. Hagafiro and Mngeta at Kilombero in '1961-1980' were found to have increasing trends and the rest of this cluster had different magnitudes of decreasing trends of their annual minima.

Figure 5.3.2.2 shows the trends of the maximum flows in the considered period of record at all the stations of the Rufiji basin in Tanzania, and the inter-type variability at flow-maxima which are described at earlier section are also visible in these figures. Little Ruaha (Mawande) and Ndembera (Madibira) at Ruaha sub-basin in '1961-1980' were found to have increasing trends of their annual maxima, where the other stations of this cluster had different magnitudes of decreasing trends of this hydrological indicator. Mtitu and Lukosi (Mtandika) at Ruaha sub-basin in '1981-1997' were found to have increasing trends of their annual maxima, where the other stations of this cluster had different magnitudes of decreasing trends of this hydrological indicator. Little Ruaha (Makalala) at Ruaha sub-basin in '1998-2013' was found to have increasing trend of their annual maxima, whereas Mbarali (Igawa) showed no trend and the rest of this cluster had different magnitudes of decreasing trends of this hydrological indicator. Mngeta at Kilombero in '1961-1980' was found to have increasing trend, whereas Lumemo and US Taveta Mission showed no trend and the rest of this cluster had different magnitudes of decreasing trends of this hydrological indicator.

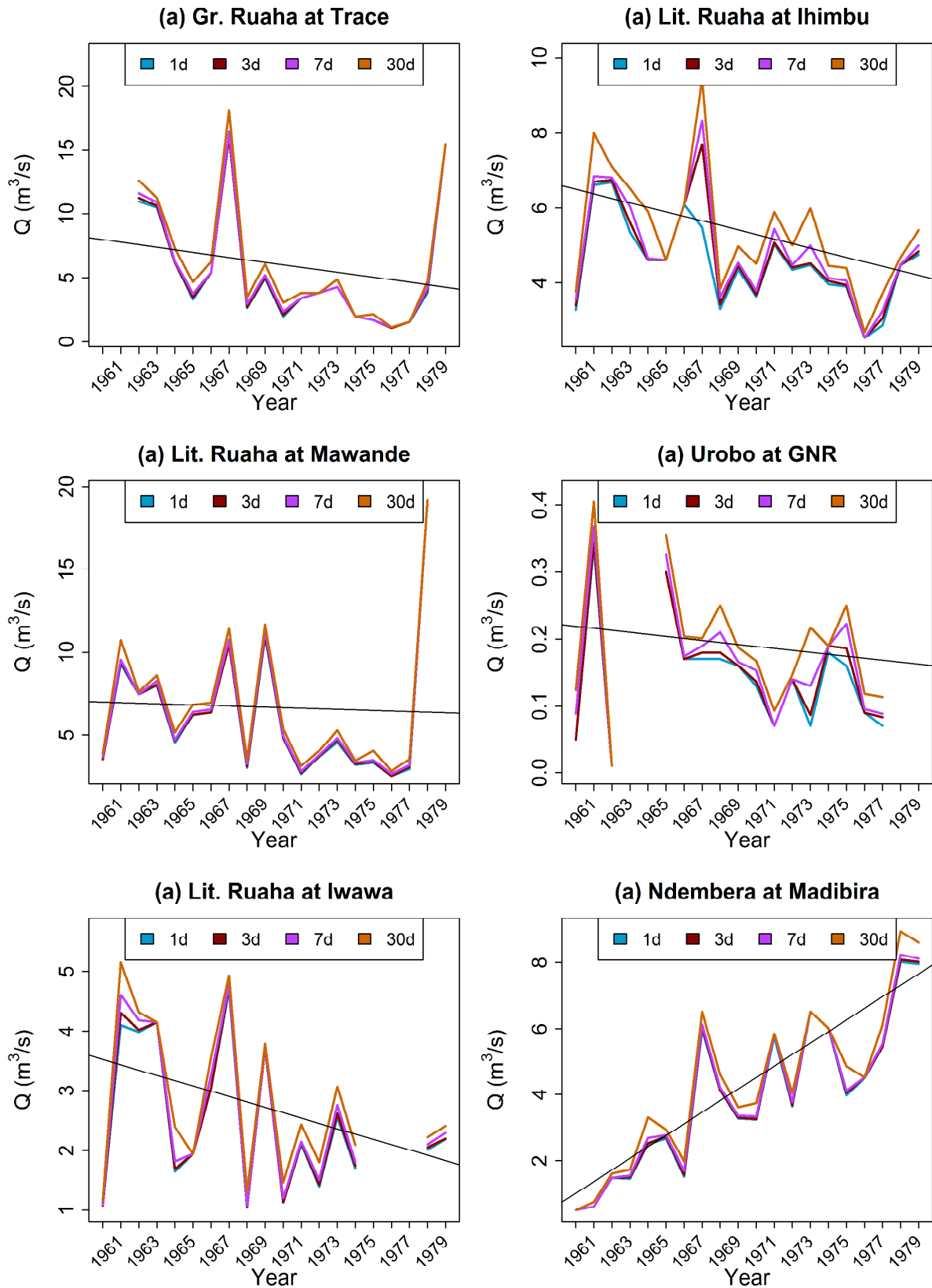


Fig 5.3.2.1. Annual flow-minima of 1, 3, 7, and 30-day means (a = Ruaha sub-basin in 1961-1980)

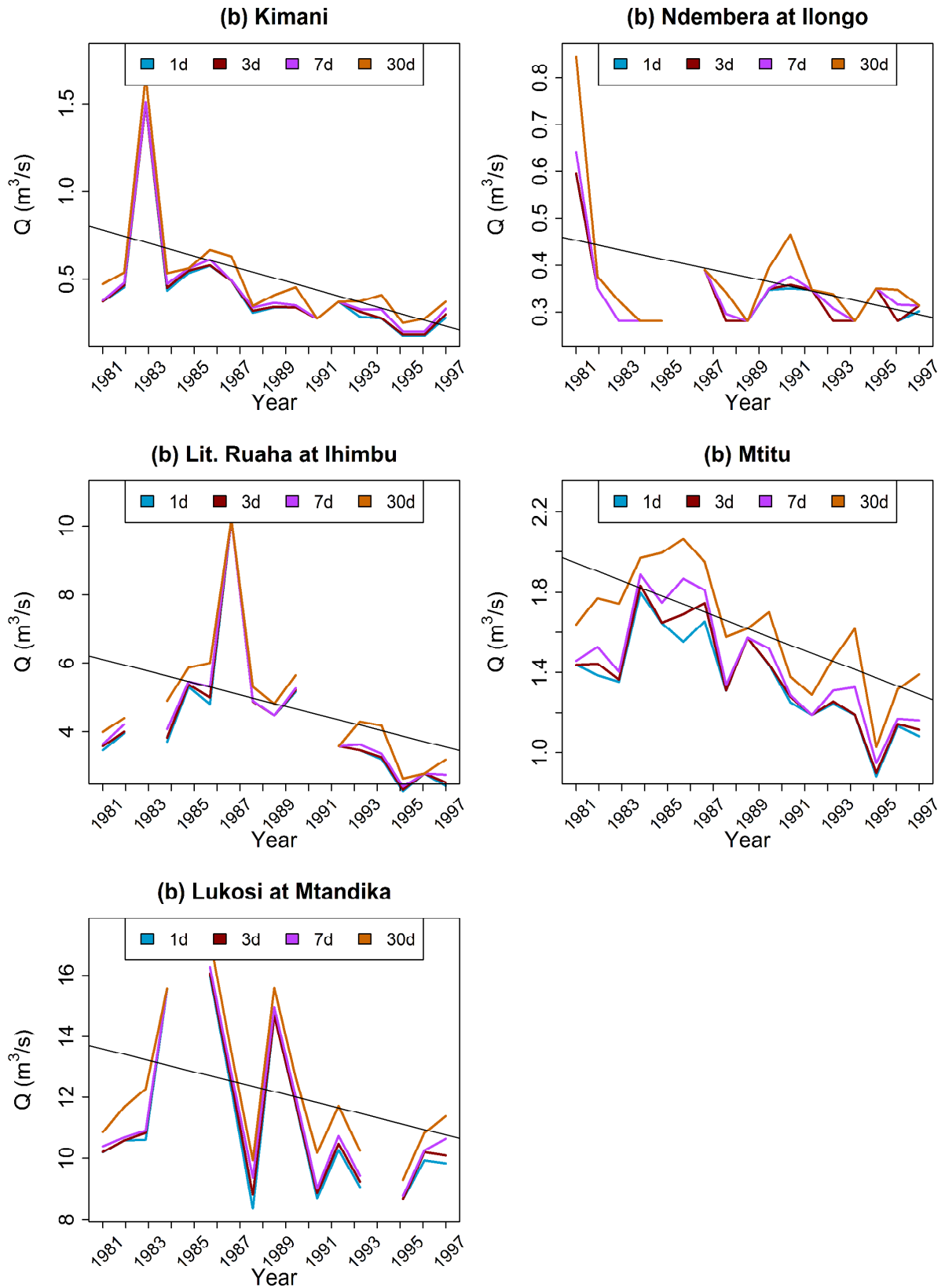


Fig 5.3.2.1. Annual flow-minima of 1, 3, 7, and 30-day means (b = Ruaha sub-basin in 1981-1997)

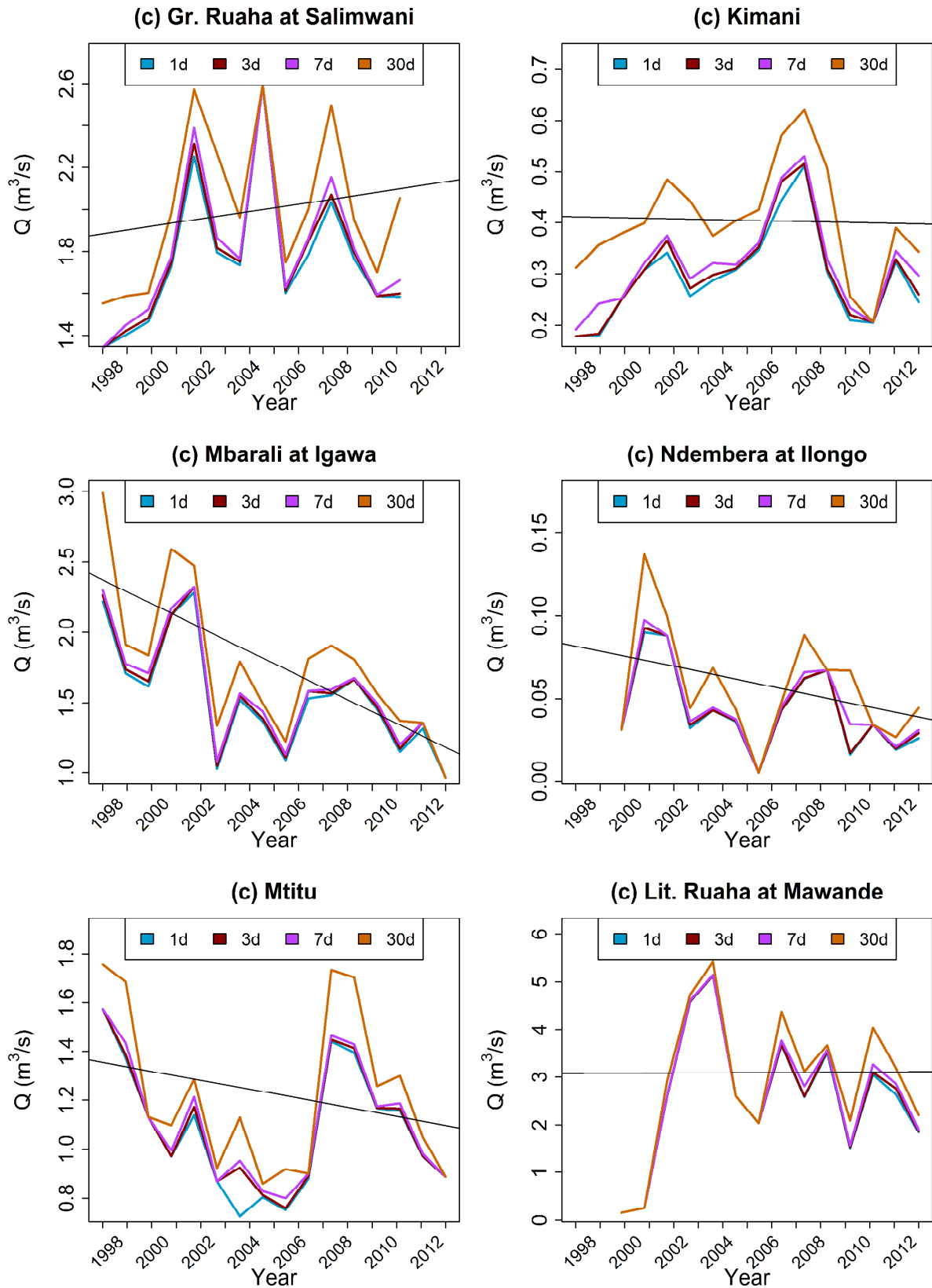


Fig 5.3.2.1. Annual flow-minima of 1, 3, 7, and 30-day means (c = Ruaha sub-basin in 1998-2013)

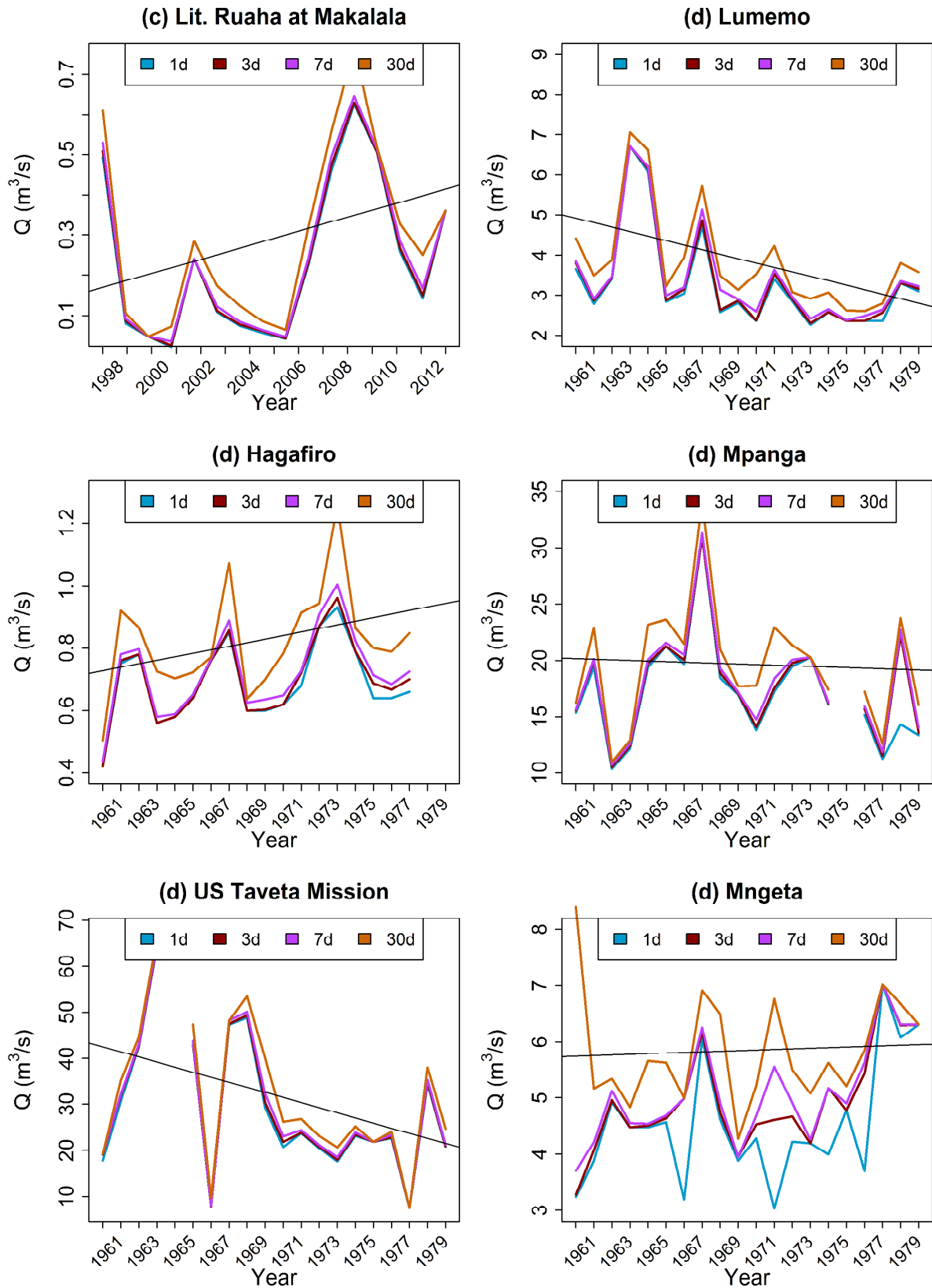


Fig 5.3.2.1. Annual flow-minima of 1, 3, 7, and 30-day means (c = Ruaha sub-basin in 1998-2013, d = Kilombero sub-basin in 1961-1980)

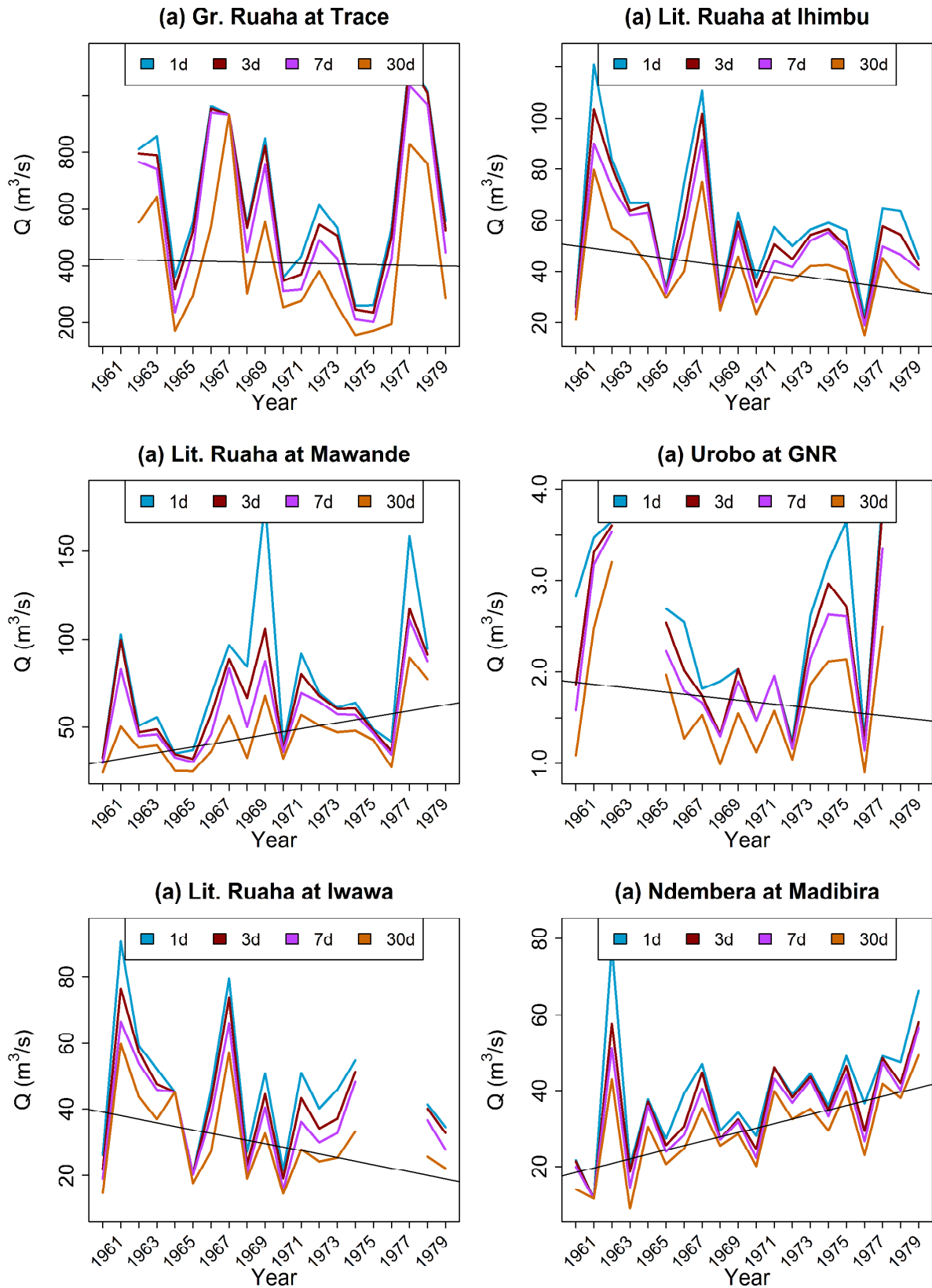


Fig 5.3.2.2. Annual flow-maxima of 1, 3, 7, and 30-day means (a = Ruaha sub-basin in 1961-1980)

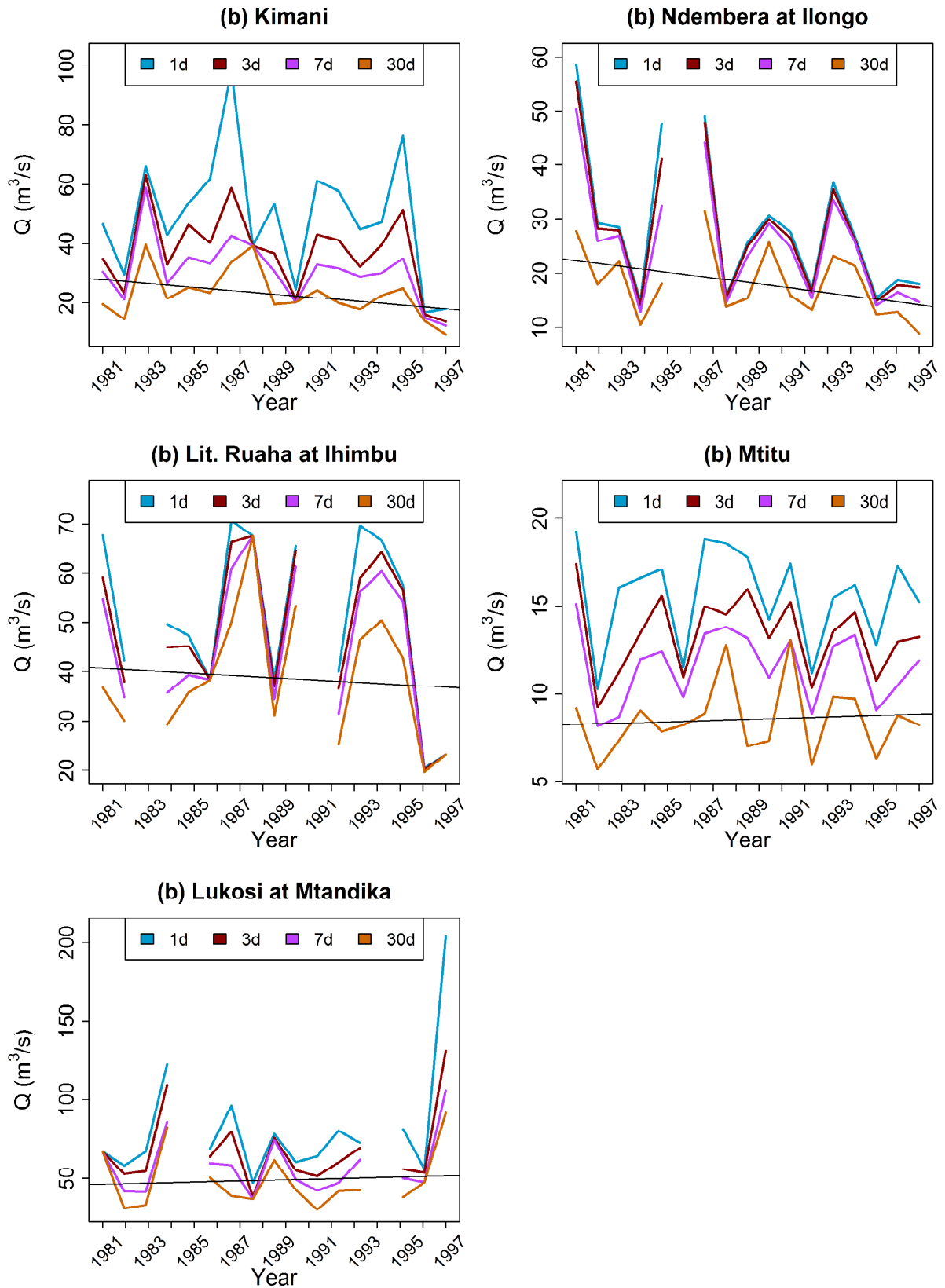


Fig 5.3.2.2. Annual flow-maxima of 1, 3, 7, and 30-day means (b = Ruaha sub-basin in 1981-1997)

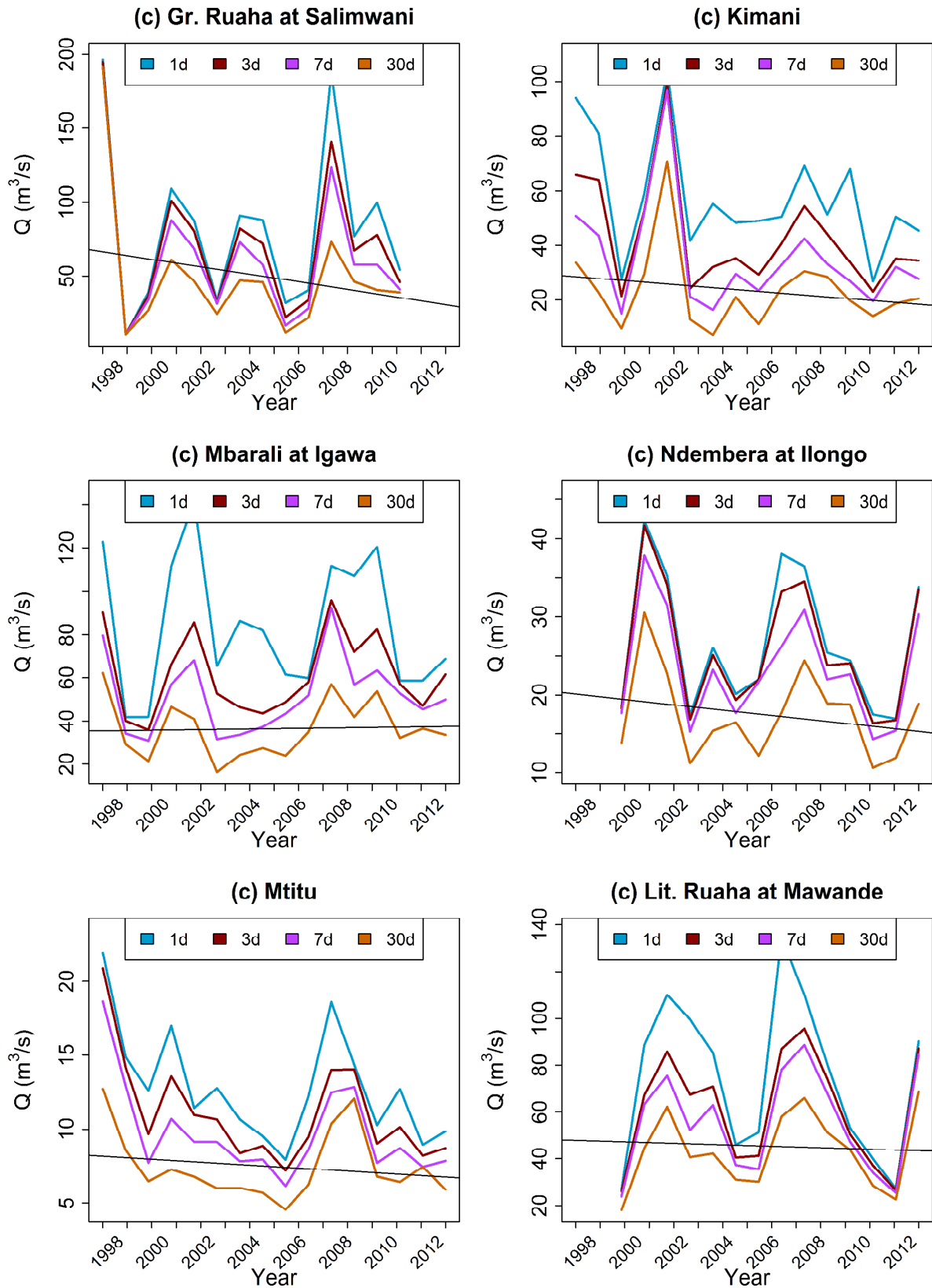


Fig 5.3.2.2. Annual flow-maxima of 1, 3, 7, and 30-day means (c = Ruaha sub-basin in 1998-2013)

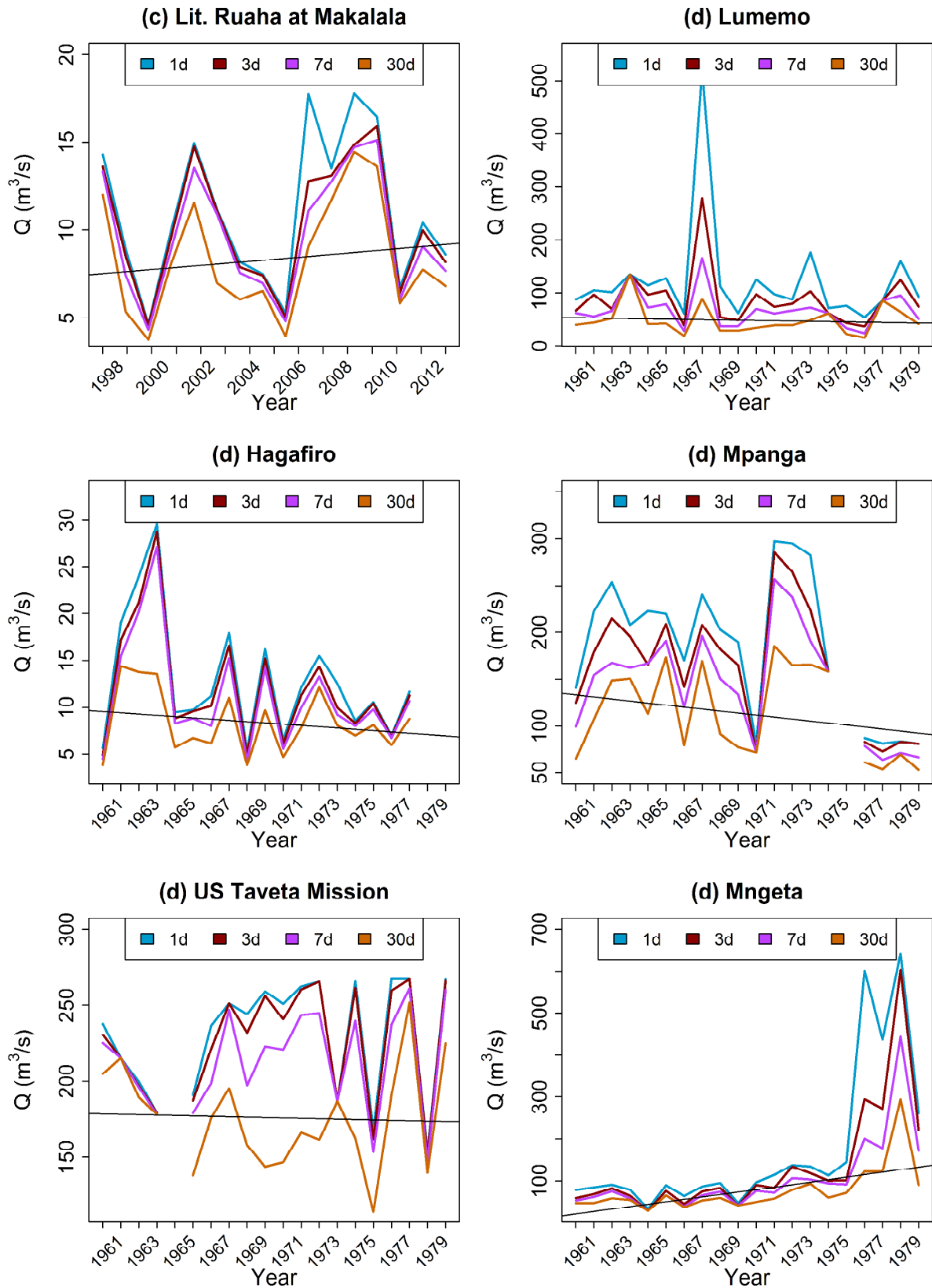


Fig 5.3.2.2. Annual flow-maxima of 1, 3, 7, and 30-day means (c = Ruaha sub-basin in 1998-2013, d = Kilombero sub-basin in 1961-1980)

5.3.3. Monthly low flows

Station-wise statistics of series average of mean-monthly low flows for all the stations of Rufiji basin are presented in Table 5.3.3.1 to explore the variations of monthly low flow conditions within and among clusters (please find the complete computations in Appendix).. Twelve (12) ecologically relevant parameters under this category of 'monthly low flows' named mean low flows of each calendar month were processed in summarized forms of statistics. Table 5.3.3.1 shows minimum, maximum, mean, range, and variability of series average of mean-monthly low flows.

Little Ruaha (Mawande), Little Ruaha (Ihimbu), Mtitu and Mpanga were found to have the lowest inter-month low-flow variability, and Ndembera (Madibira), Lukosi (Mtandika), Kimani and Hagafiro were found to have the highest inter-month low-flow variability at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.3.1). Cluster mean reveals that the Ruaha sub-basin at '1981-1997' had the lowest and the Kilombero at '1961-1980' had the highest inter-month low-flow variability on an average. Sub-basin scale observation reveals that the Kilombero had the higher inter-month low-flow variability than the Ruaha sub-basin.

Table 5.3.3.1. Statistics of monthly low flows of Rufiji basin

Cluster	Station	Max ¹	Min ¹	Range ¹	Mean ¹	Variability ²
1 <u>Series:</u> 1961 - 1980	Gr. Ruaha at Trace	7.41	3.64	3.77	5.00	75
	Lit. Ruaha at Ihimbu	2.26	0.73	1.53	1.51	102
	Lit. Ruaha at Mawande	30.51	19.38	11.13	24.45	^{lv} 46
	Urobo at GNR	53.88	30.78	23.11	43.13	54
	Lit. Ruaha at Iwawa	12.75	3.19	9.56	7.47	128
	Ndembera at Madibira	39.70	5.70	34.00	20.26	^{hv} 168
Series Mean						95
2 <u>Series:</u> 1981 - 1997	Kimani	10.97	4.56	6.41	8.61	74
	Ndembera at Ilongo	13.75	5.52	8.23	9.38	88
	Lit. Ruaha at Ihimbu	0.31	0.19	0.12	0.25	^{lv} 48
	Mtitu	6.75	2.34	4.41	4.92	90
	Lukosi at Mtandika	7.97	1.95	6.02	5.18	^{hv} 116
Series Mean						83
3 <u>Series:</u> 1998 - 2013	Gr. Ruaha at Salimwani	1.68	0.44	1.24	0.92	134
	Kimani	2.46	0.36	2.10	1.24	^{hv} 169
	Mbarali at Igawa	11.05	4.11	6.94	7.81	89
	Ndembera at Ilongo	2.78	1.42	1.36	2.09	65
	Mtitu	16.63	11.33	5.31	14.27	^{lv} 37

Table 5.3.3.1. Statistics of monthly low flows of Rufiji basin

Cluster	Station	Max ¹	Min ¹	Range ¹	Mean ¹	Variability ²
	Lit. Ruaha at Mawande	4.36	1.74	2.62	2.77	95
	Lit. Ruaha at Makalala	1.30	0.33	0.97	0.77	126
Series Mean						102
Sub-basin Mean						93
4 <u>Series:</u> 1961 - 1980	Lumemo	4.86	1.66	3.20	3.37	95
	Hagafiro	1.33	0.05	1.29	0.48	^{hv} 270
	Mpanga	2.17	1.16	1.01	1.65	^{lv} 61
	US Taveta Mission	8.64	2.95	5.70	5.74	99
	Mngeta	1.86	0.25	1.61	1.09	148
Series Mean						135
Sub-basin Mean						135

1 = Station-wise statistics of series average of mean-monthly flows, 2 = (Range/Mean)*100, hv = within-cluster highest variability, lv = within-cluster lowest variability

5.3.4. Extreme low flows

Station-wise statistics of series average of extreme low flows for all the stations of Rufiji basin are presented in Table 5.3.4.1 to explore the variations of extreme low flow conditions within and among clusters (please find the complete computations in Appendix). Three (03) ecologically relevant parameters under this category of 'monthly low flows' named frequency, event peak (minimum), and duration of extreme low flow events were processed in summarized forms of statistics. Table 5.3.4.1 shows zero-event years of extreme low flow events, mean frequency of those events, coefficient of variation (inter-annual) of those frequencies, mean of the event peaks (minimum), mean event duration, and coefficient of variation (inter-annual) in event durations for all the stations under Rufiji basin.

Little Ruaha (Ihimbu), Ndembera (Ilongo), Kimani and Mngeta were found to have the least and Ndembera (Madibira), Little Ruaha (Ihimbu), Little Ruaha (Mawande) and Mpanga were found to have the most zero-event years of extreme low flow events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.4.1). Cluster mean reveals that the Ruaha sub-basin at '1981-1997' and '1998-2013' had the least and the Ruaha sub-basin at '1961-1980' had the most zero-event years of extreme low flow events on an average. Sub-basin scale

observation reveals that the Ruaha had more zero-event years of extreme low flow events than the Kilombero sub-basin.

Great Ruaha (Trace), Little Ruaha (Ihimbu), Ndembera (Ilongo) and Mpanga were found to have the least and Little Ruaha (Ihimbu), Lukosi (Mtandika), Kimani and Lumemo were found to have the most occurrence of extreme low flow events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.4.1). Cluster mean reveals that the Ruaha sub-basin at '1961-1980' had the least and the Kilombero sub-basin at '1961-1980' had the most occurrence of extreme low flow events on an average. Sub-basin scale observation reveals that the Kilombero had more occurrences of extreme low flow events than the Ruaha sub-basin.

Little Ruaha (Ihimbu), again Little Ruaha (Ihimbu), Ndembera (Ilongo) and Mngeta were found to have the least and Urobo (GNR), Lukosi (Mtandika), Great Ruaha (Salimwani) and Mpanga were found to have the most variability (inter-annual) in occurrence of extreme low flow events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.4.1). Cluster mean reveals that the Ruaha sub-basin at '1981-1997' had the least and the Ruaha sub-basin at '1961-1980' had the most variability (inter-annual) in occurrence of extreme low flow events on an average. Sub-basin scale observation reveals that the Kilombero had more variability in occurrence of extreme low flow events than the Ruaha sub-basin.

Urobo (GNR), Little Ruaha (Ihimbu), Little Ruaha (Makalala) and Mpanga were found to have the lowest and Ndembera (Madibira), Mtitu, Little Ruaha (Mawande) and Hagafiro were found to have the highest event peak (minimum) of extreme low flow events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.4.1). Cluster mean reveals that the Ruaha sub-basin at '1998-2013' had the lowest and the Ruaha sub-basin at '1961-1980' had the highest event peak (minimum) of extreme low flow events on an average. Sub-basin scale observation reveals that the Kilombero had higher event peak (minimum) of extreme low flow events than the Ruaha sub-basin.

Little Ruaha (Iwawa), Lukosi (Mtandika), Kimani and Mngeta were found to have the shortest and Ndembera (Madibira), Little Ruaha (Ihimbu), Little Ruaha (Mawande) and Mpanga were found to have the longest event duration of extreme low flow events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.4.1). Cluster mean reveals that the Ruaha sub-basin at '1998-2013' had the shortest and the Ruaha sub-basin at '1961-

1980' had the longest event duration of extreme low flow events on an average. Sub-basin scale observation reveals that the Kilombero had longer event duration of extreme low flow events than the Ruaha sub-basin.

Little Ruaha (Mawande), Lukosi (Mtandika), Mtitu and Hagafiro were found to have the least and Ndembera (Madibira), Little Ruaha (Ihimbu), Mbarali (Igawa) and Mpanga were found to have the most variability (inter-annual) in event duration of extreme low flow events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.4.1). Cluster mean reveals that the Kilombero sub-basin at '1961-1980' had the least and the Ruaha sub-basin at '1961-1980' had the most variability (inter-annual) in event duration of extreme low flow events on an average. Sub-basin scale observation reveals that the Ruaha had more variability (inter-annual) in event duration of extreme low flow events than the Kilombero sub-basin.

Table 5.3.4.1. Statistics of extreme low flows of Rufiji basin

Cluster	Station	ZFY	M_Freq	CV_Freq	M_EP	Ev_Dur	CV_Ev_Dur
1	Gr. Ruaha at Trace	9	*1.82	68.77	96.39	18.19	77.61
<u>Series:</u>	Lit. Ruaha at Ihimbu	* 7	**2.31	*44.70	100.93	14.38	91.81
1961	Lit. Ruaha at Mawande	12	2.00	59.76	97.67	24.67	*41.23
-	Urobo at GNR	10	2.20	**82.43	*89.91	17.24	80.81
1980	Lit. Ruaha at Iwawa	10	2.30	61.66	102.01	*13.60	61.50
	Ndembera at Madibira	** 15	2.20	81.31	**122.80	**42.83	**158.08
	<i>Cluster Mean</i>	10	2.14	66.44	101.62	21.82	85.17
2	Kimani	7	2.64	45.75	99.44	15.31	65.61
<u>Series:</u>	Ndembera at Ilongo	* 3	1.71	48.15	96.08	12.01	65.50
1981	Lit. Ruaha at Ihimbu	** 9	*1.22	*36.08	*95.50	**24.67	**106.86
-	Mtitu	5	2.67	58.39	**101.73	9.87	89.77
1997	Lukosi at Mtandika	8	**3.20	**60.38	100.14	*7.24	*54.39
	<i>Cluster Mean</i>	7	2.29	49.75	98.58	13.82	76.43
3	Gr. Ruaha at Salimwani	7	2.40	**76.58	101.57	8.90	78.42
<u>Series:</u>	Kimani	* 2	**3.07	61.86	99.52	*7.33	90.41
1998	Mbarali at Igawa	5	2.08	62.95	102.15	13.07	**109.56
-	Ndembera at Ilongo	7	*1.70	*28.41	88.11	15.65	64.08
2013	Mtitu	10	3.00	56.34	97.79	12.74	*54.43
	Lit. Ruaha at Mawande	** 15	2.25	66.67	**121.34	**31.54	96.23
	Lit. Ruaha at Makalala	10	2.13	46.64	*77.15	20.29	59.36
	<i>Cluster Mean</i>	8	2.38	57.06	98.23	15.65	78.93
	<i>Sub-basin (Ruaha) Mean</i>	8	2.27	57.75	99.48	17.09	80.18
4	Lumemo	8	**5.00	68.76	100.75	5.43	57.99
<u>Series:</u>	Hagafiro	5	2.80	52.63	**102.33	8.05	*57.67
1961	Mpanga	** 10	*2.50	**84.85	*97.20	**14.89	**86.46
-	US Taveta Mission	9	2.55	66.59	101.40	13.19	67.65
1980	Mngeta	* 4	4.06	*41.65	96.35	*5.25	60.28
	<i>Cluster Mean</i>	7	3.38	62.89	99.61	9.36	66.01
	<i>Sub-basin (Kilombero) Mean</i>	7	3.38	62.89	99.61	9.36	66.01

ZFY = Numbers of zero-event years of extreme low flow events (normalized at 20 years), M_Freq = Mean

Table 5.3.4.1. Statistics of extreme low flows of Rufiji basin

Cluster	Station	ZFY	M_Freq	CV_Freq	M_EP	Ev_Dur	CV_Ev_Dur
frequency of those events (per year), CV_Freq = Coefficient of variation (inter-annual) of those frequencies, M_EP = Normalized mean of the event peaks (minimum to the event mean in % per year), Ev_Dur = Mean event duration (per year), CV-Ev_Dur = Coefficient of variation (inter-annual) in mean event durations, ** = highest within cluster, * = lowest within cluster (note: fractions in frequencies and durations are due to making average, however seemed to be advantageous for subsequent comparisons)							

5.3.5. High flow pulses

Station-wise statistics of series average of high flow pulses for all the stations of Rufiji basin are presented in Table 5.3.5.1 to explore the variations of high flow pulse conditions within and among clusters (please find the complete computations in Appendix). Three (03) ecologically relevant parameters under this category of high flow pulses' named frequency, event peak (maximum), and duration of high flow pulse events were processed in summarized forms of statistics. Table 5.3.5.1 shows zero-event years of high flow pulse events, mean frequency of those events, coefficient of variation (inter-annual) of those frequencies, mean of the event peaks (maximum), mean event duration, and coefficient of variation (inter-annual) in event durations for all the stations under Rufiji basin.

Almost all the years of the series of the Rufiji basin stations had the high flow pulse events except a few stations with 1-3 years of zero-event years. Therefore, it was hard to draw any comparative result in this category.

Great Ruaha (Trace), Ndembera (Ilongo), again Ndembera (Ilongo) and Hagafiro were found to have the least and Urobo (GNR), Lukosi (Mtandika), Mtitu and Lumemo were found to have the most occurrence of high flow pulse events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.5.1). Cluster mean reveals that the Ruaha sub-basin at '1998-2013' had the least and the Kilombero sub-basin at '1961-1980' had the most occurrence of high flow pulse events on an average. Sub-basin scale observation reveals that the Kilombero had more occurrences of high flow pulse events than the Ruaha sub-basin.

Little Ruaha (Ihimbu), Mtitu, again Mtitu and Hagafiro were found to have the least and Great Ruaha (Trace), Lukosi (Mtandika), Ndembera (Ilongo) and Lumemo were found to have the most variability (inter-annual) in occurrence of high flow pulse events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.5.1). Cluster mean reveals that the Kilombero sub-basin at '1961-1980' had the least and the Ruaha sub-basin at '1961-

1980' had the most variability (inter-annual) in occurrence of high flow pulse events on an average. Sub-basin scale observation reveals that the Ruaha had more variability in occurrence of high flow pulse events than the Kilombero sub-basin.

Little Ruaha (Ihimbu), Lukosi (Mtandika), Mtitu and Hagafiro were found to have the lowest and Great Ruaha (Trace), Kimani, Ndembera (Ilongo) and Lumemo were found to have the highest event peak (maximum) of high flow pulse events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.5.1). Cluster mean reveals that the Ruaha sub-basin at '1961-1980' had the lowest and the Ruaha sub-basin at '1998-2013' had the highest event peak (maximum) of high flow pulse events on an average. Sub-basin scale observation reveals that the Ruaha had higher event peak (maximum) of extreme low flow events than the Kilombero sub-basin.

Urobo (GNR), Mtitu, again Mtitu and Mngeta were found to have the shortest and Great Ruaha (Trace), Kimani, Ndembera (Ilongo) and Hagafiro were found to have the longest event duration of high flow pulse events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.5.1). Cluster mean reveals that the Kilombero sub-basin at '1961-1980' had the shortest and the Ruaha sub-basin at '1998-2013' had the longest event duration of high flow pulse events on an average. Sub-basin scale observation reveals that the Kilombero had longer event duration of high flow pulse events than the Ruaha sub-basin.

Great Ruaha (Trace), Ndembera (Ilongo), again Ndembera (Ilongo) and Hagafiro were found to have the least and Urobo (GNR), Lukosi (Mtandika), Great Ruaha (Salimwani) and Mpanga were found to have the most variability (inter-annual) in event duration of high flow pulse events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.5.1). Cluster mean reveals that the Ruaha sub-basin at '1998-2013' had the least and the Kilombero sub-basin at '1961-1980' had the most variability (inter-annual) in event duration of high flow pulse events on an average. Sub-basin scale observation reveals that the Kilombero had more variability (inter-annual) in event duration of high flow pulse events than the Ruaha sub-basin.

Table 5.3.5.1. Statistics of high flow pulses of Rufiji basin

Cluster	Station	ZFY	M_Freq	CV_Freq	M_EP	Ev_Dur	CV_Ev_Dur
1	Gr. Ruaha at Trace	1	*2.84	**60.11	**184.89	**98.63	*61.95
<u>Series:</u>	Lit. Ruaha at Ihimbu	0	3.95	*40.64	*115.99	67.95	67.80
1961	Lit. Ruaha at Mawande	1	3.00	54.43	145.13	96.74	68.10
-	Urobo at GNR	3	**5.65	57.70	119.74	*56.35	**88.18

Table 5.3.5.1. Statistics of high flow pulses of Rufiji basin

Cluster	Station	ZFY	M_Freq	CV_Freq	M_EP	Ev_Dur	CV_Ev_Dur
1980	Lit. Ruaha at Iwawa	2	3.94	45.58	125.78	77.81	80.57
	Ndembera at Madibira	0	4.20	47.99	117.12	58.79	75.62
	<i>Cluster Mean</i>	1	3.93	51.07	134.78	76.04	73.70
2	Kimani	0	2.71	59.54	**310.84	**109.20	75.89
<u>Series:</u>	Ndembera at Ilongo	1	*2.25	34.43	186.47	91.89	*45.87
1981	Lit. Ruaha at Ihimbu	2	3.93	42.40	137.42	61.16	68.14
-	Mtitu	0	5.65	*32.50	135.94	*42.40	51.94
1997	Lukosi at Mtandika	2	**7.67	**65.16	*127.96	47.48	**115.37
	<i>Cluster Mean</i>	1	4.44	46.80	179.73	70.43	71.44
3	Gr. Ruaha at Salimwani	1	3.60	44.30	208.71	70.77	**68.95
<u>Series:</u>	Kimani	0	3.63	37.52	254.70	74.51	61.58
1998	Mbarali at Igawa	0	3.94	43.96	175.01	66.88	47.04
-	Ndembera at Ilongo	2	*1.86	**75.73	**273.96	**157.31	*42.07
2013	Mtitu	0	**4.94	*27.14	*123.97	*49.04	52.70
	Lit. Ruaha at Mawande	1	2.60	66.30	181.33	112.03	54.36
	Lit. Ruaha at Makalala	0	2.81	52.29	140.87	96.46	61.18
	<i>Cluster Mean</i>	1	3.34	49.60	194.08	89.57	55.41
	<i>Sub-basin (Ruaha) Mean</i>	1	3.90	49.16	169.53	78.68	66.85
4	Lumemo	0	**8.75	**52.68	**159.17	42.45	103.38
<u>Series:</u>	Hagafiro	2	*4.83	*33.47	*116.41	**50.53	*43.44
1961	Mpanga	1	8.74	50.30	124.97	46.05	**173.20
-	US Taveta Mission	1	5.32	36.59	137.48	43.61	63.75
1980	Mngeta	0	8.15	48.64	138.29	*32.44	58.04
	<i>Cluster Mean</i>	1	7.16	44.34	135.26	43.02	88.36
	<i>Sub-basin (Kilombero) Mean</i>	1	7.16	44.34	135.26	43.02	88.36

ZFY = Numbers of zero-event years of extreme low flow events (normalized at 20 years), M_Freq = Mean frequency of those events (per year), CV_Freq = Coefficient of variation (inter-annual) of those frequencies, M_EP = Normalized mean of the event peaks (maximum to the event mean in % per year), Ev_Dur = Mean event duration (per year), CV-Ev_Dur = Coefficient of variation (inter-annual) in mean event durations, ** = highest within cluster, * = lowest within cluster (note: fractions in frequencies and durations are due to making average, however seemed to be advantageous for subsequent comparisons)

5.3.6. Small floods

Station-wise statistics of series average of small floods for all the stations of Rufiji basin are presented in Table 5.3.6.1 to explore the variations of small flood conditions within and among clusters (please find the complete computations in Appendix). Three (03) ecologically relevant parameters under this category of small floods' named frequency, event peak (maximum), and duration of small flood events were processed in summarized forms of statistics. Table 5.3.6.1 shows zero-event years of small flood events, mean frequency of those events, coefficient of variation (inter-annual) of those frequencies, mean of the event peaks (maximum), mean event duration, and coefficient of variation (inter-annual) in event durations for all the stations under Rufiji basin.

Almost all the stations of the Rufiji basin had 1-4 years of zero small flood events within the series except Little Ruaha (Ihimbu) at '1981-1997' and Ndembera (Ilongo) at '1998-2013' had 5 and 7 years respectively.

Great Ruaha (Trace), Ndembera (Ilongo), again Ndembera (Ilongo) and Hagafiro were found to have the least and Urobo (GNR), Lukosi (Mtandika), Mtitu and Mpanga were found to have the most occurrence of small flood events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.6.1). Cluster mean reveals that the Ruaha sub-basin at '1998-2013' had the least and the Kilombero sub-basin at '1961-1980' had the most occurrence of small flood events on an average. Sub-basin scale observation reveals that the Kilombero had more occurrences of small flood events than the Ruaha sub-basin.

Little Ruaha (Ihimbu), Ndembera (Ilongo), Little Ruaha (Mawande) and Hagafiro were found to have the least and Great Ruaha (Trace), Lukosi (Mtandika), Mbarali (Igawa) and Mngeta were found to have the most variability (inter-annual) in occurrence of small flood events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.6.1). Cluster mean reveals that the Ruaha sub-basin at '1998-2013' had the least and the Kilombero sub-basin at '1961-1980' had the most variability (inter-annual) in occurrence of small flood events on an average. Sub-basin scale observation reveals that the Kilombero had more variability in occurrence of small flood events than the Ruaha sub-basin.

Urobo (GNR), Mtitu, again Mtitu and Hagafiro were found to have the lowest and Great Ruaha (Trace), Kimani, Little Ruaha (Mawande) and Mnyera (US Taveta Mission) were found to have the highest event peak (maximum) of small flood events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.6.1). Cluster mean reveals that the Ruaha sub-basin at '1981-1997' had the lowest and the Ruaha sub-basin at '1961-1980' had the highest event peak (maximum) of small flood events on an average. Sub-basin scale observation reveals that the Kilombero had higher event peak (maximum) of extreme low flow events than the Ruaha sub-basin.

All the stations of Rufiji basin were found to have 1 - < 4 days per year mean event duration of small flood events (Table 5.3.6.1). Therefore, variability (inter-annual) in event durations of small flood events were not significant to compare at within-cluster scale. However, Kilombero shows higher variability (inter-annual) in event duration of small flood events at sub-basin scale than Ruaha.

Table 5.3.6.1. Statistics of small floods of Rufiji basin

Cluster	Station	ZFY	M_Freq	CV_Freq	M_EP	Ev_Dur	CV_Ev_Dur
1	Gr. Ruaha at Trace	3	*1.35	**73.64	**432.69	1	0
<u>Series:</u>	Lit. Ruaha at Ihimbu	2	1.83	*33.73	31.19	1	0
1961	Lit. Ruaha at Mawande	3	1.41	43.80	52.34	1	0
-	Urobo at GNR	4	**2.88	59.40	*0.89	3.35	145.54
1980	Lit. Ruaha at Iwawa	4	1.81	50.24	20.03	1.08	23.83
	Ndembera at Madibira	3	2.00	50.00	23.48	1.12	29.71
	<i>Cluster Mean</i>	3	1.88	51.80	93.43	1.42	33.18
2	Kimani	4	1.38	36.57	**36.19	1	0
<u>Series:</u>	Ndembera at Ilongo	4	*1.15	*32.55	20.89	1	0
1981	Lit. Ruaha at Ihimbu	5	2.25	50.59	28.86	1.04	13.86
-	Mtitu	1	2.56	49.30	*7.05	1.09	24.86
1997	Lukosi at Mtandika	3	**3.43	**59.13	35.12	1	0
	<i>Cluster Mean</i>	4	2.16	45.63	25.62	1.03	7.74
3	Gr. Ruaha at Salimwani	5	1.83	39.15	42.62	1	0
<u>Series:</u>	Kimani	5	1.92	34.88	29.80	1	0
1998	Mbarali at Igawa	3	1.92	**49.61	40.06	1	0
-	Ndembera at Ilongo	8	*1.11	30.00	24.69	1	0
2013	Mtitu	1	**2.27	48.52	*6.08	1	0
	Lit. Ruaha at Mawande	2	1.14	*31.77	**51.87	1	0
	Lit. Ruaha at Makalala	3	1.38	36.57	8.01	1	0
	<i>Cluster Mean</i>	4	1.65	38.64	29.02	1.00	0.00
	<i>Sub-basin (Ruaha) Mean</i>	3	1.90	45.36	49.36	1.15	13.64
4	Lumemo	1	3.74	60.40	22.50	1.09	31.63
<u>Series:</u>	Hagafiro	2	*2.06	*39.03	*5.50	1.10	23.85
1961	Mpanga	2	**3.94	68.73	55.06	1.07	22.11
-	US Taveta Mission	2	2.22	56.83	**189.02	1.06	13.41
1980	Mngeta	1	3.68	**78.38	36.82	1.47	124.65
	<i>Cluster Mean</i>	2	3.13	60.67	61.78	1.16	43.13
	<i>Sub-basin (Kilombero) Mean</i>	2	3.13	60.67	61.78	1.16	43.13

ZFY = Numbers of zero-event years of extreme low flow events (normalized at 20 years), M_Freq = Mean frequency of those events (per year), CV_Freq = Coefficient of variation (inter-annual) of those frequencies, M_EP = Normalized mean of the event peaks (maximum to the event mean in % per year), Ev_Dur = Mean event duration (per year), CV-Ev_Dur = Coefficient of variation (inter-annual) in mean event durations, ** = highest within cluster, * = lowest within cluster (note: fractions in frequencies and durations are due to making average, however seemed to be advantageous for subsequent comparisons)

5.3.7. Large floods

Station-wise statistics of series average of large floods for all the stations of Rufiji basin are presented in Table 5.3.7.1 to explore the variations of large flood conditions within and among clusters (please find the complete computations in Appendix). Three (03) ecologically relevant parameters under this category of 'large floods' named frequency, event peak (maximum), and duration of large flood events were processed in summarized forms of statistics. Table 5.3.7.1 shows zero-event years of large flood events, mean frequency of those events, coefficient of variation (inter-annual) of those frequencies, mean of the event

peaks (maximum), mean event duration, and coefficient of variation (inter-annual) in event durations for all the stations under Rufiji basin.

Urobo (GNR) at '1961-1980', Mtitu and Lukosi (Mtandika) at '1981-1997', and Mtitu at '1998-2013' of Ruaha sub-basin were found to have the fewest zero large flood event years at within-cluster scale (Table 5.3.7.1). Lumemo had the fewest and Mnyera (US Taveta Mission) had the most zero large flood event years in Kilombero sub-basin. However, Ruaha showed more zero large flood event years on an average than Kilombero sub-basin.

Occurrence of large floods at all the stations of Rufiji basin shows $1 < 2$ per year on an average; therefore it cannot give any efficient comparison in this category at within-cluster scale. However, cluster mean reveals that the Ruaha sub-basin at '1998-2013' had the least and the Kilombero sub-basin at '1961-1980' had the most occurrence of large flood events on an average. Sub-basin scale observation reveals that the Kilombero had more occurrences of large flood events than the Ruaha sub-basin. Variability (inter-annual) in occurrence of large flood events at among-cluster scale reveals that the Ruaha sub-basin at '1998-2013' had the least and the Kilombero sub-basin at '1961-1980' had the most variability on an average. Sub-basin scale observation indicates that the Kilombero had more variability in occurrence of large flood events than the Ruaha sub-basin (Table 5.3.7.1).

Urobo (GNR), Mtitu, again Mtitu and Hagafiro were found to have the lowest and Great Ruaha (Trace), Lukosi (Mtandika), Great Ruaha (Salimwani) and Mnyera (US Taveta Mission) were found to have the highest event peak (maximum) of large flood events at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.7.1). Cluster mean reveals that the Ruaha sub-basin at '1981-1997' had the lowest and the Ruaha sub-basin at '1961-1980' had the highest event peak (maximum) of large flood events on an average. Sub-basin scale observation reveals that the Kilombero had higher event peak (maximum) of extreme low flow events than the Ruaha sub-basin.

Most of the stations of Rufiji basin were found to have single day per year mean event duration of large flood events (Table 5.3.7.1). Therefore, variability (inter-annual) in event durations of large flood events were not significant to compare at within-cluster scale.

Table 5.3.7.1. Statistics of large floods of Rufiji basin

Cluster	Station	ZFY	M_Freq	CV_Freq	M_EP	Ev_Dur	CV_Ev_Dur
1	Gr. Ruaha at Trace	15	1.20	37.27	**976.00	1	0
<u>Series:</u>	Lit. Ruaha at Ihimbu	12	1.13	31.43	79.90	1	0
1961	Lit. Ruaha at Mawande	15	1.20	37.27	126.22	1	0
-	Urobo at GNR	6	1.07	24.94	*2.74	1.64	100.18
1980	Lit. Ruaha at Iwawa	12	1.00	0.00	60.52	1	0
	Ndembera at Madibira	13	1.43	55.08	54.60	1	0
	<i>Cluster Mean</i>	12	1.17	31.00	216.66	1.11	16.70
2	Kimani	14	1	0	72.78	1	0
<u>Series:</u>	Ndembera at Ilongo	15	1	0	48.07	1	0
1981	Lit. Ruaha at Ihimbu	11	1.14	33.07	66.42	1	0
-	Mtitu	7	1.09	27.64	*17.30	1	0
1997	Lukosi at Mtandika	7	1.18	34.23	**85.56	1	0
	<i>Cluster Mean</i>	11	1.08	18.99	58.03	1.00	0.00
3	Gr. Ruaha at Salimwani	15	1.25	40.00	**149.52	1.13	22.22
<u>Series:</u>	Kimani	12	1	0	79.17	1	0
1998	Mbarali at Igawa	11	1	0	114.55	1	0
-	Ndembera at Ilongo	16	1	0	38.92	1	0
2013	Mtitu	8	1	0	*15.21	1	0
	Lit. Ruaha at Mawande	15	1	0	118.17	1	0
	Lit. Ruaha at Makalala	15	1.25	40.00	16.43	1	0
	<i>Cluster Mean</i>	13	1.07	11.43	76.00	1.02	3.17
	<i>Sub-basin (Ruaha) Mean</i>	12	1.11	20.47	116.90	1.04	6.62
4	Lumemo	3	1.12	29.71	133.35	1	0
<u>Series:</u>	Hagafiro	11	1.11	30.00	*17.52	1.06	15.79
1961	Mpanga	6	1.36	36.64	210.35	1	0
-	US Taveta Mission	13	1.57	50.07	**263.68	1	0
1980	Mngeta	5	1.20	46.72	187.07	1.13	31.05
	<i>Cluster Mean</i>	8	1.27	38.63	162.39	1.04	9.37
	<i>Sub-basin (Kilombero) Mean</i>	8	1.27	38.63	162.39	1.04	9.37

ZFY = Numbers of zero-event years of extreme low flow events (normalized at 20 years), M_Freq = Mean frequency of those events (per year), CV_Freq = Coefficient of variation (inter-annual) of those frequencies, M_EP = Normalized mean of the event peaks (maximum to the event mean in % per year), Ev_Dur = Mean event duration (per year), CV-Ev_Dur = Coefficient of variation (inter-annual) in mean event durations, ** = highest within cluster, * = lowest within cluster (note: fractions in frequencies and durations are due to making average, however seemed to be advantageous for subsequent comparisons)

5.3.8. Rate and frequency of water condition changes

Station-wise series average of rate and frequency of water condition changes for all the stations of Rufiji basin are presented in Table 5.3.8.1 to explore the variations of changing water conditions within and among clusters (please find the complete computations in Appendix). Three (03) ecologically relevant parameters under this category of 'rate and frequency of water condition changes' named falling rate, rising rate, and hydrologic reversals were summarized in mean form for all the stations under Rufiji basin.

Little Ruaha (Mawande), Little Ruaha (Ihimbu), Little Ruaha (Makalala) and Mnyera (Us Taveta Mission) were found to have the lowest and Urobo (GNR), Kimani, again Kimani and Mngeta were found to have the highest falling rate (normalized to mean) at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.8.1). Cluster mean reveals that the Ruaha sub-basin at '1961-1980' had the lowest and Kilombero sub-basin at '1961-1980' had the highest falling rate (normalized to mean) on an average. Sub-basin scale observation reveals that the Kilombero had higher falling rate (normalized to mean) than the Ruaha.

Little Ruaha (Mawande), Ndembera (Ilongo), Little Ruaha (Makalala) and Mnyera (Us Taveta Mission) were found to have the lowest and Great Ruaha (Trace), Kimani, again Kimani and Mngeta were found to have the highest rising rate (normalized to mean) at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.8.1). Cluster mean reveals that the Ruaha sub-basin at '1961-1980' had the lowest and Kilombero sub-basin at '1961-1980' had the highest rising rate (normalized to mean) on an average. Sub-basin scale observation reveals that the Kilombero had higher rising rate (normalized to mean) than the Ruaha.

Great Ruaha (Trace), Ndembera (Ilongo), Little Ruaha (Makalala) and Mnyera (Us Taveta Mission) were found to have the lowest and Little Ruaha (Ihimbu), Kimani, again Kimani and Mngeta were found to have the highest hydrologic reversal at within-cluster scale for the cluster 1, 2, 3, and 4 respectively (Table 5.3.8.1). Cluster mean reveals that the Ruaha sub-basin at '1981-1997' had the lowest and Kilombero sub-basin at '1961-1980' had the highest hydrologic reversal on an average. Sub-basin scale observation reveals that the Kilombero had higher hydrologic reversal than the Ruaha sub-basin.

Table 5.3.8.1. Rate and frequency of water condition changes in Rufiji Basin

Cluster	Station	Series	FR *	nFR *	RR *	nRR *	HR *
1	Gr. Ruaha at Trace	1961-1980	8.61	7.10	24.09	**19.86	*81.53
	Lit. Ruaha at Ihimbu	1961-1980	1.10	6.19	2.28	12.86	**111.35
	Lit. Ruaha at Mawande	1961-1980	0.91	*4.55	2.39	*11.93	91.95
	Urobo at GNR	1961-1980	0.08	**13.70	0.13	21.63	92.24
	Lit. Ruaha at Iwawa	1961-1980	0.64	5.39	1.59	13.46	98.33
	Ndembera at Madibira	1961-1980	0.73	5.53	1.65	12.51	93.75
		<i>Cluster Mean</i>	2.01	7.08	5.35	15.38	94.86

Table 5.3.8.1. Rate and frequency of water condition changes in Rufiji Basin

Cluster	Station	Series	FR *	nFR *	RR *	nRR *	HR *
2	Kimani	1981-1997	0.75	**14.17	1.90	**35.67	**84.12
	Ndembera at Ilongo	1981-1997	0.40	6.57	0.69	*11.37	*51.75
	Lit. Ruaha at Ihimbu	1981-1997	0.72	*4.69	1.77	11.52	82.40
	Mtitu	1981-1997	0.31	8.55	0.50	13.87	83.47
	Lukosi at Mtandika	1981-1997	1.58	7.14	3.19	14.38	81.67
	<i>Cluster Mean</i>		0.75	8.22	1.61	17.36	76.68
3	Gr. Ruaha at Salimwani	1998-2013	1.16	9.22	2.95	23.41	70.27
	Kimani	1998-2013	0.80	**14.59	2.06	**37.76	**106.50
	Mbarali at Igawa	1998-2013	1.36	11.63	3.82	32.69	95.56
	Ndembera at Ilongo	1998-2013	0.24	5.06	0.62	13.25	74.29
	Mtitu	1998-2013	0.22	6.81	0.41	12.79	81.75
	Lit. Ruaha at Mawande	1998-2013	0.88	5.02	2.79	15.79	73.33
	Lit. Ruaha at Makalala	1998-2013	0.09	*2.81	0.27	*8.79	*51.94
	<i>Cluster Mean</i>		0.68	7.88	1.85	20.64	79.09
	<i>Sub-basin Mean</i>		1.15	7.73	2.94	17.79	83.54
4	Lumemo	1961-1980	2.26	18.66	4.60	38.01	139.35
	Hagafiro	1961-1980	0.28	8.79	0.44	13.87	114.67
	Mpanga	1961-1980	5.23	12.07	9.20	21.24	114.21
	US Taveta Mission	1961-1980	3.15	*3.95	5.49	*6.88	*106.21
	Mngeta	1961-1980	5.12	**22.29	11.94	**52.01	**142.60
	<i>Cluster Mean</i>		3.21	13.15	6.34	26.40	123.41
	<i>Sub-basin Mean</i>		3.21	13.15	6.34	26.40	123.41

* FR = Falling Rate (m³/sec per falling day), RR = Rising Rate (m³/sec per rising day), HR = Hydrologic Reversal (times/year), nFR = Normalized FR to mean (%), nRR = Normalized RR to mean (%), ** = highest within cluster, * = lowest within cluster

6. DISCUSSION

The ecologically relevant characteristics of flow-regime calculated for Rufiji basin in Tanzania are analyzed and discussed in this chapter. Both the stream itself and the contained ecosystem are strongly influenced by the dynamics of such characteristic hydrological parameters chosen from The Nature Conservancy (2009) and selected for the analysis of this study. The critical issues of those characteristics, their comparative dynamics in Rufiji basin, and inference of their associated ramifications are discussed here categorically. Variability in their statistics provided an ensemble of ecohydrological clues by which the stations of Rufiji basin could be sorted out at their susceptibility to associated ecological responses. Based on those clues, the stations which showed higher variability might be inferred to be responsive to positive ramifications and the stations which indicated lower variability might be inferred to be responsive to negative ramifications on stream and ecosystem.

The biota present in a stream have survived in a natural range of annual disturbances of flow-regime and are unable to establish self-sustaining populations if the flow-regime vary considerably from year-to-year without maintaining a well suit of harmonic flow cycles (Cooke, 2006). Freshwater ecosystems, therefore, have evolved to the rhythms of natural hydrologic variability (Tilman, 2003) and, presumably, will continue to survive provided that such rhythms of disturbances are maintained or do not change appreciably (Cooke, 2006). Chicharo *et al.* (2006) studied evaluation of how inter-annual changes in flow volume affect biotic (specially fish) assemblages and concluded that changes in the dominant feeding groups of the aquatic systems due to such flow variability might have consequences on water quality, particularly in relation to the occurrence of planktonic blooms. Deviation from natural ranges of variations in the dynamic flow patterns of such ecosystems might not be efficient in promoting their integrity and sustainability (based on Sanz *et al.*, 2005). The current study was thus focused particularly at higher degrees of inter-annual variations in flow metrics than that of its contemporary stations and such recognition might be helpful for both the stream and ecosystem in their protection and restoration measures.

The clustering idea of the stations based on perceived conditions for the ecohydrological analyses of current interest paved a new avenue of managing and processing irregular hydrological data for exploration of readily understandable information and messages. Subsequent data cleaning process generated an outlier-free time-series of discharge for the stations efficiently available for determining eco-relevant statistics. Data completeness

showed that 74%~96% flow data per considered period of records selected were available for subsequent analyses. Mean-monthly flows indicated a seasonal distinction in flow patterns where there were clearly visible peaks around the month of Mar-Apr and drops around Oct-Nov at annual cycles for almost all stations of the Rufiji basin in Tanzania. Flow magnitudes were found to be higher in Kilombero sub-basin than in most of the cases of Ruaha. According to flow-duration curves, the highest variations of flows at high flow thresholds to the respective means at Ndembera (Madibira), Ndembera (Ilongo), again Ndembera (Ilongo), and Mnyera (US Taveta Mission) stations within Ruaha '1961-1980', Ruaha '1981-1997', Ruaha '1998-2013', and Kilombero '1961-1980' clusters respectively signifies relative moistness within the clusters. On the contrary, the highest variations of flows at low flow thresholds to the respective means at Urobo (GNR), Lukosi (Mtandika), Mtitu, and Mpanga stations within Ruaha '1961-1980', Ruaha '1981-1997', Ruaha '1998-2013', and Kilombero '1961-1980' clusters respectively signifies relative dryness within the clusters. On an average, Ruaha '1961-1980' cluster and the Ruaha sub-basin at large were found to be the most moist, and Kilombero '1961-1980' cluster and the Kilombero sub-basin at large were found to be the most dry in the Rufiji basin. The steep shape in the upper region of the flow-duration curves of the stations Lukosi (Mtandika) at '1981-1997', and Lumemo and Mngeta at '1961-1980' exhibited high flows for short period, and the same in the lower region of the stations Urobo (GNR) at '1961-1980', Ndembera (Ilongo) and Little Ruaha (Mawande and Makalala) at '1998-2013', and Mnyera (US Taveta Mission) at '1961-1980' exhibited low flows for short period.

6.1. Monthly water conditions

Higher month-to-month variability in series average of mean-monthly flows in a couple of stations of Rufiji basin indicated annual fluctuations of flow-regime with greater magnitude. Large fluctuations in annual river flows bring water-related disturbance events like floods to some and droughts to others, ruining the agricultural productions, and may have severe impact and vulnerability on ecosystem as well (Rockstrom *et al*, 2014). Replenishing water arriving as intense rainfall, overwhelming flood defences and escaping from the stream before storage for irrigation, soil moisture, providing water and habitat to floodplain ecosystems might cause such dramatic changing patterns in magnitude of monthly flows. Dynamic patterns of monthly water conditions with larger range of variations might fail to promote the integrity and sustainability of freshwater aquatic ecosystems. In

addition, shoreline populations, heat and light properties, and water quality parameters might experience excessive swings due to such inter-month flow variations which might result in the loss of ecosystem services (Tilman, 2003).

Variability in monthly water conditions provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Little Ruaha (Iwawa) at '1961-1980', Little Ruaha (Ihimbu) at '1981-1997' and Great Ruaha (Salimwani) at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be more responsive to associated ramifications on stream and ecosystem. On the contrary, Urobo (GNR) at '1961-1980', Ndembera (Ilongo) at '1981-1997' and Mtitu at '1998-2013' of Ruaha sub-basin, and Mpanga at '1961-1980' of Kilombero sub-basin might be inferred to be less responsive to those consequences. Thus, among all the four clusters, the Ruaha sub-basin at '1981-1997' might be critical and the Kilombero sub-basin at '1961-1980' might be trivial in their exposure to those repercussions. Nevertheless, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations than Ruaha sub-basin.

6.2. Annual water extremes

Higher inter-type (annual minima of 1, 3, 7, and 30-day means) flow-minima variability in a couple of stations of Rufiji basin indicated fluctuations of water extreme (minima) within the considered period of record with greater magnitude. These higher fluctuations reveal that extremely low single-day annual minima were more frequent within the considered period of record in those stations which might be inferred as a cause of recurrence of nearly diminished flow-magnitude condition shocking or stressful for intolerant biota of the ecosystem to sustain. Biological integrity of fish and macro-invertebrate communities were strongly linked with the diminished flow-magnitude conditions and there were chances of biological impairment to be augmented even exponentially with the increment of the severity of diminished stream flows (Carlisle *et al.*, 2010). Because the magnitude of streamflows dictate the evolutionary adaptations of many river biota (Bunn and Arthington, 2002), increasingly common aquatic taxa in the stations with diminished flow-magnitude might be inferred to develop the ability to permanently migrate or temporarily leave that ecosystem, which might have profound effects on ecosystem structure and function (Carlisle *et al.*, 2010). In places

where flow rates are negligible or absent, filamentous and tufted algal periphytons might form a gelatinous and unanchored floating mat (Cushing and Allan, 2001).

Inter-type (annual minima of 1, 3, 7, and 30-day means) variability in flow-minima provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Urobo (GNR) at '1961-1980' and Kimani at '1981-1997' and '1998-2013' of Ruaha sub-basin, and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be more responsive to associated ramifications on stream and ecosystem. On the contrary, Little Ruaha (Mawande) at '1961-1980' and '1998-2013' and Lukosi (Mtandika) at '1981-1997' of Ruaha sub-basin, and Mnyera (US Taveta Mission) at '1961-1980' of Kilombero sub-basin might be inferred to be less responsive to those consequences. Thus, among all the four clusters, the Ruaha sub-basin at '1998-2013' might be critical and the Ruaha sub-basin at '1981-1997' might be trivial in their exposure to those repercussions. Nevertheless, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations than Ruaha sub-basin.

Higher inter-type (annual maxima of 1, 3, 7, and 30-day means) flow-maxima variability in a couple of stations of Rufiji basin indicated fluctuations of water extreme (maxima) within the considered period of record with greater magnitude. These higher fluctuations reveal that extremely low single-day annual maxima were more frequent within the considered period of record in those stations which might be inferred as a cause of recurrence of inflated flow-magnitude condition shocking or stressful for intolerant biota of the ecosystem to sustain. Poff and Zimmerman (2010) reviewed ecological responses based on flow magnitude which revealed that extremely inflated flow conditions were associated with life cycle disruption of the population living in that water, reduced species richness in that ecosystem, altered assemblage and loss of sensitive species from that aquatic environment. Particular to the invertebrate communities, such type of flow events were found to be influential in creating greater diversity and variability in their functional traits (Lambeets *et al.*, 2008; Lambeets *et al.*, 2009). Particle-bound nutrients in the catchment as well as in the bottom of the river were found to be mobilized by erosion process to a high extent due to such higher flow-maxima (Zessner *et al.*, 2005). In case of filamentous and tufted algal Periphytons which typically attach themselves to objects to avoid being washed away by fast current (Cushing and Allan, 2001) might face difficulty to sustain under higher flow-maxima conditions.

Inter-annual (annual maxima of 1, 3, 7, and 30-day means) variability in flow-maxima provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Great Ruaha (Trace) at '1961-1980' and Kimani at '1981-1997' and '1998-2013' of Ruaha sub-basin, and Lumemo at '1961-1980' of Kilombero sub-basin might be inferred to be more responsive to associated ramifications on stream and ecosystem. On the contrary, Ndembera (Madibira) at '1961-1980', Little Ruaha (Ihimbu) at '1981-1997' and Little Ruaha (Makalala) at '1998-2013' of Ruaha sub-basin, and Mnyera (US Taveta Mission) at '1961-1980' of Kilombero sub-basin might be inferred to be less responsive to those consequences. Thus, among all the four clusters, the Ruaha sub-basin at '1998-2013' might be critical and the Ruaha sub-basin at '1961-1980' might be trivial in their exposure to those repercussions. Nevertheless, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations than Ruaha sub-basin.

Trends in annual minima (1, 3, 7, and 30-day means) provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Decreasing trends in particular in this category of flow metrics signify that the stations having such trends were in pressure at low flow regime in the later part of the considered periods of record and had an inclination or likelihood to be inclined towards dryness or lack of sufficient flows to allow the stream and dependent ecosystem to be sustainable and healthy, while increasing trends indicate a relative flow stabilization against flow shortage or even drought. Based on this clue, all the stations except Ndembera (Madibira) at '1961-1980', all the stations at '1981-1997', other than Great Ruaha (Salimwani), Little Ruaha (Mawande) and Little Ruaha (Makalala) at '1998-2013' of Ruaha sub-basin, and other than Hagafiro and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be more responsive to aforementioned associated ramifications on stream and ecosystem due to their decreasing trends in flow-minima. On the contrary, Ndembera (Madibira) at '1961-1980', and Great Ruaha (Salimwani), Little Ruaha (Mawande) and Little Ruaha (Makalala) at '1998-2013' of Ruaha sub-basin, and Hagafiro and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be less responsive to those consequences, rather more responsive to relative flow stabilization against flow shortage.

Trends in annual maxima (1, 3, 7, and 30-day means) provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned

ecological responses. Increasing trends in particular in this category of flow metrics signify that the stations having such trends were vulnerable at high flow regime in the later part of the considered periods of record and had an inclination or likelihood to be inclined towards wetness or excess of flows to allow the stream and dependent ecosystem to be sustainable and healthy, while decreasing trends indicate a relative flow stabilization against flow excess or even flood. Based on this clue, Little Ruaha (Mawande) and Ndembera (Madibira) at '1961-1980', Mtitu and Lukosi (Mtandika) at '1981-1997' and Little Ruaha (Makalala) at '1998-2013' of Ruaha sub-basin, and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be more responsive to aforementioned associated ramifications on stream and ecosystem due to their increasing trends in flow-maxima. On the contrary, other than these stations at all the clusters might be inferred to be less responsive to those consequences, rather more responsive to relative flow stabilization against flow excess.

6.3. Monthly low flows

Monthly low flows being the dominant flow condition in most of the rivers have strong influences on the diversity and number of organisms that can live in the river providing base flow to them. Such flows being subsided by rainfall associated surface runoff and being sustained by groundwater discharge typically determine the persistent coverage of aquatic habitat for most of the year (The Nature Conservancy, 2009). These are the advantages of this flow-regime component, while higher variability in its metrics might produce different scenario. Higher month-to-month variability in series average of monthly low flows in a couple of stations of Rufiji basin indicated annual fluctuations of low flow conditions with greater magnitude. Development of phytoplankton population might be inferred to be hampered more in waters around these stations since, according to Allan (1995), such free-floating organisms proliferate sizeable population well in slow moving conditions and backwaters as being unable to maintain in fast flowing streams, and since the dynamic patterns of monthly low flow conditions with larger range of variations might not be efficient enough to promote their harmonic development. Adaptations of seedling establishment, seed release and dispersal of riparian plants might be impaired more in waters around these stations as well since, according to Gilbert (2009), harmonic low flows which are biologically important to most of such communities in the riparian zone were found to be lacking there. As long as a couple of stations of the Rufiji basin were inclined to these sorts of threats, they were concurrently unfavorable to the advantages of this flow-regime component, together

giving signal for negative ramifications; other circumstances at some other stations in both categories of ecological responses might produce positive ramifications.

Variability in monthly low flow conditions provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Ndembera (Madibira) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Kimani at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Little Ruaha (Mawande) at '1961-1980', Little Ruaha (Ihimbu) at '1981-1997' and Mtitu at '1998-2013' of Ruaha sub-basin, and Mpanga at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Kilombero sub-basin at '1961-1980' might be critical and the Ruaha sub-basin at '1981-1997' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

6.4. Extreme low flows

Extreme low flows may provide necessary conditions for certain selective species of the stream which can be benefitted from a concentrated collection of some aquatic preys. Such events at low-lying floodplains may enable certain species of plants to regenerate through drying out of water (The Nature Conservancy, 2009). These are the advantages of this flow-regime component, while higher variability in its metrics might produce different scenario. Higher variability in series average of extreme low flows in a couple of stations of Rufiji basin indicated different indices of variations *viz*, in the number of years having no extreme low flows, in within-year and year-to-year frequency of extreme low flow events, in series-averages of mean event peaks (minima) of extreme low flow events, in within-year and year-to-year mean event durations of extreme low flow events, and all of these variations with greater magnitudes. Highly variable extreme low flows were found to be critical for aquatic communities, specially threatening for vulnerable taxa as of having likelihoods of removal from the ecosystem which leaving more space for the opportunistic could augment the share of small-sized species (Daufresne *et al.*, 2009). In addition, such extreme flows were found to reconfigure biomass fluxes and food web structure (Ledger, 2013). Ledger (2013) mentioned

that whilst it might be possible to lead a greater extinction for some predators by higher extreme low flows, others might benefit from short-term increases in *r*-selected focal prey species that were able to exploit such disturbance. Walters and Post (2008) found strong impacts of extreme low flow events on food web structure rather than food-chain length. Stream community structure was found to be relatively insensitive to a wide range of flow variation, but quite sensitive to extremely low flow events (Walters, 2011, Walters and Post, 2011). Highly variable extreme low flows can be stressful for many organisms in terms of water chemistry, temperature, and dissolved oxygen availability and can cause considerable mortality (The Nature Conservancy, 2009). As long as a couple of stations of the Rufiji basin were inclined to these sorts of threats, they were concurrently unfavorable to the advantages of this flow-regime component, together giving signal for negative ramifications; other circumstances at some other stations in both categories of ecological responses might produce positive ramifications.

Variability in number of years within the considered period of record having no extreme low flows provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Little Ruaha (Ihimbu) at '1961-1980', Ndembera (Ilongo) at '1981-1997' and Kimani at '1998-2013' of Ruaha sub-basin, and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Ndembera (Madibira) at '1961-1980', Little Ruaha (Ihimbu) at '1981-1997' and Little Ruaha (Mawande) at '1998-2013' of Ruaha sub-basin, and Mpanga at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Ruaha sub-basin at '1981-1997' and '1998-2013' might be critical and the Ruaha sub-basin at '1961-1980' might be trivial in their exposure to those repercussions. Nevertheless, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

Variability in number of occurrences of extreme low flow events per year provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Little Ruaha (Ihimbu) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Kimani at '1998-2013' of Ruaha sub-basin, and Lumemo at '1961-1980' of Kilombero sub-basin might be inferred to be

responsive to negative ramifications on stream and ecosystem. On the contrary, Great Ruaha (Trace) at '1961-1980', Little Ruaha (Ihimbu) at '1981-1997' and Ndembera (Ilongo) at '1998-2013' of Ruaha sub-basin, and Mpanga at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Kilombero sub-basin at '1961-1980' might be critical and the Ruaha sub-basin at '1961-1980' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

Interannual variability in occurrence of extreme low flow events provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Urobo (GNR) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Great Ruaha (Salimwani) at '1998-2013' of Ruaha sub-basin, and Mpanga at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Little Ruaha (Ihimbu) at '1961-1980' and '1981-1997', and Ndembera (Ilongo) at '1998-2013' of Ruaha sub-basin, and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Ruaha sub-basin at '1961-1980' might be critical and the Ruaha sub-basin at '1981-1997' might be trivial in their exposure to those repercussions. Nevertheless, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

Variability in series-average of mean event peaks (minima) of extreme low flow events provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Ndembera (Madibira) at '1961-1980', Mtitu at '1981-1997' and Little Ruaha (Mawande) at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Urobo (GNR) at '1961-1980', Little Ruaha (Ihimbu) at '1981-1997' and Little Ruaha (Makalala) at '1998-2013' of Ruaha sub-basin, and Mpanga at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Ruaha sub-basin at '1961-1980' might be critical and the Ruaha sub-

basin at '1998-2013' might be trivial in their exposure to those repercussions. Nevertheless, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

Variability in series-average of mean event durations per year of extreme low flow events provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Ndembera (Madibira) at '1961-1980', Little Ruaha (Ihimbu) at '1981-1997' and Little Ruaha (Mawande) at '1998-2013' of Ruaha sub-basin, and Mpanga at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Little Ruaha (Iwawa) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Kimani at '1998-2013' of Ruaha sub-basin, and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Ruaha sub-basin at '1961-1980' might be critical and the Ruaha sub-basin at '1998-2013' might be trivial in their exposure to those repercussions. Nevertheless, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

Interannual variability in mean event durations of extreme low flow events provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Ndembera (Madibira) at '1961-1980', Little Ruaha (Ihimbu) at '1981-1997' and Mbarali (Igawa) at '1998-2013' of Ruaha sub-basin, and Mpanga at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Little Ruaha (Mawande) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Mtitu at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Ruaha sub-basin at '1961-1980' might be critical and the Kilombero sub-basin at '1961-1980' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Ruaha might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Kilombero sub-basin.

6.5. High flow pulses

Rain-fed high flow pulses as brief flush of fresh water provide disruptions in low flows, aid reliefs from thermal and hypoxia conditions, deliver a nourishing subsidy of organic material or other food to support the aquatic food web, and increase access of mobile stream-biota to up- and downstream areas (The Nature Conservancy, 2009). These events were found to prevent encroachment of vegetation towards river channels, deliver large amounts of sediment and organic matter downstream in the process, move and scour gravels for native and recreational fish spawners, and suppress non-native populations in the stream (Mathews and Richter, 2007). These are the advantages of this flow-regime component, while higher variability in its metrics might produce different scenario. Higher variability in series average of high flow pulse events in a couple of stations of Rufiji basin indicated different indices of variations *viz.*, in the number of years having no high flow pulses, in within-year and year-to-year frequency of high flow pulse events, in series-averages of mean event peaks (minima) of high flow pulse events, in within-year and year-to-year mean event durations of high flow pulse events, and all of these variations with greater magnitudes. Occurrence of high flows were reported to be particularly detrimental during spawning, hatching and early life stages of some fish as that could destroy entire year classes if they coincided with the egg or larval stage (Allen, 1951; Hayes, 1995). Species with synchronous or shorter periods of reproduction might be affected at flow changes to high since having limited chance of adaptation to unpredictable flow rises (McDowall and Eldon, 1997). As long as a couple of stations of the Rufiji basin were inclined to these sorts of threats, they were concurrently unfavorable to the advantages of this flow-regime component, together giving signal for negative ramifications; other circumstances at some other stations in both categories of ecological responses might produce positive ramifications.

Variability in number of occurrences of high flow pulse events per year provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Urobo (GNR) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Mtitu at '1998-2013' of Ruaha sub-basin, and Lumemo at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Great Ruaha (Trace) at '1961-1980', Ndembera (Ilongo) at '1981-1997' and Ndembera (Ilongo) at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be

responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Kilombero sub-basin at '1961-1980' might be critical and the Ruaha sub-basin at '1998-2013' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

Interannual variability in occurrence of high flow pulse events provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Great Ruaha (Trace) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Ndembera (Ilongo) at '1998-2013' of Ruaha sub-basin, and Lumemo at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Little Ruaha (Ihimbu) at '1961-1980', Mtitu at '1981-1997' and Mtitu at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Ruaha sub-basin at '1961-1980' might be critical and the Kilombero sub-basin at '1961-1980' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Ruaha might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Kilombero sub-basin.

Variability in series-average of mean event peaks (maxima) of high flow pulse events provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Great Ruaha (Trace) at '1961-1980', Kimani at '1981-1997' and Ndembera (Ilongo) at '1998-2013' of Ruaha sub-basin, and Lumemo at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Little Ruaha (Ihimbu) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Mtitu at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Ruaha sub-basin at '1998-2013' might be critical and the Ruaha sub-basin at '1961-1980' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Ruaha might be relatively more responsive to those sorts of stream and

ecosystem degradations and less responsive to the advantages of this flow-regime component than Kilombero sub-basin.

Variability in series-average of mean event durations per year of high flow pulse events provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Great Ruaha (Trace) at '1961-1980', Kimani at '1981-1997' and Ndembera (Ilongo) at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Urobo (GNR) at '1961-1980', Mtitu at '1981-1997' and Mtitu at '1998-2013' of Ruaha sub-basin, and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Ruaha sub-basin at '1998-2013' might be critical and the Kilombero sub-basin at '1961-1980' might be trivial in their exposure to those repercussions. Nevertheless, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

Interannual variability in event duration of high flow pulse events provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Urobo (GNR) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Great Ruaha (Salimwani) at '1998-2013' of Ruaha sub-basin, and Mpanga at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Great Ruaha (Trace) at '1961-1980', Ndembera (Ilongo) at '1981-1997' and Ndembera (Ilongo) at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Kilombero sub-basin at '1961-1980' might be critical and the Ruaha sub-basin at '1998-2013' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

6.6. Small floods

Small floods are beneficial for fish and other mobile organisms as they became able to move upstream, downstream, and out into floodplains or flooded wetlands to access additional habitats such as secondary channels, backwaters, sloughs, and shallow flooded areas for substantial food resources, warm shelters, nutrients, and insects providing fuel for rapid growth of them (The Nature Conservancy, 2009). Small floods were also found to aid the reproduction process of native riparian plants and could decrease the density of non-native species (Mathews and Richter, 2007). These are the advantages of this flow-regime component, while higher variability in its metrics might produce different scenario. Higher variability in series average of small flood events in a couple of stations of Rufiji basin indicated different indices of variations *viz.*, in the number of years having no small floods, in within-year and year-to-year frequency of small flood events, in series-averages of mean event peaks (minima) of small flood events, in within-year and year-to-year mean event durations of small flood events, and all of these variations with greater magnitudes. Small floods were found to be the driver to carry larvae of some opportunistic invasive (Charteris *et al.*, 2003). Furthermore, such types of flow events were reported to negatively affect recruitment process and rate of some adult population regulating their spawning and incubation by causing high mortality of emergent fry (Jowett, 1995; Hayes, 1995). Rosser and Pearson (1995) reported about the susceptibility of stream fauna to depletion at increased frequency and magnitude of small floods and a relatively low rate of their recovery. As long as a couple of stations of the Rufiji basin were inclined to these sorts of threats, they were concurrently unfavorable to the advantages of this flow-regime component, together giving signal for negative ramifications; other circumstances at some other stations in both categories of ecological responses might produce positive ramifications.

Variability in number of occurrences of small flood events per year provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Urobo (GNR) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Mtitu at '1998-2013' of Ruaha sub-basin, and Mpanga at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Great Ruaha (Trace) at '1961-1980' and Ndembera (Ilongo) at '1981-1997' and '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive

ramifications on stream and ecosystem. Thus, among all the four clusters, the Kilombero sub-basin at '1961-1980' might be critical and the Ruaha sub-basin at '1998-2013' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

Interannual variability in occurrence of small flood events provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Great Ruaha (Trace) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Mbarali (Igawa) at '1998-2013' of Ruaha sub-basin, and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Little Ruaha (Ihimbu) at '1961-1980', Ndembera (Ilongo) at '1981-1997' and Little Ruaha (Mawande) at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Kilombero sub-basin at '1961-1980' might be critical and the Ruaha sub-basin at '1998-2013' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

Variability in series-average of mean event peaks (maxima) of small flood events provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Great Ruaha (Trace) at '1961-1980', Kimani at '1981-1997' and Little Ruaha (Mawande) at '1998-2013' of Ruaha sub-basin, and Mnyera (US Taveta Mission) at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Urobo (GNR) at '1961-1980' and Mtitu at '1981-1997' and '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Ruaha sub-basin at '1961-1980' might be critical and the Ruaha sub-basin at '1981-1997' might be trivial in their exposure to those repercussions. Nevertheless, on an average, Kilombero might be relatively more responsive to those sorts of stream and

ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

6.7. Large floods

Large floods are beneficial in rearranging both the biological and physical structure of a river and its floodplain, in creating new competitive advantages for particular species by flushing others, and in forming key habitats such as oxbow lakes and floodplain wetlands (The Nature Conservancy, 2009). These are the advantages of this flow-regime component, while higher variability in its metrics might produce different scenario. Higher variability in series average of large flood events in a couple of stations of Rufiji basin indicated different indices of variations *viz.*, in the number of years having no large floods, in within-year and year-to-year frequency of large flood events, in series-averages of mean event peaks (minima) of large flood events, in within-year and year-to-year mean event durations of large flood events, and all of these variations with greater magnitudes. Large floods were found to reduce certain stocks of fishes (Jowett and Richardson, 1989), invertebrates (Quinn and Hickey, 1990), and periphytons (Biggs *et al.*, 1990). Such floods were found to especially affect recently emerged fry and juvenile fishes, presumably because they were weaker swimmers, and their re-colonization rates after such events were found to be relatively slower (Cooke, 2006). Small fishes and macro-invertebrates in streams with large floods were found to colonize new areas rapidly and were often dominant (Scarsbrook and Townsend, 1993). In such flow conditions, the periphyton community was found to be usually sparse, with low species richness and diversity (Biggs, 1990). As long as a couple of stations of the Rufiji basin were inclined to these sorts of threats, they were concurrently unfavorable to the advantages of this flow-regime component, together giving signal for negative ramifications; other circumstances at some other stations in both categories of ecological responses might produce positive ramifications.

Variability in number of years within the considered period of record having no large flood events provided an ecohydrological clue by which the stations of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Urobo (GNR) at '1961-1980', Mtitu and Lukosi (Mtandika) at '1981-1997' and Mtitu at '1998-2013' of Ruaha sub-basin, and Lumemo at '1961-1980' of Kilombero sub-basin might be inferred to be positive to beneficial responses on stream and ecosystem as of having the fewest zero

large flood event years at within-cluster scale. Mnyera (US Taveta Mission) at '1961-1980' of Kilombero sub-basin might not be positive to beneficial responses in that sense. Between sub-basins, on an average, Ruaha might not be positive to beneficial responses.

Variability in number of occurrences of large flood events per year and interannual variability in occurrences of those events provided an ecohydrological clue by which the clusters and sub-basins of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, among all the four clusters, Kilombero at '1961-1980' might be critical and Ruaha sub-basin at '1998-2013' might be trivial in their exposure to those repercussions on stream and ecosystem. Between sub-basins, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

Variability in series-average of annual means of event peaks (maxima) of large flood events provided an ecohydrological clue by which the clusters and sub-basins of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Great Ruaha (Trace) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Great Ruaha (Salimwani) at '1998-2013' of Ruaha sub-basin, and Mnyera (US Taveta Mission) at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Urobo (GNR) at '1961-1980' and Mtitu at '1981-1997' and '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to positive ramifications on stream and ecosystem. Thus, among all the four clusters, the Ruaha at '1961-1980' might be critical and the Ruaha sub-basin at '1981-1997' might be trivial in their exposure to those repercussions. Nevertheless, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the advantages of this flow-regime component than Ruaha sub-basin.

6.8. Water condition changes

Water condition changes in terms of rise, fall and reversals of flows are associated with balancing the flow regime to all of its environmentally significant components. Rises of the flow inspire high flow or flood regime necessary for the ecosystem components at a particular level and time. Similarly, falls of the flow control low flow regime of the stream

creating necessary habitats for spawners and sensitive biota, and influencing light penetration to depth and temperature modification. Flow reversals from rise to fall or from fall to rise might be important in disrupting the contaminant pathway which has potential implication in pollution management (Quinn, 1988). These are the positive signals of this indicator, while higher variability in its metrics might produce different scenario. Higher rates and frequencies in series average of water condition changes in a couple of stations of Rufiji basin indicated different indices of variations *viz*, fall rate, rise rate, hydrologic reversals with greater magnitudes. Higher falling rates of the flow might indicate comparative dryer condition of the stream and consequences associated with dryness or even drought. Such variability in falling rates of the flow might increase the likelihood to influence the dominant flows of the stream. Similarly, higher rising rates of the flow might indicate comparative wet condition of the stream and consequences associated with wetness or even flood. Such variability in rising rates of the flow might increase the likelihood to influence the harmonic flood regime of the stream. Together, these variability might induce the natural flow regime to be out of phases which might have ecological impacts such as drowning of riparian vegetation and wetlands which are adapted to temporary inundation (NSW Govt., 2014). Such higher tendency of water condition changes in terms of rise, fall and reversals of flows might cause sudden and abnormally rapid changes in the volume and speed of water in a river system, poor bank stability, slumping, loss of riparian vegetation, erosion and sedimentation etc. (NSW Govt., 2014). Higher variability in the indicators of water condition changes in a couple of stations of the Rufiji basin might induce an inclination to these sorts of threats which in turn might give a signal for negative ramifications. On the other hand, lower variability in these flow metrics at some other stations might indicate comparative stability in water condition changes.

Higher falling rate of the flow provided an ecohydrological clue by which the clusters and sub-basins of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Urobo (GNR) at '1961-1980', Kimani at '1981-1997' and '1998-2013' of Ruaha sub-basin, and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Little Ruaha (Mawande) at '1961-1980', Little Ruaha (Ihimbu) at '1981-1997' and Little Ruaha (Makalala) at '1998-2013' of Ruaha sub-basin, and Mnyera (Us Taveta Mission) at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to stabilization of water condition changes. Thus, among all the four clusters, the Kilombero at '1961-1980'

might be critical and the Ruaha sub-basin at '1961-1980' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the stabilization of water condition changes than Ruaha sub-basin.

Higher rising rate of the flow provided an ecohydrological clue by which the clusters and sub-basins of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Great Ruaha (Trace) at '1961-1980', Kimani at '1981-1997' and '1998-2013' of Ruaha sub-basin, and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Little Ruaha (Mawande) at '1961-1980', Ndembera (Ilongo) at '1981-1997' and Little Ruaha (Makalala) at '1998-2013' of Ruaha sub-basin, and Mnyera (Us Taveta Mission) at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to stabilization of water condition changes. Thus, among all the four clusters, the Kilombero at '1961-1980' might be critical and the Ruaha sub-basin at '1961-1980' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the stabilization of water condition changes than Ruaha sub-basin.

Higher hydrologic reversals provided an ecohydrological clue by which the clusters and sub-basins of Rufiji basin could be sorted out at their susceptibility to aforementioned ecological responses. Based on this clue, Little Ruaha (Ihimbu) at '1961-1980', Kimani at '1981-1997' and '1998-2013' of Ruaha sub-basin, and Mngeta at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to negative ramifications on stream and ecosystem. On the contrary, Great Ruaha (Trace) at '1961-1980', Ndembera (Ilongo) at '1981-1997' and Little Ruaha (Makalala) at '1998-2013' of Ruaha sub-basin, and Mnyera (Us Taveta Mission) at '1961-1980' of Kilombero sub-basin might be inferred to be responsive to stabilization of water condition changes. Thus, among all the four clusters, the Kilombero at '1961-1980' might be critical and the Ruaha sub-basin at '1981-1997' might be trivial in their exposure to those repercussions. Between sub-basins, on an average, Kilombero might be relatively more responsive to those sorts of stream and ecosystem degradations and less responsive to the stabilization of water condition changes than Ruaha sub-basin.

6.9. Summarization of flow based eco-ramifications

Table 6.9.1 indicates a compilation of aforementioned eco-ramifications across the meaningfully extractable metrics of the full spectrum of ecologically relevant hydrological characteristics selected for this study. Column headings of the table refers to as follows: A is monthly water conditions, Bn is annual flow minima, Bx is annual flow maxima, C is monthly low flows, E is extremely low flows, H is high flow pulses, S is small floods, L is large floods, W is water condition changes, 0 is zero-event years, 1 is frequency of events, 2 is inter-annual variability of frequency of events, 3 is event peak, 4 is event duration, 5 is inter-annual variability in event duration, P is likelihoods of positive ramifications, and N is likelihoods of negative ramifications. Scores under P and N column indicate relative ranking of the stations at their inferred ecological status and group-wise scores provide a basis for zonation of the stations.

7. CONCLUSIONS

Ecologically relevant characteristics of flow regime were reckoned in this study as efficient ecohydrological contrivance to surmise eco-ramifications from flow-ecology relationships, particularly for the Rufiji basin in Tanzania; thus providing a convenient way to portray the flow behavior oriented ecological status of the basin in a manner of cause and effect. The simple concept and method used here had been able to produce such desired outcome in the case where the time-series flow data were not completely regular both spatially and temporally and where there were no flow alteration reference to link with. In the full spectrum of eco-relevant flow statistics selected for this study, the stations namely Great Ruaha (Trace) at '1961-1980', Lukosi (Mtandika) at '1981-1997' and Kimani at '1998-2013' of Ruaha sub-basin and Mngeta at '1961-1980' of Kilombero sub-basin were relatively more responsive to negative ramifications associated with those parameters. And the stations namely Urobo (GNR) at '1961-1980', Ndembera (Madibira) and Little Ruaha (Ihimbu) at '1981-1997', and Mtitu at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin were relatively more responsive to positive ramifications associated with those parameters.

Great Ruaha (Trace) at '1961-1980' of Ruaha sub-basin were found to be responsive to the negative ramifications particularly associated with higher variability in annual flow-maxima, high flow pulses, inter-annual variability in the occurrence of small flood events, mean small and large flood maxima, and flow rising rates. Lukosi (Mtandika) at '1981-1997' of Ruaha sub-basin were found to be responsive to the negative ramifications particularly associated with higher variability in monthly low flow condition, frequency of extreme low flow, high flow and small flood events, inter-annual variability in the duration of high flow pulses, and mean large flood maxima. Kimani at '1998-2013' of Ruaha sub-basin were found to be particularly responsive to the negative ramifications associated with higher variability in annual water extremes, monthly low flow condition, frequency of extreme low flow events, and rate and frequency of water condition changes. Mngeta at '1961-1980' of Kilombero sub-basin were found to be particularly responsive to the negative ramifications associated with higher variability in annual flow-minima, inter-annual variability in the occurrence of small flood events, and rate and frequency of water condition changes. Thus, these stations might be inferred to be in critical ecological condition in Rufiji basin due to their variability in the aforementioned flow-metrics and associated negative ramifications on stream and ecosystem.

On the other hand, the stations namely Urobo (GNR) at '1961-1980', Ndembera (Madibira) and Little Ruaha (Ihimbu) at '1981-1997', and Mtitu at '1998-2013' of Ruaha sub-basin, and Hagafiro at '1961-1980' of Kilombero sub-basin might be inferred to be relatively stable against these negative ramifications on stream and ecosystem as to have the likelihood to use the advantages of those eco-relevant flow-metrics. Being suggested by maximum types of eco-relevant hydrological parameters, Kilombero sub-basin might be inferred to be in critical ecological condition in Rufiji basin whereas Ruaha sub-basin might be inferred to be relatively stable.

A zonation could also be possible to establish based on the criteria where particular ecologically relevant characteristics of flow-regime were in critical condition, in the same way suggested by the maximum number of flow-metrics. Thus, an annual extreme water pressure zone in the Rufiji basin, which was comprised of Great Ruaha (Trace) and Urobo (GNR) at '1961-1980', and Kimani at '1981-1997', and '1998-2013' in Ruaha, and Lumemo and Mngeta at '1961-1980' in Kilombero, might have likeliness of eco-ramifications related to loss of sensitive species, shock or stress, bio-impairment, migration, life-cycle disruption, reduced species richness, altered assemblage etc. Similarly, an extreme low flow pressure zone in the Rufiji basin, which was comprised of Ndembera (Madibira) at '1961-1980', Little Ruaha (Ihimbu) and Lukosi (Mtandika) at '1981-1997', and Little Ruaha (Mawande) at '1998-2013' in Ruaha, and Mpanga at '1961-1980' in Kilombero, might have likeliness of eco-ramifications related to removal of sensitive taxa, increment of opportunistic species, reconfiguration of food-web structure, mortality of temperature intolerant species etc. Likewise, a high flow pressure zone in the Rufiji basin, which was comprised of Great Ruaha (Trace) at '1961-1980', Lukosi (Mtandika) at '1981-1997', and Ndembera (Ilongo) at '1998-2013' in Ruaha, and Lumemo at '1961-1980' in Kilombero, might have likeliness of eco-ramifications related to failure of spawning and hatching, impact on early life stages, destruction of entire year-class etc. Also, a small flood pressure zone in the Rufiji basin, which was comprised of Great Ruaha (Trace) at '1961-1980' and Lukosi (Mtandika) at '1981-1997' in Ruaha, and the relative pressure zone of this kind could not be identified in Kilombero, might have likeliness of eco-ramifications related to larval transportation of opportunistic invasive, interference with recruitment, higher mortality of emergent fry, lower recovery after depletion etc. Besides, a large flood pressure zone in the Rufiji basin, which was comprised of Great Ruaha (Trace) at '1961-1980', Lukosi (Mtandika) at '1981-1997', and Great Ruaha (Salimwani) at '1998-2013' in Ruaha, and Mnyera (US Taveta Mission) at

'1961-1980' in Kilombero, might have likeliness of eco-ramifications related to flashing weaker swimmers (e.g., fry and juvenile), slower re-colonization of washed out biota, low diversity in periphytons etc. Finally, a water condition changing pressure zone in the Rufiji basin, which was comprised of Kimani at '1981-1997' and '1998-2013' in Ruaha, and Mngeta at '1961-1980' in Kilombero, might have likeliness of eco-ramifications related to drought stress at falls, entrapment in floodplains at rises, stress at frequent reversals, drowning of riparian vegetation, poor bank stability, rapid changes in flow speed etc.

The explored information from this study, which were about the relative responsiveness of the stations to ecosystem ramifications inferred from ecologically relevant characteristics of flow-regime, about the meticulous associations of the stations to these flow-metrics, about the interactions of more responsive stations with specific flow-metrics from the spectrum, and about the zonation based on criticalness of stations to flow-statistics oriented ramifications, may be very useful to the river basin managers for deciding future management measures and strategies of the Rufiji system. These sorts of information may guide subsequent environmental flow recommendations for achieving healthy river ecosystems in Rufiji basin. These statistics may be incorporated in the basin restoration plan to devise efficient starting point rather than to play haphazardly which may be a reference for fine-tuning any relevant hydrological modelling parameters planned for this basin. Knowledge on gross ecological status at particular river points and courses inferred from these statistics may help to set spatial prioritization of research needs in the basin. The results of this study in total may serve as a useful model for the other river basins of the region.

Environmental flows can be prescribed for the catchment, even for the sub-catchments, as part of a long-term and adaptive management strategy, in a process run subsequent to this study to address the inferred ramifications on stream and ecosystem there in Rufiji basin. The most important water management challenges in this system may be expected in coming years, since the economic activities, which might have been several folds higher in recent past than the long past due to meet the increased demand of water, may continue to increase with addition of new plans for more anthropogenic modifications in the basin. Choices about the design and operation of any new initiatives or even about the decision of next-days management strategies in the places with inferred conditions of ecological criticalness in the Rufiji basin may persuade ecological breakdown of the river system and dependent terrestrial systems (based on McClain et al., 2014). To face such future water management challenges

in a region of greater interest of water security like East African nation Tanzania, such a prior investigation of stream and ecosystem conditions, which may seem to be a big challenge initially for a large basin like Rufiji, can conveniently and efficiently be done by the advent of ecohydrological clues of eco-relevant flow metrics. Hence, the inference of ecological status from flow-ecology relationships in this current study appears to be a milestone in Rufiji basin ecohydrology.

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Appendix

Computed statistics of ecologically relevant
hydrological parameters
(Case: Rufiji basin in Tanzania)

Table 9.1. Column headings' attributes of Table 9.2

<i>CH_T9.2*</i>	<i>Category</i>	<i>Eco-relevant Attributes</i>
1		Mean flow for January
2		Mean flow for February
3		Mean flow for March
4		Mean flow for April
5		Mean flow for May
6	Monthly water conditions	Mean flow for June
7		Mean flow for July
8		Mean flow for August
9		Mean flow for September
10		Mean flow for October
11		Mean flow for November
12		Mean flow for December
13	Annual extreme water conditions	Annual minima, 1-day mean
14		Annual minima, 3-day means
15		Annual minima, 7-day means
16		Annual minima, 30-day means
17		Annual maxima, 1-day mean
18		Annual maxima, 3-day means
19		Annual maxima, 7-day means
20		Annual maxima, 30-day means
21	Monthly low flows	Mean low flow for January
22		Mean low flow for February
23		Mean low flow for March
24		Mean low flow for April
25		Mean low flow for May
26		Mean low flow for June
27		Mean low flow for July
28		Mean low flow for August
29		Mean low flow for September
30		Mean low flow for October
31		Mean low flow for November
32		Mean low flow for December
33	Extreme low flows	Frequency of events per year
34		Mean peak flow (minimum)
35		Mean duration (days) of events
36	High flow pulses	Frequency of events per year
37		Mean peak flow (maximum)
38		Mean duration (days) of events
39	Small floods	Frequency of events per year
40		Mean peak flow (maximum)
41		Mean duration (days) of events
42	Large floods	Frequency of events per year
43		Mean peak flow (maximum)
44		Mean duration (days) of events
45	Water condition changes	Falling rate (m ³ /sec per falling day)
46		Rising rate (m ³ /sec per rising day)
47		Hydrologic reversals (times/year)

* CH_T9.2 = Column headings of Table 9.2

Table 9.2.1. Eco-relevant statistics of Sub-basin: Ruaha, Station: Gr. Ruaha (Trace), Series: 1961-1980 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1961	9.14	32.46	48.40	52.16	30.37	14.27	8.87	5.50	3.15	NA	NA	246.12	2.23	2.23	2.23	2.23	510.70	468.40	438.01	253.36	6.19	11.00	27.80	39.70
1962	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1963	224.09	450.93	532.10	444.00	269.92	96.33	46.93	27.15	23.86	15.14	24.27	147.74	11.00	11.27	11.63	12.62	811.00	795.00	764.43	551.43	NA	NA	NA	NA
1964	383.13	455.55	639.58	490.47	259.79	116.24	NA	44.23	29.99	NA	13.09	12.20	10.51	10.66	10.93	11.28	857.00	789.00	739.43	643.67	NA	NA	NA	NA
1965	42.17	41.89	81.05	161.96	125.66	60.84	34.23	22.99	14.58	10.18	7.31	35.73	6.19	6.19	6.31	7.31	360.10	317.77	237.03	171.78	19.80	19.10	NA	NA
1966	64.88	114.12	213.10	250.47	146.84	56.96	26.16	14.26	NA	5.75	5.99	16.15	3.32	3.49	3.76	4.67	550.80	521.17	454.10	295.93	36.50	NA	NA	NA
1967	22.59	36.84	67.04	NA	179.44	102.61	47.60	25.78	14.09	8.46	9.14	521.71	5.39	5.39	5.39	6.26	963.00	953.67	940.29	537.83	17.25	22.16	37.90	NA
1968	743.84	635.45	NA	NA	535.07	209.19	99.49	58.76	39.38	26.65	18.91	26.02	16.01	16.01	16.43	18.12	932.00	932.00	932.00	932.00	NA	NA	NA	NA
1969	42.23	274.56	218.56	119.98	73.74	37.88	21.86	14.74	9.61	5.85	3.51	7.76	2.67	2.72	2.97	3.48	544.70	532.50	448.83	302.71	35.70	NA	NA	NA
1970	177.52	341.89	399.45	524.87	238.47	88.11	39.88	25.38	17.08	11.54	6.43	48.30	4.93	5.02	5.21	6.07	849.00	822.00	754.86	552.63	12.10	NA	NA	NA
1971	78.73	236.04	213.88	143.43	75.20	32.25	19.67	12.47	7.17	4.78	3.22	NA	2.00	2.13	2.38	3.06	358.30	346.33	311.34	253.87	NA	NA	NA	NA
1972	49.51	178.58	249.14	272.31	153.24	NA	28.15	15.66	9.65	5.28	3.85	129.15	3.42	3.42	3.42	3.82	433.90	369.50	317.04	275.69	29.90	43.80	NA	NA
1973	313.46	347.07	314.16	245.72	143.09	NA	NA	NA	10.05	5.03	NA	15.29	3.83	3.83	3.83	3.83	614.10	544.23	491.20	381.16	NA	NA	NA	NA
1974	26.41	39.77	61.76	207.86	255.87	NA	61.98	30.91	14.10	7.80	5.71	11.95	4.27	4.27	4.27	4.85	532.50	505.80	427.11	259.06	12.99	34.03	43.50	NA
1975	87.69	88.73	146.33	121.92	78.30	41.36	19.46	11.47	7.57	4.60	2.80	NA	2.00	2.00	2.00	2.00	259.00	246.27	211.93	156.28	29.90	NA	NA	NA
1976	58.40	61.21	118.45	165.14	119.03	55.48	22.17	10.85	5.92	3.53	2.18	3.23	1.71	1.71	1.71	2.18	260.90	236.13	202.74	171.49	21.20	39.80	NA	NA
1977	69.57	198.41	79.49	75.85	69.65	37.58	13.76	5.32	1.73	NA	NA	NA	1.08	1.08	1.14	1.14	529.90	501.73	423.11	195.27	4.30	NA	NA	NA
1978	NA	211.69	649.13	561.17	NA	NA	NA	10.23	5.10	2.37	NA	148.32	1.57	1.57	1.57	1.57	1123.00	1112.00	1034.57	829.60	NA	NA	NA	NA
1979	122.02	589.00	593.10	736.17	479.90	227.70	69.96	30.94	16.31	7.65	4.69	56.12	3.83	4.05	4.19	4.69	1014.00	1008.33	969.86	758.70	NA	NA	NA	NA
1980	147.05	232.41	223.88	271.75	162.95	76.06	33.60	19.10	NA	NA	NA	NA	15.50	15.50	15.50	15.50	556.20	524.17	447.16	285.03	NA	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1961	21.53	10.51	7.05	3.95	2.23	NA	NA	13.40	1	2.23	24	5	139.73	26	1	510.70	1	NA	NA	NA	9.07	16.81	101	
1962	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1963	NA	NA	32.50	16.28	19.33	12.21	11.00	NA	NA	NA	NA	6	363.53	44	5	471.86	1	NA	NA	NA	10.45	38.12	91	
1964	NA	NA	NA	34.50	22.86	NA	10.95	10.51	NA	NA	NA	2	429.00	117	NA	NA	NA	1	857.00	NA	12.92	35.30	70	
1965	NA	43.00	28.42	17.25	12.21	8.45	6.19	8.61	NA	NA	NA	5	118.44	46	1	360.10	1	NA	NA	NA	3.42	9.44	87	
1966	NA	36.50	18.10	11.63	NA	5.01	3.32	7.05	1	3.32	4	2	293.69	101	1	550.80	1	NA	NA	NA	6.90	15.99	97	
1967	NA	NA	34.80	17.25	10.95	6.19	5.39	34.00	NA	NA	NA	6	226.32	34	1	197.30	1	1	963.00	1	5.38	12.62	135	
1968	NA	NA	NA	NA	32.50	20.95	18.10	16.01	NA	NA	NA	4	457.98	61	NA	NA	NA	2	923.00	1	12.01	18.09	95	
1969	NA	28.73	17.67	12.21	7.59	4.09	2.67	3.20	3	3.09	13	1	535.20	186	1	544.70	1	NA	NA	NA	3.42	11.96	71	
1970	NA	NA	31.30	20.49	13.24	8.94	4.93	5.20	NA	NA	NA	4	255.50	60	2	506.80	1	NA	NA	NA	9.65	24.78	83	
1971	NA	23.84	16.38	9.32	5.47	3.42	2.00	NA	2	2.71	20	1	357.60	176	1	358.30	1	NA	NA	NA	3.53	11.94	76	
1972	NA	NA	21.19	12.01	7.11	3.83	3.42	5.50	5	3.75	5	3	243.13	66	2	420.50	1	NA	NA	NA	9.47	26.54	82	
1973	NA	NA	NA	NA	6.82	3.83	NA	4.50	1	3.83	5	3	215.85	51	1	614.10	1	NA	NA	NA	14.46	42.75	62	
1974	NA	NA	NA	19.93	10.00	5.99	4.27	4.27	NA	NA	NA	3	212.78	62	1	532.50	1	NA	NA	NA	6.90	17.87	93	
1975	NA	28.10	13.80	9.65	6.26	3.83	2.00	NA	1	2.00	35	1	242.60	184	1	259.00	1	NA	NA	NA	4.00	16.25	79	
1976	NA	35.70	13.80	8.02	4.50	2.66	1.71	2.00	2	2.19	40	1	242.60	188	1	260.90	1	NA	NA	NA	2.32	6.51	75	
1977	NA	23.84	8.02	3.42	1.08	NA	NA	NA	1	1.08	36	2	303.30	87	1	529.90	1	NA	NA	NA	7.02	26.27	68	
1978	NA	NA	NA	7.41	3.42	1.57	NA	3.80	2	2.69	18	2	743.85	53	1	452.50	1	1	1123.00	1	21.17	53.26	64	
1979	NA	NA	43.50	22.76	10.71	5.73	3.83	7.60	1	3.83	1	2	603.35	125	1	229.60	1	1	1014.00	1	14.15	43.94	68	
1980	NA	NA	24.39	15.50	NA	NA	NA	NA	NA	NA	NA	1	512.10	209	1	556.20	1	NA	NA	NA	7.33	29.25	52	

Table 9.2.2. Eco-relevant statistics of Sub-basin: Ruaha, Station: Lit. Ruaha (Uhimbu), Series: 1961-1980 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1961	10.38	16.69	20.58	14.46	12.85	7.66	7.09	5.50	4.48	3.79	5.32	NA	3.29	3.40	3.55	3.77	27.29	26.18	23.51	21.16	6.14	11.55	NA	10.75
1962	42.20	49.27	78.95	57.20	32.54	23.00	18.12	15.34	11.65	10.93	8.39	10.80	6.61	6.70	6.84	8.00	121.10	103.50	90.14	79.72	NA	NA	NA	NA
1963	23.39	35.81	50.54	43.11	28.87	20.95	16.81	13.35	10.60	7.66	8.66	NA	6.68	6.74	6.81	7.08	83.70	80.97	73.07	56.82	NA	NA	NA	NA
1964	33.25	45.00	50.52	41.20	25.89	19.44	16.06	13.73	10.85	8.28	6.58	8.54	5.35	5.60	6.04	6.52	66.80	63.73	62.06	42.42	8.99	10.83	NA	NA
1965	14.18	17.85	34.75	36.99	20.80	14.73	11.77	10.30	8.25	7.07	5.93	11.73	4.62	4.63	4.66	5.90	66.99	66.06	62.96	42.42	8.99	10.83	NA	NA
1966	14.72	14.48	NA	25.91	15.78	12.52	10.05	7.87	6.11	4.82	NA	8.69	4.62	4.62	4.62	4.62	32.70	32.12	31.56	29.70	12.28	12.77	NA	NA
1967	11.61	NA	25.93	39.24	28.17	19.28	14.61	12.59	9.92	7.13	NA	NA	6.09	6.09	6.09	6.09	74.60	61.60	55.17	40.08	9.67	NA	NA	NA
1968	31.17	42.00	57.19	75.15	45.90	31.53	24.75	19.41	16.03	11.14	9.44	15.93	5.47	7.70	8.33	9.44	110.80	101.70	91.54	75.16	NA	NA	NA	NA
1969	22.06	24.84	24.26	23.20	18.06	12.04	9.14	7.44	5.77	4.57	4.10	NA	3.31	3.43	3.62	3.85	30.05	28.64	26.49	24.90	NA	NA	NA	NA
1970	21.46	29.68	41.63	30.53	18.41	13.56	10.58	8.70	7.13	6.95	4.98	17.31	4.35	4.46	4.55	4.98	62.90	59.30	55.63	45.94	9.20	NA	NA	NA
1971	20.08	21.35	22.54	19.14	13.75	8.51	7.74	7.13	6.02	6.27	4.74	NA	3.64	3.69	3.79	4.51	37.53	33.92	27.97	23.42	12.56	NA	NA	NA
1972	20.06	20.11	34.04	32.92	20.84	13.95	11.37	8.75	7.36	6.15	5.95	13.28	5.03	5.08	5.44	5.89	57.34	50.63	44.25	37.95	11.28	NA	NA	NA
1973	NA	27.70	36.00	27.39	20.29	13.56	11.01	9.18	7.34	5.87	5.57	9.94	4.35	4.42	4.48	5.00	49.93	44.96	41.76	36.20	NA	NA	NA	NA
1974	21.15	28.92	27.18	39.89	33.54	18.86	15.07	11.04	8.78	6.85	6.38	9.46	4.48	4.53	5.00	5.99	56.35	54.26	52.10	42.18	9.50	NA	NA	NA
1975	NA	27.39	41.57	31.65	24.13	16.18	12.53	10.02	8.35	6.45	4.53	12.09	3.96	4.05	4.13	4.46	58.90	56.47	55.27	42.60	NA	NA	NA	NA
1976	23.12	27.42	34.49	37.27	22.75	17.28	13.81	10.2	NA	5.66	4.42	5.17	3.90	3.94	4.05	4.40	56.03	49.87	48.24	40.25	12.69	NA	NA	NA
1977	12.32	9.50	13.44	15.08	11.46	7.15	5.81	5.15	3.67	2.72	4.40	7.94	2.53	2.53	2.53	2.68	22.46	20.06	18.94	15.08	7.26	7.03	7.11	11.19
1978	15.10	19.11	43.27	30.15	18.92	12.35	9.58	7.73	6.01	4.43	4.79	9.39	2.87	3.06	3.26	3.72	64.70	57.57	49.86	45.41	10.20	12.34	NA	NA
1979	14.32	24.10	31.58	35.40	27.17	19.72	14.32	10.50	7.97	5.84	4.98	13.32	4.48	4.48	4.49	4.69	63.67	54.35	46.68	35.70	10.73	NA	12.30	NA
1980	22.94	21.62	25.24	30.00	21.26	14.51	10.83	9.28	7.33	6.07	5.53	12.24	4.76	4.85	5.00	5.41	45.28	42.48	40.87	32.60	NA	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1961	9.07	6.87	6.09	4.84	4.09	3.29	3.99	NA	2	3.64	34	2	18.87	62	1	27.29	1	NA	NA	NA	0.85	1.33	133	
1962	NA	NA	NA	13.78	9.90	9.29	7.01	6.61	NA	NA	NA	5	49.89	58	2	20.42	1	2	107.95	1	2.10	4.19	137	
1963	NA	NA	NA	12.03	8.99	6.87	6.68	NA	NA	NA	NA	3	35.57	88	NA	NA	NA	1	83.70	1	1.26	2.35	139	
1964	NA	NA	NA	12.52	9.33	7.03	6.09	5.35	NA	NA	NA	3	30.61	91	1	17.41	1	1	66.80	1	1.56	3.02	130	
1965	NA	12.77	10.83	9.44	7.18	5.91	4.62	4.84	2	4.62	1	4	29.62	58	2	21.60	1	1	66.99	1	1.15	2.31	129	
1966	13.23	11.79	8.55	7.28	5.10	4.62	NA	5.90	4	4.62	2	4	20.29	40	2	27.73	1	NA	NA	0.64	1.10	109		
1967	NA	NA	13.78	10.36	8.34	6.09	NA	NA	NA	NA	NA	6	19.52	36	NA	NA	NA	1	74.60	1	1.30	3.53	85	
1968	NA	NA	NA	NA	13.53	9.12	5.47	8.87	NA	NA	NA	6	35.38	53	2	37.84	1	1	110.80	1	1.60	3.76	113	
1969	NA	9.69	7.81	6.80	5.01	3.75	3.31	NA	2	3.67	19	1	28.81	169	1	30.05	1	1	NA	NA	0.55	1.00	96	
1970	NA	12.41	9.31	7.82	6.16	5.66	4.35	6.72	2	4.47	4	4	28.07	55	2	44.03	1	1	NA	NA	1.10	2.64	104	
1971	9.69	7.59	7.27	6.64	5.60	4.62	3.64	NA	2	4.13	12	2	22.37	75	1	37.53	1	1	NA	NA	0.76	1.69	83	
1972	NA	11.93	9.93	8.06	6.41	5.45	5.03	8.57	NA	NA	NA	5	21.69	45	3	32.33	1	1	NA	NA	1.17	2.28	117	
1973	NA	12.31	10.38	8.23	6.49	5.03	4.35	5.38	1	4.35	13	5	19.87	38	2	33.74	1	1	NA	NA	0.91	1.92	106	
1974	NA	NA	12.78	9.76	7.42	5.60	4.62	4.48	2	4.55	2	5	21.42	49	2	36.85	1	1	NA	NA	1.34	2.30	122	
1975	NA	NA	10.82	8.90	7.58	5.60	3.96	4.09	2	4.22	16	3	30.89	68	2	39.54	1	1	NA	NA	0.80	1.81	97	
1976	NA	NA	12.49	NA	NA	5.03	3.96	3.90	4	4.19	9	1	54.16	212	1	56.03	1	1	NA	NA	1.07	2.10	98	
1977	8.64	6.18	5.45	4.62	2.87	2.53	2.87	4.82	4	3.05	21	6	15.97	18	2	20.02	1	1	NA	NA	0.62	1.35	106	
1978	NA	10.82	8.73	6.79	5.17	3.96	2.87	5.53	1	2.87	46	6	22.13	31	2	22.43	1	1	64.70	1	1.02	2.57	109	
1979	NA	NA	11.74	9.07	6.79	5.03	4.48	7.74	2	4.48	11	4	28.91	59	2	27.40	1	1	63.67	1	1.27	2.36	114	
1980	NA	11.56	9.93	8.90	6.49	4.89	4.76	4.89	NA	NA	NA	4	24.72	54	3	29.11	1	1	NA	NA	0.87	1.95	100	

Table 9.2.3. Eco-relevant statistics of Sub-basin: Ruaha, Station: Lit. Ruaha (Mawande), Series: 1961-1980 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1961	12.81	20.70	23.85	15.20	11.77	8.04	7.80	5.92	4.72	3.92	6.46	NA	3.51	3.51	3.64	3.86	32.72	32.22	29.36	24.36	6.03	14.58	NA	11.13
1962	48.36	34.67	49.93	38.87	29.27	24.33	21.07	18.25	15.19	14.25	11.37	12.82	9.25	9.40	9.54	10.74	102.75	99.65	82.91	50.24	NA	NA	NA	NA
1963	24.54	29.69	34.82	31.97	24.18	19.26	16.44	12.50	10.00	8.02	8.70	12.30	7.47	7.47	7.63	7.63	50.80	47.09	45.06	38.29	NA	NA	NA	NA
1964	24.09	30.19	36.82	33.21	23.06	19.76	17.58	15.85	13.12	10.52	8.99	8.77	7.99	8.05	8.27	8.59	55.71	48.84	45.97	39.71	13.91	NA	NA	NA
1965	13.17	14.68	21.16	22.85	15.59	10.92	8.87	7.77	6.41	5.62	5.17	8.24	4.52	4.66	4.70	5.15	34.93	34.50	32.64	25.15	9.82	10.99	14.75	NA
1966	12.63	16.91	21.91	22.90	14.90	11.29	9.60	8.35	7.43	6.98	7.66	10.00	6.21	6.23	6.39	6.84	36.92	31.76	29.97	24.86	9.89	9.52	14.47	NA
1967	11.76	12.15	18.08	25.95	17.54	12.56	10.00	9.21	8.37	7.35	9.28	35.22	6.36	6.37	6.55	6.97	68.39	57.36	45.81	35.95	9.83	9.54	13.26	NA
1968	34.78	36.84	46.64	56.23	38.69	33.58	29.41	22.79	17.73	13.94	11.60	22.41	10.45	10.46	10.78	11.45	96.92	88.87	83.44	56.60	NA	NA	NA	NA
1969	23.03	31.79	25.52	23.80	16.13	10.04	7.66	6.26	5.21	3.92	3.64	NA	2.98	3.06	3.21	3.50	84.32	66.73	49.98	32.34	NA	NA	NA	NA
1970	NA	44.38	60.72	51.09	29.33	22.08	19.72	17.59	15.40	14.35	11.67	23.30	10.93	11.09	11.31	11.67	179.00	105.74	87.66	68.06	NA	NA	NA	NA
1971	28.30	29.97	27.41	21.70	15.21	10.58	9.44	7.73	6.58	6.50	5.52	9.63	4.79	4.84	4.93	5.36	39.55	36.97	35.75	32.03	NA	NA	NA	NA
1972	18.47	18.83	49.04	46.55	25.52	11.99	8.31	5.68	4.47	3.20	3.27	8.94	2.62	2.69	2.78	3.10	91.87	80.14	69.53	57.12	11.41	11.98	NA	NA
1973	NA	48.21	49.29	37.43	22.70	12.29	9.59	7.92	6.18	4.61	5.06	NA	3.67	3.71	3.77	4.04	69.53	67.95	64.63	51.06	NA	NA	NA	NA
1974	20.95	27.91	22.20	37.57	43.78	17.67	13.63	10.02	7.73	5.99	5.51	9.69	4.55	4.72	4.82	5.27	61.45	60.62	57.57	47.13	10.72	NA	NA	NA
1975	36.28	26.53	46.89	29.59	20.25	12.48	9.02	7.34	5.97	4.40	3.53	21.33	3.16	3.22	3.31	3.43	64.10	60.81	57.07	48.01	NA	NA	NA	NA
1976	27.89	26.64	38.41	39.75	21.43	14.10	10.78	8.59	6.56	5.24	4.09	5.59	3.29	3.36	3.46	4.03	48.81	47.86	46.51	42.75	13.40	NA	NA	NA
1977	24.00	21.28	19.17	17.40	13.41	7.98	6.21	5.49	3.75	2.82	4.98	NA	2.50	2.51	2.63	2.80	41.84	36.51	34.16	27.14	7.51	10.99	12.52	13.48
1978	52.58	54.21	82.59	64.70	41.52	26.47	17.49	10.92	6.80	4.30	4.89	21.21	2.92	3.04	3.14	3.51	158.64	117.40	111.12	89.55	NA	NA	NA	NA
1979	35.04	60.64	NA	74.92	65.47	52.53	44.46	39.22	33.65	27.80	NA	NA	19.18	19.18	19.18	19.18	94.77	91.38	87.48	77.36	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1961	9.63	6.58	6.96	5.11	4.28	3.51	3.51	NA	1	3.51	24	3	22.56	43	1	32.72	1	NA	NA	NA	0.88	1.88	106	
1962	NA	NA	NA	NA	13.89	12.79	10.18	9.25	NA	NA	NA	7	25.97	48	NA	NA	NA	1	102.75	NA	1.18	2.81	114	
1963	NA	NA	14.06	10.90	9.01	7.47	7.47	11.16	NA	NA	NA	2	30.57	137	1	50.80	1	NA	NA	NA	0.55	1.52	88	
1964	NA	NA	NA	14.66	11.96	9.44	8.76	7.99	NA	NA	NA	1	52.01	281	1	55.71	1	NA	NA	NA	0.68	2.45	76	
1965	12.58	9.44	8.09	7.09	5.88	5.28	4.52	4.76	NA	NA	NA	4	18.69	40	1	34.93	1	NA	NA	NA	0.37	0.69	71	
1966	12.38	10.23	8.82	7.49	7.15	6.83	6.21	7.21	NA	NA	NA	6	17.22	27	2	32.11	1	NA	NA	NA	0.79	1.62	87	
1967	13.19	10.90	9.48	8.79	7.79	7.02	6.36	11.02	NA	NA	NA	4	31.57	51	2	55.75	1	NA	NA	NA	1.04	1.89	95	
1968	NA	NA	NA	NA	NA	12.46	10.45	10.77	NA	NA	NA	4	47.92	89	3	61.24	1	1	96.92	1	0.92	3.20	76	
1969	12.17	7.60	6.84	5.56	4.25	3.56	2.98	NA	2	3.38	29	1	59.56	161	1	84.32	1	NA	NA	NA	0.60	2.67	54	
1970	NA	NA	NA	NA	13.82	12.63	10.93	13.85	NA	NA	NA	2	57.62	166	1	32.02	1	1	179.00	1	1.46	3.98	94	
1971	12.18	9.89	8.97	7.07	6.16	5.45	4.79	6.29	NA	NA	NA	2	26.95	82	1	39.55	1	NA	NA	NA	0.44	0.91	84	
1972	NA	9.16	6.94	4.93	3.31	2.62	2.68	5.38	3	3.64	23	3	34.11	57	1	91.87	1	NA	NA	0.82	1.96	106		
1973	14.31	10.89	8.74	7.42	5.20	4.07	3.67	NA	1	3.67	23	3	30.53	49	1	69.53	1	NA	NA	0.74	1.40	83		
1974	NA	14.91	11.52	8.60	6.73	5.19	4.55	4.78	NA	NA	NA	4	33.31	54	2	49.59	1	NA	NA	0.83	1.97	118		
1975	NA	10.58	7.63	6.73	5.18	4.00	3.22	3.16	1	3.16	39	2	47.65	99	2	51.10	1	NA	NA	1.09	2.03	122		
1976	NA	12.20	9.43	7.17	5.84	4.84	3.29	3.67	3	3.62	8	1	48.05	191	1	48.81	1	NA	NA	0.63	1.40	115		
1977	9.69	6.42	5.74	4.78	3.27	2.50	2.86	NA	4	3.66	16	2	26.80	71	1	41.84	1	NA	NA	1.00	2.38	94		
1978	NA	NA	13.91	8.25	5.38	3.54	2.92	6.76	1	2.92	36	4	61.75	62	2	57.85	1	1	158.64	1	2.01	7.06	86	
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	86.91	134	NA	NA	NA	2	93.80	NA	1.28	3.58	78	
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

Table 9.2.4. Eco-relevant statistics of Sub-basin: Ruaha, Station: Urobo (GNR), Series: 1961-1980 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1961	0.40	0.77	1.06	0.88	0.95	0.72	0.42	0.28	0.17	0.24	0.41	0.70	0.05	0.05	0.09	0.12	2.83	1.86	1.59	1.09	0.35	NA	NA	NA
1962	2.25	1.78	1.96	1.85	1.10	0.62	0.49	NA	0.47	0.41	0.42	0.53	0.34	0.35	0.37	0.41	3.47	3.31	3.18	2.48	NA	NA	NA	NA
1963	1.48	1.47	2.11	3.12	1.49	0.65	0.46	NA	1.38	NA	NA	0.02	0.01	0.01	0.01	0.01	3.65	3.60	3.54	3.20	NA	NA	NA	NA
1964	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1965	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1966	0.56	0.81	1.50	1.57	0.69	0.42	0.41	0.41	0.45	0.43	0.37	0.44	0.30	0.30	0.33	0.36	2.69	2.54	2.23	1.97	0.33	NA	NA	NA
1967	0.37	0.47	0.59	1.20	0.76	0.42	0.32	0.29	0.28	0.24	0.24	0.70	0.17	0.17	0.17	0.20	2.55	2.02	1.80	1.28	0.27	0.35	NA	NA
1968	1.19	0.94	1.41	1.39	0.77	0.39	0.33	0.36	0.42	0.22	0.25	0.31	0.17	0.18	0.19	0.20	1.82	1.75	1.67	1.53	NA	NA	NA	NA
1969	0.36	0.94	0.66	0.59	0.53	0.32	0.30	0.33	0.34	0.29	0.25	0.25	0.17	0.18	0.21	0.25	1.90	1.32	1.30	0.99	0.22	0.37	NA	NA
1970	NA	0.73	1.45	1.19	0.65	0.33	0.33	0.39	0.40	0.40	0.24	0.29	0.16	0.16	0.17	0.19	2.03	2.03	1.90	1.55	NA	0.37	NA	NA
1971	0.51	0.89	0.99	0.82	0.98	0.36	0.30	0.27	0.27	0.27	0.17	0.22	0.13	0.14	0.15	0.17	1.47	1.47	1.47	1.12	0.34	NA	NA	NA
1972	0.24	0.12	1.24	1.31	0.81	0.39	0.27	0.27	0.25	0.23	0.26	0.30	0.07	0.07	0.07	0.09	1.96	1.96	1.96	1.58	0.08	0.07	0.17	NA
1973	0.44	0.81	0.94	1.02	0.70	0.38	0.30	0.25	0.23	0.15	0.15	0.18	0.14	0.14	0.14	0.15	1.24	1.24	1.24	1.16	0.31	NA	NA	NA
1974	0.31	0.48	0.38	1.69	1.34	0.43	0.30	0.23	0.28	0.27	0.22	0.30	0.07	0.09	0.13	0.22	2.62	2.37	2.15	1.87	0.16	0.32	0.07	NA
1975	0.48	0.57	1.42	1.76	1.24	0.47	0.38	0.39	0.37	0.31	NA	NA	0.18	0.19	0.19	0.19	3.21	2.97	2.63	2.12	0.31	0.35	NA	NA
1976	0.37	0.47	1.37	1.83	1.12	0.46	0.38	0.34	0.28	0.31	0.25	0.28	0.16	0.19	0.22	0.25	3.65	2.72	2.61	2.14	0.25	0.25	NA	NA
1977	0.43	0.44	0.31	0.88	0.70	0.28	0.19	0.16	0.17	0.13	0.12	0.22	0.09	0.09	0.10	0.12	1.26	1.23	1.14	0.91	0.30	0.31	0.25	0.25
1978	0.23	0.38	2.20	1.29	0.41	0.29	0.27	0.25	0.20	0.16	0.12	0.24	0.07	0.08	0.09	0.11	3.92	3.80	3.35	2.50	0.16	0.20	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	0.38	0.38	0.54	0.93	0.93	0.30	0.22	0.32	0.34	0.30	NA	0.70	0.20	0.20	0.20	0.20	2.58	1.48	1.39	1.23	0.29	0.27	0.33	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1961	NA	NA	NA	0.23	0.12	0.05	0.30	NA	1	0.05	36	3	1.17	93	2	0.88	2	1	2.83	1	0.11	0.17	109	
1962	NA	NA	NA	NA	0.34	0.34	0.36	0.36	NA	NA	NA	2	2.04	164	1	0.71	1	1	3.47	2	0.09	0.21	101	
1963	NA	NA	NA	NA	NA	NA	NA	0.01	2	0.01	15	2	2.49	111	1	1.43	20	1	3.65	1	0.13	0.19	79	
1964	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1965	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1966	NA	0.34	0.35	0.33	NA	NA	0.30	0.33	NA	NA	NA	6	0.89	54	5	0.71	3	1	2.69	1	0.18	0.26	114	
1967	NA	0.33	0.22	0.27	0.24	0.17	0.17	0.27	NA	NA	NA	9	0.68	21	4	1.22	1	1	2.55	1	0.10	0.12	99	
1968	NA	0.30	0.30	0.30	0.37	0.17	0.20	0.20	NA	NA	NA	7	0.61	33	2	0.65	5	1	1.82	1	0.05	0.06	102	
1969	NA	0.28	0.27	0.28	0.33	0.26	0.22	0.17	NA	NA	NA	10	0.46	16	4	0.45	1	1	1.90	1	0.05	0.09	95	
1970	NA	0.27	0.27	0.36	0.38	0.38	0.16	0.17	1	0.16	3	5	0.79	49	2	0.64	7	1	2.03	3	0.04	0.07	57	
1971	NA	0.22	0.26	0.26	0.23	0.16	0.13	0.17	2	0.15	6	3	0.65	59	1	1.47	7	NA	NA	NA	0.06	0.06	51	
1972	NA	0.23	0.23	0.23	0.19	0.19	0.23	0.26	1	0.07	35	2	1.41	47	1	1.20	1	1	1.96	7	0.07	0.09	41	
1973	NA	0.28	0.28	0.23	0.23	0.14	0.14	0.14	2	0.15	35	1	1.13	170	1	1.24	2	NA	NA	NA	0.04	0.06	33	
1974	NA	0.28	0.23	0.22	0.23	0.19	0.19	0.19	2	0.12	5	9	0.67	15	6	0.73	1	1	2.62	1	0.07	0.12	115	
1975	NA	NA	0.35	0.35	0.33	0.18	NA	NA	NA	NA	NA	6	0.80	43	NA	NA	NA	1	3.21	1	0.09	0.17	110	
1976	NA	0.38	0.38	0.29	0.20	0.25	0.16	0.20	1	0.16	1	7	0.78	30	3	0.62	1	1	3.65	1	0.08	0.12	134	
1977	NA	0.20	0.16	0.12	0.14	0.09	0.09	0.10	7	0.13	16	8	0.57	15	5	0.79	1	NA	NA	NA	0.05	0.09	116	
1978	0.31	0.27	0.27	0.18	0.20	0.14	0.07	0.12	3	0.13	22	4	1.27	22	4	0.87	1	1	3.92	1	0.11	0.18	100	
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1980	NA	0.20	0.20	0.25	0.29	0.25	NA	0.20	NA	NA	NA	12	0.59	16	4	0.58	1	2	2.10	1	0.08	0.15	112	

Table 9.2.5. Eco-relevant statistics of Sub-basin: Ruaha, Station: Lit. Ruaha (Iwawa), Series: 1961-1980 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1961	6.34	10.94	14.01	9.80	7.76	4.97	4.17	2.84	1.97	1.27	1.44	6.59	1.08	1.08	1.10	1.16	26.06	21.71	18.96	14.72	4.30	7.44	NA	7.08
1962	25.26	39.63	58.15	48.89	26.36	16.90	13.11	11.00	8.41	7.25	5.60	6.98	4.10	4.30	4.60	5.15	90.70	76.40	66.49	59.80	7.29	NA	NA	NA
1963	15.86	27.45	40.22	31.53	21.61	15.03	12.05	9.56	7.42	5.06	4.87	NA	3.99	4.02	4.18	4.31	59.20	57.40	53.89	43.68	NA	NA	NA	NA
1964	24.56	35.35	36.15	27.38	17.56	13.13	10.58	9.01	6.93	5.09	NA	NA	4.15	4.15	4.15	4.15	52.21	47.54	45.78	36.96	NA	NA	NA	NA
1965	6.81	10.76	NA	25.30	14.46	9.87	7.04	5.99	4.63	3.63	2.46	5.00	1.65	1.69	1.82	2.40	45.10	45.10	45.10	45.10	5.57	6.42	NA	NA
1966	9.00	7.97	11.96	17.51	11.14	7.34	6.11	4.77	3.43	2.13	NA	4.48	1.94	1.94	1.94	1.94	20.46	20.41	20.16	17.71	6.42	7.28	NA	NA
1967	6.29	9.98	18.63	26.37	19.27	13.78	10.30	7.85	5.96	4.19	4.90	15.27	3.04	3.04	3.26	3.56	45.80	42.43	37.83	27.12	5.36	5.78	NA	NA
1968	20.41	30.58	40.68	57.16	38.34	24.11	17.23	12.96	9.60	6.32	4.98	8.65	4.68	4.73	4.77	4.93	79.50	73.57	66.03	57.16	NA	NA	NA	NA
1969	13.84	17.81	18.67	16.87	12.17	8.07	5.76	4.68	3.39	2.24	1.47	NA	1.04	1.05	1.08	1.31	27.02	23.08	20.76	19.01	NA	NA	NA	NA
1970	11.28	17.33	29.08	22.20	12.75	8.70	6.64	5.39	4.29	4.80	NA	10.55	3.72	3.72	3.76	3.79	50.92	44.47	40.48	32.71	4.45	7.32	NA	NA
1971	11.64	12.20	13.43	9.59	7.35	5.09	4.23	3.03	2.10	1.88	1.51	3.70	1.13	1.14	1.20	1.47	21.52	19.11	15.68	14.54	8.31	NA	NA	7.95
1972	10.95	8.12	23.71	22.01	13.46	8.44	6.46	5.15	3.87	2.85	2.52	7.94	2.10	2.12	2.15	2.44	51.05	43.29	36.26	27.73	5.96	5.46	NA	5.14
1973	12.99	14.22	23.32	19.14	13.16	8.44	6.46	5.27	3.77	2.39	2.18	5.36	1.40	1.44	1.51	1.80	40.18	34.21	29.92	24.15	6.16	NA	NA	NA
1974	12.49	19.89	14.20	24.11	22.51	13.05	10.13	7.27	5.34	3.80	3.20	5.86	2.56	2.62	2.76	3.06	45.82	37.13	32.84	25.23	5.73	NA	NA	NA
1975	20.23	18.59	32.54	21.70	16.54	11.71	8.48	6.66	5.11	3.52	2.24	6.10	1.70	1.74	1.81	2.09	54.76	51.36	48.30	33.33	NA	NA	NA	NA
1976	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1977	7.01	5.61	8.40	9.21	6.79	4.50	3.21	2.59	1.67	NA	2.04	3.62	1.14	1.14	1.14	1.14	15.42	13.37	11.62	9.45	3.07	4.57	4.31	6.81
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	9.71	15.55	20.21	24.32	18.73	12.98	9.20	6.63	4.82	3.03	2.43	8.44	2.01	2.05	2.10	2.22	41.39	40.13	36.68	25.55	5.97	NA	NA	NA
1980	12.78	12.68	16.96	21.82	14.06	9.06	7.19	5.74	4.24	3.08	2.57	6.57	2.19	2.20	2.30	2.42	34.59	32.85	27.65	22.10	NA	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1961	6.07	4.30	3.80	1.72	1.61	1.08	1.08	1.81	3	1.54	27	5	10.77	31	1	26.06	1	NA	NA	NA	0.54	0.79	121	
1962	NA	NA	NA	NA	7.22	6.40	4.93	4.10	NA	NA	NA	4	25.70	77	2	11.29	1	1	90.70	1	1.25	2.80	113	
1963	NA	NA	NA	NA	6.40	4.30	3.99	NA	NA	NA	NA	2	32.98	137	NA	NA	NA	1	59.20	1	0.65	2.07	91	
1964	NA	NA	NA	7.87	6.00	4.15	NA	NA	NA	NA	NA	1	48.31	265	NA	NA	NA	1	52.21	1	1.20	3.09	101	
1965	NA	7.87	6.42	5.29	4.20	2.91	1.71	1.65	1	1.65	8	6	14.57	27	3	23.69	1	NA	NA	0.61	1.38	85		
1966	8.17	6.68	5.43	4.07	2.54	1.94	NA	2.91	2	1.94	8	2	13.87	92	1	20.46	2	NA	NA	0.27	0.59	91		
1967	NA	NA	NA	6.68	5.29	3.42	3.04	6.05	NA	NA	NA	7	16.43	35	3	30.39	1	1	NA	0.68	1.60	97		
1968	NA	NA	NA	7.84	7.84	5.34	4.68	4.76	NA	NA	NA	4	26.44	76	1	14.76	1	1	79.50	1	1.08	2.91	114	
1969	NA	6.81	5.22	4.17	2.78	1.40	1.04	NA	2	1.18	19	1	23.73	182	1	27.02	1	1	NA	0.36	0.99	87		
1970	NA	7.81	5.91	4.87	3.72	3.79	NA	4.18	NA	NA	NA	2	32.84	108	1	16.69	1	1	50.92	1	0.75	1.95	88	
1971	5.95	4.60	3.87	2.56	1.78	1.45	1.13	1.87	4	1.61	19	4	13.09	36	2	20.20	1	1	NA	0.35	0.87	102		
1972	NA	7.86	6.10	4.41	3.15	2.26	2.10	4.78	1	2.10	4	5	22.68	43	4	18.28	1	1	51.05	1	0.66	1.72	105	
1973	NA	7.50	5.85	4.62	3.00	1.89	1.40	2.35	1	1.40	25	4	14.60	50	2	25.94	1	1	NA	0.51	1.47	95		
1974	NA	NA	NA	6.22	4.51	3.00	2.84	2.56	NA	NA	NA	4	15.05	61	1	9.52	1	1	45.82	1	0.50	1.30	90	
1975	NA	NA	7.50	5.85	4.26	2.92	1.81	1.70	1	1.70	14	4	20.11	62	1	10.04	1	1	54.76	1	0.61	1.83	85	
1976	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1977	5.61	3.75	2.84	2.19	1.36	NA	1.14	2.13	5	1.48	10	7	9.01	14	2	13.66	1	1	NA	0.29	0.67	86		
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1979	NA	NA	7.79	5.85	3.70	2.39	2.01	4.31	3	2.05	3	4	17.43	60	2	29.05	1	1	NA	0.63	1.45	117		
1980	NA	7.72	6.74	5.10	3.28	2.35	2.19	3.07	NA	NA	NA	5	13.19	45	2	23.45	1	1	NA	0.51	1.11	102		

Table 9.2.6. Eco-relevant statistics of Sub-basin: Ruaha, Station: Ndembera (Madibira), Series: 1961-1980 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1961	5.50	6.55	13.84	5.29	1.33	NA	NA	0.57	0.65	0.66	NA	8.17	0.50	0.50	0.50	0.50	21.65	21.38	19.99	14.10	2.98	4.34	7.97	1.95
1962	NA	NA	NA	NA	7.64	NA	1.57	1.26	1.05	0.86	0.78	1.97	0.61	0.61	0.61	0.76	11.67	11.67	11.67	11.67	NA	NA	NA	NA
1963	13.63	26.40	36.68	29.34	11.07	5.41	3.75	2.71	2.03	1.62	2.60	NA	1.49	1.49	1.49	1.61	78.20	57.66	51.25	42.97	3.75	NA	NA	NA
1964	4.09	8.55	NA	NA	NA	NA	4.48	3.89	3.00	2.17	1.92	2.07	1.46	1.51	1.55	1.73	20.17	18.67	14.64	8.86	3.21	3.21	NA	NA
1965	8.20	12.33	19.12	29.28	13.94	7.88	6.11	5.36	4.30	3.34	3.42	6.68	2.50	2.53	2.69	3.31	37.67	37.04	36.03	30.55	6.39	7.88	NA	NA
1966	7.86	18.62	18.49	18.11	10.54	7.16	4.91	3.82	3.07	3.08	3.51	10.69	2.67	2.74	2.78	2.95	27.41	25.64	23.88	20.68	4.63	7.69	NA	NA
1967	10.35	7.95	18.39	23.12	17.82	10.27	6.80	5.51	4.24	2.86	2.79	16.38	1.52	1.58	1.69	1.97	39.21	30.69	28.38	24.71	7.42	6.89	NA	NA
1968	25.41	27.94	34.19	31.95	24.89	18.61	12.62	9.78	8.37	7.66	6.63	9.31	5.96	6.05	6.13	6.51	47.06	44.86	40.49	35.38	NA	NA	NA	NA
1969	18.15	24.71	23.98	19.20	14.06	14.06	7.86	6.94	5.81	5.06	4.61	6.23	4.12	4.13	4.21	4.61	29.58	27.34	27.10	25.48	NA	NA	NA	NA
1970	14.05	21.15	27.05	23.22	13.27	8.93	7.39	6.36	5.33	4.21	3.65	10.98	3.28	3.31	3.37	3.62	34.28	32.50	31.92	28.65	7.14	NA	NA	NA
1971	20.09	19.28	NA	NA	NA	NA	5.35	6.12	5.05	3.87	4.15	8.26	3.25	3.26	3.34	3.74	28.15	24.55	22.23	20.16	NA	NA	NA	NA
1972	17.63	21.78	37.66	33.50	16.75	9.64	7.72	6.43	6.43	NA	NA	11.80	5.76	5.86	5.86	5.86	46.20	46.20	43.20	39.83	NA	NA	NA	NA
1973	19.66	25.41	29.70	28.52	12.84	8.68	7.02	6.20	NA	4.84	8.13	7.09	3.64	3.68	3.76	4.04	38.97	38.11	36.79	32.55	NA	NA	NA	NA
1974	11.81	17.93	17.34	32.88	NA	15.01	10.28	7.67	NA	NA	NA	11.76	6.51	6.51	6.51	6.51	44.65	43.72	42.66	35.21	6.84	NA	NA	NA
1975	26.30	21.21	28.42	18.83	13.27	8.54	6.77	NA	6.92	6.78	NA	12.45	6.02	6.02	6.02	6.02	35.98	34.83	33.24	29.56	NA	NA	NA	NA
1976	21.30	28.72	38.89	36.61	15.69	10.62	8.26	6.74	5.47	5.12	5.59	6.28	3.97	4.04	4.11	4.86	49.10	46.57	44.26	39.87	NA	NA	NA	NA
1977	14.05	16.17	20.25	20.90	13.55	8.28	5.83	4.91	NA	9.20	9.41	10.63	4.50	4.53	4.53	4.53	36.63	29.47	26.68	23.00	7.95	NA	NA	NA
1978	21.49	32.91	41.39	31.61	18.60	11.31	9.41	8.04	6.69	6.31	6.48	11.90	5.45	5.45	5.54	6.12	49.10	48.57	47.46	41.80	NA	NA	NA	NA
1979	20.60	33.30	NA	36.88	27.99	14.37	14.18	12.18	10.31	9.10	9.89	20.26	8.02	8.08	8.24	8.93	47.51	42.04	40.06	38.01	NA	NA	NA	NA
1980	38.16	44.14	42.73	48.70	34.71	NA	NA	NA	10.87	9.37	8.81	17.16	7.95	8.02	8.11	8.59	66.40	58.07	56.69	49.33	NA	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1961	1.01	NA	NA	0.50	0.65	0.65	0.65	0.82	5	1.00	24	9	10.43	8	2	21.16	1	NA	NA	NA	1.05	1.48	79	
1962	3.21	NA	1.49	1.24	0.81	0.61	0.61	0.81	1	0.61	163	1	10.80	18	1	11.67	2	NA	NA	0.39	0.35	36		
1963	7.00	4.37	3.21	2.43	1.75	1.49	1.75	NA	1	1.49	18	1	55.77	137	NA	NA	NA	1	78.20	NA	2.08	3.48	90	
1964	NA	NA	4.13	3.24	2.36	1.72	1.63	1.46	3	1.55	5	3	10.44	4	1	20.17	2	NA	NA	0.59	0.84	66		
1965	8.25	7.16	4.91	4.77	3.83	2.88	2.50	3.75	NA	NA	NA	5	13.85	38	1	37.67	1	NA	NA	0.63	1.02	115		
1966	8.25	6.14	4.08	3.45	2.67	2.83	3.08	2.99	NA	NA	NA	4	16.31	43	2	23.42	1	NA	NA	0.33	1.05	105		
1967	NA	7.79	6.19	4.83	3.83	1.97	1.52	5.59	1	1.52	4	5	18.29	41	4	25.07	1	NA	NA	0.46	1.26	101		
1968	NA	NA	NA	9.01	7.53	7.10	6.03	5.96	NA	NA	NA	5	17.85	63	2	12.78	1	1	47.06	1	0.46	1.44	85	
1969	NA	8.50	7.49	6.37	5.45	4.46	4.12	4.34	NA	NA	NA	4	13.82	56	2	21.52	1	NA	NA	0.34	1.05	96		
1970	NA	8.05	6.93	5.84	4.75	3.67	3.28	4.63	NA	NA	NA	4	17.22	54	2	27.92	1	NA	NA	0.40	1.31	111		
1971	NA	NA	5.06	4.41	3.72	3.40	3.25	4.11	NA	NA	NA	7	11.49	11	3	20.42	1	NA	NA	0.72	1.23	93		
1972	NA	8.39	7.18	5.76	NA	NA	NA	8.39	NA	NA	NA	4	36.99	59	1	15.22	1	3	46.10	NA	0.95	2.63	95	
1973	NA	7.65	6.61	5.76	NA	3.64	7.07	5.86	NA	NA	NA	5	15.30	45	2	25.80	1	NA	NA	0.69	1.55	113		
1974	NA	NA	9.03	6.51	NA	NA	NA	6.67	NA	NA	NA	5	20.30	45	3	32.54	1	NA	NA	0.77	1.99	77		
1975	NA	7.42	6.18	NA	6.61	6.02	NA	NA	NA	NA	NA	2	26.33	107	2	26.85	1	NA	NA	0.75	1.69	90		
1976	NA	NA	7.30	6.07	4.97	4.41	3.97	4.82	NA	NA	NA	6	14.96	38	NA	NA	NA	1	49.10	1	0.61	1.85	110	
1977	NA	6.78	5.26	4.50	NA	7.01	7.24	6.90	NA	NA	NA	4	18.83	63	4	20.98	1	NA	NA	0.66	2.00	84		
1978	NA	NA	8.64	7.30	6.07	5.86	5.45	6.84	NA	NA	NA	6	15.97	45	1	24.03	1	1	49.10	1	0.70	1.85	120	
1979	NA	NA	NA	NA	NA	8.64	8.02	NA	NA	NA	NA	2	41.78	166	NA	NA	NA	2	46.24	1	0.79	2.59	111	
1980	NA	NA	NA	NA	NA	8.24	7.95	9.01	NA	NA	NA	2	43.43	136	1	31.91	1	1	66.40	1	1.17	2.30	98	

Table 9.2.7. Eco-relevant statistics of Sub-basin: Ruaha, Station: Kimani, Series: 1981-1997 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1981	14.80	16.80	14.97	15.99	5.62	2.46	1.56	1.13	0.80	0.63	0.50	1.02	0.37	0.37	0.38	0.47	46.51	34.90	30.50	19.56	NA	NA	NA	NA
1982	3.18	6.36	13.09	11.98	6.09	2.49	1.49	1.00	0.74	0.54	0.81	5.17	0.45	0.46	0.48	0.54	29.61	23.20	21.16	14.66	1.28	NA	NA	NA
1983	31.40	23.00	36.90	21.39	9.59	5.73	4.01	3.12	2.55	1.80	1.80	5.40	1.50	1.50	1.51	1.65	65.97	63.21	58.87	39.58	NA	NA	NA	NA
1984	17.15	20.19	16.46	7.01	3.08	1.73	1.33	0.96	0.75	0.62	0.68	10.00	0.43	0.45	0.47	0.53	42.91	32.89	26.49	21.40	NA	NA	NA	NA
1985	11.19	24.26	13.19	10.09	3.80	2.02	1.38	1.04	0.83	0.66	NA	11.32	0.53	0.55	0.56	0.56	53.76	46.32	35.50	25.16	NA	NA	NA	NA
1986	16.08	14.17	21.46	10.86	5.90	3.25	1.73	1.32	1.01	0.82	0.75	NA	0.58	0.58	0.61	0.67	61.81	40.23	33.32	23.36	NA	NA	NA	NA
1987	23.83	NA	28.52	12.73	6.07	2.66	1.64	1.15	0.83	0.70	0.80	0.99	0.49	0.49	0.49	0.63	98.38	58.79	42.68	33.84	NA	NA	NA	NA
1988	5.03	NA	NA	11.81	3.94	1.92	1.16	0.82	0.54	0.41	0.43	0.44	0.31	0.32	0.34	0.35	39.27	39.27	39.27	39.27	1.55	NA	NA	NA
1989	5.15	12.71	14.97	10.81	4.52	2.15	1.24	0.89	0.65	0.47	0.49	3.69	0.34	0.34	0.37	0.41	53.38	36.76	30.73	19.54	1.34	NA	NA	NA
1990	NA	NA	13.08	11.56	4.44	2.06	1.25	0.91	0.68	0.51	0.49	0.79	0.34	0.34	0.35	0.45	24.52	21.18	20.17	20.17	NA	NA	NA	NA
1991	NA	NA	7.57	23.32	6.29	2.50	1.41	0.94	0.64	0.65	0.42	NA	0.28	0.28	0.28	0.28	61.21	43.05	32.97	24.23	NA	NA	NA	NA
1992	5.01	12.60	15.74	7.08	3.98	2.07	1.22	0.82	0.57	0.42	NA	2.01	0.37	0.37	0.37	0.37	57.83	41.18	31.67	19.99	NA	NA	NA	NA
1993	8.19	17.57	14.13	11.20	4.38	2.11	1.21	0.87	0.61	0.45	0.48	0.37	0.29	0.32	0.33	0.37	44.77	32.24	28.83	17.92	NA	NA	NA	NA
1994	1.65	5.76	21.17	11.47	3.66	1.73	1.04	0.71	0.55	0.46	0.43	0.47	0.28	0.28	0.33	0.41	47.06	39.51	30.08	22.47	0.28	NA	NA	NA
1995	0.72	2.81	24.21	7.68	3.12	1.50	0.97	0.63	0.51	0.41	0.27	0.51	0.18	0.19	0.20	0.25	76.55	51.32	35.04	24.82	0.41	1.19	NA	NA
1996	2.08	11.94	NA	NA	NA	2.00	1.13	0.76	0.56	0.39	0.29	1.20	0.18	0.19	0.20	0.28	16.87	16.24	15.02	13.99	0.90	NA	NA	NA
1997	2.96	8.54	6.97	6.11	2.48	1.26	0.76	0.49	0.43	0.38	0.56	NA	0.28	0.30	0.33	0.37	18.02	13.72	12.38	9.37	0.68	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1981	NA	NA	1.33	0.97	0.73	0.53	0.37	0.45	2	0.38	5	4	11.15	61	1	46.51	1	NA	NA	NA	0.80	2.61	94	
1982	NA	NA	1.32	0.90	0.67	0.45	0.46	1.50	NA	NA	NA	4	9.05	63	1	29.61	1	NA	NA	NA	0.56	1.10	110	
1983	NA	NA	NA	NA	NA	1.50	1.50	1.59	NA	NA	NA	1	65.74	364	NA	NA	NA	1	65.97	1	1.21	3.45	95	
1984	NA	1.50	1.18	0.78	0.63	0.49	0.43	0.58	NA	NA	NA	3	22.36	81	2	36.78	1	NA	NA	NA	1.11	2.37	103	
1985	NA	1.59	1.18	0.90	0.73	0.53	NA	NA	NA	NA	NA	2	37.94	127	2	38.84	1	NA	NA	NA	0.93	2.52	89	
1986	NA	1.26	1.50	1.18	0.90	0.63	0.58	NA	NA	NA	NA	2	19.46	127	NA	NA	NA	1	61.81	1	0.97	1.86	96	
1987	NA	NA	1.33	1.03	0.73	0.58	0.49	0.71	NA	NA	NA	7	13.37	31	1	50.75	1	1	98.38	1	1.22	2.99	92	
1988	NA	1.50	0.97	0.73	0.45	0.34	0.31	0.33	5	0.35	10	2	18.95	69	2	26.46	1	NA	NA	NA	0.35	1.15	66	
1989	NA	1.59	0.97	0.84	0.53	0.37	0.34	0.90	2	0.36	10	3	14.68	76	2	33.21	1	NA	NA	NA	0.73	1.73	106	
1990	NA	1.50	1.07	0.78	0.58	0.45	0.34	0.58	1	0.34	16	3	15.16	51	2	23.81	1	NA	NA	NA	0.42	1.06	73	
1991	NA	NA	1.18	0.78	0.53	0.49	0.28	NA	2	0.34	7	1	57.04	155	NA	NA	NA	1	61.21	1	0.88	3.54	55	
1992	NA	1.59	1.03	0.68	0.45	0.37	NA	0.49	2	0.39	9	2	22.19	112	1	57.83	1	NA	NA	NA	0.84	1.74	86	
1993	NA	1.68	1.03	0.78	0.58	0.41	0.41	0.29	3	0.37	18	1	41.54	203	1	44.77	1	NA	NA	NA	0.78	2.04	65	
1994	NA	1.33	0.90	0.58	0.49	0.41	0.41	0.41	4	0.38	12	1	36.05	178	1	47.06	1	NA	NA	NA	0.72	1.27	73	
1995	NA	1.17	0.90	0.49	0.49	0.20	0.22	0.18	2	0.29	37	2	23.88	82	NA	NA	NA	1	76.55	1	0.63	1.17	62	
1996	NA	1.50	0.90	0.68	0.41	0.25	0.18	0.20	2	0.29	32	5	5.28	23	1	16.87	1	NA	NA	NA	0.29	0.76	69	
1997	1.68	0.91	0.58	0.41	0.39	0.34	0.28	NA	4	0.36	15	3	6.75	55	1	18.02	1	NA	NA	NA	0.38	0.93	96	

Table 9.2.8. Eco-relevant statistics of Sub-basin: Ruaha, Station: Ndembera (Ilongo), Series: 1981-1997 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1981	10.72	16.59	10.56	27.76	7.14	4.30	3.15	2.21	1.32	1.05	NA	3.43	0.59	0.60	0.64	0.84	58.60	55.49	50.36	27.76	NA	NA	NA	NA
1982	6.75	7.26	12.75	17.17	7.09	3.14	1.90	1.11	0.65	0.38	0.89	6.76	0.35	0.35	0.35	0.37	29.19	28.22	25.92	17.87	2.53	NA	NA	NA
1983	21.05	15.22	17.40	12.53	5.12	3.61	2.27	1.44	0.85	0.44	0.35	2.78	0.28	0.28	0.28	0.32	28.46	27.89	26.93	22.21	NA	NA	NA	NA
1984	8.66	7.93	8.75	NA	3.32	1.33	1.01	0.69	0.41	NA	0.35	2.66	0.28	0.28	0.28	0.28	14.81	14.22	12.91	10.47	NA	NA	NA	NA
1985	6.87	17.66	10.08	NA	NA	NA	0.99	0.74	0.54	0.36	NA	9.20	0.28	0.28	0.28	0.28	47.78	41.21	32.46	18.03	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	26.29	22.81	30.84	20.17	11.54	5.55	4.14	3.58	2.13	0.64	NA	3.73	0.39	0.39	0.39	0.39	49.09	47.87	44.26	31.47	NA	NA	NA	NA
1988	5.87	10.32	NA	NA	6.72	4.97	NA	NA	0.67	0.36	0.44	0.80	0.28	0.28	0.30	0.34	15.72	15.52	14.58	13.83	NA	NA	NA	NA
1989	5.28	8.70	10.25	14.53	4.35	2.45	1.32	0.73	0.44	0.30	NA	10.94	0.28	0.28	0.28	0.28	25.65	24.99	23.20	15.37	2.12	NA	NA	NA
1990	15.71	17.15	25.35	12.33	11.68	4.55	2.62	2.13	1.34	0.61	0.40	1.43	0.35	0.35	0.35	0.39	30.65	29.93	29.11	25.69	NA	NA	NA	NA
1991	6.28	15.41	7.20	13.79	6.96	3.35	1.28	1.14	0.60	0.82	1.03	NA	0.35	0.36	0.38	0.47	27.63	26.51	24.88	15.37	1.69	NA	NA	NA
1992	6.37	9.99	13.16	5.95	5.36	1.95	0.85	0.64	0.40	NA	NA	3.97	0.35	0.35	0.35	0.35	17.04	16.50	15.37	13.26	3.58	NA	NA	NA
1993	8.56	14.75	18.73	15.96	9.52	3.54	1.92	1.26	0.78	NA	NA	0.34	0.28	0.28	0.31	0.34	36.83	35.52	33.61	23.26	NA	NA	NA	NA
1994	4.68	9.35	16.80	17.14	5.73	2.38	1.20	0.88	0.53	0.36	NA	0.65	0.28	0.28	0.28	0.28	26.83	26.21	25.80	21.37	0.94	NA	NA	NA
1995	4.33	6.03	11.45	9.15	3.01	1.35	0.61	0.43	NA	NA	NA	NA	0.35	0.35	0.35	0.35	15.47	14.87	14.09	12.48	1.62	NA	NA	NA
1996	1.62	7.77	10.08	10.38	3.28	1.41	0.65	0.42	NA	NA	NA	NA	0.28	0.28	0.32	0.35	18.65	17.76	16.48	12.90	0.28	3.35	NA	NA
1997	2.20	2.60	6.18	8.82	3.61	1.15	0.43	NA	NA	NA	NA	NA	0.30	0.31	0.31	0.31	17.95	17.32	14.67	8.86	0.30	1.26	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1981	NA	NA	2.65	1.90	0.89	0.59	NA	1.35	NA	NA	NA	4	16.28	68	NA	NA	NA	1	58.60	1	0.58	1.24	53	
1982	NA	2.31	1.45	0.89	0.51	0.35	0.39	2.93	1	0.35	13	3	13.79	77	2	20.21	1	NA	NA	NA	0.32	0.48	48	
1983	NA	2.77	1.59	1.20	0.59	0.35	0.28	0.65	1	0.28	26	2	17.40	111	1	28.46	1	NA	NA	NA	0.37	0.48	53	
1984	1.76	1.09	0.89	0.59	0.28	NA	NA	0.28	2	0.28	9	3	8.47	46	1	14.81	1	NA	NA	NA	0.27	0.43	43	
1985	NA	NA	0.89	0.66	0.48	0.28	NA	NA	1	0.28	14	2	29.36	60	1	16.19	1	1	47.78	1	0.90	1.68	36	
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1987	NA	NA	2.52	2.25	0.89	0.39	NA	1.20	NA	NA	NA	2	26.65	143	NA	NA	NA	1	49.09	1	0.72	1.09	41	
1988	NA	NA	NA	NA	0.48	0.28	0.35	0.39	2	0.30	14	2	12.23	60	1	15.72	1	NA	NA	NA	0.18	0.20	39	
1989	3.31	1.59	0.98	0.59	0.39	0.28	NA	NA	1	0.28	31	2	21.42	101	2	22.03	1	NA	NA	NA	0.35	0.65	45	
1990	NA	NA	1.46	1.84	0.98	0.43	0.35	0.35	2	0.35	7	3	11.95	81	1	30.65	1	NA	NA	NA	0.48	0.68	76	
1991	NA	1.92	0.98	0.89	0.39	0.35	0.73	NA	1	0.35	4	2	14.56	91	1	27.63	1	NA	NA	NA	0.35	0.66	68	
1992	NA	1.09	0.73	0.53	0.35	NA	NA	1.53	1	0.35	8	3	9.21	64	1	17.04	1	NA	NA	NA	0.31	0.49	42	
1993	NA	2.52	1.59	0.98	0.54	NA	NA	0.28	2	0.31	15	1	36.52	197	NA	NA	NA	1	36.83	1	0.46	0.89	58	
1994	3.69	1.52	1.03	0.66	0.39	0.28	NA	0.28	3	0.30	8	1	26.33	164	1	26.83	1	NA	NA	NA	0.35	0.62	63	
1995	1.75	0.81	0.54	0.35	NA	NA	NA	NA	1	0.35	9	2	8.49	76	1	15.47	1	NA	NA	NA	0.25	0.42	62	
1996	2.31	0.90	0.54	0.35	NA	NA	NA	NA	3	0.30	4	2	9.89	69	1	18.65	1	NA	NA	NA	0.26	0.50	47	
1997	1.92	0.66	0.31	NA	NA	NA	NA	NA	3	0.33	6	2	11.42	65	1	17.95	1	NA	NA	NA	0.25	0.54	54	

Table 9.2.9. Eco-relevant statistics of Sub-basin: Ruaha, Station: Lit. Ruaha (Himbu), Series: 1981-1997 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1981	18.60	32.93	29.50	36.01	20.76	14.46	10.62	8.98	7.14	NA	4.01	8.57	3.46	3.58	3.65	3.99	67.70	59.11	54.74	36.84	NA	NA	NA	NA
1982	16.21	20.39	28.69	24.23	17.79	11.74	9.57	7.62	5.96	5.10	NA	25.48	3.96	4.00	4.21	4.40	42.25	37.99	34.90	30.09	8.81	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	23.46	NA	NA	28.30	21.73	16.07	11.70	8.94	6.16	4.94	6.23	20.72	3.71	3.83	4.07	4.92	49.70	45.01	35.78	29.24	NA	NA	NA	NA
1985	24.18	30.78	31.65	34.01	22.80	15.00	11.77	9.98	8.07	6.20	9.90	NA	5.31	5.38	5.46	5.86	47.36	45.31	39.34	35.86	NA	NA	NA	NA
1986	25.15	32.65	31.18	NA	NA	15.95	11.43	9.32	7.40	6.34	6.91	16.24	4.82	5.01	5.32	6.01	38.37	38.37	38.37	38.37	NA	NA	NA	NA
1987	27.15	37.70	48.84	41.43	27.84	19.42	14.89	11.53	NA	NA	NA	NA	10.20	10.20	10.20	10.20	70.70	66.35	60.95	50.09	NA	NA	NA	NA
1988	NA	NA	NA	36.77	21.40	16.38	12.19	9.80	7.70	5.86	5.86	9.03	4.89	4.89	4.91	5.31	67.57	67.57	67.57	67.57	NA	NA	NA	NA
1989	16.90	21.73	25.72	29.25	21.09	16.06	11.51	9.34	7.29	5.95	5.32	13.94	4.48	4.48	4.48	4.83	38.56	37.05	34.64	31.13	11.01	11.43	NA	NA
1990	NA	NA	NA	51.37	NA	16.95	12.68	10.73	8.27	6.25	6.04	7.36	5.17	5.22	5.27	5.65	65.50	64.57	61.36	53.40	NA	NA	NA	NA
1991	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1992	14.31	20.27	24.66	19.11	15.07	10.55	8.36	6.96	5.44	4.25	NA	11.24	3.58	3.58	3.58	3.58	39.99	36.68	31.40	25.30	10.20	10.11	NA	NA
1993	14.49	29.58	41.56	36.98	24.26	15.44	12.07	9.75	7.82	5.64	6.01	4.32	3.46	3.46	3.63	4.30	69.70	58.98	56.24	46.52	8.98	NA	NA	NA
1994	NA	20.18	49.87	29.53	20.42	12.30	9.91	8.31	6.39	5.37	4.20	6.16	3.19	3.25	3.35	4.18	66.68	64.20	60.34	50.44	NA	NA	NA	NA
1995	12.65	17.86	41.21	24.94	16.63	11.44	8.35	7.18	5.46	3.98	2.78	4.13	2.27	2.31	2.40	2.63	57.66	56.58	54.19	42.76	10.17	11.51	NA	NA
1996	13.51	NA	NA	NA	17.09	11.53	9.20	7.48	6.34	4.84	3.37	NA	2.78	2.78	2.78	2.78	20.41	20.11	19.65	19.65	8.07	NA	NA	NA
1997	NA	14.72	15.72	NA	13.12	9.59	7.55	5.61	4.11	3.27	4.51	NA	2.42	2.52	2.74	3.18	23.19	23.19	23.19	23.19	NA	11.15	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1981	NA	NA	9.76	8.06	6.18	NA	3.46	4.48	1	3.46	20	5	21.66	46	NA	NA	NA	1	67.70	1	1.01	2.24	109	
1982	NA	11.01	8.56	6.79	5.31	3.96	NA	NA	1	3.96	3	2	37.85	113	2	40.64	1	NA	NA	NA	0.82	1.53	108	
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1984	10.91	NA	10.29	7.74	5.17	3.71	4.76	4.97	1	3.71	4	3	36.21	63	3	41.57	1	NA	NA	NA	0.93	2.30	120	
1985	NA	NA	10.64	9.24	6.95	5.60	5.31	NA	NA	NA	NA	3	25.47	85	2	33.00	1	NA	NA	NA	0.70	1.60	104	
1986	NA	NA	10.11	8.73	6.49	4.82	5.74	7.50	NA	NA	NA	5	22.19	36	4	25.96	2	NA	NA	NA	0.67	1.42	84	
1987	NA	NA	NA	10.20	NA	NA	NA	NA	NA	NA	NA	3	58.33	79	1	56.10	1	2	70.15	1	1.14	4.79	65	
1988	NA	NA	11.01	8.90	6.49	4.89	4.89	5.89	NA	NA	NA	5	22.04	31	1	18.63	1	1	67.57	1	0.55	0.75	64	
1989	NA	NA	10.29	8.56	6.49	5.03	4.48	8.98	NA	NA	NA	7	17.83	35	4	23.65	1	NA	NA	NA	0.88	1.96	106	
1990	NA	NA	11.19	9.41	7.42	5.45	5.17	5.96	NA	NA	NA	6	20.61	20	1	19.29	1	1	65.50	1	0.61	1.14	53	
1991	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1992	10.46	9.76	7.58	6.18	4.75	3.58	NA	5.53	1	3.58	9	3	27.72	66	3	28.40	1	NA	NA	NA	1.12	2.19	97	
1993	NA	NA	10.64	9.07	6.56	4.89	4.69	3.46	2	3.65	8	5	22.45	47	1	17.55	1	1	69.70	1	0.69	2.22	97	
1994	NA	10.68	9.07	7.31	5.43	4.25	3.19	4.19	2	3.66	7	5	21.03	37	NA	NA	NA	1	66.68	1	0.68	1.49	71	
1995	NA	9.33	7.81	6.08	4.77	3.14	2.45	2.27	1	2.27	69	1	56.90	181	NA	NA	NA	1	57.66	1	0.58	1.41	84	
1996	NA	10.04	8.13	6.99	5.35	3.86	2.78	NA	1	2.78	38	4	16.94	25	3	19.88	1	NA	NA	NA	0.20	0.99	31	
1997	11.33	8.30	6.37	4.77	3.33	2.90	2.42	NA	1	2.42	65	2	20.78	53	2	21.61	1	NA	NA	NA	0.24	0.56	43	

Table 9.2.10. Eco-relevant statistics of Sub-basin: Ruaha, Station: Mfitu, Series: 1981-1997 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1981	4.11	6.31	5.21	8.61	4.01	3.16	2.63	2.58	2.19	2.55	1.64	3.19	1.44	1.44	1.46	1.64	19.24	17.40	15.11	9.18	2.58	NA	2.82	NA
1982	4.56	3.70	4.92	4.27	3.54	2.39	2.14	1.99	1.79	2.22	2.73	5.31	1.39	1.44	1.53	1.77	10.30	9.25	8.16	5.69	NA	2.38	NA	2.78
1983	7.37	5.28	5.43	4.47	NA	3.00	2.48	2.23	1.82	1.90	1.86	3.05	1.35	1.37	1.40	1.74	16.08	11.22	8.69	7.36	NA	NA	NA	NA
1984	4.92	5.83	5.71	8.42	5.39	3.83	3.31	2.68	2.15	2.06	2.84	7.09	1.80	1.83	1.89	1.97	16.60	13.47	11.96	9.05	NA	NA	NA	NA
1985	5.02	5.63	5.22	7.86	4.57	3.15	2.94	2.90	2.49	2.10	3.01	4.27	1.65	1.65	1.75	2.00	17.09	15.59	12.41	7.86	NA	NA	NA	NA
1986	4.70	4.70	5.84	7.25	4.73	3.72	2.81	2.58	2.18	2.06	2.24	5.16	1.56	1.69	1.87	2.06	11.50	10.95	9.83	8.21	NA	NA	2.56	NA
1987	7.74	7.11	8.54	5.47	4.54	3.22	2.94	2.87	2.41	2.15	2.17	2.71	1.65	1.75	1.81	1.95	18.81	14.98	13.43	8.87	NA	NA	NA	NA
1988	3.04	6.11	7.10	NA	NA	NA	2.18	2.08	1.85	1.62	1.90	2.54	1.31	1.31	1.34	1.58	18.57	14.50	13.82	12.80	1.65	NA	2.56	NA
1989	5.52	4.84	5.93	NA	5.33	3.72	3.00	2.73	2.16	1.78	2.03	6.48	1.57	1.57	1.57	1.62	17.76	15.97	13.19	7.01	NA	NA	NA	NA
1990	4.61	4.60	6.53	7.10	3.95	2.99	2.62	2.61	2.19	1.86	2.12	1.96	1.44	1.44	1.52	1.70	14.21	13.18	10.92	7.34	2.25	2.37	NA	NA
1991	NA	7.28	3.95	8.98	4.10	2.84	2.62	2.40	1.89	1.71	1.38	2.69	1.25	1.28	1.29	1.38	17.42	15.22	13.08	13.08	NA	NA	2.38	NA
1992	3.17	4.97	NA	5.13	4.41	2.76	2.30	2.00	1.69	1.45	3.78	2.45	1.19	1.19	1.19	1.29	11.16	10.35	8.86	5.95	2.13	1.86	NA	NA
1993	2.47	5.18	8.85	6.97	4.10	2.86	2.65	2.39	2.03	1.68	1.77	1.58	1.25	1.26	1.31	1.47	15.47	13.56	12.74	9.85	1.49	NA	NA	NA
1994	4.01	6.11	9.34	4.40	4.22	2.54	2.37	2.20	1.80	1.80	1.72	2.08	1.19	1.19	1.33	1.62	16.21	14.62	13.36	9.74	1.19	NA	NA	NA
1995	3.46	3.61	6.12	4.14	3.23	2.29	1.79	1.77	1.47	1.29	1.06	1.59	0.88	0.90	0.95	1.03	12.79	10.75	9.08	6.30	2.48	2.23	NA	NA
1996	4.48	6.34	6.05	7.58	3.99	NA	1.94	1.87	1.67	1.67	1.32	2.40	1.13	1.14	1.17	1.32	17.29	12.98	10.49	8.78	2.29	2.75	2.26	NA
1997	2.88	4.97	3.96	6.39	3.60	NA	2.05	1.65	1.41	1.62	1.93	8.03	1.08	1.11	1.16	1.39	15.22	13.26	11.90	8.23	1.08	NA	1.58	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1981	NA	2.66	2.56	2.38	1.88	1.87	1.44	2.20	1	1.44	5	6	5.92	45	2	4.99	2	1	19.24	1	0.30	0.50	79	
1982	2.47	2.20	2.11	1.87	1.65	1.65	1.39	2.61	1	1.39	2	7	5.22	29	5	6.93	1	NA	NA	NA	0.24	0.38	68	
1983	NA	2.56	2.20	2.03	1.65	1.65	1.44	1.35	2	1.40	6	4	6.01	44	2	4.16	2	1	16.08	1	0.35	0.56	71	
1984	NA	NA	NA	2.47	1.96	1.80	1.81	2.30	NA	NA	NA	4	9.06	71	3	7.79	1	1	16.60	1	0.41	0.71	86	
1985	NA	NA	2.56	2.76	2.20	1.95	1.65	NA	NA	NA	NA	3	7.81	103	1	6.49	1	1	17.09	1	0.27	0.41	74	
1986	NA	NA	2.56	2.38	2.03	1.79	1.56	2.15	NA	NA	NA	7	4.65	37	2	10.24	1	NA	NA	NA	0.26	0.41	77	
1987	NA	NA	2.59	2.75	2.03	1.79	1.79	1.65	NA	NA	NA	4	6.59	67	1	5.07	1	1	18.81	1	0.37	0.63	91	
1988	2.56	NA	2.03	1.95	1.65	1.33	1.40	1.31	4	1.38	4	9	4.56	15	3	5.43	1	1	18.57	1	0.34	0.52	74	
1989	NA	NA	2.77	2.46	1.79	1.65	1.57	2.40	NA	NA	NA	4	9.26	61	3	7.74	1	1	17.76	1	0.34	0.55	90	
1990	NA	2.61	2.47	2.29	1.88	1.65	1.57	1.44	1	1.44	3	7	5.15	33	3	8.90	1	NA	NA	NA	0.32	0.58	94	
1991	NA	2.56	2.38	2.07	1.79	1.47	1.25	1.34	5	1.34	6	7	6.61	27	1	4.93	1	2	17.24	1	0.37	0.56	90	
1992	2.82	2.52	2.03	1.72	1.54	1.31	1.19	1.57	1	1.19	31	9	5.04	19	5	7.34	1	NA	NA	NA	0.24	0.37	86	
1993	NA	2.66	2.38	2.20	1.72	1.47	1.41	1.25	2	1.28	11	6	4.55	35	1	3.53	1	1	15.47	1	0.26	0.50	97	
1994	NA	2.37	2.20	1.95	1.57	1.51	1.27	1.44	3	1.30	5	6	4.72	29	NA	NA	NA	1	16.21	1	0.31	0.50	96	
1995	2.38	1.72	1.65	1.51	1.31	1.08	0.97	0.88	4	1.19	24	4	5.65	39	3	7.25	1	NA	NA	NA	0.17	0.31	91	
1996	2.78	NA	1.65	1.65	1.51	1.25	1.13	1.20	3	1.26	13	4	9.94	39	3	9.49	1	1	17.29	1	0.46	0.58	81	
1997	2.21	NA	1.65	1.57	1.19	1.23	1.23	2.11	5	1.21	10	5	7.85	29	3	12.52	1	NA	NA	NA	0.28	0.52	74	

Table 9.2.11. Eco-relevant statistics of Sub-basin: Ruaha, Station: Lukosi (Mbandika), Series: 1981-1997 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1981	21.87	22.16	NA	36.58	25.59	18.84	15.86	14.81	13.40	12.93	10.87	17.27	10.20	10.20	10.39	10.87	66.50	66.50	66.50	66.50	14.28	15.78	NA	NA
1982	15.85	18.20	18.03	23.25	25.22	17.02	14.96	13.15	11.68	14.61	15.46	30.44	10.59	10.59	10.69	11.68	57.96	52.79	41.72	30.75	12.08	12.93	12.21	16.63
1983	32.64	22.01	24.19	27.04	29.98	23.01	19.10	16.66	14.62	13.23	12.82	15.71	10.61	10.84	10.92	12.26	66.59	54.50	41.34	32.89	NA	15.62	18.02	NA
1984	21.94	26.92	28.71	49.86	NA	NA	NA	21.13	18.25	16.84	18.64	NA	15.54	15.57	15.57	15.57	122.71	109.25	85.96	82.46	15.54	18.44	15.62	NA
1985	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1986	24.62	26.51	28.94	49.07	40.79	32.71	25.66	22.58	19.92	17.99	17.89	35.75	15.97	16.06	16.26	17.17	68.73	63.58	59.40	50.44	NA	NA	NA	NA
1987	37.84	36.00	37.03	29.21	30.83	22.56	20.48	18.72	16.40	15.33	14.57	14.59	12.26	12.50	12.77	13.47	96.15	79.89	58.19	38.77	NA	NA	NA	NA
1988	18.65	21.22	NA	27.02	19.03	17.15	13.71	12.94	11.46	10.16	13.52	16.23	8.35	8.82	9.38	9.94	47.23	38.21	36.78	36.78	12.26	13.94	NA	NA
1989	35.02	25.68	30.09	54.61	54.26	36.12	27.55	24.05	20.66	17.53	16.59	28.15	14.68	14.68	14.95	15.58	78.20	75.53	74.23	61.33	NA	NA	NA	NA
1990	26.33	27.50	38.43	37.78	28.73	22.64	18.88	17.42	15.29	13.46	17.14	14.98	11.78	11.81	12.02	12.65	60.14	54.98	49.35	42.76	NA	17.35	NA	NA
1991	20.01	27.66	16.60	29.37	25.79	18.04	16.46	14.89	12.73	11.81	11.02	19.13	8.70	8.87	9.02	10.18	63.79	51.38	42.24	29.82	13.86	15.32	12.65	NA
1992	13.64	22.83	NA	36.98	35.19	NA	19.52	16.62	14.78	12.53	16.34	13.12	10.27	10.47	10.74	11.71	80.28	59.92	47.19	41.79	10.98	10.27	NA	NA
1993	12.66	20.94	31.97	39.39	29.72	19.08	17.44	15.95	14.03	11.61	10.70	10.58	9.07	9.25	9.43	10.25	72.47	69.09	61.58	42.73	10.59	17.18	17.76	NA
1994	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1995	19.83	19.40	32.32	35.17	30.95	23.09	NA	12.15	15.79	11.65	9.78	12.26	8.67	8.67	8.78	9.30	81.48	55.71	50.18	37.92	14.52	12.60	17.85	NA
1996	17.76	28.58	NA	43.23	34.35	24.80	19.70	15.82	12.31	11.18	11.80	15.67	9.93	10.20	10.26	10.84	55.66	53.42	47.54	47.54	10.30	15.17	NA	NA
1997	NA	20.53	NA	51.46	NA	NA	NA	13.96	11.91	12.44	15.04	70.04	9.83	10.09	10.64	11.38	204.22	131.24	105.69	91.48	NA	11.83	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1981	NA	16.41	15.11	13.84	12.18	11.38	10.20	11.64	2	10.21	10	11	26.66	14	4	34.12	1	1	66.50	1	1.40	2.87	85	
1982	16.66	15.41	13.84	12.18	10.98	11.58	10.59	16.82	1	10.59	6	22	22.60	7	8	34.06	1	NA	NA	NA	1.70	2.71	102	
1983	NA	NA	17.74	15.54	13.84	12.18	10.98	10.61	1	10.61	1	6	28.85	39	3	34.88	1	1	66.59	1	1.37	2.83	96	
1984	NA	NA	NA	NA	17.29	15.97	15.57	NA	NA	NA	NA	8	36.25	26	4	31.46	1	1	122.71	1	2.07	4.34	66	
1985	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1986	NA	NA	NA	NA	NA	16.88	15.97	18.16	NA	NA	NA	2	62.15	179	NA	NA	NA	2	65.11	1	1.45	3.19	89	
1987	NA	NA	NA	17.29	15.11	13.84	12.59	12.26	NA	NA	NA	3	39.44	89	1	25.58	1	1	96.15	1	1.56	3.27	88	
1988	16.41	15.08	13.00	12.18	10.20	8.35	9.07	10.22	6	9.59	8	12	23.53	11	6	32.05	1	NA	NA	NA	0.84	2.12	70	
1989	NA	NA	NA	NA	NA	15.54	14.68	NA	NA	NA	NA	2	61.62	168	1	47.36	1	1	78.20	1	1.84	3.86	94	
1990	NA	NA	18.18	15.95	14.68	12.59	11.78	11.81	NA	NA	NA	5	28.03	49	3	38.02	1	NA	NA	NA	1.03	2.61	70	
1991	NA	16.41	15.54	13.71	12.18	8.70	8.88	13.44	2	9.29	13	9	27.63	19	2	46.55	1	1	63.79	1	1.26	1.96	101	
1992	NA	NA	17.74	15.54	13.42	11.78	10.59	11.38	2	10.43	3	9	28.46	15	5	38.01	1	1	80.28	1	1.46	4.07	63	
1993	NA	17.51	16.41	15.11	12.39	10.59	10.20	9.07	4	9.82	13	6	31.14	29	4	25.65	1	1	72.47	1	0.90	2.56	71	
1994	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1995	NA	17.90	NA	10.20	13.84	10.59	9.02	8.67	6	9.93	10	9	24.20	20	2	31.39	1	1	81.48	1	1.64	3.54	101	
1996	NA	NA	17.71	14.68	10.71	10.20	9.93	10.61	5	10.35	5	6	31.13	31	4	38.92	1	NA	NA	NA	1.26	2.36	80	
1997	NA	NA	NA	13.00	10.59	10.59	9.83	NA	3	10.34	5	5	52.67	18	1	33.66	1	2	147.85	1	3.95	5.50	49	

Table 9.2.12. Eco-relevant statistics of Sub-basin: Ruaha, Station: Gr- Ruaha (salimwani), Series: 1998-2013 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1998	NA	177.95	NA	105.27	9.76	5.00	3.64	2.87	2.27	1.93	1.63	1.56	1.34	1.34	1.34	1.55	196.56	194.81	191.81	191.27	NA	NA	NA	NA
1999	3.30	3.36	NA	NA	7.94	4.59	3.13	2.45	2.11	1.90	1.67	2.02	1.40	1.42	1.45	1.59	10.81	10.81	10.81	10.81	1.46	2.35	NA	NA
2000	4.33	9.66	21.07	21.91	6.43	3.58	2.43	2.07	1.77	2.26	2.41	17.68	1.47	1.48	1.53	1.60	39.06	36.75	34.10	27.22	2.50	4.15	NA	NA
2001	53.13	51.36	NA	25.64	11.09	7.30	4.73	3.50	2.62	2.14	1.99	3.85	1.73	1.75	1.77	1.98	109.06	101.18	87.66	61.36	NA	NA	NA	NA
2002	23.98	42.56	41.51	28.75	14.10	6.36	4.39	3.34	2.84	2.67	2.92	4.29	2.25	2.32	2.39	2.57	87.43	80.39	68.65	46.42	NA	NA	NA	NA
2003	16.71	14.63	10.76	24.16	8.94	4.73	3.60	3.03	2.63	2.53	2.50	NA	1.80	1.82	1.87	2.27	33.70	32.02	31.39	24.73	NA	NA	NA	NA
2004	15.24	16.61	31.99	46.67	10.48	5.43	3.96	2.81	2.37	1.98	2.18	6.63	1.74	1.75	1.77	1.96	90.85	82.09	72.93	47.02	NA	NA	NA	NA
2005	18.78	26.01	36.47	30.62	11.91	5.90	4.20	3.35	2.79	NA	NA	NA	2.59	2.59	2.59	2.59	87.84	72.08	57.95	45.86	NA	NA	NA	NA
2006	2.25	4.65	9.28	10.24	6.09	4.05	3.07	2.53	2.21	1.90	1.90	NA	1.60	1.61	1.63	1.75	31.97	22.62	16.76	12.05	1.60	2.84	NA	NA
2007	19.81	20.98	14.93	8.66	5.20	3.73	3.09	2.70	2.34	2.13	2.07	4.44	1.79	1.85	1.86	2.00	40.52	33.79	28.32	22.18	NA	NA	NA	NA
2008	25.19	57.48	64.77	34.84	11.44	6.79	4.67	3.71	2.85	2.51	2.77	3.80	2.04	2.07	2.15	2.50	187.19	141.17	123.33	73.15	NA	NA	NA	NA
2009	6.74	31.21	39.75	34.34	12.81	6.03	4.21	3.20	2.26	1.99	3.67	NA	1.77	1.80	1.81	1.95	77.01	67.39	57.82	46.16	4.54	NA	NA	NA
2010	40.29	31.25	36.06	18.05	8.25	5.13	3.80	2.79	2.27	1.86	1.78	3.02	1.59	1.59	1.59	1.70	99.65	77.88	57.95	40.62	NA	NA	NA	NA
2011	6.79	11.41	25.86	32.38	10.88	5.60	3.91	2.66	2.09	2.07	22.44	NA	1.59	1.60	1.66	2.06	54.36	45.84	40.99	39.01	2.08	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	15.22	18.58	51.15	39.75	12.88	6.15	4.37	NA	NA	2.42	2.30	NA	1.74	1.74	1.78	1.94	106.49	98.01	80.86	58.56	NA	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1998	NA	4.37	3.08	2.51	2.02	1.72	1.59	1.34	3	1.55	20	2	194.27	67	NA	NA	NA	2	195.36	2	3.60	7.36	59	
1999	NA	3.63	2.68	2.34	2.01	1.52	1.40	1.41	7	1.55	8	4	6.58	24	2	8.63	1	NA	NA	NA	0.15	0.39	59	
2000	NA	2.79	2.17	1.79	1.65	1.52	1.47	NA	3	1.55	18	5	16.68	40	3	26.48	1	NA	NA	NA	0.57	1.23	54	
2001	NA	NA	4.36	2.79	2.25	2.01	1.73	1.98	1	1.73	2	4	36.34	52	2	21.22	1	1	109.06	1	0.72	1.73	39	
2002	NA	NA	3.85	3.08	2.61	2.26	2.25	2.60	NA	NA	NA	4	24.87	60	2	47.84	1	NA	NA	NA	0.97	2.25	59	
2003	NA	4.10	3.19	2.88	2.42	1.80	1.80	NA	NA	NA	NA	2	18.80	106	1	33.70	1	NA	NA	NA	0.62	1.53	43	
2004	NA	NA	3.44	2.57	2.13	1.75	1.74	3.86	2	1.74	4	3	32.53	82	2	50.66	1	NA	NA	NA	0.91	2.54	66	
2005	NA	NA	3.63	3.08	2.59	NA	NA	NA	NA	NA	NA	1	81.90	231	1	87.84	1	NA	NA	NA	1.61	5.27	58	
2006	NA	3.42	2.78	2.30	2.07	1.85	1.63	NA	3	1.65	9	3	9.06	49	1	31.97	1	NA	NA	NA	0.27	0.91	91	
2007	4.36	3.30	2.90	2.52	2.12	2.06	1.84	1.79	NA	NA	NA	4	14.25	50	2	26.01	1	NA	NA	NA	0.58	1.24	119	
2008	NA	NA	4.17	3.29	2.51	2.51	2.04	2.82	NA	NA	NA	8	22.13	34	NA	NA	NA	1	187.19	1	2.87	6.66	96	
2009	NA	NA	3.63	2.68	1.94	1.81	1.77	NA	1	1.77	1	3	29.46	80	2	41.83	1	NA	NA	NA	0.95	2.62	70	
2010	NA	4.47	3.34	2.43	2.06	1.74	1.59	1.62	2	1.60	16	4	22.72	56	1	99.65	1	NA	NA	NA	1.08	3.02	90	
2011	NA	4.49	3.41	2.33	1.98	1.59	NA	NA	1	1.59	8	4	25.56	59	3	35.60	1	NA	NA	NA	0.81	2.77	76	
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
2013	NA	NA	3.92	NA	NA	1.89	1.74	NA	1	1.74	3	3	38.42	72	NA	NA	NA	1	106.49	1	1.68	4.70	75	

Table 9.2.13. Eco-relevant statistics of Sub-basin: Ruaha, Station: Kimani, Series: 1998-2013 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
1998	15.46	29.73	24.52	13.95	4.28	2.08	1.24	0.86	0.61	0.43	0.41	0.32	0.18	0.18	0.19	0.31	94.18	65.86	50.75	33.75	NA	NA	NA	NA	NA
1999	1.00	1.02	16.57	11.60	3.78	1.84	0.91	0.69	0.55	0.50	0.50	0.67	0.18	0.18	0.24	0.36	80.94	63.96	43.53	22.65	0.34	0.69	1.10	NA	NA
2000	1.71	3.35	8.31	7.51	3.27	1.63	0.99	0.73	0.56	0.46	0.62	9.19	0.25	0.25	0.25	0.38	27.60	21.43	15.13	9.58	0.66	1.19	NA	NA	NA
2001	26.99	25.06	26.27	NA	4.88	2.59	1.55	1.06	0.79	0.58	0.42	13.31	0.31	0.31	0.32	0.40	59.07	52.68	52.15	29.51	NA	NA	NA	NA	NA
2002	70.05	28.70	19.21	13.22	5.28	2.54	1.47	1.01	0.71	0.58	0.55	1.27	0.34	0.37	0.38	0.49	103.98	99.43	96.78	70.70	NA	NA	NA	NA	NA
2003	8.99	6.01	4.56	12.81	3.91	2.13	1.11	0.75	0.60	0.45	0.56	2.27	0.26	0.27	0.29	0.44	41.68	24.12	21.22	12.90	NA	NA	NA	NA	NA
2004	5.29	5.39	NA	NA	4.01	1.90	1.13	0.73	0.58	0.41	0.55	7.07	0.29	0.30	0.32	0.37	55.22	32.10	16.42	7.21	NA	NA	NA	NA	NA
2005	13.03	10.41	17.08	13.13	4.20	2.14	1.39	1.03	0.78	0.62	0.50	0.49	0.31	0.31	0.32	0.40	48.20	35.40	29.52	21.05	NA	NA	NA	NA	NA
2006	0.76	2.75	7.93	8.84	4.13	2.15	1.32	0.92	0.70	0.51	0.52	8.87	0.35	0.35	0.36	0.43	48.87	29.25	23.34	11.16	0.35	1.14	NA	NA	NA
2007	21.15	22.80	14.76	6.96	3.23	1.87	1.34	1.04	0.79	0.65	0.62	2.73	0.45	0.48	0.49	0.57	50.41	40.66	32.88	24.38	NA	NA	NA	NA	NA
2008	10.14	25.89	27.56	15.36	4.29	2.37	1.52	1.20	0.90	0.77	0.69	2.08	0.51	0.52	0.53	0.62	68.98	54.35	42.45	30.51	NA	NA	NA	NA	NA
2009	3.74	20.95	18.76	NA	4.82	2.35	1.55	1.20	0.89	0.63	0.80	2.29	0.30	0.31	0.33	0.51	51.23	44.11	33.23	28.41	NA	NA	NA	NA	NA
2010	11.57	14.46	18.98	5.60	2.73	1.33	0.87	0.64	0.48	0.33	0.31	1.52	0.21	0.22	0.23	0.26	67.87	33.85	26.75	19.70	NA	NA	NA	NA	NA
2011	1.71	3.18	9.01	10.23	3.96	1.70	0.90	0.58	0.41	NA	0.33	5.08	0.21	0.21	0.21	0.21	26.68	23.04	19.55	14.20	0.59	1.12	NA	NA	NA
2012	11.56	9.14	17.30	12.14	4.26	2.30	1.23	0.70	0.48	0.39	0.46	0.57	0.32	0.33	0.35	0.39	50.41	35.21	32.15	18.73	NA	NA	NA	NA	NA
2013	2.30	5.39	17.31	9.39	4.90	2.07	1.03	0.73	0.51	0.44	0.35	3.19	0.25	0.26	0.30	0.34	45.31	34.51	27.64	20.53	0.70	NA	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47		
1998	NA	1.51	1.03	0.78	0.51	0.37	0.31	0.18	5	0.29	8	1	67.48	216	NA	NA	NA	1	94.18	1	1.53	4.12	99		
1999	NA	1.18	0.73	0.59	0.49	0.37	0.31	0.18	2	0.26	12	6	11.80	28	NA	NA	NA	1	80.94	1	0.64	1.39	96		
2000	NA	1.25	0.84	0.63	0.49	0.29	0.25	NA	2	0.27	8	4	9.21	59	2	19.14	NA	NA	NA	NA	0.28	0.87	91		
2001	NA	NA	1.25	0.90	0.63	0.49	0.31	0.38	1	0.31	8	4	29.25	53	2	31.32	1	1	59.07	1	1.27	4.24	89		
2002	NA	NA	1.16	0.84	0.63	0.53	0.34	0.37	1	0.34	1	3	35.70	81	NA	NA	NA	1	103.98	1	2.12	5.13	89		
2003	NA	NA	0.91	0.62	0.52	0.35	0.26	0.31	4	0.32	6	4	9.02	56	2	24.75	1	NA	NA	NA	0.48	1.20	118		
2004	NA	1.47	0.91	0.60	0.44	0.33	0.29	0.74	5	0.32	5	5	11.24	34	3	23.27	1	NA	NA	NA	0.38	1.41	98		
2005	NA	NA	1.15	0.88	0.63	0.54	0.35	0.31	2	0.33	5	2	23.03	117	1	48.20	1	NA	NA	NA	0.55	1.76	93		
2006	NA	NA	1.10	0.76	0.61	0.48	0.36	1.04	2	0.35	4	4	12.19	57	2	43.53	1	NA	NA	NA	0.49	1.36	103		
2007	NA	1.50	1.19	0.91	0.64	0.60	0.48	0.45	NA	NA	NA	2	28.76	128	2	30.37	1	NA	NA	NA	0.77	1.62	120		
2008	NA	NA	1.31	1.04	0.76	0.63	0.51	0.92	NA	NA	NA	6	11.61	47	1	5.69	1	1	68.98	1	0.86	1.99	130		
2009	NA	NA	1.38	1.04	0.70	0.54	0.51	0.30	1	0.30	6	4	16.02	60	3	24.23	1	NA	NA	NA	0.75	1.63	114		
2010	1.07	1.00	0.70	0.55	0.39	0.24	0.21	0.22	2	0.21	29	3	18.77	68	NA	NA	NA	1	67.87	1	0.87	1.98	120		
2011	NA	1.21	0.57	0.50	0.38	NA	0.21	0.22	5	0.26	6	4	12.76	49	2	24.91	1	NA	NA	NA	0.40	1.28	104		
2012	NA	NA	0.85	0.57	0.40	0.32	0.36	0.35	4	0.34	2	3	16.65	68	1	50.41	1	NA	NA	NA	0.68	1.45	113		
2013	NA	1.31	0.88	0.60	0.43	0.32	0.25	0.27	7	0.30	5	3	18.16	71	2	31.78	1	NA	NA	NA	0.68	1.56	127		

Table 9.2.14. Eco-relevant statistics of Sub-basin: Ruaha, Station: Mbarali (Igawa), Series: 1998-2013 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1998	33.08	61.29	41.34	30.68	16.13	10.21	8.05	6.62	5.31	3.88	3.76	3.02	2.22	2.27	2.30	2.99	122.83	90.10	79.56	62.18	NA	NA	NA	NA
1999	7.27	6.12	25.28	20.02	8.46	6.09	4.70	3.97	3.08	2.44	2.04	3.61	1.71	1.74	1.78	1.92	41.80	40.09	34.21	29.26	2.89	3.02	NA	NA
2000	7.67	9.29	18.24	17.82	7.27	4.88	3.81	3.04	2.36	1.85	4.03	16.30	1.62	1.65	1.71	1.84	41.98	35.77	30.96	21.32	3.20	4.71	NA	NA
2001	43.80	41.31	33.78	18.76	12.03	8.33	6.67	5.17	4.16	3.27	2.69	6.62	2.12	2.12	2.17	2.59	111.63	66.16	57.01	46.65	NA	NA	NA	NA
2002	24.72	38.25	34.13	25.59	13.11	8.65	6.59	5.25	4.08	2.81	2.68	4.23	2.28	2.32	2.33	2.48	141.81	85.62	68.07	40.91	NA	NA	NA	NA
2003	16.03	8.29	8.24	14.57	5.31	3.74	2.99	2.22	1.84	1.63	1.51	NA	1.03	1.05	1.08	1.33	65.38	52.74	31.59	16.23	NA	4.72	4.14	NA
2004	17.00	14.70	17.79	23.81	8.48	5.67	4.38	3.32	2.84	2.01	1.94	NA	1.52	1.55	1.57	1.79	86.33	46.50	33.64	24.21	NA	NA	NA	NA
2005	21.49	21.99	24.28	19.69	8.18	5.64	4.35	3.44	2.51	1.83	1.70	NA	1.37	1.39	1.44	1.50	81.95	43.57	37.17	27.48	NA	NA	NA	NA
2006	5.55	10.86	20.06	18.68	9.19	5.20	3.81	2.90	2.08	1.48	1.26	17.53	1.09	1.11	1.13	1.22	61.49	48.93	43.47	23.82	1.67	3.31	NA	NA
2007	27.41	30.78	31.09	18.46	9.72	6.76	5.17	4.02	2.78	2.01	1.92	6.93	1.53	1.58	1.58	1.81	59.80	58.06	51.88	34.94	NA	NA	NA	NA
2008	17.18	57.62	41.82	28.37	12.83	8.57	NA	4.94	3.33	2.63	2.25	8.37	1.55	1.57	1.59	1.91	111.74	95.83	92.26	57.08	5.88	NA	NA	NA
2009	9.59	28.06	38.85	30.61	11.34	7.29	5.35	3.92	2.82	1.90	4.30	NA	1.67	1.67	1.67	1.81	107.08	72.09	56.85	41.94	4.99	NA	NA	NA
2010	35.89	47.80	50.68	24.32	10.69	7.25	5.70	3.97	2.75	1.96	2.03	6.60	1.46	1.47	1.50	1.57	120.43	82.33	63.32	53.80	NA	NA	NA	NA
2011	7.04	14.04	12.01	32.22	11.93	6.14	4.52	3.27	2.23	1.94	1.48	15.12	1.15	1.17	1.20	1.37	58.61	57.15	52.92	32.22	3.20	NA	NA	NA
2012	16.46	16.35	35.82	25.89	10.10	6.30	5.18	3.19	2.26	1.66	NA	NA	1.32	1.36	1.36	1.36	58.77	47.18	45.49	36.46	1.32	5.54	NA	NA
2013	7.30	15.36	29.81	19.38	6.62	4.55	3.18	2.33	1.63	1.18	NA	NA	0.97	0.97	0.97	0.97	68.77	61.54	50.10	33.60	2.64	5.87	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1998	NA	NA	NA	NA	4.54	3.41	2.81	2.22	NA	NA	NA	3	39.68	94	NA	NA	NA	1	122.83	1	1.97	6.08	92	
1999	NA	5.15	4.14	3.68	2.71	2.22	1.84	1.71	NA	NA	NA	5	16.14	38	2	30.00	1	NA	NA	NA	0.75	2.24	81	
2000	5.46	4.26	3.36	2.71	2.09	1.62	1.86	4.19	1	1.62	2	6	19.76	36	3	37.60	1	NA	NA	NA	1.01	2.68	115	
2001	NA	NA	5.90	4.46	3.42	2.83	2.12	2.13	NA	NA	NA	6	22.72	45	1	22.55	1	1	111.63	1	2.45	5.61	113	
2002	NA	NA	5.72	4.47	3.41	2.44	2.32	2.28	NA	NA	NA	4	21.52	65	NA	NA	NA	1	141.81	1	2.10	4.83	117	
2003	4.11	3.31	2.52	1.86	1.65	1.28	1.03	NA	3	1.20	16	6	16.76	24	2	47.05	1	NA	NA	0.94	1.89	119		
2004	NA	5.08	3.78	2.89	2.26	1.74	1.52	NA	1	1.52	10	2	22.69	99	NA	NA	NA	1	86.33	1	1.18	2.59	121	
2005	NA	4.87	3.84	2.78	2.14	1.67	1.37	NA	5	1.57	4	2	27.80	99	1	81.95	1	NA	NA	NA	1.48	3.19	115	
2006	NA	4.29	3.41	2.30	1.75	1.24	1.09	3.31	1	1.09	54	7	22.15	26	3	55.65	1	NA	NA	NA	1.28	3.15	115	
2007	NA	5.82	4.63	3.27	2.22	1.86	1.53	1.58	2	1.56	7	4	20.10	59	2	39.15	1	NA	NA	NA	1.14	2.78	107	
2008	NA	NA	NA	4.14	2.77	2.12	1.55	3.41	1	1.55	7	5	27.52	47	1	25.18	1	1	111.74	1	1.66	4.96	77	
2009	NA	5.94	4.46	3.30	2.12	1.67	1.67	NA	1	1.67	2	2	54.94	111	1	16.20	1	1	107.08	1	1.68	6.87	72	
2010	NA	NA	4.54	3.44	2.26	1.50	1.46	1.75	2	1.52	15	3	37.63	76	1	21.77	1	1	120.43	1	1.47	5.76	79	
2011	NA	5.22	3.91	2.58	1.93	1.25	1.15	1.61	4	1.38	9	2	46.63	110	2	52.17	1	NA	NA	NA	0.60	2.19	63	
2012	NA	5.63	3.85	2.48	2.03	1.36	NA	NA	2	1.34	9	2	40.15	102	2	51.12	1	NA	NA	NA	0.88	3.45	49	
2013	4.92	3.91	2.70	2.12	1.36	0.97	NA	NA	2	1.16	24	4	32.76	39	4	40.34	1	NA	NA	NA	1.16	2.93	94	

Table 9.2.15. Eco-relevant statistics of Sub-basin: Ruaha, Station: Ndembera (Ilongo), Series: 1998-2013 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1998	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1999	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	0.76	2.26	8.95	11.15	3.54	0.78	0.39	0.25	0.15	0.06	NA	3.10	0.03	0.03	0.03	0.03	18.40	18.26	17.68	13.80	0.29	0.81	NA	NA
2001	11.07	21.59	26.42	12.24	6.05	3.35	1.59	0.98	0.47	0.26	0.14	1.29	0.09	0.09	0.10	0.14	42.31	41.69	37.83	30.50	NA	NA	NA	NA
2002	8.34	14.88	21.61	12.74	5.47	2.12	0.96	0.57	0.36	0.15	0.17	NA	0.09	0.09	0.10	0.10	35.22	34.11	31.46	22.67	NA	NA	NA	NA
2003	3.22	4.70	3.85	11.15	3.85	1.12	0.49	0.30	0.18	0.09	0.05	0.08	0.03	0.03	0.04	0.04	17.40	16.83	15.28	11.19	NA	NA	NA	NA
2004	0.36	4.63	12.30	15.35	4.78	1.22	0.58	0.37	0.37	0.12	0.08	2.23	0.04	0.04	0.04	0.07	26.07	25.10	23.21	15.38	0.18	0.89	NA	NA
2005	10.03	15.88	9.87	10.76	5.24	1.90	0.81	0.52	0.32	0.10	0.04	0.09	0.04	0.04	0.04	0.04	20.14	19.38	17.67	16.48	NA	NA	NA	NA
2006	0.47	3.81	4.64	12.11	5.24	2.78	0.76	0.37	0.15	0.03	NA	9.25	0.01	0.01	0.01	0.01	21.97	21.95	21.68	12.17	0.09	NA	NA	NA
2007	15.84	16.65	17.53	8.34	5.08	2.45	1.24	0.75	0.39	0.15	0.07	NA	0.04	0.04	0.05	0.05	38.01	33.22	26.24	17.73	NA	NA	NA	NA
2008	7.58	21.13	20.75	17.26	6.00	3.68	1.57	0.90	0.43	0.19	0.11	3.46	0.06	0.06	0.07	0.09	36.46	34.55	30.84	24.38	NA	NA	NA	NA
2009	11.17	9.15	16.33	17.83	6.04	2.56	1.19	0.64	0.30	0.13	NA	0.26	0.02	0.02	0.03	0.07	25.44	23.77	21.98	18.97	NA	NA	NA	NA
2010	14.13	13.98	16.94	11.25	5.32	2.10	1.04	0.61	0.30	0.13	0.09	0.02	0.02	0.02	0.03	0.07	24.40	24.04	22.63	18.80	NA	NA	NA	NA
2011	3.18	3.98	5.89	10.51	3.85	1.24	0.39	0.24	0.12	0.05	NA	NA	0.03	0.03	0.03	0.03	17.51	16.37	14.35	10.61	0.34	NA	NA	NA
2012	4.59	6.43	9.70	11.16	3.41	0.86	0.41	0.22	0.10	0.03	0.05	NA	0.02	0.02	0.02	0.03	16.95	16.76	15.41	11.89	NA	NA	NA	NA
2013	5.77	7.75	17.11	12.52	5.50	1.64	0.65	0.41	0.19	0.09	0.05	NA	0.03	0.03	0.03	0.04	33.85	33.55	30.30	18.90	NA	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1998	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1999	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
2000	1.26	0.54	0.31	0.20	0.10	0.03	NA	0.50	1	0.03	20	2	11.56	93	1	18.40	1	NA	NA	NA	0.14	0.37	76	
2001	NA	NA	1.20	0.66	0.35	0.20	0.09	0.12	NA	NA	NA	2	23.05	132	NA	NA	NA	NA	NA	NA	0.34	0.80	59	
2002	NA	1.20	0.73	0.43	0.27	0.09	0.09	NA	NA	NA	NA	1	33.56	220	1	35.22	1	NA	NA	NA	0.32	0.92	58	
2003	NA	0.66	0.39	0.23	0.13	0.08	0.03	0.04	2	0.03	16	1	17.40	184	NA	NA	NA	NA	NA	NA	0.14	0.29	75	
2004	NA	0.65	0.44	0.32	0.17	0.05	0.04	0.26	2	0.05	5	5	6.81	35	1	26.07	1	NA	NA	NA	0.24	0.31	126	
2005	NA	1.13	0.65	0.38	0.18	0.06	0.04	0.05	1	0.04	33	1	19.47	217	1	20.14	1	NA	NA	NA	0.21	0.40	82	
2006	NA	1.21	0.52	0.22	0.06	0.01	NA	0.18	2	0.03	11	5	8.96	40	2	21.20	1	NA	NA	NA	0.17	0.65	78	
2007	NA	0.92	0.95	0.56	0.22	0.09	0.04	NA	2	0.05	7	1	33.28	239	NA	NA	NA	NA	NA	1	0.35	0.83	88	
2008	NA	NA	1.15	0.67	0.21	0.11	0.06	0.26	NA	NA	NA	2	22.37	137	NA	NA	NA	NA	1	36.46	0.42	1.04	80	
2009	NA	NA	0.91	0.48	0.23	0.07	NA	NA	NA	NA	NA	2	15.14	129	1	25.44	1	NA	NA	NA	0.29	1.04	67	
2010	NA	1.29	0.84	0.45	0.20	0.08	0.02	0.13	2	0.02	4	1	24.18	228	1	24.40	1	NA	NA	NA	0.19	0.54	60	
2011	NA	0.56	0.16	0.19	0.06	0.03	NA	NA	2	0.04	13	1	15.96	170	1	17.51	1	NA	NA	NA	0.15	0.45	82	
2012	1.41	0.58	0.27	0.16	0.06	0.02	0.02	NA	2	0.03	28	1	16.95	180	NA	NA	NA	NA	NA	NA	0.14	0.47	52	
2013	NA	0.95	0.50	0.30	0.08	0.06	0.03	NA	1	0.03	22	1	33.41	199	1	33.85	1	NA	NA	NA	0.22	0.64	57	

Table 9.2.16. Eco-relevant statistics of Sub-basin: Ruaha, Station: Mtiyu, Series: 1998-2013 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1998	9.81	12.32	7.74	8.90	5.31	3.74	3.59	3.52	3.31	2.33	2.06	1.77	1.57	1.57	1.76	21.93	20.88	18.61	12.69	NA	NA	NA	NA	NA
1999	4.72	3.72	6.13	7.47	4.64	3.38	2.92	3.00	2.29	1.88	1.81	2.07	1.37	1.39	1.69	14.86	14.18	12.90	8.54	2.07	1.89	NA	NA	NA
2000	2.61	3.50	6.38	4.94	3.22	2.14	1.87	1.86	1.46	1.21	NA	3.77	1.13	1.13	1.13	12.58	9.66	7.72	6.48	1.54	NA	NA	NA	NA
2001	7.18	4.38	3.65	5.25	3.66	2.61	2.22	1.95	1.54	1.34	1.12	2.21	0.97	0.97	1.10	17.01	13.56	10.69	7.27	NA	NA	NA	NA	NA
2002	4.06	5.30	5.66	6.54	3.22	2.35	2.08	1.95	1.66	1.35	1.29	1.78	1.14	1.17	1.29	11.42	10.95	9.13	6.78	2.54	NA	NA	NA	NA
2003	4.81	3.75	3.27	5.56	2.94	2.30	1.77	1.51	1.34	1.17	0.93	2.12	0.87	0.87	0.92	12.75	10.65	9.12	6.01	NA	2.35	1.58	NA	NA
2004	3.43	4.29	4.94	5.47	2.33	1.91	1.77	1.47	1.38	1.32	1.36	3.10	0.73	0.92	0.95	1.13	10.66	8.34	7.80	6.04	1.88	2.36	2.32	NA
2005	4.73	4.89	5.58	5.17	3.04	2.20	2.08	1.81	1.45	1.28	1.07	0.89	0.80	0.81	0.86	0.92	9.52	8.86	7.93	5.70	NA	NA	NA	NA
2006	1.55	2.20	3.18	3.82	3.75	2.04	1.54	1.42	1.13	1.01	0.96	NA	0.75	0.76	0.86	0.92	7.92	7.20	6.16	4.53	0.86	1.25	2.37	NA
2007	5.03	5.66	5.74	4.15	3.12	2.23	1.87	2.19	1.52	1.30	1.10	NA	0.88	0.89	0.90	0.90	12.18	9.46	8.59	6.25	NA	NA	NA	NA
2008	5.30	8.05	5.85	10.25	5.24	3.69	3.00	2.77	2.11	1.74	1.97	4.90	1.44	1.45	1.73	18.57	14.02	12.44	10.35	NA	NA	NA	NA	NA
2009	3.95	5.51	NA	8.26	4.45	3.27	2.97	2.58	2.17	1.77	2.68	2.60	1.40	1.41	1.45	14.36	14.03	12.83	12.04	NA	NA	NA	NA	NA
2010	6.74	5.32	5.40	4.11	4.37	2.84	2.46	2.17	1.82	1.42	1.36	1.93	1.17	1.17	1.26	10.27	9.01	7.70	6.79	NA	NA	NA	NA	NA
2011	2.94	5.98	4.84	5.78	3.80	2.46	2.03	1.79	1.59	1.66	1.33	4.53	1.16	1.17	1.30	12.68	10.14	8.70	6.43	1.42	2.01	NA	NA	NA
2012	3.68	3.25	NA	4.54	3.17	2.01	1.70	1.46	1.26	1.05	1.66	1.45	0.97	0.97	1.05	8.93	8.18	7.44	7.44	2.55	1.96	NA	NA	NA
2013	3.80	3.06	4.61	4.69	2.99	1.66	1.38	1.35	1.10	1.03	NA	NA	0.89	0.89	0.89	9.85	8.70	7.84	5.92	1.07	1.75	1.57	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1998	NA	NA	NA	NA	NA	2.11	1.79	1.57	NA	NA	NA	3	8.57	110	NA	NA	NA	1	21.93	1	0.49	0.81	81	
1999	NA	NA	NA	NA	2.11	1.57	1.51	1.37	NA	NA	NA	5	6.00	61	2	6.66	1	1	14.86	1	0.22	0.43	66	
2000	2.11	1.95	1.69	1.65	1.29	1.13	NA	2.17	NA	NA	NA	6	4.79	36	2	6.44	1	1	12.58	1	0.25	0.44	78	
2001	NA	2.38	1.95	1.58	1.37	1.19	0.97	0.97	2	1.02	7	5	4.79	46	1	4.76	1	1	17.01	1	0.24	0.37	99	
2002	NA	2.11	1.79	1.72	1.38	1.25	1.16	1.14	NA	NA	NA	7	3.62	31	2	7.56	1	NA	NA	NA	0.22	0.41	92	
2003	2.33	1.87	1.65	1.37	1.25	0.97	0.87	0.92	2	0.92	25	5	5.23	35	2	5.53	1	1	12.75	1	0.24	0.46	98	
2004	1.93	1.69	1.47	1.16	1.07	0.73	0.91	1.44	3	0.90	7	6	4.04	31	4	5.82	1	NA	NA	NA	0.22	0.37	96	
2005	2.47	1.89	1.90	1.51	1.28	1.14	0.91	0.80	2	0.87	23	6	3.35	32	2	6.11	1	NA	NA	NA	0.19	0.36	95	
2006	2.19	1.61	1.46	1.16	1.01	0.80	0.75	NA	7	0.92	10	6	3.06	21	2	5.45	1	NA	NA	NA	0.12	0.26	96	
2007	NA	1.84	1.72	1.69	1.34	1.16	0.88	NA	2	0.95	9	3	5.10	59	1	3.37	1	1	12.18	1	0.20	0.39	97	
2008	NA	NA	NA	2.49	1.82	1.54	1.44	NA	NA	NA	NA	3	8.25	102	2	6.28	1	1	18.57	1	0.28	0.61	81	
2009	NA	NA	NA	2.39	1.58	1.65	1.58	1.40	NA	NA	NA	4	7.72	67	3	5.94	1	1	14.36	1	0.17	0.30	72	
2010	NA	NA	2.12	1.95	1.58	1.28	1.17	1.21	NA	NA	NA	6	3.58	42	2	6.56	1	NA	NA	NA	0.20	0.35	81	
2011	NA	2.32	1.84	1.65	1.42	1.18	1.16	1.57	NA	NA	NA	5	5.08	45	1	9.23	1	1	12.68	1	0.22	0.41	83	
2012	2.18	1.85	1.58	1.37	1.16	0.97	1.17	0.99	3	1.00	10	6	4.49	23	5	5.17	1	NA	NA	NA	0.10	0.27	47	
2013	1.97	1.56	1.33	1.22	1.05	0.89	NA	NA	3	1.00	13	3	5.74	44	3	6.33	1	NA	NA	NA	0.14	0.31	46	

Table 9.2.17. Eco-relevant statistics of Sub-basin: Ruaha, Station: Liti, Ruaha (Mawande), Series: 1998-2013 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
1998	53.82	74.27	54.30	50.98	30.28	16.24	9.72	7.37	NA	NA	NA	NA	5.72	5.72	5.72	5.72	118.20	109.42	99.25	74.50	NA	NA	NA	NA	NA
1999	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	3.26	6.37	16.56	12.59	4.31	1.92	1.35	1.06	0.57	0.22	NA	NA	0.15	0.15	0.15	0.15	27.18	26.13	23.98	18.05	1.37	2.43	7.27	7.19	
2001	40.84	38.18	41.22	31.39	18.98	10.62	6.20	3.80	2.09	1.10	0.40	NA	0.24	0.24	0.24	0.24	88.73	67.03	63.19	44.51	NA	NA	NA	NA	NA
2002	35.48	49.57	57.92	44.33	23.16	13.79	9.20	6.87	5.28	4.26	2.94	9.15	2.59	2.59	2.59	2.92	109.96	85.79	75.48	62.21	NA	NA	NA	NA	NA
2003	38.49	36.46	26.42	39.62	17.85	11.86	9.05	7.45	5.21	4.91	5.66	8.49	4.57	4.59	4.60	4.72	99.61	67.20	52.41	40.62	NA	NA	NA	NA	NA
2004	14.30	13.79	40.93	42.02	18.01	10.78	8.58	7.03	6.32	5.44	5.60	12.00	5.13	5.13	5.15	5.42	85.37	70.86	62.90	42.15	8.53	NA	NA	NA	NA
2005	25.59	26.57	31.17	25.79	11.67	8.56	7.20	6.26	5.05	3.56	NA	NA	2.59	2.59	2.59	2.59	45.95	40.45	37.35	31.18	NA	NA	NA	NA	NA
2006	5.50	16.99	20.68	27.91	17.99	12.17	9.21	7.77	6.14	3.74	NA	NA	2.03	2.03	2.03	2.03	51.38	41.17	35.59	30.26	3.24	5.82	NA	NA	NA
2007	55.98	58.22	54.58	38.84	24.67	16.87	11.72	9.69	7.92	6.31	4.86	15.80	3.67	3.69	3.77	4.37	134.44	86.98	78.11	58.00	NA	NA	NA	NA	NA
2008	30.68	58.07	56.74	54.97	34.05	20.90	13.67	9.73	5.73	3.74	3.82	15.24	2.58	2.59	2.80	3.12	110.08	95.75	88.69	65.85	NA	NA	NA	NA	NA
2009	24.92	28.48	44.79	47.21	21.81	12.44	9.31	7.06	5.30	3.83	6.56	8.00	3.51	3.55	3.57	3.66	80.48	74.16	67.82	51.31	NA	NA	NA	NA	NA
2010	31.00	30.91	43.42	23.70	16.07	10.49	8.91	7.21	5.39	3.29	2.25	3.84	1.50	1.52	1.56	2.09	53.25	50.46	47.22	43.74	NA	NA	NA	NA	NA
2011	9.91	14.04	19.22	27.40	15.34	10.73	8.60	7.08	5.43	4.80	4.15	12.42	3.05	3.10	3.26	4.04	39.96	37.16	34.09	28.70	3.35	6.66	NA	NA	NA
2012	13.52	14.45	20.28	20.38	12.78	NA	NA	4.70	4.71	3.33	4.10	NA	2.63	2.76	2.86	3.19	27.51	26.84	25.54	22.69	10.39	NA	NA	NA	NA
2013	NA	NA	32.46	67.96	18.33	11.46	8.70	7.77	4.87	3.79	2.42	NA	1.84	1.86	1.90	2.20	90.29	87.15	84.52	68.67	NA	NA	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47		
1998	NA	NA	8.42	5.72	NA	NA	NA	NA	NA	NA	NA	1	112.65	224	NA	NA	NA	1	118.20	1	2.21	6.69	58		
1999	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
2000	2.32	1.63	1.21	0.86	0.37	0.15	NA	NA	4	1.31	38	5	11.98	13	1	27.18	1	NA	NA	NA	0.29	1.05	70		
2001	NA	8.06	4.56	2.59	1.54	0.56	0.24	NA	1	0.24	72	1	70.27	181	1	88.73	1	NA	NA	NA	0.96	3.24	84		
2002	NA	NA	7.54	5.74	5.13	3.43	2.59	3.10	NA	NA	NA	2	63.36	112	1	18.95	1	1	109.96	1	1.25	3.57	64		
2003	NA	10.24	8.23	6.52	4.78	4.57	5.24	5.82	NA	NA	NA	2	46.06	116	1	99.61	1	NA	NA	NA	1.00	2.09	67		
2004	NA	9.43	7.72	6.38	5.55	5.13	5.15	8.37	NA	NA	NA	3	32.95	81	2	53.54	1	NA	NA	NA	0.81	2.35	77		
2005	9.52	7.69	6.80	5.64	4.42	2.59	NA	NA	NA	NA	NA	1	38.75	176	1	45.95	1	NA	NA	NA	0.47	1.63	70		
2006	NA	10.19	8.64	6.87	5.31	2.03	NA	NA	NA	NA	NA	3	20.94	63	1	51.38	1	NA	NA	NA	0.70	3.42	50		
2007	NA	NA	NA	8.79	7.13	5.58	4.09	3.67	NA	NA	NA	2	64.02	139	1	28.00	1	1	134.44	1	1.30	5.04	63		
2008	NA	NA	NA	7.63	4.56	3.01	2.58	7.52	NA	NA	NA	3	48.86	90	1	28.15	1	1	110.08	1	1.11	3.60	75		
2009	NA	10.35	7.94	6.30	4.45	3.54	3.51	4.89	NA	NA	NA	7	19.15	33	1	80.48	1	NA	NA	NA	0.65	2.20	76		
2010	NA	9.44	7.97	6.33	4.60	2.35	1.50	1.78	3	1.75	6	3	22.92	72	1	53.25	1	NA	NA	NA	0.63	1.77	101		
2011	NA	9.66	7.87	6.12	4.91	3.78	3.05	4.10	NA	NA	NA	4	21.61	55	2	33.15	1	NA	NA	NA	0.53	1.58	106		
2012	10.47	NA	NA	4.08	4.08	2.71	2.63	NA	NA	NA	NA	1	26.92	151	1	27.51	1	NA	NA	NA	0.40	1.09	61		
2013	NA	9.75	8.02	6.69	3.58	2.56	1.84	NA	1	1.84	11	1	86.24	173	1	90.29	1	NA	NA	NA	0.96	2.46	78		

Table 9.2.18. Eco-relevant statistics of Sub-basin: Ruaha, Station: Lit. Ruaha (Makalala), Series: 1998-2013 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1998	9.74	11.35	11.48	10.78	7.12	4.56	3.07	2.30	1.57	0.86	0.67	0.83	0.49	0.51	0.53	0.61	14.29	13.59	13.32	12.02	NA	NA	NA	NA
1999	1.28	1.54	5.00	3.78	2.49	1.70	1.05	0.76	0.43	0.19	0.19	NA	0.08	0.09	0.09	0.11	8.92	8.52	7.42	5.37	0.96	1.19	1.92	NA
2000	1.12	1.75	3.32	3.15	1.44	0.73	0.50	0.35	0.14	NA	NA	1.52	0.05	0.05	0.05	0.05	4.65	4.58	4.32	3.74	0.66	0.91	NA	1.86
2001	2.84	5.13	7.76	6.05	3.82	2.45	1.69	1.08	0.60	0.26	0.07	0.86	0.02	0.02	0.03	0.07	10.00	9.62	8.95	8.12	NA	NA	NA	NA
2002	4.03	7.88	11.50	8.30	4.98	3.07	2.09	1.33	0.90	0.53	0.36	0.87	0.24	0.24	0.24	0.29	14.97	14.75	13.51	11.54	1.59	NA	NA	NA
2003	2.48	2.10	2.19	6.95	2.25	1.61	1.01	0.64	0.34	0.19	NA	0.56	0.11	0.11	0.12	0.17	11.17	11.10	10.90	6.96	1.87	1.91	1.72	NA
2004	2.65	NA	3.57	6.04	2.80	1.71	1.27	0.89	0.62	0.30	0.13	1.38	0.07	0.08	0.08	0.12	8.20	7.88	7.55	6.05	1.39	NA	NA	NA
2005	3.33	NA	5.48	5.49	2.88	1.84	1.30	0.87	0.45	0.22	0.16	0.10	0.06	0.06	0.06	0.09	7.49	7.40	6.96	6.54	NA	NA	NA	NA
2006	0.91	2.19	2.94	3.94	3.34	2.15	1.44	0.98	0.53	0.23	0.07	NA	0.04	0.04	0.05	0.06	5.30	5.07	4.82	3.95	0.13	1.53	NA	NA
2007	5.65	8.05	8.71	6.63	4.51	3.14	2.00	1.64	1.05	0.47	0.33	1.04	0.23	0.23	0.24	0.32	17.76	17.76	12.78	9.06	NA	NA	NA	NA
2008	4.83	9.03	11.19	10.37	7.60	5.10	3.37	2.35	1.39	0.81	0.67	3.37	0.46	0.47	0.49	0.56	13.49	13.08	12.74	11.71	NA	NA	NA	NA
2009	6.93	10.08	NA	12.54	8.31	5.70	3.97	2.58	1.61	0.89	1.95	2.99	0.63	0.63	0.65	0.77	17.78	14.87	14.71	14.44	NA	NA	NA	NA
2010	7.45	10.04	13.41	9.49	7.14	4.54	3.21	2.23	1.49	0.92	0.57	NA	0.51	0.51	0.52	0.52	16.45	15.89	15.13	13.59	NA	NA	NA	NA
2011	2.21	3.96	5.49	NA	3.94	2.34	1.60	1.11	0.74	0.52	0.34	1.56	0.26	0.27	0.29	0.33	6.68	6.44	6.06	5.83	1.12	NA	NA	NA
2012	2.08	3.76	6.41	6.73	3.91	2.48	1.75	1.24	0.78	0.42	0.31	1.53	0.14	0.15	0.17	0.25	10.39	9.97	9.07	7.75	1.37	1.93	NA	NA
2013	2.28	4.16	5.88	6.49	NA	NA	1.72	1.27	0.82	0.55	NA	1.22	0.36	0.36	0.36	0.36	8.62	8.18	7.66	6.80	1.43	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1998	NA	NA	NA	1.84	1.26	0.66	0.49	0.70	NA	NA	NA	1	14.27	269	1	14.29	1	NA	NA	NA	0.13	0.45	50	
1999	1.88	1.20	0.87	0.64	0.27	0.10	0.08	NA	3	0.10	11	7	2.55	21	1	8.92	1	NA	NA	NA	0.08	0.20	55	
2000	0.92	0.61	0.41	0.29	0.05	NA	NA	0.34	1	0.05	24	4	2.54	33	1	4.65	1	NA	NA	NA	0.07	0.23	57	
2001	NA	NA	1.34	0.74	0.39	0.15	0.02	0.18	1	0.02	37	3	4.15	72	1	10.00	1	NA	NA	NA	0.07	0.20	45	
2002	NA	NA	1.54	1.06	0.82	0.26	0.24	0.24	NA	NA	NA	2	8.44	118	NA	NA	1	1	14.97	1	0.11	0.22	35	
2003	NA	1.28	0.81	0.46	0.23	0.11	NA	0.13	3	0.14	7	2	6.30	90	1	11.17	1	NA	NA	NA	0.06	0.17	48	
2004	NA	1.50	1.07	0.70	0.45	0.17	0.07	0.33	1	0.07	33	3	4.87	58	2	6.28	1	NA	NA	NA	0.06	0.20	37	
2005	NA	1.52	1.13	0.62	0.32	0.14	0.09	0.06	3	0.11	22	2	5.79	83	2	5.81	1	NA	NA	NA	0.05	0.21	49	
2006	NA	1.78	1.18	0.73	0.36	0.11	0.04	NA	2	0.09	25	2	3.38	91	1	5.30	1	NA	NA	NA	0.05	0.23	70	
2007	NA	NA	1.77	1.40	0.64	0.32	0.26	0.23	NA	NA	NA	2	6.91	129	NA	NA	1	1	17.76	1	0.11	0.35	69	
2008	NA	NA	NA	1.87	1.08	0.58	0.46	1.16	NA	NA	NA	2	9.55	143	2	9.87	1	NA	NA	NA	0.11	0.36	66	
2009	NA	NA	NA	NA	1.19	0.68	0.63	1.87	NA	NA	NA	3	10.80	95	1	5.22	1	2	16.56	1	0.14	0.44	55	
2010	NA	NA	NA	NA	1.18	0.69	0.51	NA	NA	NA	NA	2	8.70	132	NA	NA	1	1	16.45	1	0.09	0.37	40	
2011	NA	1.94	1.37	0.87	0.63	0.38	0.26	0.29	NA	NA	NA	5	3.65	38	2	6.14	1	NA	NA	NA	0.06	0.23	52	
2012	NA	NA	1.46	1.00	0.40	0.20	0.14	0.18	3	0.17	4	2	6.52	119	1	10.39	1	NA	NA	NA	0.07	0.23	47	
2013	NA	NA	1.43	1.03	0.65	0.36	NA	0.70	NA	NA	NA	3	4.22	56	2	6.14	1	NA	NA	NA	0.11	0.28	56	

Table 9.2.19. Eco-relevant statistics of Sub-basin: Kilombero, Station: Lumemo, Series: 1961-1980 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1961	NA	10.54	7.85	28.19	25.18	9.94	11.27	6.76	5.00	4.87	13.30	19.26	3.65	3.80	3.85	4.41	87.74	67.08	62.41	40.09	NA	4.56	3.88	5.47
1962	25.67	21.23	29.96	39.70	29.00	15.36	10.35	7.89	5.73	4.82	4.00	4.56	2.79	2.87	2.91	3.49	104.94	97.02	56.17	44.53	NA	NA	NA	NA
1963	6.85	7.75	26.95	48.77	20.88	11.96	8.73	6.31	4.88	4.08	8.54	9.42	3.40	3.43	3.45	3.88	101.45	70.17	66.49	52.60	4.35	5.31	5.68	NA
1964	13.33	9.49	NA	73.65	NA	18.93	14.58	11.87	9.97	8.72	7.47	7.98	6.71	6.71	6.71	7.06	134.62	134.62	134.62	134.62	NA	7.08	NA	NA
1965	13.08	11.03	14.30	40.48	18.00	11.88	9.36	8.30	7.25	6.90	7.00	8.85	6.07	6.15	6.19	6.62	113.84	96.66	72.78	41.40	7.08	6.71	NA	NA
1966	11.53	11.66	21.30	41.85	21.57	14.04	6.31	4.61	3.67	4.11	4.10	4.42	2.84	2.88	2.99	3.22	127.48	104.72	78.94	42.60	7.06	NA	NA	NA
1967	4.05	5.76	6.48	13.25	18.40	11.41	8.01	6.21	5.38	4.10	6.26	17.47	3.04	3.15	3.20	3.95	61.93	38.63	28.35	18.95	3.04	3.21	3.58	4.59
1968	21.76	13.41	32.48	88.71	34.90	21.43	12.56	9.15	7.89	6.24	6.79	7.17	4.72	4.86	5.13	5.72	519.06	279.19	166.08	88.71	NA	NA	NA	NA
1969	4.97	7.15	19.44	21.30	21.95	10.72	7.55	5.57	4.22	3.57	4.39	3.66	2.58	2.63	3.14	3.48	112.28	54.61	37.24	28.58	3.95	4.72	6.65	NA
1970	NA	15.09	21.86	24.89	12.66	7.90	6.13	4.59	4.24	3.66	3.15	3.83	2.81	2.86	2.90	3.13	62.13	48.91	37.80	28.93	NA	6.19	NA	NA
1971	5.09	5.28	11.45	31.23	19.01	10.05	7.86	5.33	4.28	4.10	3.57	4.02	2.37	2.38	2.60	3.52	124.63	97.49	70.15	34.43	2.37	2.66	4.40	NA
1972	5.40	6.74	13.66	35.73	33.76	17.11	10.40	7.25	5.98	4.41	5.25	NA	3.39	3.53	3.63	4.23	97.73	74.27	61.73	39.30	3.39	4.00	6.99	NA
1973	NA	8.97	12.48	32.68	29.86	12.38	8.00	5.70	4.14	3.38	3.28	3.89	2.85	2.90	2.96	3.07	87.78	79.88	67.27	39.44	NA	6.85	7.27	NA
1974	4.29	3.67	4.63	39.42	34.99	12.05	8.66	6.00	4.34	3.67	3.05	3.57	2.26	2.31	2.42	2.91	176.94	103.14	72.61	49.23	2.66	2.34	2.26	6.40
1975	6.18	3.85	7.52	NA	25.06	11.27	7.35	5.27	4.26	3.46	3.11	6.42	2.58	2.58	2.65	3.06	71.77	62.18	62.18	62.18	3.26	2.58	3.95	NA
1976	6.52	6.06	12.53	19.43	16.02	10.00	6.79	5.94	4.05	3.65	3.04	2.63	2.37	2.37	2.39	2.63	76.12	43.62	33.76	22.40	3.62	3.57	4.61	NA
1977	4.85	3.51	8.21	13.78	11.76	7.40	5.65	3.89	2.98	2.61	7.06	9.75	2.37	2.37	2.49	2.61	54.61	36.90	23.94	15.18	2.37	2.68	2.44	6.45
1978	6.48	7.63	20.54	NA	19.80	9.42	6.74	5.01	3.66	3.06	7.98	9.54	2.37	2.57	2.64	2.80	85.58	85.58	85.58	85.58	4.79	6.19	6.39	NA
1979	15.34	22.88	29.26	64.10	33.73	19.62	11.62	8.70	6.89	5.35	4.28	5.90	3.30	3.30	3.35	3.81	160.62	124.18	95.45	64.60	6.11	NA	NA	NA
1980	10.10	8.77	NA	32.84	28.39	11.65	8.17	5.89	4.29	3.64	4.19	5.18	3.10	3.16	3.22	3.57	92.91	74.49	51.68	41.56	4.97	5.70	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1961	NA	NA	NA	5.61	4.22	3.65	6.96	NA	NA	NA	NA	12	18.21	20	5	32.87	1	1	87.74	1	2.92	6.13	145	
1962	NA	NA	NA	6.86	5.10	4.35	3.40	2.79	2	2.91	4	4	36.06	62	1	15.79	1	2	100.98	1	2.27	5.34	139	
1963	NA	NA	7.20	5.57	4.40	3.54	3.40	5.21	NA	NA	NA	13	17.34	19	7	17.78	1	1	101.45	1	2.44	6.38	132	
1964	NA	NA	NA	NA	NA	NA	7.08	6.71	NA	NA	NA	3	56.58	99	2	24.05	3	1	134.62	1	1.64	4.81	79	
1965	NA	NA	NA	7.45	6.82	6.28	6.07	6.26	NA	NA	NA	2	61.86	181	1	47.16	1	1	113.84	1	2.04	4.61	123	
1966	NA	NA	5.30	3.93	3.30	3.08	2.84	3.46	2	2.93	3	7	19.94	29	2	17.90	1	1	127.48	1	2.13	4.04	144	
1967	NA	NA	6.76	5.04	4.29	3.78	3.78	6.22	1	3.04	1	16	11.66	13	6	25.76	1	NA	NA	1.62	3.15	156		
1968	NA	NA	NA	NA	7.13	5.45	4.72	4.77	NA	NA	NA	5	57.20	64	3	13.38	1	1	519.06	1	5.82	12.38	161	
1969	NA	NA	6.58	4.77	3.71	3.09	3.05	2.58	4	2.90	2	10	12.19	18	1	13.29	1	1	112.28	1	1.61	3.05	172	
1970	NA	6.78	5.27	4.00	3.71	3.44	2.81	2.81	5	2.92	4	2	30.37	84	1	62.13	1	NA	NA	1.87	3.27	131		
1971	NA	NA	6.38	4.61	3.85	3.57	3.18	2.89	5	2.69	4	13	14.80	12	5	16.44	1	1	124.63	1	2.19	4.14	158	
1972	NA	NA	NA	6.38	4.93	3.85	3.80	NA	NA	NA	NA	15	13.56	14	5	13.39	1	1	97.73	1	2.24	5.67	126	
1973	NA	NA	6.78	4.66	3.67	3.01	2.85	2.89	4	2.92	7	2	43.80	96	NA	NA	NA	1	87.78	1	1.52	2.98	131	
1974	NA	NA	7.06	4.93	3.71	3.18	2.81	2.66	10	2.66	7	8	21.72	18	2	14.29	1	1	176.94	1	2.46	4.89	159	
1975	NA	NA	6.00	4.40	3.66	3.05	2.93	2.81	6	2.87	10	12	14.49	11	6	15.78	1	1	71.77	1	1.37	3.14	123	
1976	NA	NA	5.81	4.45	3.67	3.31	2.81	2.37	5	2.73	7	12	10.73	13	7	15.49	1	1	76.12	1	1.65	3.04	154	
1977	7.41	5.94	4.19	3.31	2.37	2.37	2.61	4.00	13	2.66	6	14	13.87	11	7	28.48	1	NA	NA	1.69	2.62	149		
1978	NA	NA	5.59	4.29	2.76	2.81	2.37	5.54	3	2.73	12	10	18.44	20	5	21.03	1	2	81.02	1	1.87	3.10	124	
1979	NA	NA	NA	7.47	5.81	4.29	3.63	3.30	NA	NA	NA	7	29.00	41	2	14.01	1	1	160.62	1	4.02	5.95	153	
1980	NA	NA	6.91	4.96	3.86	3.12	3.10	3.57	NA	NA	NA	8	17.89	24	3	18.49	1	1	92.91	1	1.84	3.38	128	

Table 9.2.20. Eco-relevant statistics of Sub-basin: Kilombero, Station: Hagafiro, Series: 1961-1980 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1961	1.35	3.01	3.49	3.49	3.05	1.68	1.38	0.97	0.74	0.55	0.78	2.80	0.42	0.42	0.44	0.50	5.63	4.89	4.46	3.81	0.73	1.98	2.12	2.27
1962	8.11	11.00	NA	12.36	6.20	3.37	2.35	1.76	1.36	1.39	0.92	1.57	0.75	0.76	0.78	0.92	19.03	17.19	15.47	14.39	NA	NA	NA	NA
1963	4.41	3.70	11.37	10.62	NA	3.69	2.64	1.89	1.41	0.93	1.84	3.11	0.78	0.78	0.80	0.87	23.96	21.17	20.19	13.74	NA	NA	NA	NA
1964	4.39	7.28	13.20	6.38	3.75	2.86	2.34	1.59	1.29	0.75	0.99	1.86	0.56	0.56	0.58	0.72	29.57	28.76	27.10	13.53	1.84	NA	NA	NA
1965	1.64	2.23	3.73	3.54	4.66	1.71	1.25	1.14	1.00	0.82	0.88	NA	0.58	0.58	0.59	0.70	9.49	8.81	8.28	5.73	0.88	1.15	2.05	NA
1966	3.47	3.46	4.90	5.85	2.86	1.95	1.53	1.17	0.95	0.76	1.08	NA	0.64	0.64	0.65	0.72	9.74	9.58	8.83	6.73	2.00	2.07	NA	NA
1967	3.37	4.35	5.20	5.30	3.73	2.31	1.82	1.40	1.15	0.87	NA	6.03	0.76	0.76	0.76	0.77	11.21	10.18	7.98	6.17	2.09	NA	NA	NA
1968	6.69	9.98	10.19	9.78	5.88	3.70	2.57	2.17	1.77	1.39	1.15	2.14	0.85	0.86	0.89	1.07	17.92	16.62	15.24	11.04	NA	NA	NA	NA
1969	2.78	2.76	2.71	3.76	2.49	1.76	1.42	1.21	0.93	0.81	NA	NA	0.60	0.60	0.63	0.64	5.40	4.93	4.24	3.80	2.05	2.15	1.88	2.25
1970	3.75	5.53	9.26	6.02	3.29	2.35	1.85	1.41	1.06	0.83	0.73	3.25	0.60	0.60	0.64	0.70	16.22	15.21	14.18	9.70	1.39	NA	NA	NA
1971	2.33	3.34	4.54	4.23	NA	1.95	1.42	1.16	0.90	0.82	1.12	NA	0.62	0.62	0.65	0.78	6.53	6.11	5.58	4.66	1.61	1.66	NA	NA
1972	4.02	4.63	7.52	5.67	3.56	2.35	1.85	1.37	1.10	0.95	1.05	2.66	0.68	0.72	0.73	0.91	12.12	11.30	9.98	7.83	2.24	NA	NA	NA
1973	3.35	4.99	10.05	10.36	5.22	3.38	2.53	1.94	1.42	1.11	1.18	2.57	0.87	0.87	0.91	0.94	15.51	14.34	13.28	9.23	2.01	NA	NA	NA
1974	3.84	5.66	4.66	7.58	7.22	4.02	2.99	2.14	1.67	1.33	1.45	1.86	0.93	0.96	1.00	1.26	12.54	9.98	7.99	8.05	NA	NA	NA	NA
1975	3.59	4.80	6.92	5.77	4.10	2.73	2.04	1.74	1.41	1.11	0.88	1.94	0.79	0.79	0.82	0.86	8.56	8.29	7.99	7.00	1.61	NA	NA	NA
1976	3.77	3.65	6.22	7.39	3.76	2.62	1.89	1.49	1.16	1.15	0.80	1.22	0.64	0.69	0.71	0.80	10.59	10.44	9.80	8.09	2.17	NA	NA	NA
1977	2.66	3.00	4.65	3.04	5.92	2.30	1.69	1.33	0.99	0.82	1.35	2.18	0.64	0.67	0.68	0.79	6.94	6.81	6.73	5.99	1.19	2.10	NA	NA
1978	3.47	4.29	8.66	6.05	3.68	2.66	1.96	1.42	1.16	1.02	1.10	3.24	0.66	0.70	0.72	0.85	11.68	11.29	10.71	8.78	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1961	2.00	1.51	1.19	0.85	0.62	0.42	0.42	0.68	6	0.66	13	5	3.47	33	3	4.96	1	NA	NA	NA	0.21	0.39	150	
1962	NA	NA	1.86	1.56	1.20	1.10	0.75	0.75	2	0.75	4	6	6.99	35	1	2.94	1	2	18.20	2	0.37	0.81	104	
1963	NA	NA	2.14	1.52	1.17	0.78	0.78	1.39	2	0.78	2	7	6.43	34	3	5.64	1	1	23.96	1	0.61	0.70	130	
1964	1.76	NA	1.88	1.36	1.05	0.56	0.78	1.03	3	0.71	8	4	8.80	58	1	3.07	1	1	29.57	1	0.54	0.50	125	
1965	2.07	1.37	1.13	1.01	0.89	0.68	0.58	NA	3	0.71	7	6	3.38	22	2	6.51	1	NA	NA	0.27	0.31	127		
1966	NA	1.67	1.35	1.02	0.85	0.68	0.64	NA	4	0.69	11	3	4.53	60	2	6.35	2	NA	NA	0.21	0.34	108		
1967	NA	1.97	1.62	1.24	0.99	0.76	NA	1.85	1	0.76	16	4	5.56	58	2	10.02	1	NA	NA	0.34	0.59	129		
1968	NA	NA	NA	1.92	1.58	1.11	0.90	0.85	NA	NA	5	5	6.81	54	3	5.95	1	1	17.92	1	0.33	0.60	132	
1969	1.67	1.58	1.22	0.93	0.81	0.60	NA	NA	3	0.69	6	4	2.91	40	1	5.40	1	NA	NA	0.18	0.28	139		
1970	NA	2.08	1.70	1.21	0.93	0.72	0.60	1.20	2	0.63	18	6	5.50	37	2	5.99	1	1	16.22	1	0.26	0.53	117	
1971	NA	1.66	1.25	0.99	0.78	0.68	0.62	NA	5	0.68	9	8	2.75	19	3	4.41	1	NA	NA	0.23	0.38	99		
1972	NA	2.08	1.50	1.25	0.94	0.81	0.68	1.45	1	0.68	8	3	6.03	77	2	3.61	1	1	12.12	1	0.23	0.41	127	
1973	NA	NA	2.23	1.67	1.16	0.87	0.87	0.95	NA	NA	NA	5	5.27	53	2	4.42	1	1	15.51	1	0.26	0.48	95	
1974	NA	NA	NA	1.78	1.39	1.14	0.95	0.93	NA	NA	NA	7	3.48	40	3	2.89	1	1	12.54	1	0.23	0.41	111	
1975	NA	NA	1.78	1.67	1.19	0.95	0.79	0.79	2	0.79	3	4	3.75	62	2	6.01	1	NA	NA	0.18	0.29	88		
1976	NA	2.20	1.78	1.34	1.04	0.87	0.64	0.83	3	0.71	5	2	5.96	107	1	10.59	2	NA	NA	0.21	0.35	89		
1977	NA	1.91	1.44	1.14	0.79	0.64	0.95	0.93	4	0.73	4	5	3.72	42	3	5.00	1	NA	NA	0.16	0.24	93		
1978	NA	2.27	1.61	1.19	1.04	0.87	0.66	2.07	1	0.66	7	3	6.19	80	1	5.33	1	1	11.68	1	0.22	0.32	101	
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

Table 9.2.21. Eco-relevant statistics of Sub-basin: Kilombero, Station: Mpanga, Series: 1961-1980 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1961	21.91	30.53	32.22	44.97	49.27	20.26	21.60	16.93	17.40	16.68	NA	47.22	15.35	15.58	15.65	16.26	140.78	125.19	99.20	64.91	15.35	21.60	20.24	17.26
1962	88.24	80.90	96.22	101.73	64.75	43.05	38.92	35.46	30.32	27.74	24.20	28.60	19.38	19.95	20.12	22.92	222.18	179.09	154.27	107.19	NA	NA	NA	NA
1963	60.92	69.19	99.61	137.24	67.69	NA	40.15	35.55	31.83	27.17	NA	11.56	10.33	10.50	10.69	10.94	253.85	214.75	167.46	148.66	NA	NA	NA	NA
1964	12.90	60.69	92.86	132.63	66.70	50.30	43.66	40.48	35.79	31.45	27.48	31.61	12.15	12.38	12.57	12.90	207.97	195.84	161.88	150.69	12.15	NA	NA	NA
1965	38.13	43.66	63.39	103.79	46.70	34.91	30.30	28.88	25.98	24.93	23.45	28.88	19.38	19.76	20.08	23.18	222.50	165.60	166.86	113.24	27.06	28.68	NA	NA
1966	37.30	39.76	NA	113.06	51.67	38.33	32.70	29.37	26.77	24.30	25.02	30.89	21.29	21.29	21.60	23.63	219.60	208.96	191.20	173.51	26.42	30.64	NA	NA
1967	35.02	39.14	45.82	65.69	64.66	41.38	30.51	27.06	26.28	22.21	28.82	75.37	19.67	20.05	20.50	21.49	169.95	141.98	120.59	79.57	26.09	29.01	31.29	NA
1968	58.81	65.23	133.66	159.09	89.33	67.12	53.13	45.01	40.10	35.38	35.53	43.20	30.96	30.96	31.34	34.12	240.46	207.81	196.36	169.26	NA	NA	NA	NA
1969	46.78	43.77	52.98	80.63	55.66	35.66	31.58	30.00	25.69	22.55	23.51	25.57	18.44	18.86	19.28	21.01	202.84	182.27	150.56	91.51	NA	NA	NA	NA
1970	46.64	76.00	69.40	59.99	38.60	31.03	28.26	25.97	23.68	20.45	17.80	39.12	16.99	17.08	17.19	17.71	189.90	164.94	133.80	77.39	22.24	31.94	NA	NA
1971	31.53	46.42	NA	NA	49.35	29.75	29.26	23.06	20.70	NA	18.54	22.40	13.79	14.08	14.75	17.75	81.07	71.62	71.62	20.68	20.68	24.45	NA	NA
1972	NA	37.13	NA	156.65	87.38	43.87	36.00	29.70	29.61	24.03	22.96	56.72	17.24	17.57	18.38	22.96	297.30	285.04	256.76	185.80	NA	24.13	NA	NA
1973	91.84	NA	84.22	145.95	98.56	43.81	37.24	31.79	26.84	23.49	23.44	30.29	19.45	19.76	20.07	21.39	294.89	264.51	237.59	164.76	NA	NA	NA	NA
1974	47.03	NA	NA	148.65	NA	49.60	37.67	29.83	27.21	22.88	21.59	NA	20.29	20.29	20.29	20.29	281.92	223.47	190.97	165.49	24.76	NA	NA	NA
1975	NA	NA	67.74	NA	79.25	42.67	32.54	28.38	24.33	21.56	17.89	30.71	16.12	16.22	16.33	17.41	157.91	157.91	157.91	157.91	NA	NA	NA	NA
1976	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1977	34.29	27.24	41.33	59.89	42.04	NA	23.63	21.95	18.63	17.57	20.23	32.33	15.17	15.70	15.96	17.23	87.27	83.18	79.02	61.04	20.74	18.80	19.93	32.33
1978	29.55	33.95	52.29	52.62	38.06	27.53	23.10	19.33	16.79	13.86	18.13	24.51	11.22	11.51	11.85	12.58	81.56	72.74	63.52	53.37	21.74	23.86	27.63	32.57
1979	40.73	54.02	NA	NA	NA	55.86	44.93	37.73	32.47	27.22	26.53	NA	14.30	22.26	22.70	23.77	83.76	83.18	71.22	69.38	21.55	14.30	NA	NA
1980	40.74	32.93	42.83	47.20	44.84	28.74	25.63	22.74	19.98	17.01	16.22	27.12	13.35	13.53	14.00	16.06	81.20	81.20	66.37	52.63	31.51	26.22	32.62	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1961	25.45	17.26	16.99	15.46	16.99	16.12	NA	20.59	7	16.35	11	18	45.36	6	7	45.63	1	2	139.41	1	3.88	8.11	134	
1962	NA	NA	NA	32.93	28.21	26.09	21.29	19.38	NA	NA	NA	5	69.45	57	1	53.65	1	1	222.18	1	6.31	11.58	131	
1963	NA	NA	NA	NA	29.33	25.13	NA	10.33	1	10.33	31	4	86.34	62	1	46.89	1	1	253.85	1	7.51	14.67	111	
1964	NA	NA	NA	NA	32.93	29.01	26.09	24.16	1	12.15	31	4	75.87	74	1	47.23	1	1	207.97	1	3.95	6.06	115	
1965	NA	30.96	29.01	27.06	24.16	21.29	20.24	19.38	NA	NA	NA	11	50.32	21	3	52.18	1	1	222.50	1	5.37	9.03	126	
1966	NA	NA	30.96	28.03	24.16	23.20	21.29	23.20	NA	NA	NA	11	53.40	20	4	59.30	1	1	219.60	1	4.43	8.30	101	
1967	NA	NA	27.06	27.06	24.48	20.24	19.67	27.06	NA	NA	NA	7	66.71	34	2	59.74	1	1	163.08	1	5.20	8.66	121	
1968	NA	NA	NA	NA	NA	32.93	31.94	30.96	NA	NA	NA	1	204.58	365	NA	NA	NA	1	240.46	1	7.25	12.41	144	
1969	NA	NA	29.98	28.03	24.16	20.24	19.38	18.44	NA	NA	NA	6	62.39	42	1	40.86	1	1	202.84	1	4.64	8.08	132	
1970	32.93	29.98	27.06	24.16	21.29	18.44	16.99	21.25	1	16.99	2	6	65.98	35	3	52.26	1	1	189.90	1	5.12	8.39	120	
1971	31.26	26.69	26.36	20.99	19.15	NA	15.54	13.79	2	14.67	8	11	43.52	8	6	63.41	1	NA	NA	NA	3.60	5.30	88	
1972	NA	NA	31.09	28.63	24.76	21.92	17.24	30.60	NA	NA	NA	11	67.08	17	4	57.09	1	2	202.61	1	7.73	12.80	114	
1973	NA	NA	NA	28.63	24.76	21.92	20.07	19.45	NA	NA	NA	5	108.07	46	1	43.72	2	2	248.44	1	9.95	16.13	117	
1974	NA	NA	31.65	27.45	24.30	20.90	20.29	NA	NA	NA	NA	8	73.83	17	5	60.86	1	1	281.92	1	8.74	15.74	87	
1975	NA	NA	26.50	26.50	22.13	19.09	16.42	16.12	1	16.12	12	11	51.90	13	3	60.86	1	2	150.10	1	4.91	8.38	96	
1976	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1977	31.03	NA	22.13	20.41	17.19	15.17	16.17	19.21	5	16.12	6	14	45.21	9	9	57.48	1	NA	NA	NA	3.02	5.31	117	
1978	29.80	25.08	21.00	17.53	14.63	12.64	11.22	18.41	2	14.04	36	15	40.30	9	7	57.72	1	NA	NA	NA	2.75	5.01	116	
1979	NA	NA	NA	NA	28.58	24.39	22.13	NA	1	14.30	1	12	48.57	14	9	64.78	1	NA	NA	NA	3.07	7.49	77	
1980	32.62	26.22	24.42	21.57	18.26	14.69	13.56	13.35	4	14.73	11	6	48.85	27	4	67.40	1	NA	NA	NA	1.96	3.42	123	

Table 9.2.22. Eco-relevant statistics of Sub-basin: Kilombero, Station: Mnyera (US Taveta Mission), Series: 1961-1980 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
1961	32.60	23.30	20.17	NA	NA	96.48	NA	162.54	181.26	167.61	107.32	84.24	17.78	19.05	19.21	19.21	237.88	230.86	225.24	204.99	17.78	20.90	18.89	NA	
1962	76.59	58.88	48.47	44.80	35.88	38.84	81.97	125.62	166.07	NA	128.49	92.59	30.63	31.92	32.18	35.17	215.19	215.19	215.19	215.19	65.25	53.91	42.57	39.65	
1963	82.53	65.69	55.59	47.48	64.94	164.91	NA	NA	NA	187.98	118.05	98.38	42.46	42.65	43.07	44.62	199.66	196.70	195.77	189.18	68.09	61.25	52.88	44.49	
1964	85.21	75.09	70.15	67.63	NA	119.26	73.91	75.89	77.60	101.95	NA	96.24	64.21	64.37	65.07	66.04	179.22	179.17	178.19	178.19	NA	NA	68.42	66.04	
1965	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1966	62.16	57.06	55.30	48.66	51.39	66.04	NA	NA	101.54	136.51	102.67	76.57	43.09	43.28	43.81	47.37	190.64	187.03	178.98	138.05	59.10	54.76	49.61	46.19	
1967	55.68	9.65	54.59	47.44	56.61	155.63	127.65	NA	NA	NA	159.75	NA	7.78	7.78	7.98	9.68	236.62	221.17	198.35	175.70	10.02	7.78	51.74	44.94	
1968	104.10	91.91	86.79	76.14	NA	72.24	79.29	106.31	127.49	193.37	109.59	82.41	47.34	47.53	48.22	48.22	251.12	251.12	246.93	195.25	NA	NA	NA	67.82	
1969	79.58	70.65	64.67	56.91	60.42	64.08	117.15	142.31	156.88	119.11	88.38	75.46	48.85	49.34	50.13	53.42	244.16	232.24	197.17	157.82	NA	67.82	60.61	52.46	
1970	70.02	65.73	59.81	45.57	47.78	77.78	43.57	71.21	95.89	140.99	67.66	43.32	29.29	30.40	32.25	40.07	259.00	256.05	222.87	143.64	67.42	63.11	47.86	43.48	
1971	42.35	36.51	29.97	34.40	26.90	44.90	31.46	50.87	142.58	118.35	86.91	52.95	20.69	21.83	23.06	26.24	250.83	240.88	220.82	146.77	38.37	31.32	27.89	25.74	
1972	NA	41.32	34.93	28.92	27.08	90.72	126.17	98.87	164.03	159.35	124.20	98.14	23.78	23.87	24.44	26.85	262.46	260.31	243.69	166.28	NA	36.84	30.58	26.40	
1973	76.01	59.81	40.66	30.10	23.30	60.16	112.54	NA	76.37	159.92	124.64	102.24	20.42	20.75	21.14	23.15	265.76	265.76	244.80	161.38	68.79	43.74	35.45	25.74	
1974	81.36	60.05	33.11	24.20	21.25	50.81	113.12	139.44	NA	130.13	129.94	59.06	17.57	17.94	18.49	20.64	186.68	186.68	186.68	186.68	NA	45.01	25.87	21.22	
1975	47.36	41.90	37.71	32.13	25.96	73.61	122.31	90.07	154.88	111.58	72.84	55.69	23.20	23.47	23.98	25.26	265.94	261.36	239.79	162.38	41.96	40.06	34.56	27.89	
1976	44.46	36.49	32.00	27.29	23.55	NA	53.57	65.45	84.74	112.59	48.51	38.10	21.86	21.86	21.86	21.86	167.66	161.53	153.39	113.87	40.74	32.91	29.86	24.96	
1977	32.77	28.69	25.99	25.89	26.65	NA	118.31	149.45	169.81	153.35	94.38	73.70	22.67	22.90	23.40	24.08	267.60	259.64	237.29	190.71	29.72	27.03	23.63	23.80	
1978	50.11	38.55	31.58	27.17	NA	128.19	NA	NA	NA	199.18	8.70	NA	7.45	7.45	7.45	7.45	267.34	267.34	267.34	261.15	251.68	42.37	35.24	29.01	24.34
1979	71.26	58.48	49.41	40.29	39.18	58.82	100.82	62.70	111.82	138.78	114.30	91.19	34.35	34.70	35.32	38.04	153.77	151.71	146.96	139.66	61.95	53.08	42.08	36.73	
1980	NA	58.17	47.77	37.21	26.02	38.94	80.16	119.13	107.69	219.10	122.62	86.84	20.77	20.86	21.27	24.75	267.16	266.17	260.28	225.02	NA	54.09	42.14	31.56	
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47		
1961	NA	40.51	NA	NA	NA	NA	NA	69.76	3	20.18	18	6	153.40	27	4	198.91	1	NA	NA	NA	5.28	9.40	67		
1962	30.63	31.43	49.90	NA	NA	NA	NA	NA	NA	NA	NA	6	129.23	34	3	196.56	1	NA	NA	NA	2.49	3.76	98		
1963	42.46	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4	146.59	51	2	198.60	1	NA	NA	NA	1.51	4.06	48		
1964	NA	NA	66.17	64.21	NA	68.15	NA	NA	NA	NA	NA	9	113.95	32	4	157.29	1	NA	NA	NA	1.26	5.22	47		
1965	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
1966	43.09	45.91	NA	NA	66.50	NA	NA	65.84	NA	NA	NA	8	83.58	27	1	190.64	1	NA	NA	NA	3.57	6.80	105		
1967	43.60	NA	NA	NA	NA	NA	NA	NA	1	7.78	31	6	107.65	22	2	210.61	1	NA	NA	NA	4.48	7.41	84		
1968	NA	47.34	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	196.29	107	2	248.92	1	NA	NA	NA	2.81	4.70	110		
1969	48.85	50.37	64.69	NA	NA	NA	NA	NA	NA	NA	NA	5	151.27	66	3	216.49	1	NA	NA	NA	3.56	6.94	123		
1970	45.11	48.73	29.29	40.36	45.32	NA	48.82	38.65	NA	NA	NA	7	123.93	31	1	123.76	1	2	256.05	1	3.50	5.83	119		
1971	22.06	20.69	21.49	23.12	68.65	NA	61.81	42.90	3	21.41	7	5	112.51	24	1	250.83	1	NA	NA	2.89	5.14	104			
1972	23.78	27.19	NA	NA	NA	NA	NA	NA	1	23.78	5	2	248.88	101	NA	NA	NA	2	261.38	1	3.03	5.37	96		
1973	20.42	23.88	NA	NA	45.31	NA	NA	NA	2	22.37	13	5	156.32	41	3	161.18	1	1	265.76	1	2.19	4.35	99		
1974	18.55	17.57	NA	NA	NA	NA	NA	51.22	3	21.08	18	5	107.79	40	2	169.59	2	NA	NA	2.40	3.68	123			
1975	23.44	23.20	52.95	57.07	NA	NA	54.09	48.31	2	23.32	6	8	133.84	21	3	208.85	1	1	265.94	1	5.19	6.38	160		
1976	21.86	NA	36.95	44.28	45.56	NA	40.92	34.97	1	21.86	25	4	107.72	23	1	167.66	1	NA	NA	2.55	2.95	160			
1977	22.67	NA	52.41	69.95	NA	NA	40.92	34.97	7	23.87	4	2	243.62	90	1	234.78	1	1	267.60	1	4.77	7.09	124		
1978	NA	39.38	NA	NA	NA	10.59	7.45	NA	3	13.39	11	5	162.39	11	1	192.17	1	3	261.86	1	4.14	8.92	85		
1979	34.35	40.92	NA	54.23	69.77	NA	NA	NA	NA	NA	NA	7	109.43	33	5	138.04	1	NA	NA	2.07	3.20	160			
1980	20.77	21.96	54.09	NA	36.09	NA	NA	NA	2	21.39	8	4	130.75	48	1	137.51	1	1	267.16	1	2.18	3.18	106		

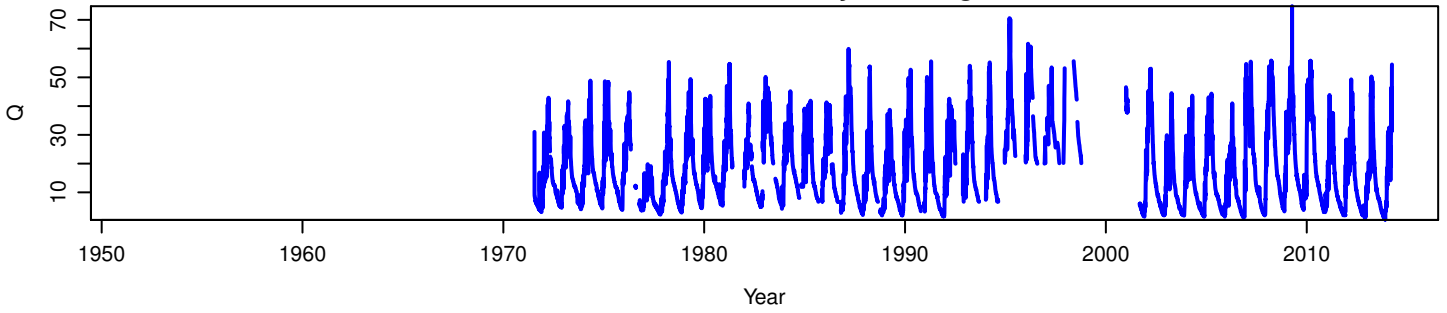
Table 9.2.23. Eco-relevant statistics of Sub-basin: Kilombero, Station: Mngeta, Series: 1961-1980 (please find column headings in Table 9.1)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1961	16.44	22.59	28.50	35.94	42.34	23.17	21.72	13.65	10.02	8.81	19.16	22.15	3.24	3.28	3.70	8.40	79.25	59.39	53.40	47.03	3.24	10.36	NA	NA
1962	23.05	27.84	26.97	40.55	37.37	23.20	14.96	11.61	7.92	7.00	5.53	7.85	3.88	4.06	4.21	5.16	85.50	69.03	62.23	47.44	11.67	11.73	NA	NA
1963	10.09	8.57	18.50	58.39	32.03	18.46	12.24	8.95	6.94	5.59	10.95	11.41	4.92	4.96	5.12	5.34	91.50	82.97	76.09	58.58	7.08	7.14	7.14	NA
1964	26.78	24.06	37.84	52.95	35.39	19.71	12.23	9.22	6.81	5.51	4.83	6.21	4.48	4.48	4.55	4.83	79.70	65.33	58.53	28.29	10.23	NA	NA	NA
1965	6.88	6.51	8.11	NA	20.54	10.69	12.23	9.53	9.06	7.36	9.09	16.42	4.48	4.51	4.54	5.66	33.26	28.82	28.29	28.29	4.48	4.48	5.45	NA
1966	24.93	35.54	43.09	NA	36.88	22.22	12.70	9.53	9.06	6.16	5.81	7.19	4.57	4.64	4.69	5.63	90.50	77.13	66.03	66.03	11.33	NA	11.70	NA
1967	12.52	7.29	12.91	19.26	NA	29.41	16.79	11.19	7.97	NA	15.82	25.85	3.19	4.99	4.99	4.99	64.29	45.04	39.21	36.93	5.08	5.26	5.39	3.19
1968	21.16	16.77	30.74	50.93	38.66	34.02	19.69	12.41	8.93	7.14	9.86	22.56	6.06	6.17	6.26	6.91	87.40	75.53	66.23	53.42	NA	NA	NA	NA
1969	7.70	8.37	31.86	55.05	40.30	26.00	13.92	11.02	6.98	7.83	9.25	6.92	4.62	4.74	4.91	6.50	95.80	84.37	75.04	59.70	7.01	7.01	11.30	NA
1970	11.59	18.52	21.33	NA	26.11	14.42	8.88	7.18	6.96	5.06	4.33	8.68	3.88	3.95	3.95	4.27	47.26	41.31	41.26	41.26	5.34	10.25	10.36	NA
1971	5.23	5.99	15.59	48.17	34.71	18.44	15.66	10.13	7.71	9.90	8.43	9.49	4.28	4.53	4.68	5.21	97.20	90.83	77.16	49.77	4.53	4.53	4.92	NA
1972	26.93	15.22	19.93	54.87	40.79	24.23	16.23	10.88	8.84	7.23	6.84	34.02	3.03	4.61	5.56	6.76	114.60	84.17	72.66	58.09	12.74	10.25	5.65	NA
1973	20.44	22.46	24.79	74.29	54.38	20.96	13.96	9.74	7.59	10.06	7.86	5.49	4.22	4.67	4.91	5.50	137.80	134.20	106.89	79.54	NA	NA	NA	NA
1974	13.54	NA	NA	84.26	72.82	31.46	19.33	12.17	8.57	6.23	5.57	5.60	4.19	4.19	4.26	5.07	134.40	118.83	103.77	94.42	4.19	NA	NA	NA
1975	10.48	7.43	13.06	46.71	48.58	21.99	14.51	10.52	8.64	7.02	5.79	6.65	3.99	5.17	5.17	5.63	113.20	101.13	94.77	60.33	3.99	5.71	8.08	NA
1976	15.24	11.09	42.33	65.19	39.69	25.84	15.96	11.64	8.91	6.83	5.80	5.33	4.78	4.78	4.90	5.21	144.80	102.30	92.59	72.33	6.27	6.27	9.60	NA
1977	8.47	6.17	NA	104.57	87.30	28.54	NA	9.49	8.44	NA	NA	34.20	3.70	5.44	5.63	5.84	601.80	294.40	200.54	122.95	5.20	5.63	NA	NA
1978	24.36	14.27	29.49	115.10	51.56	18.01	12.26	9.58	8.31	7.30	NA	NA	7.02	7.02	7.02	7.02	437.90	271.90	177.57	122.98	NA	12.70	NA	NA
1979	36.35	30.80	129.12	246.99	168.99	90.45	23.07	13.32	12.29	8.27	NA	11.61	6.08	6.30	6.31	6.67	642.60	603.67	444.60	294.08	NA	NA	NA	NA
1980	11.87	23.48	NA	58.45	79.32	23.56	50.29	9.54	8.02	8.12	7.73	NA	6.31	6.31	6.31	6.31	261.10	221.67	171.49	91.47	9.10	NA	NA	NA
Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
1961	NA	7.47	NA	11.23	7.98	7.08	8.54	NA	2	3.96	7	10	27.07	30	7	39.68	1	NA	NA	NA	3.38	5.10	188	
1962	NA	NA	11.48	10.03	6.95	5.57	4.48	3.88	5	4.54	4	9	17.72	28	1	29.62	1	1	85.50	1	2.01	2.81	195	
1963	NA	NA	10.36	7.34	6.17	5.23	4.92	6.95	3	5.13	4	15	19.72	13	7	26.80	1	1	91.50	2	1.92	3.21	185	
1964	NA	NA	10.17	7.27	5.45	5.13	4.48	4.48	7	4.82	7	4	32.48	54	3	52.36	1	NA	NA	NA	1.37	2.78	173	
1965	12.75	8.25	8.05	6.35	5.50	5.23	5.29	4.72	5	4.72	5	19	16.29	5	11	26.78	1	NA	NA	NA	1.85	3.60	145	
1966	NA	NA	10.25	6.23	NA	5.29	4.57	4.82	5	4.74	4	5	34.74	39	2	38.17	1	1	90.50	1	2.41	4.90	141	
1967	NA	NA	NA	8.18	5.29	NA	4.99	NA	3	4.42	1	12	23.04	16	9	36.36	1	NA	NA	NA	2.39	4.54	145	
1968	NA	NA	NA	10.05	7.01	6.29	6.06	8.05	NA	NA	NA	7	25.15	41	3	30.15	1	1	87.40	1	2.23	4.13	181	
1969	NA	NA	11.48	8.11	6.17	5.45	4.62	4.77	3	4.84	4	8	23.77	24	4	28.60	1	1	95.80	1	2.46	4.34	185	
1970	NA	11.23	5.56	6.18	5.15	4.48	3.92	3.88	6	4.77	10	9	20.72	18	5	28.38	1	NA	NA	NA	1.48	2.96	164	
1971	NA	NA	12.31	8.46	7.01	6.17	5.34	4.28	7	4.54	4	10	23.75	17	4	33.82	1	1	97.20	1	1.71	3.25	177	
1972	NA	NA	NA	9.56	7.49	6.27	3.03	10.30	1	3.03	2	6	45.10	45	2	37.28	1	2	97.75	1	4.35	8.31	141	
1973	NA	NA	10.83	8.84	6.27	5.71	5.35	4.22	3	4.81	9	5	35.99	47	1	19.68	9	1	137.80	2	5.01	9.34	119	
1974	NA	NA	NA	6.27	6.57	5.71	5.17	4.67	4	4.68	13	4	51.36	40	2	50.82	1	1	134.40	1	6.06	10.37	104	
1975	NA	NA	11.91	9.56	7.49	6.27	5.17	5.17	4	4.88	4	7	28.25	26	2	19.81	1	1	113.20	1	3.39	5.77	110	
1976	NA	NA	NA	9.56	7.52	6.31	5.20	4.78	4	5.10	6	10	26.55	23	1	67.21	2	1	144.80	1	5.26	10.59	132	
1977	NA	NA	NA	8.56	7.52	NA	NA	3.70	3	4.60	1	7	88.21	18	3	28.10	1	3	288.57	1	19.31	42.12	89	
1978	NA	NA	10.63	9.10	7.52	7.02	NA	NA	NA	NA	NA	3	123.23	76	NA	NA	NA	1	437.90	1	10.99	38.56	71	
1979	NA	NA	NA	12.06	8.56	6.08	NA	6.31	NA	NA	NA	4	173.24	70	1	59.79	1	1	642.60	1	14.76	43.18	115	
1980	NA	NA	NA	8.03	7.52	7.02	6.31	NA	NA	NA	NA	9	44.79	22	2	46.20	1	1	261.10	1	9.98	28.86	92	

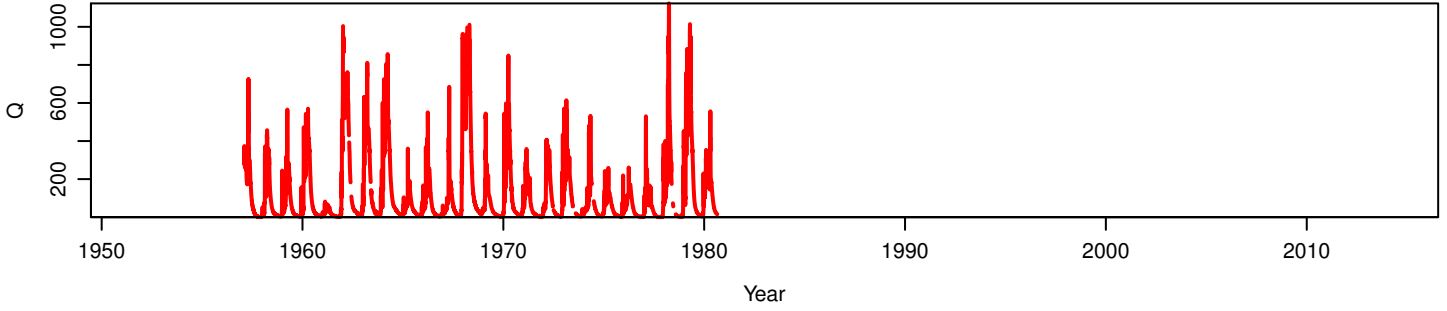
Annex I

Hydrographs of different stations of Rufiji basin
in Tanzania with crude historical discharge data

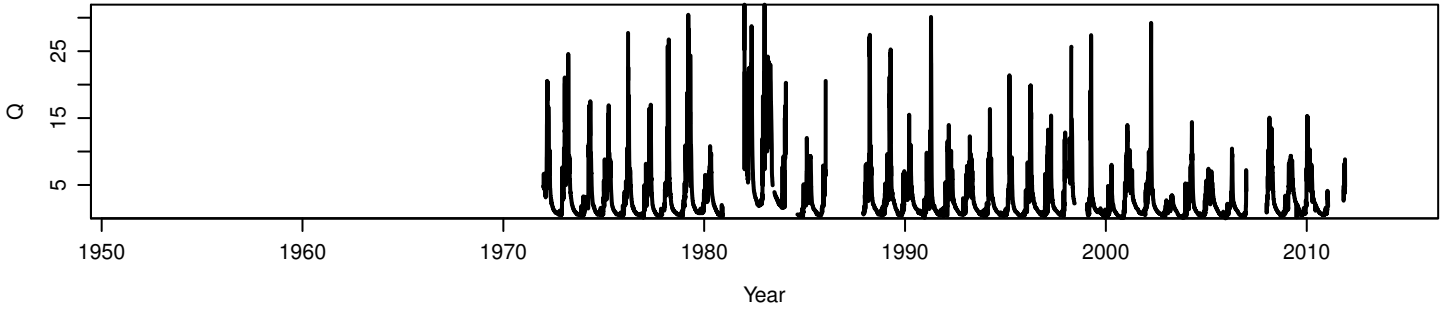
Lit Ruaha Ir Ndiuka Daily Discharge



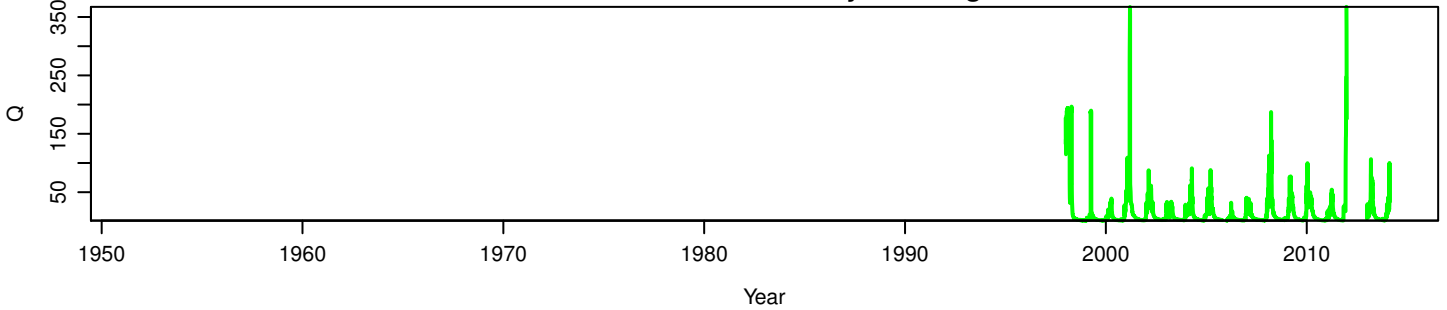
Gr Ruaha Trace Daily Discharge



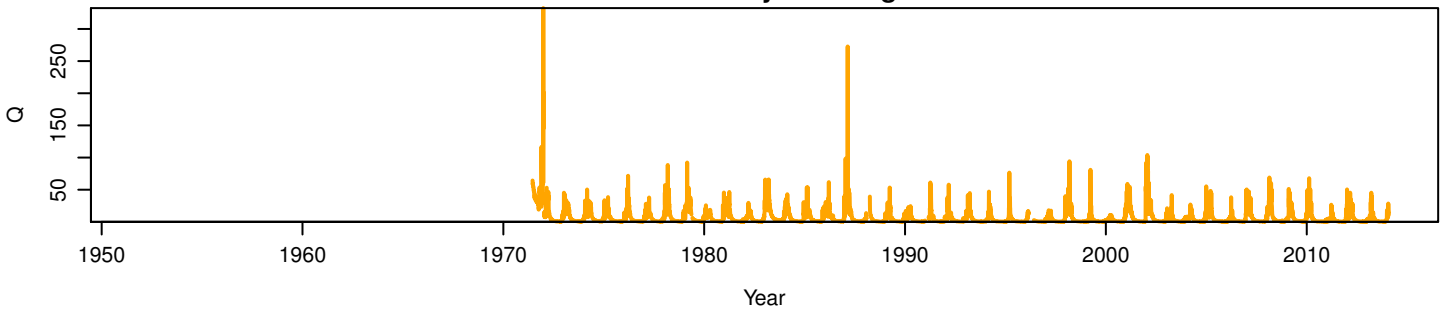
Chimala Daily Discharge



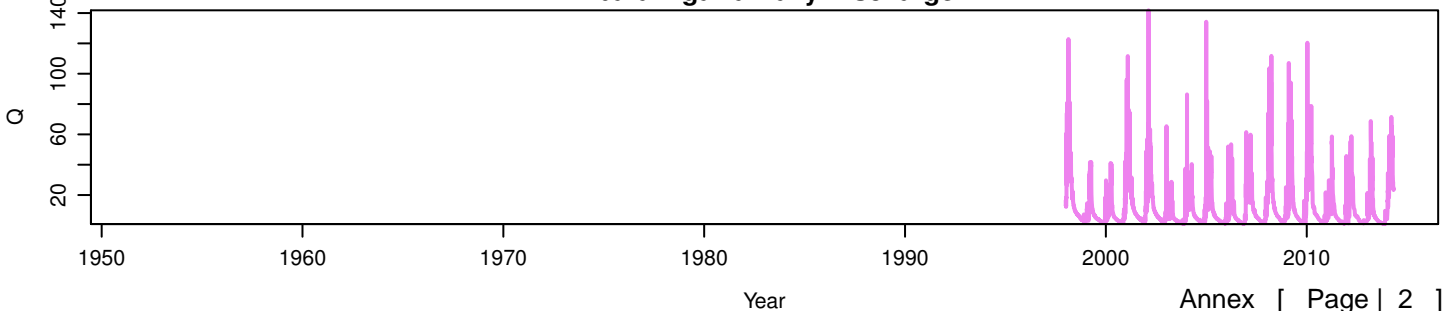
Gr Ruaha Salimwani Daily Discharge



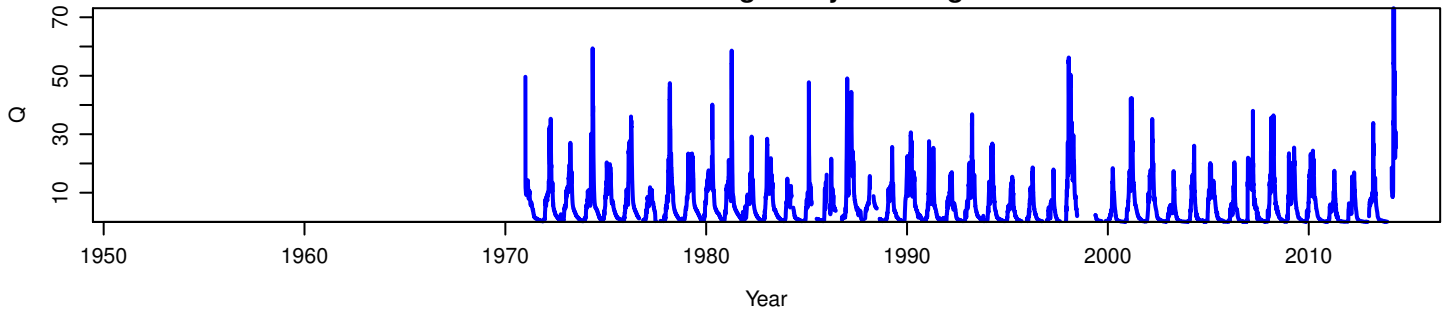
Kimani Daily Discharge



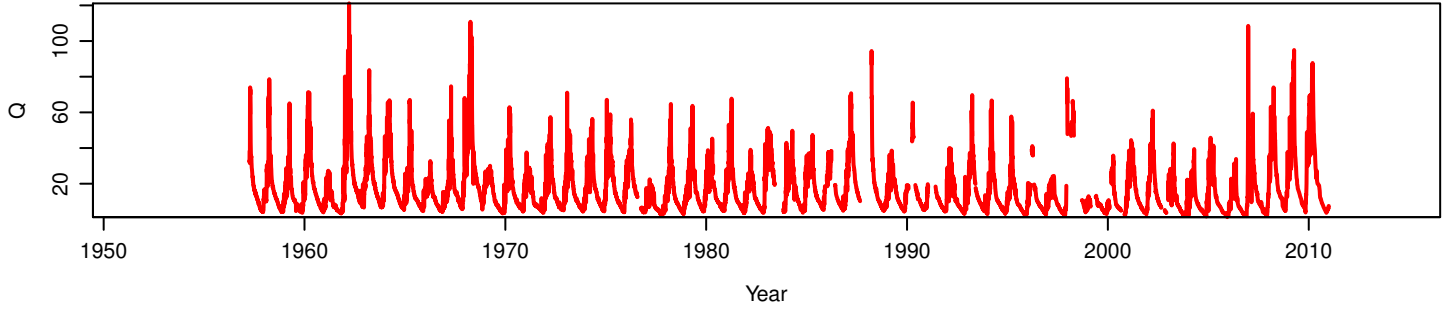
Mbarali Igawa Daily Discharge



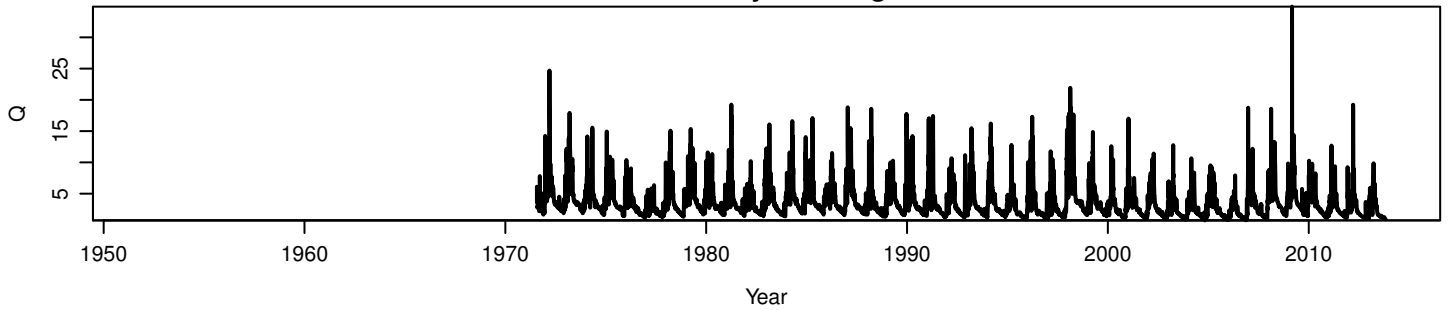
Ndembera Ilongo Daily Discharge



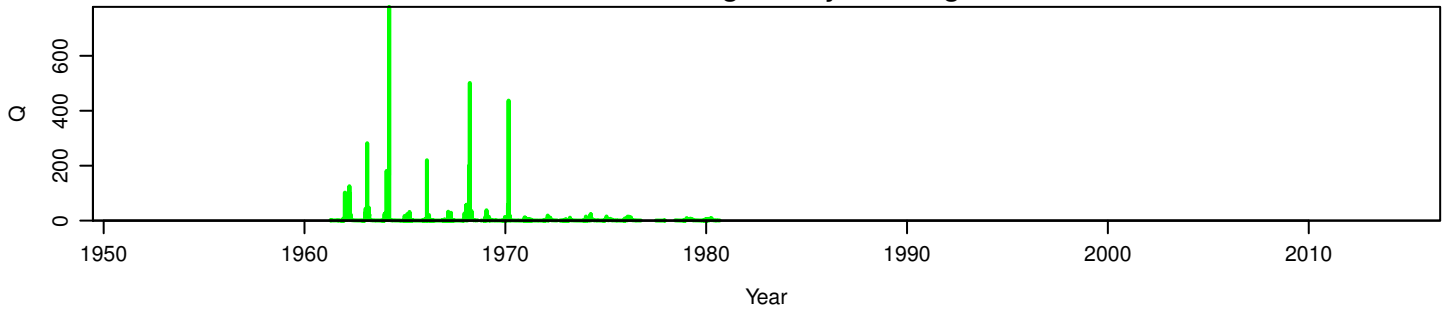
Lit Ruaha Ihimbu Daily Discharge



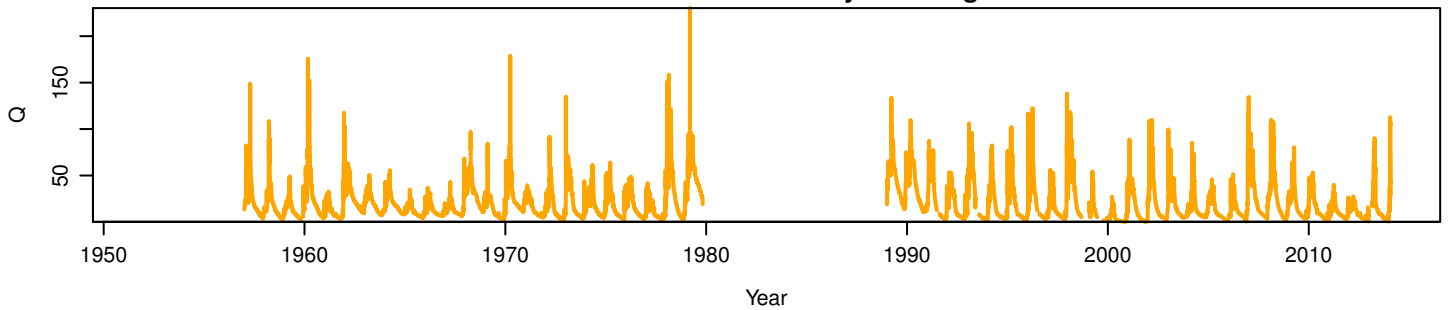
Mtitu Daily Discharge



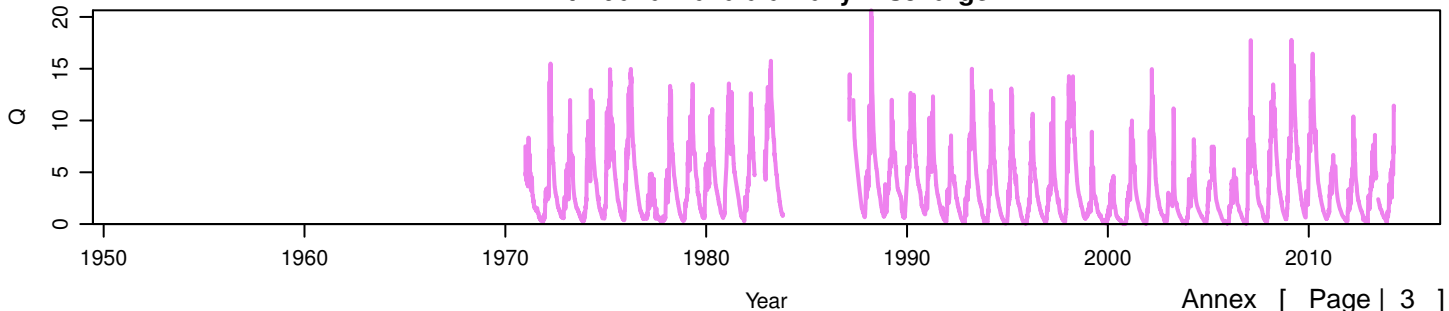
Ruaha Malangali Daily Discharge



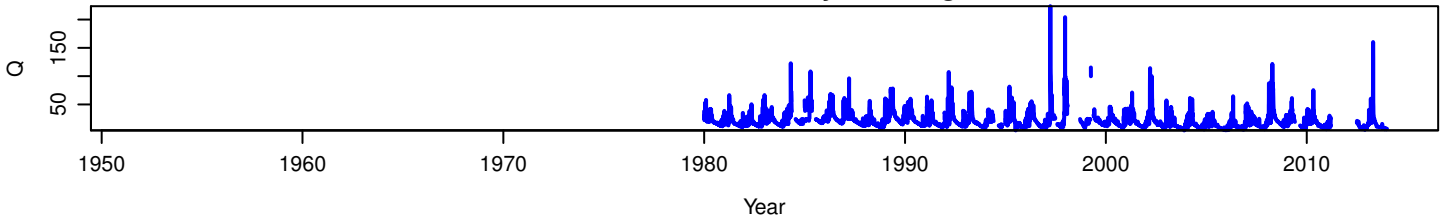
Lit Ruaha Mawande Daily Discharge



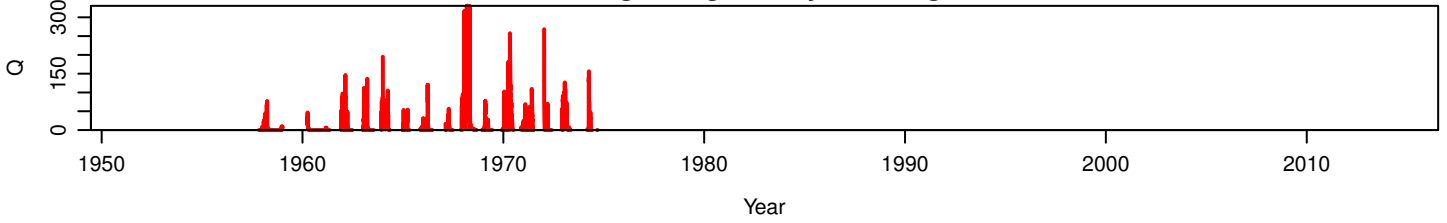
Lit Ruaha Makalala Daily Discharge



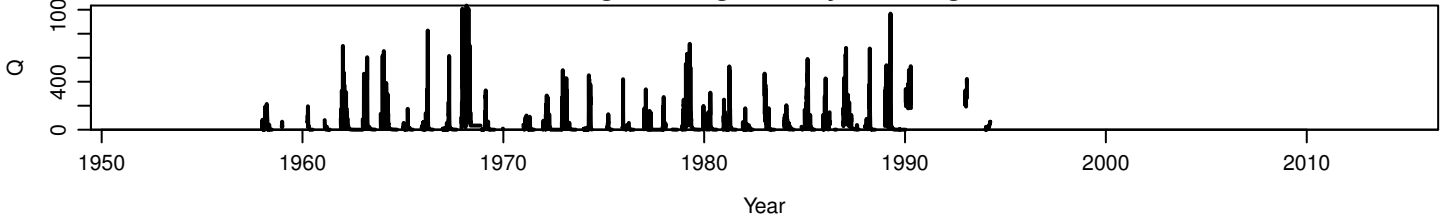
Lukosi Mtandika Daily Discharge



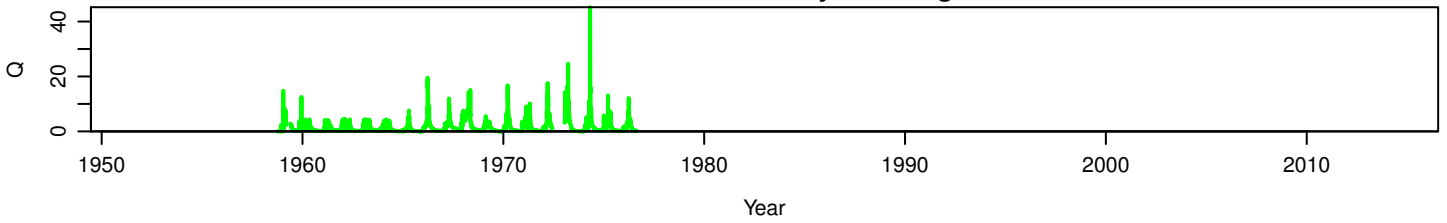
Kizigo Ilangali Daily Discharge



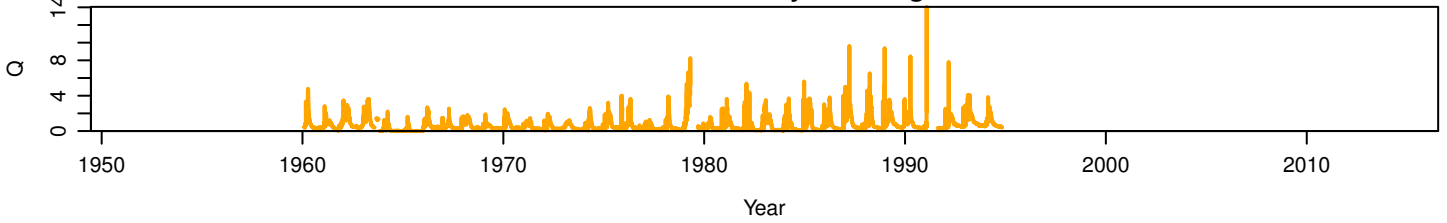
Kizigo Chinugulu Daily Discharge



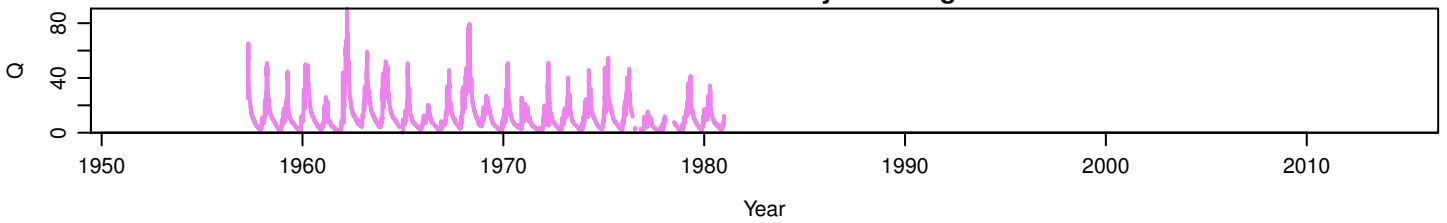
Mswiswi Wilima Daily Discharge



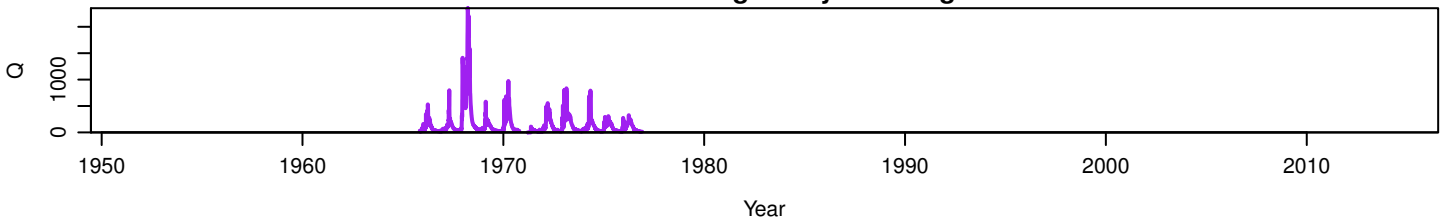
Urobo GNR Daily Discharge



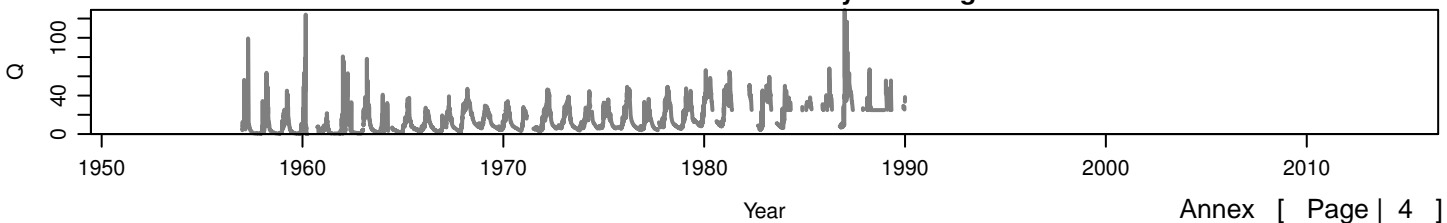
Lit Ruaha Iwawa Daily Discharge



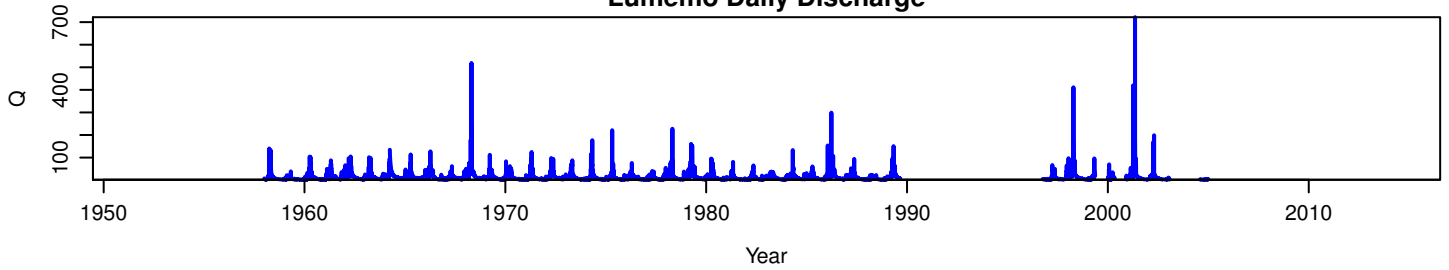
Gr Ruaha Gorge Daily Discharge



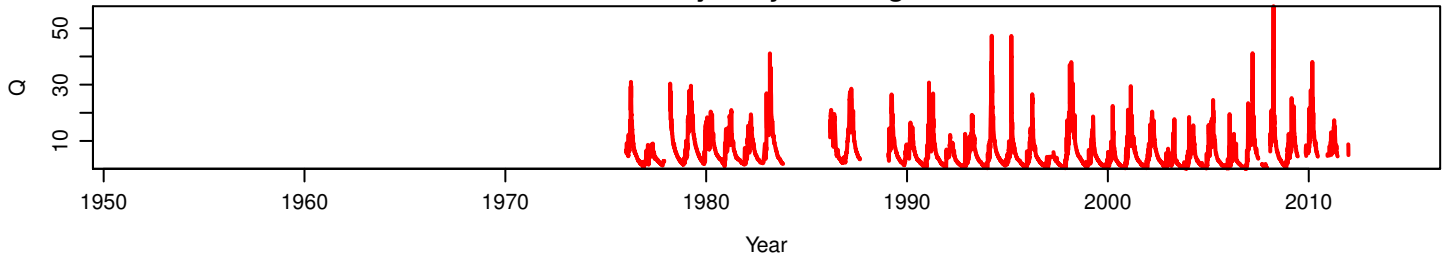
Ndembera Madibira Daily Discharge



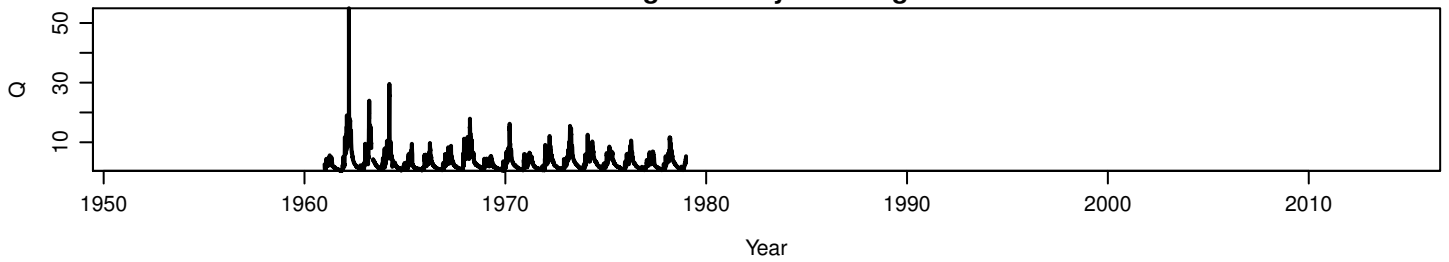
Lumemo Daily Discharge



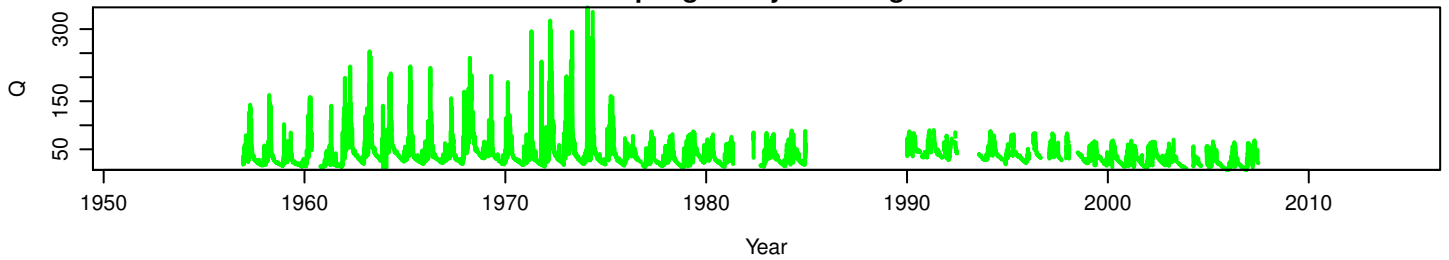
Ruhudji Daily Discharge



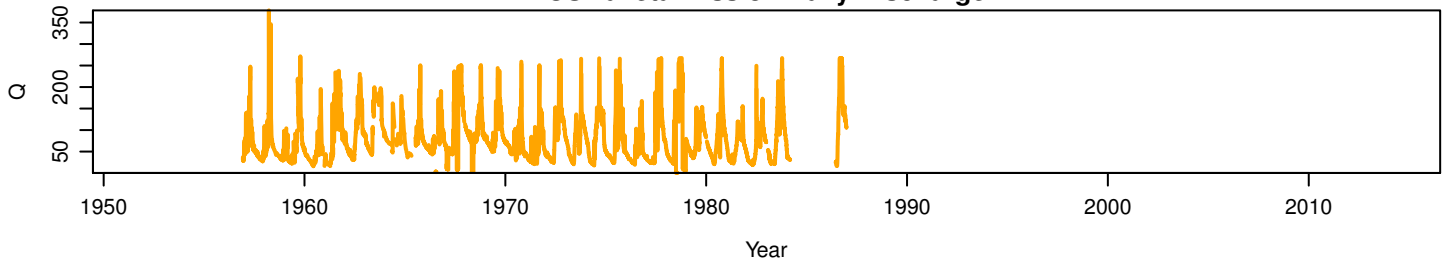
Hagafiro Daily Discharge



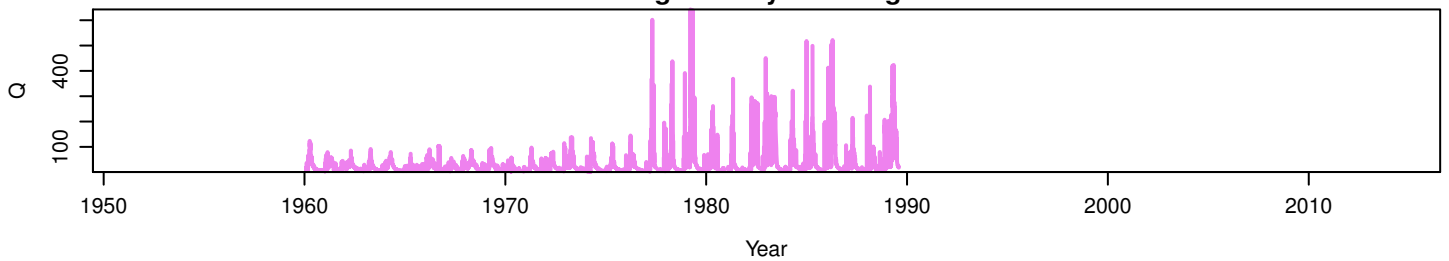
Mpanga Daily Discharge



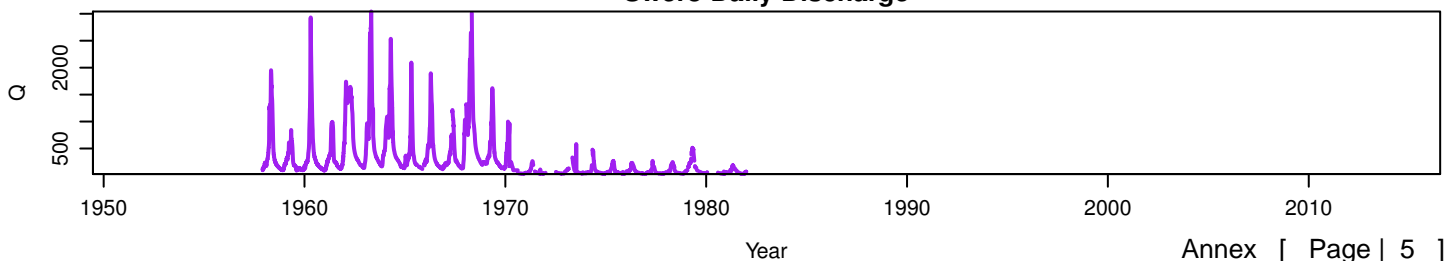
US Taveta Mission Daily Discharge



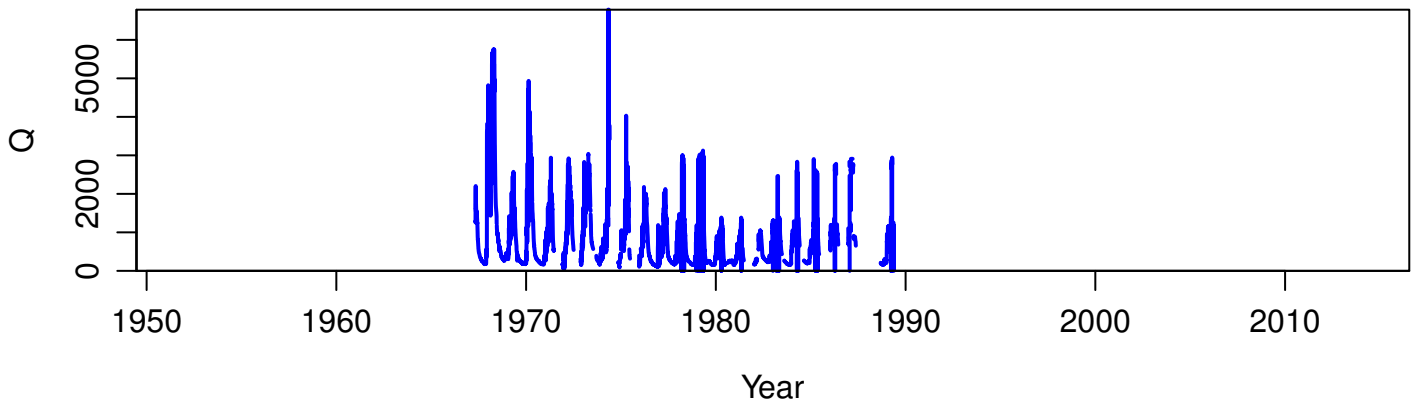
Mngeta Daily Discharge



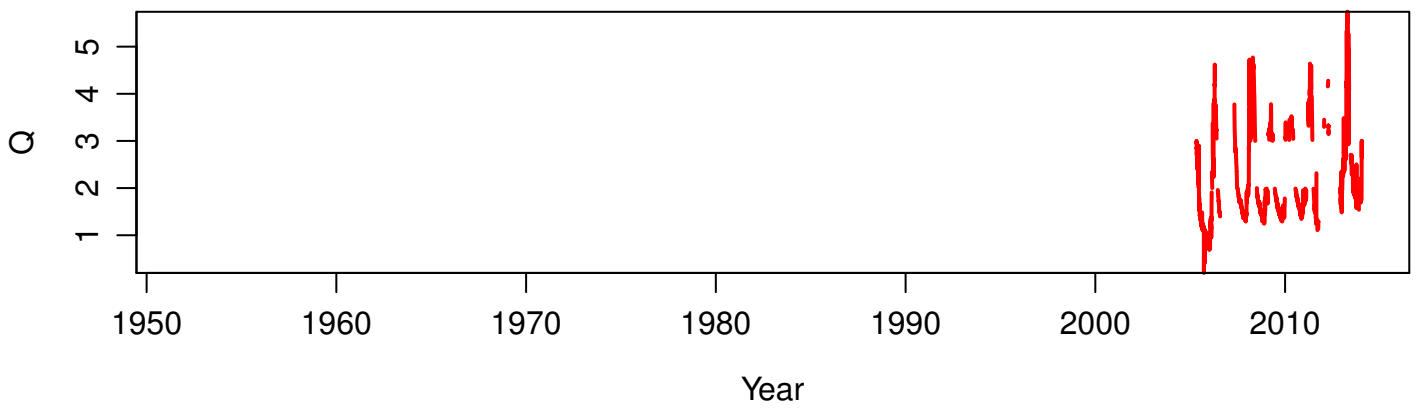
Swero Daily Discharge



Pangani Daily Discharge



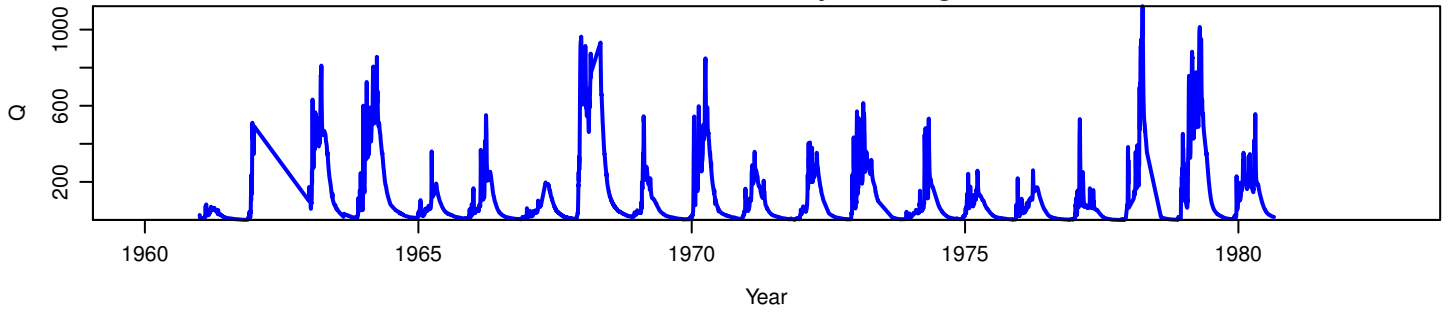
Utete Daily Discharge



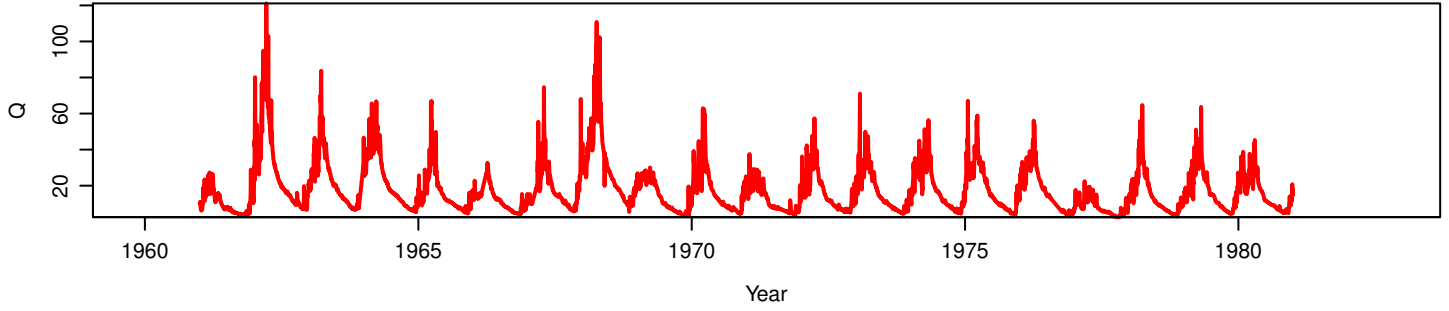
Annex II

Hydrographs of different stations
of Rufiji basin in Tanzania
with filtered and clustered discharge data

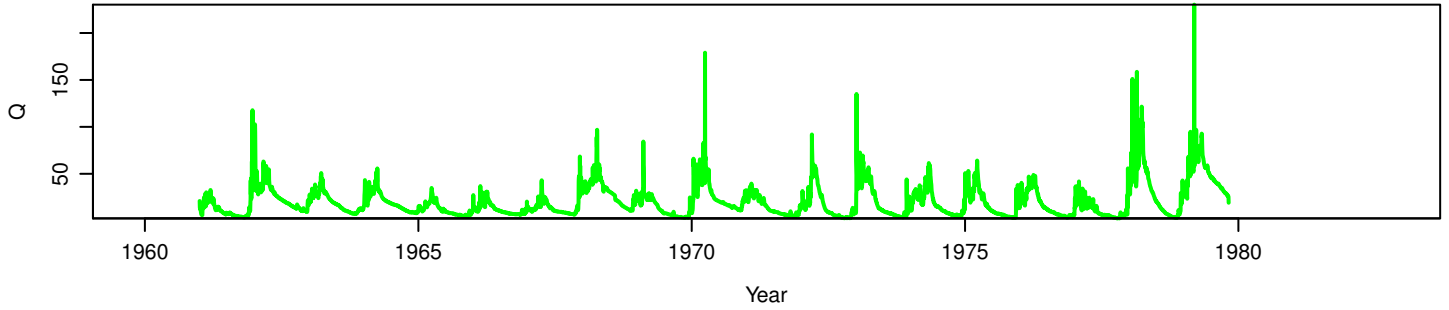
Gr Ruaha Trace Daily Discharge



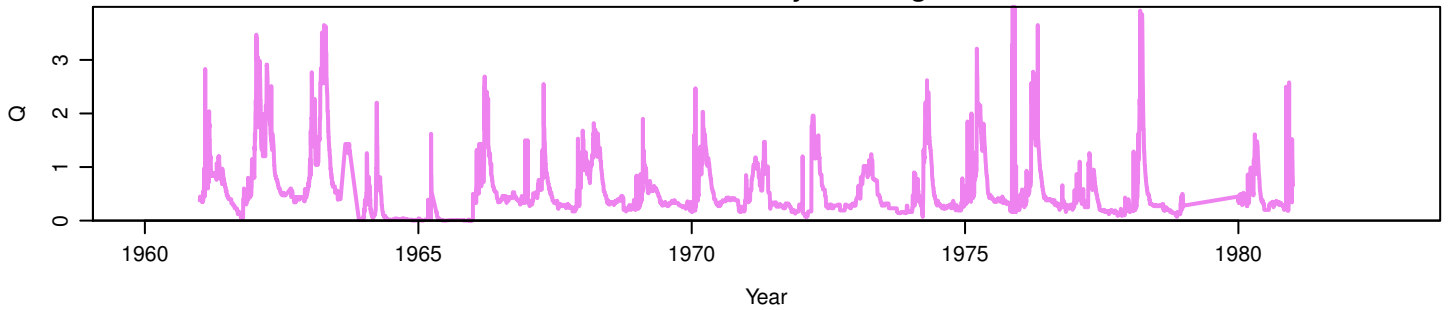
Lit Ruaha Ihimbu Daily Discharge



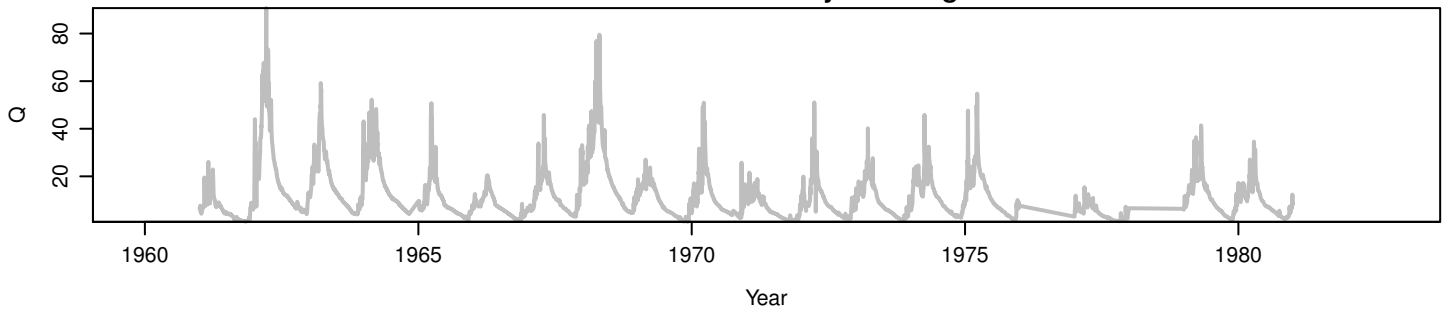
Lit Ruaha Mawande Daily Discharge



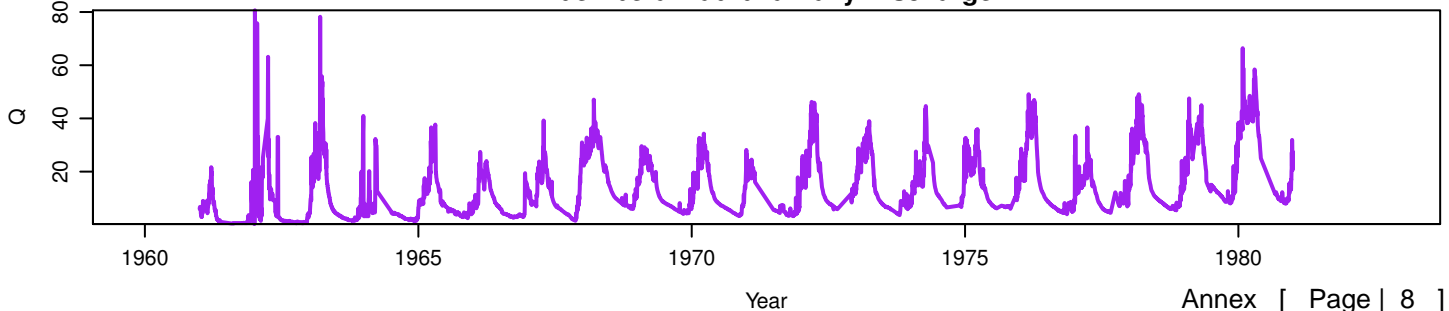
Urobo GNR Daily Discharge



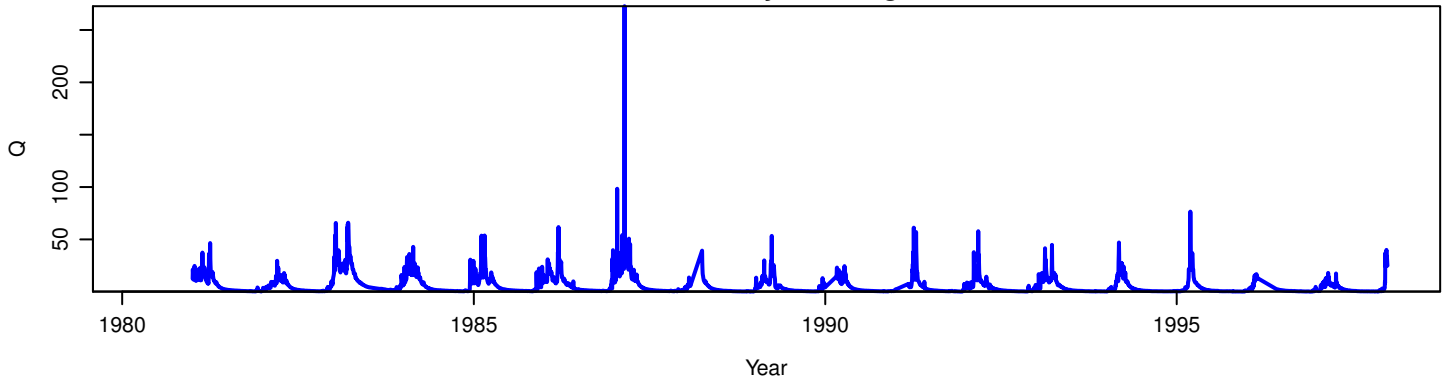
Lit Ruaha Iwawa Daily Discharge



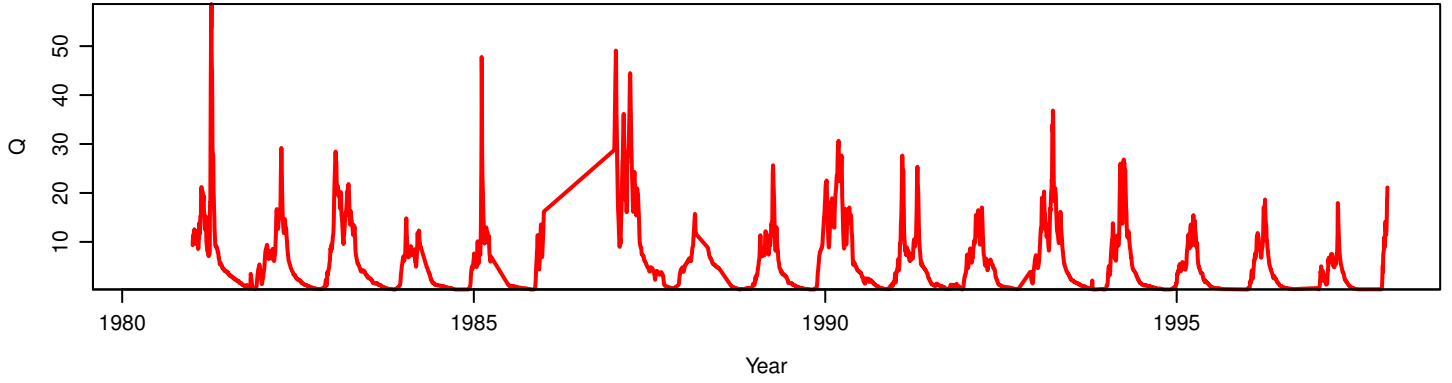
Ndembera Madibira Daily Discharge



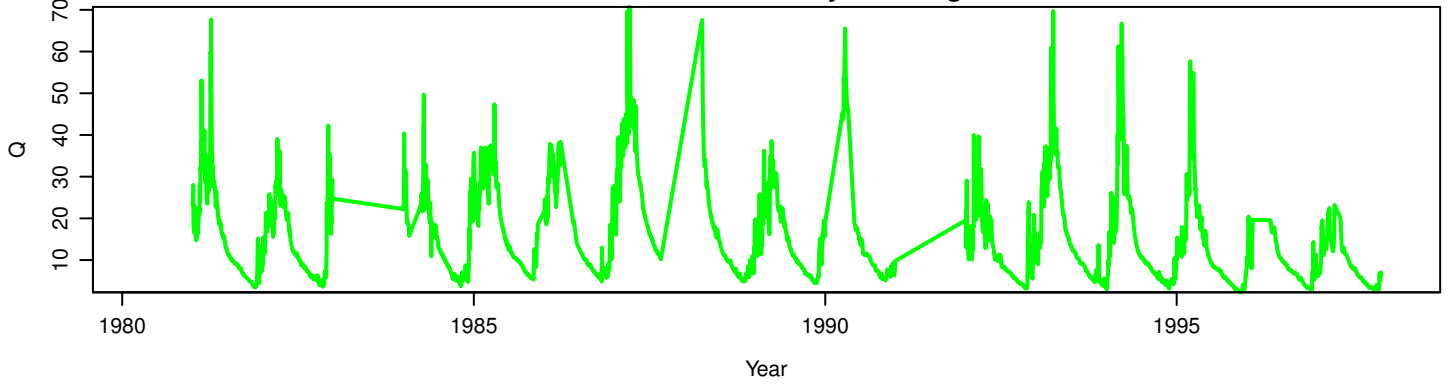
Kimani Daily Discharge



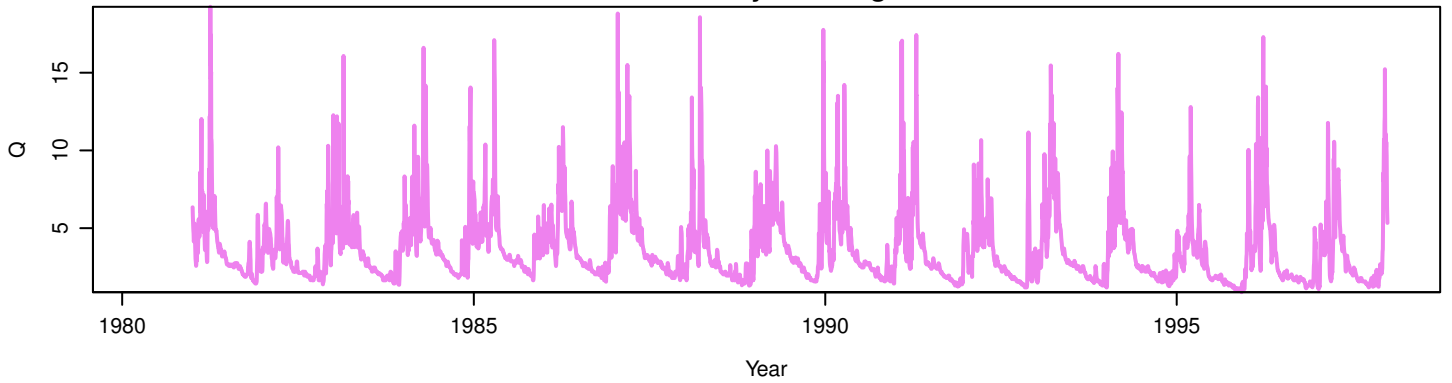
Ndembera Ilongo Daily Discharge



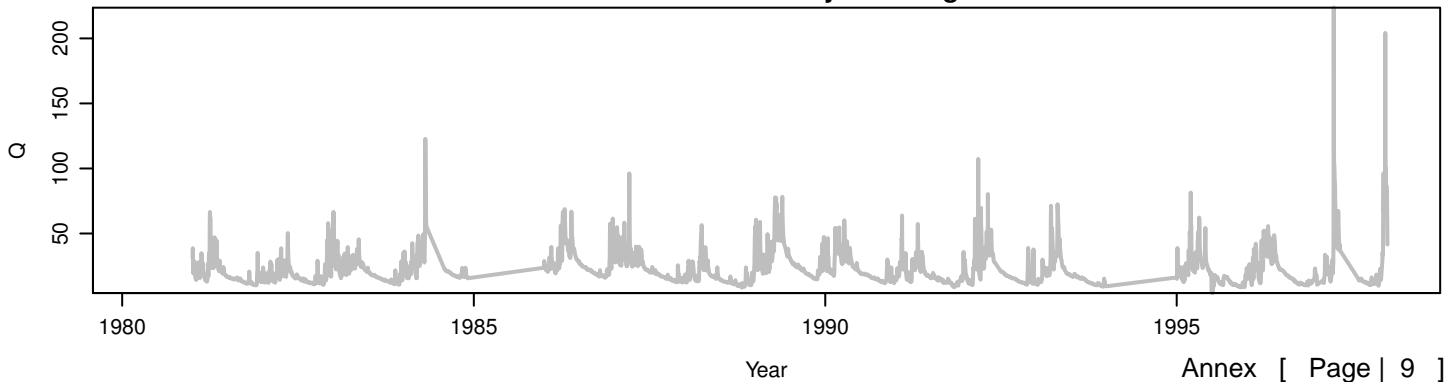
Lit Ruaha Ihimbu Daily Discharge



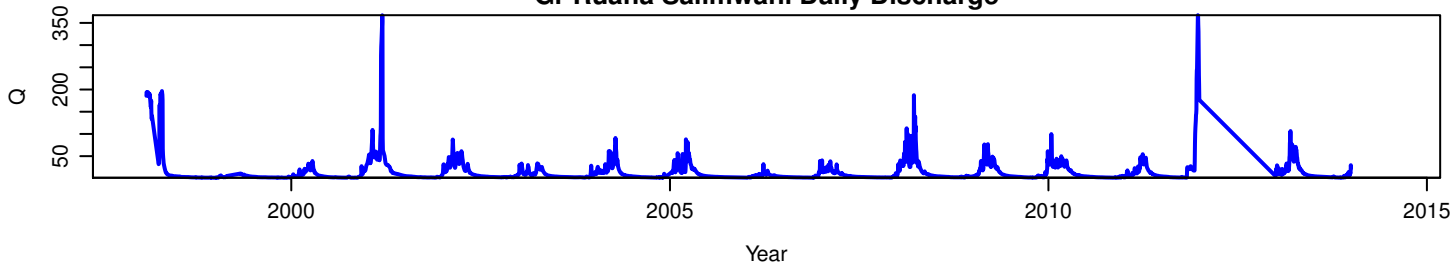
Mtitu Daily Discharge



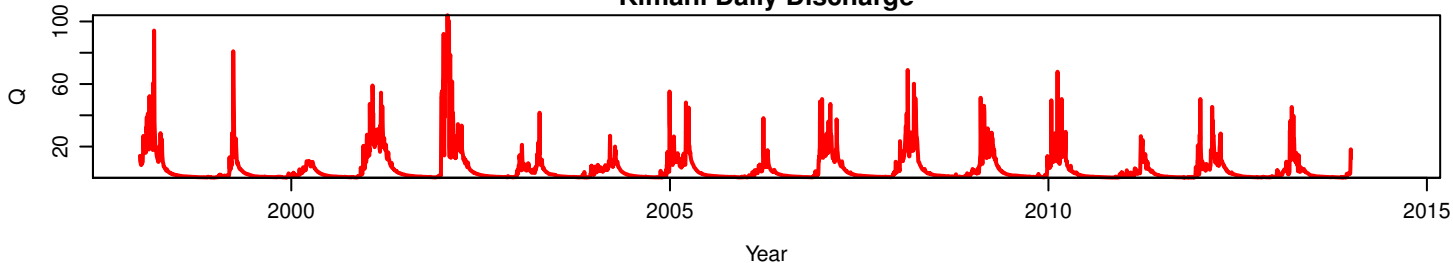
Lukosi Mtandika Daily Discharge



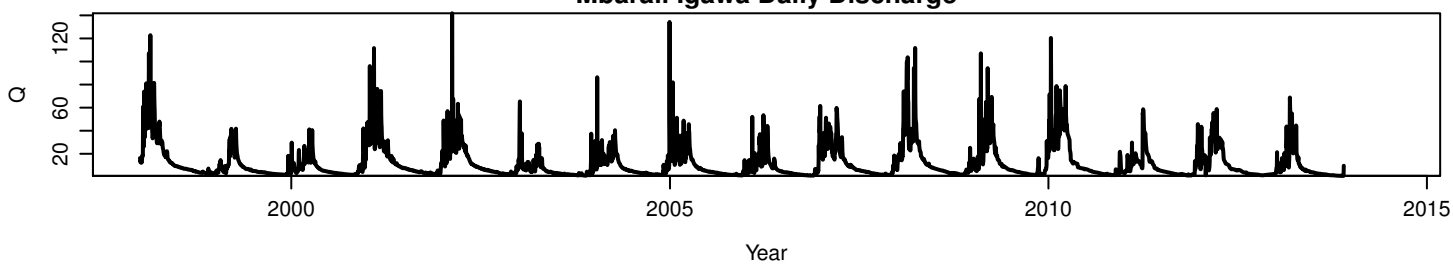
Gr Ruaha Salimwani Daily Discharge



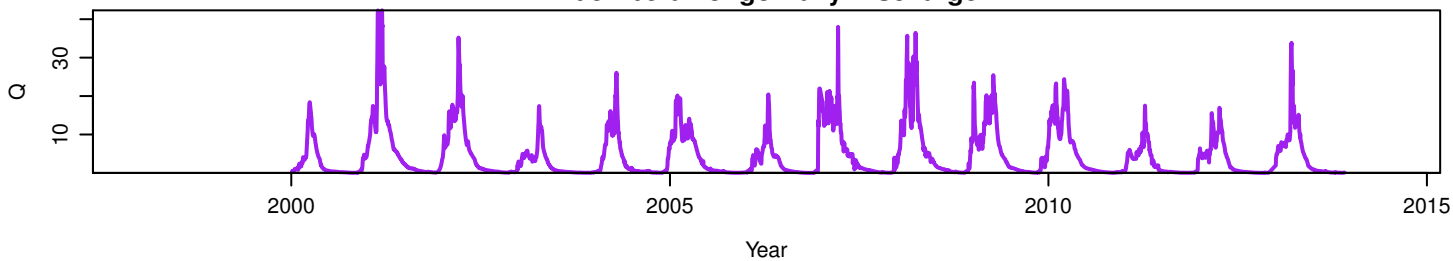
Kimani Daily Discharge



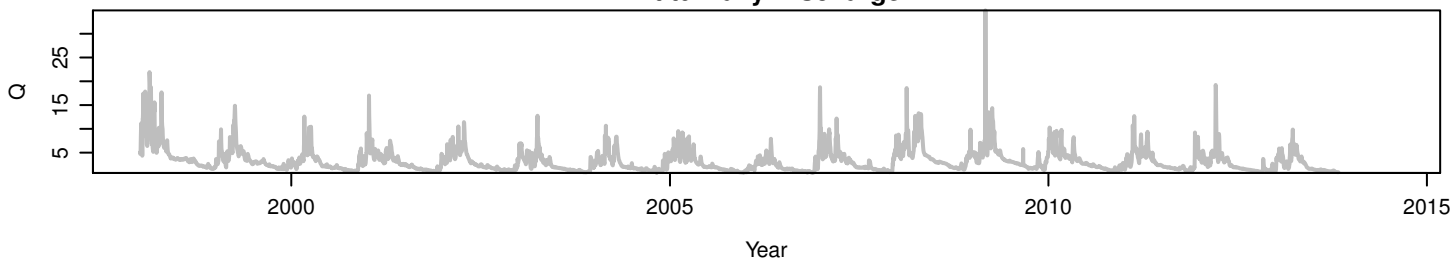
Mbarali Igawa Daily Discharge



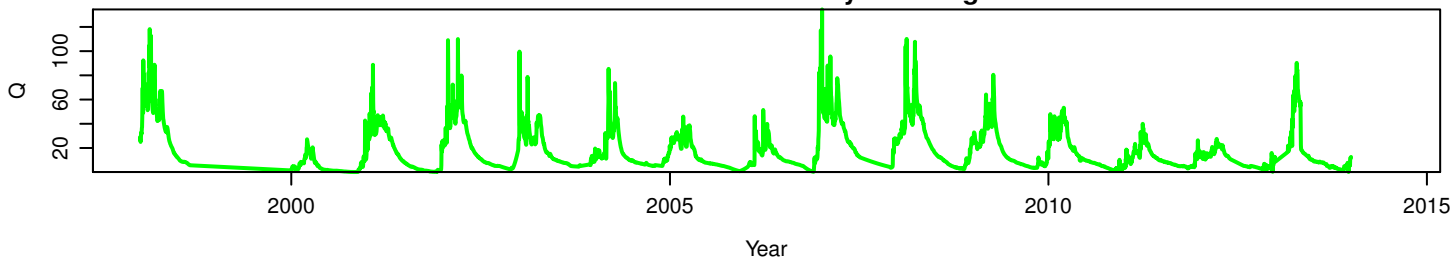
Ndembera Ilongo Daily Discharge



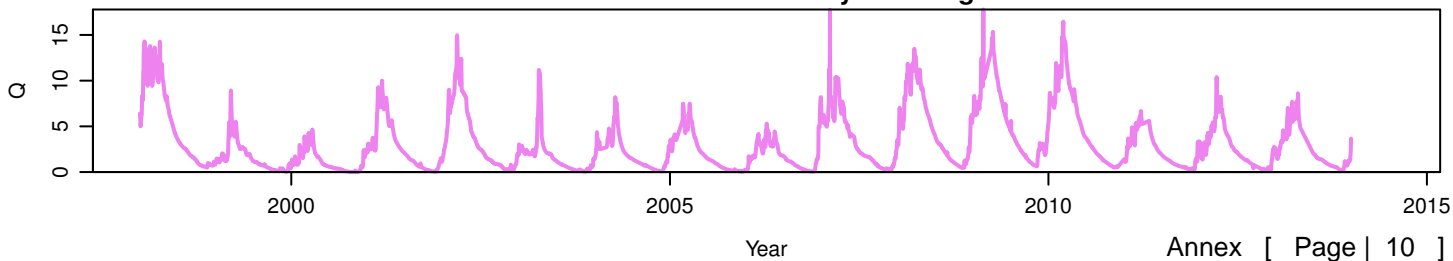
Mtitu Daily Discharge



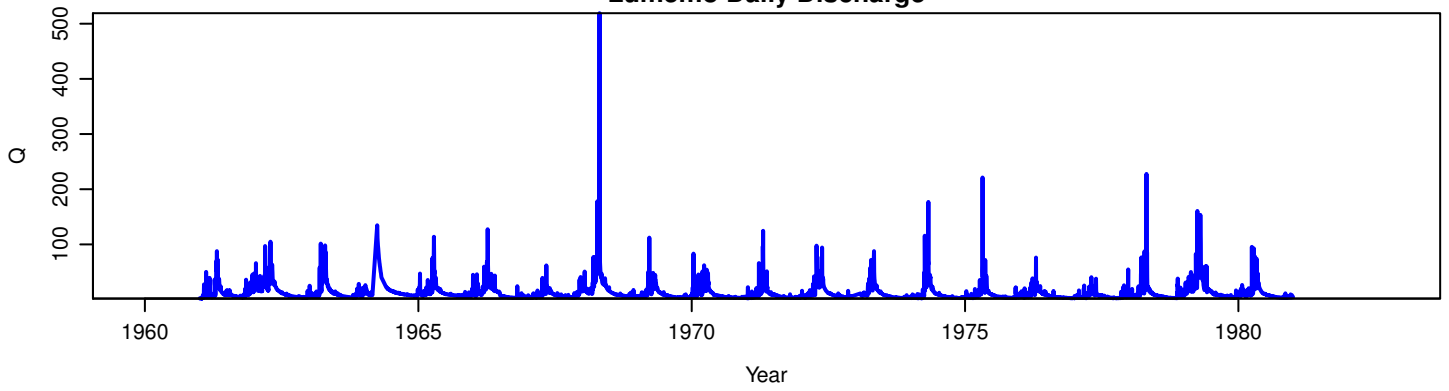
Lit Ruaha Mawande Daily Discharge



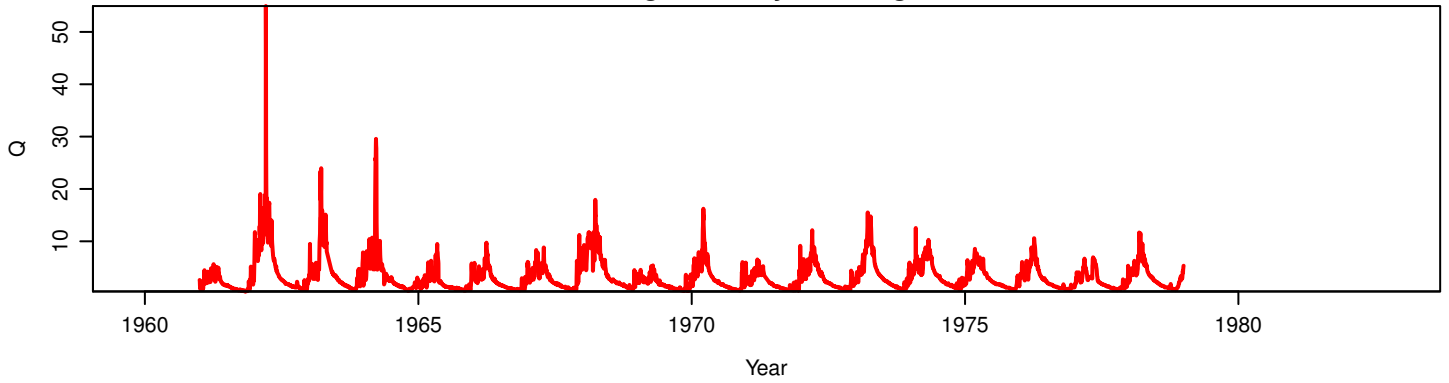
Lit Ruaha Makalala Daily Discharge



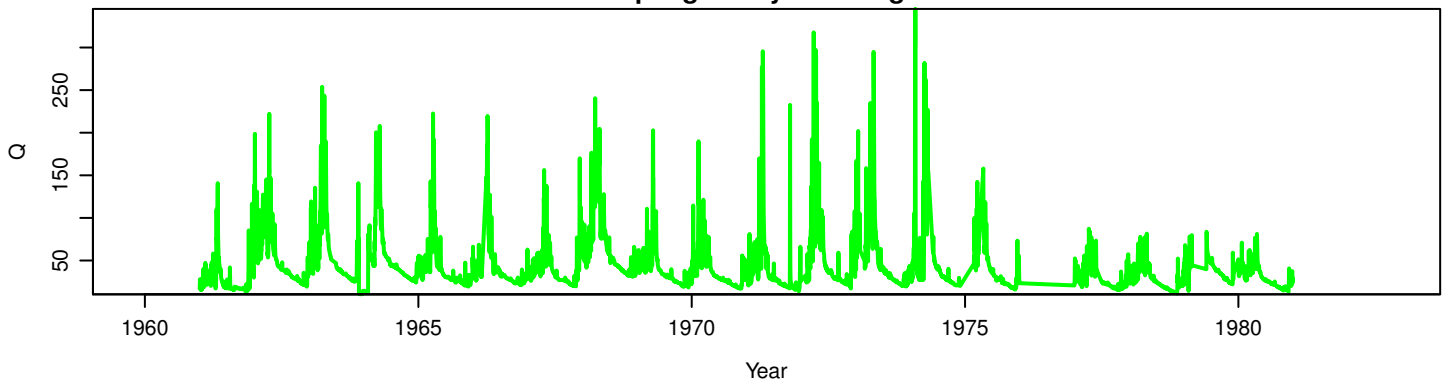
Lumemo Daily Discharge



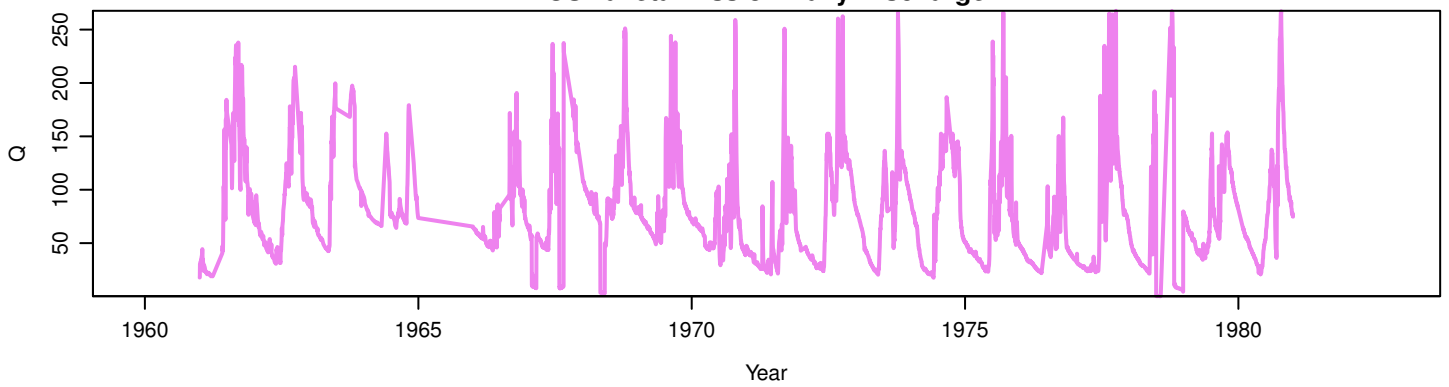
Hagafiro Daily Discharge



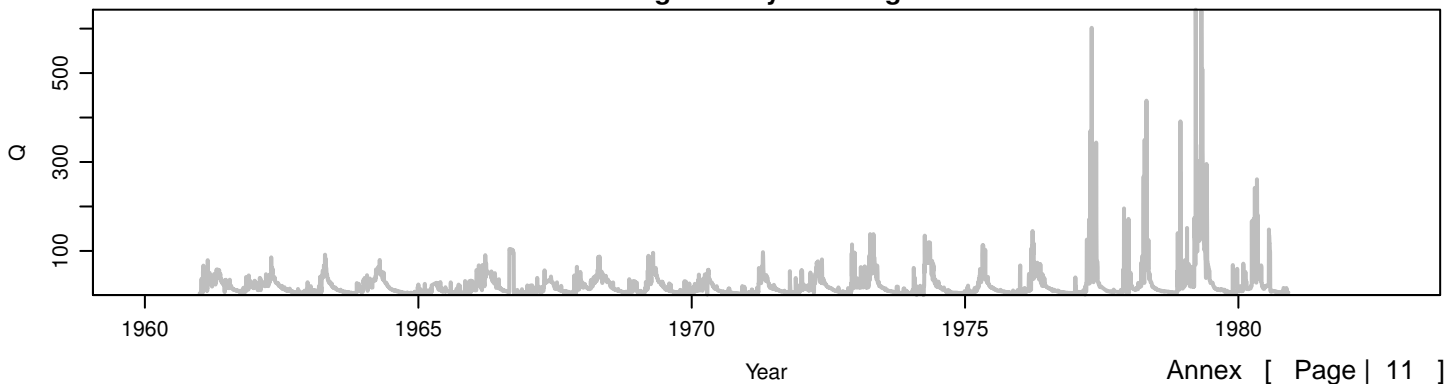
Mpanga Daily Discharge



US Taveta Mission Daily Discharge



Mngeta Daily Discharge



Annex III

Flow statistics, data cleaning and completeness
(Removal of outliers and suspicious data points
from clustered flow data of Rufiji basin)

Flow statistics and data cleaning

Fig.1 shows a time series (1961-1980) of discharge statistics in 'Great Ruaha at Trace' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal Oct 1961 and 1977, and Nov 1977 as suspicious data points within the general discharge pattern. Furthermore, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.1 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 4.25 ($\sim R/M$) and 0.00 to 1.07 ($\sim CV$) respectively (Tab.1). Combinedly the discharge in Nov 1961 and 1978, and Dec 1971, 1975 and 1977 are outside of those variability domains (Fig.1) and thus the corresponding discharge data of these particular year-months along with the suspicious points in 'Great Ruaha at Trace' station were considered to be outliers (Tab.1) in 1961-1980 time series.

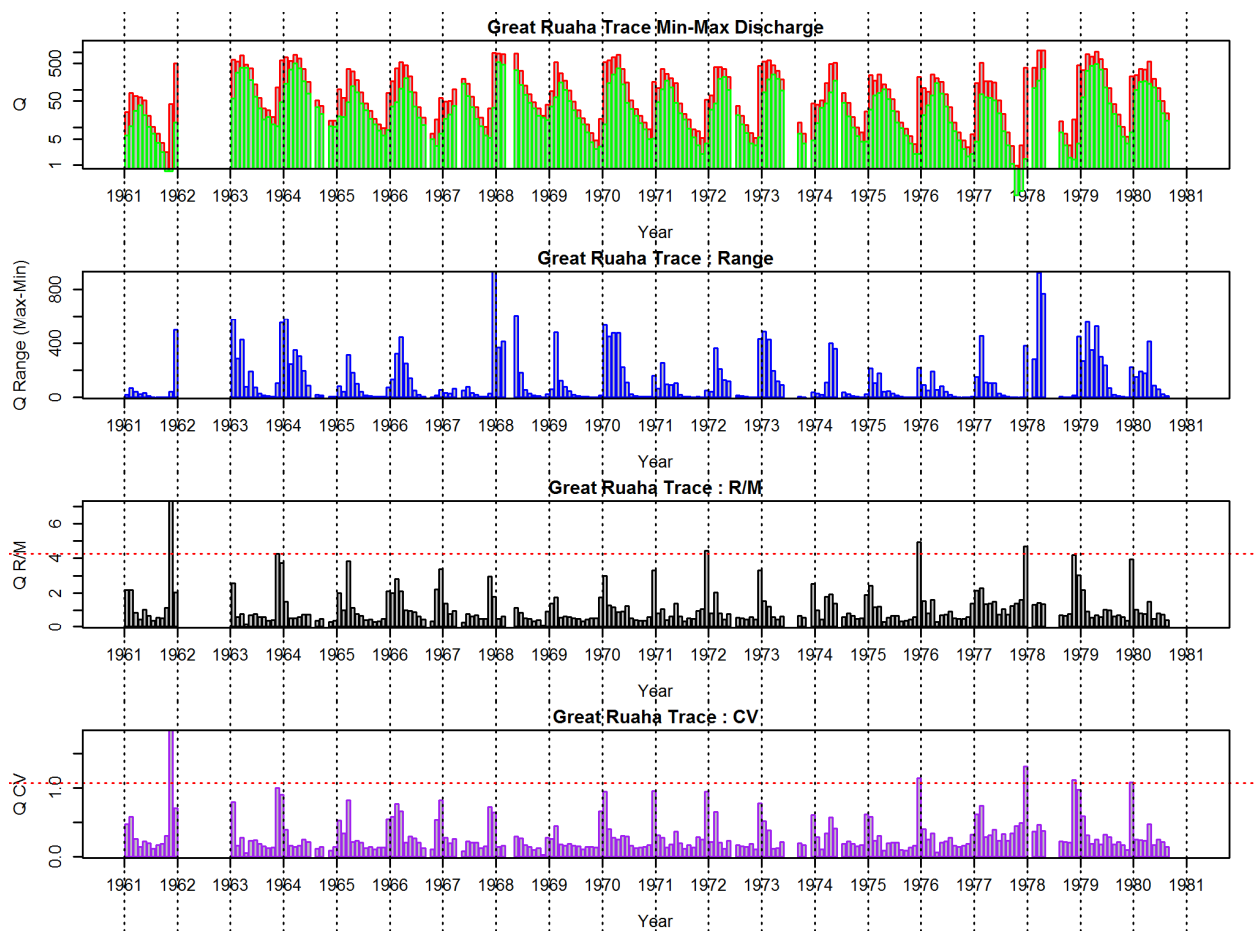


Fig.1 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1961-1980' in 'Great Ruaha at Trace' station under Ruaha sub-basin

Fig.2 shows a time series (1961-1980) of discharge statistics in 'Little Ruaha at Ihimbu' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.2 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 1.70 (~R/M) and 0.00 to 0.46 (~CV) respectively (Tab.1). Combinedly the discharge in Nov 1966 and 1967, Dec 1961, 1967, 1969 and 1971, and Jan 1973 and 1975 are outside of those variability domains (Fig.2) and thus the corresponding discharge data of these particular year-months in 'Little Ruaha at Ihimbu' station were considered to be outliers (Tab.1) in 1961-1980 time series.

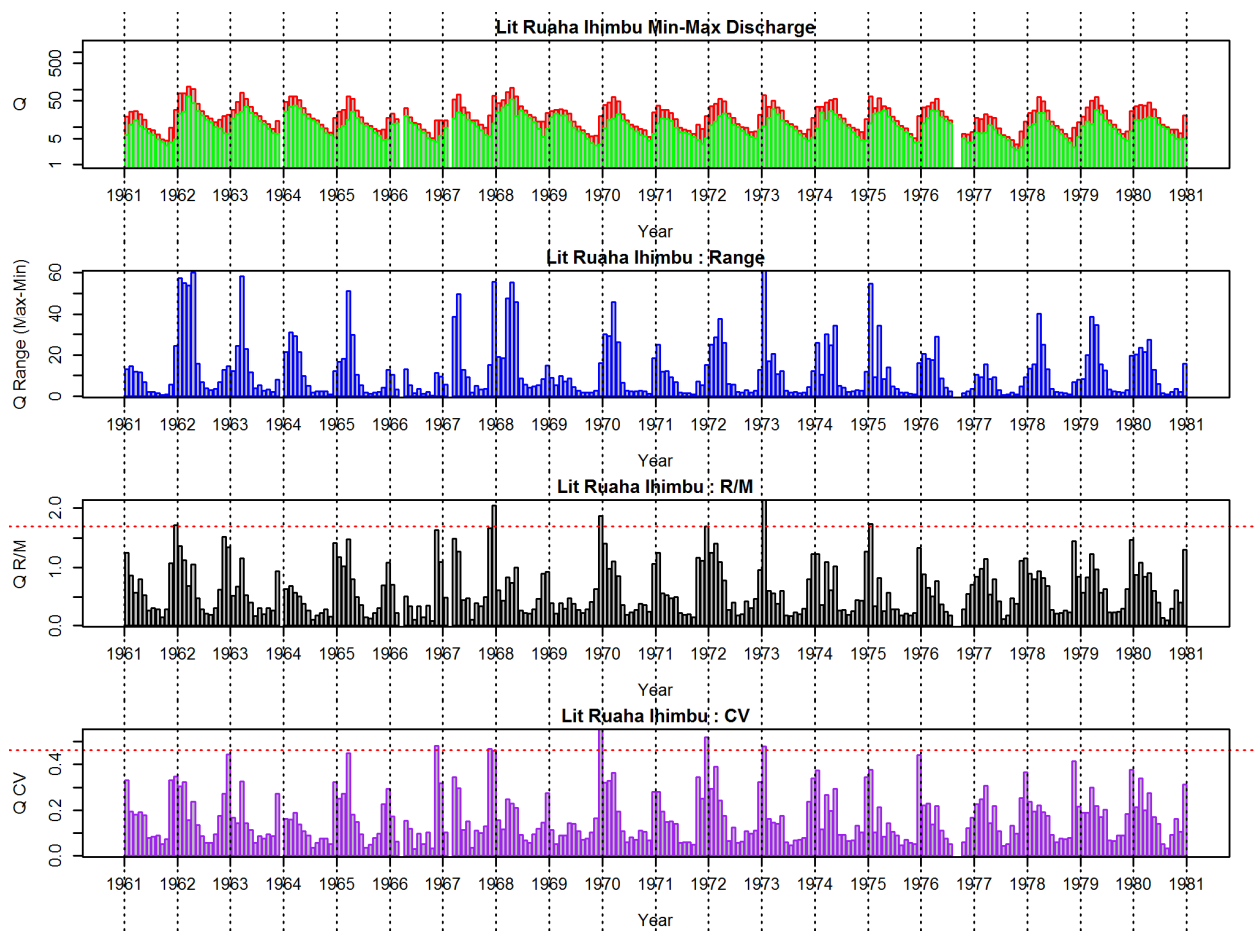


Fig.2 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1961-1980' in 'Little Ruaha at Ihimbu' station under Ruaha sub-basin

Fig.3 shows a time series (1961-1980) of discharge statistics in 'Little Ruaha at Mawande' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.3 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 2.42 (~R/M) and 0.00 to 0.55 (~CV) respectively (Tab.1). Combinedly the discharge in Dec 1961, 1969, 1973 and 1977, and Jan 1970 and 1973, and Mar 1979 are outside of those variability domains (Fig.3) and thus the corresponding discharge data of these particular year-months in 'Little Ruaha at Mawande' station were considered to be outliers (Tab.1) in 1961-1980 time series.

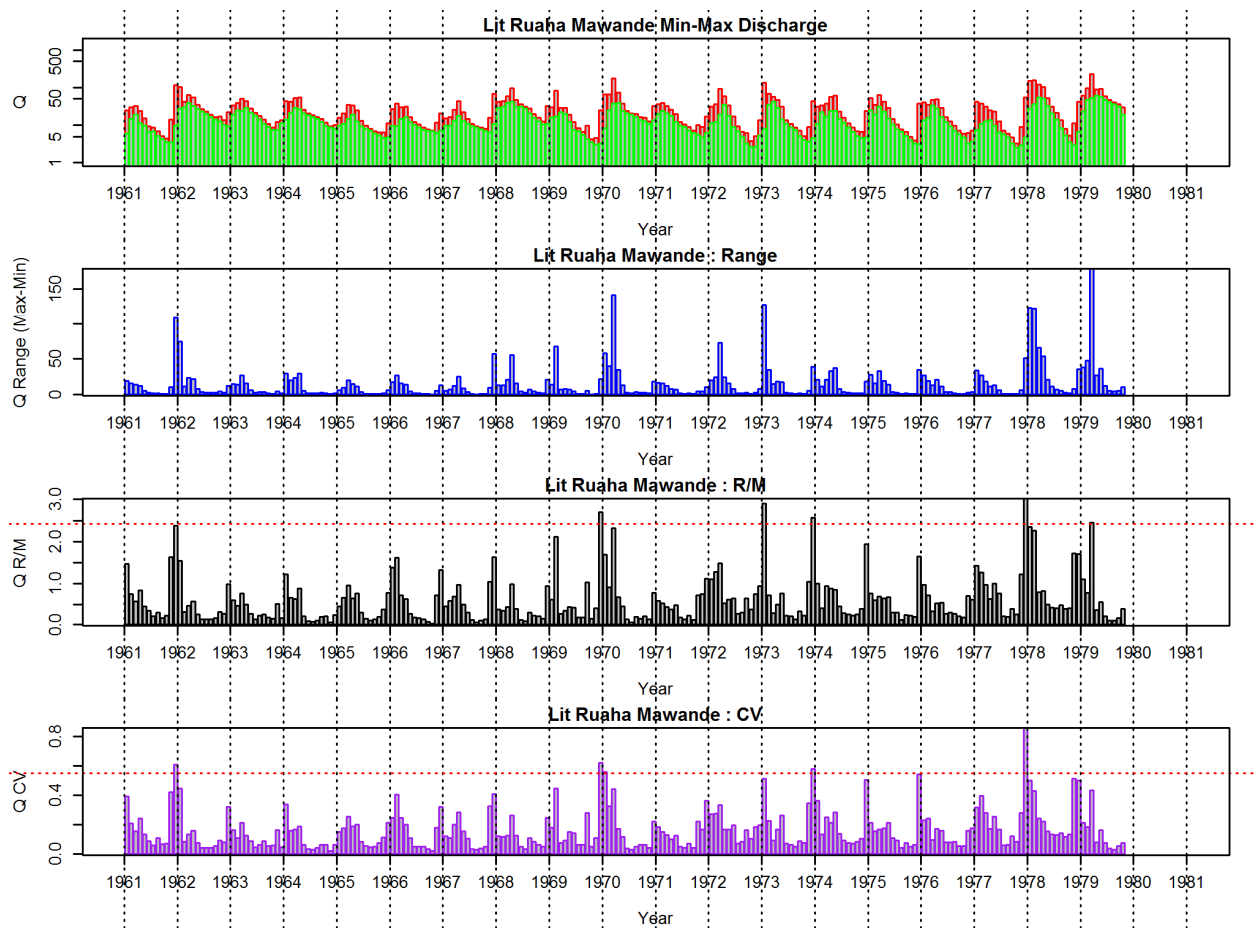


Fig.3 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1961-1980' in 'Little Ruaha at Mawande' station under Ruaha sub-basin

Fig.4 shows a time series (1961-1980) of discharge statistics in 'Urobo at Great North Road (GNR)' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal total 1964 and 1965 as suspicious data points within the general discharge pattern. Furthermore, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.4 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 5.45 (~R/M) and 0.00 to 1.40 (~CV) respectively (Tab.1). Combinedly the discharge in Nov 1975 and 1980, Dec 1965 and 1975, and Jan 1970 are outside of those variability domains (Fig.4) and thus the corresponding discharge data of these particular year-months in 'Urobo at Great North Road (GNR)' station along with the suspicious points were considered to be outliers (Tab.1) in 1961-1980 time series.

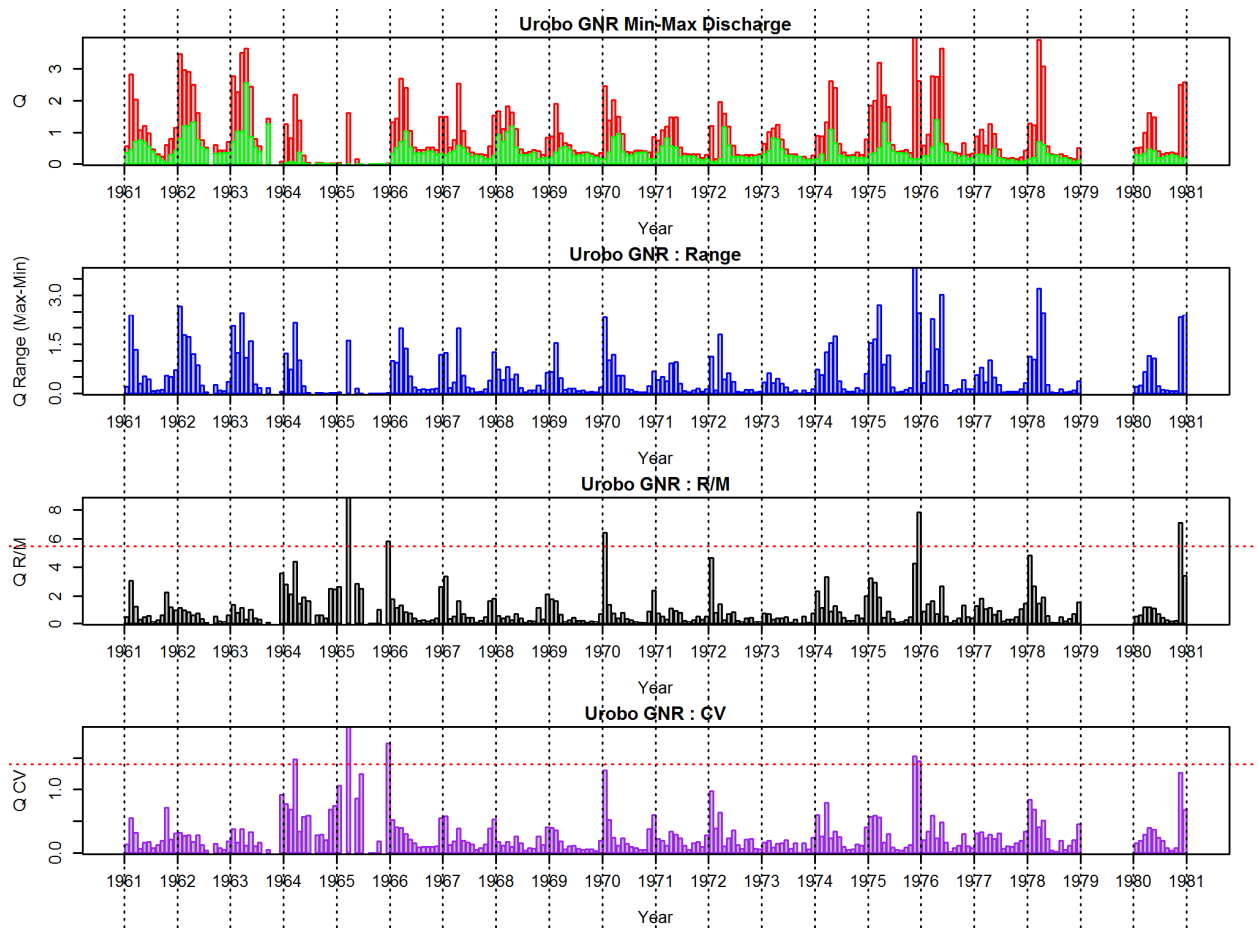


Fig.4 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1961-1980' in 'Urobo at GNR' station under Ruaha sub-basin

Fig.5 shows a time series (1961-1980) of discharge statistics in 'Little Ruaha at Iwawa' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.5 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 1.93 (~R/M) and 0.00 to 0.56 (~CV) respectively (Tab.1). Combinedly the discharge in Nov 1966 and 1970, Dec 1963 and 1969, and Mar 1965 are outside of those variability domains (Fig.5) and thus the corresponding discharge data of these particular year-months along with the suspicious points in 'Little Ruaha at Iwawa' station were considered to be outliers (Tab.1) in 1961-1980 time series.

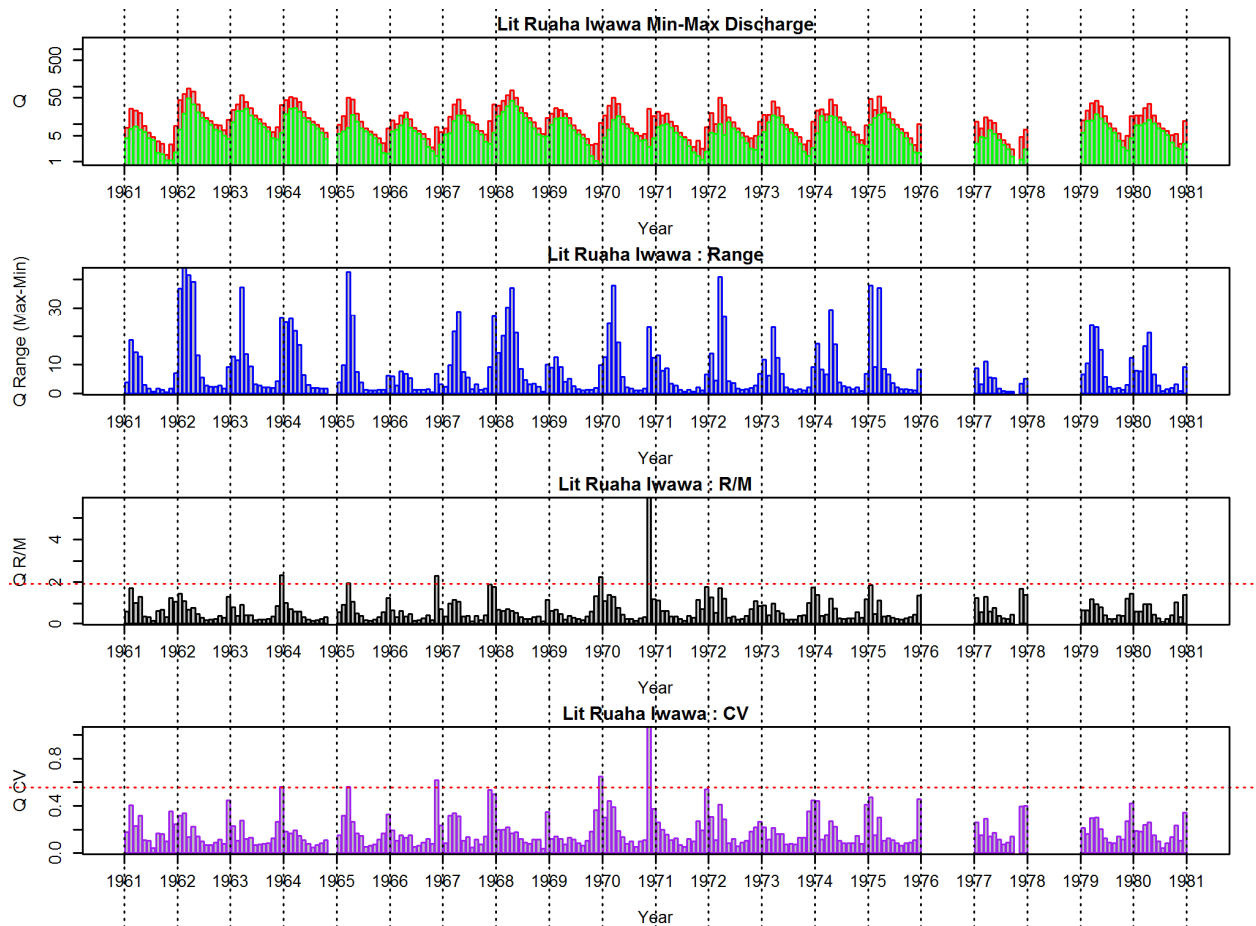


Fig.5 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1961-1980' in 'Little Ruaha at Iwawa' station under Ruaha sub-basin

Fig.6 shows a time series (1961-1980) of discharge statistics in 'Ndembera at Madibira' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal Jan 1962 as suspicious data point within the general discharge pattern. Furthermore, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.6 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 2.67 (~R/M) and 0.00 to 0.79 (~CV) respectively (Tab.1). Combinedly the discharge in Nov 1961 Feb 1962, Apr 1962, Jun 1962 and Dec 1963 Mar 1964 are outside of those variability domains (Fig.6) and thus the corresponding discharge data of these particular year-months along with the suspicious point in 'Ndembera at Madibira' station were considered to be outliers (Tab.1) in 1961-1980 time series.

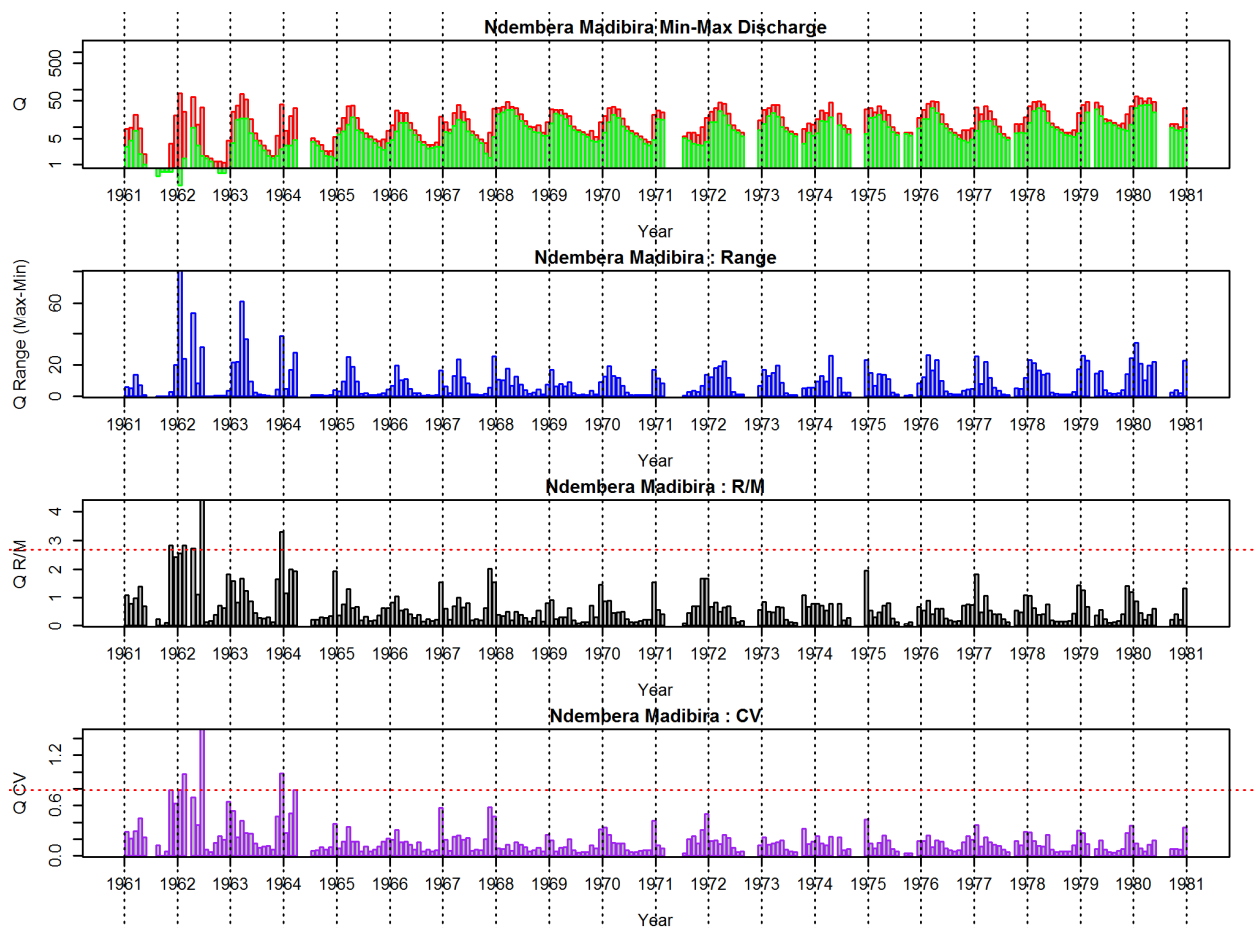


Fig.6 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1961-1980' in 'Ndembera at Madibira' station under Ruaha sub-basin

Table Ann-III.1. Outliers with descriptive statistics in '1961-1980' series of Ruaha sub-basin

Station	P(0.98)	Outliers	Min	Max	Range	Mean	R/M	SD	CV
Gr Ruaha at Trace	<i>Q98(R/M)</i> 0.00-4.25 <i>Q98(CV)</i> 0.00-1.07	Oct-61	0.70	2.23	1.53	1.34	1.14	0.41	0.31
		Nov-61	0.70	42.64	41.94	5.75	7.30	10.57	1.84
		Dec-71	3.83	54.48	50.65	11.45	4.43	10.91	0.95
		Dec-75	2.00	219.30	217.30	43.94	4.95	50.31	1.14
		Oct-77	0.16	0.97	0.81	0.59	1.38	0.26	0.45
		Nov-77	0.21	3.42	3.21	1.98	1.62	0.98	0.50
		Dec-77	1.50	383.30	381.80	81.14	4.71	106.64	1.31
		Nov-78	1.44	16.40	14.96	3.55	4.21	3.96	1.11
Lit Ruaha at Ihimbu	<i>Q98(R/M)</i> 0.00-1.70 <i>Q98(CV)</i> 0.00-0.46	Dec-61	4.68	28.85	24.17	14.11	1.71	4.90	0.35
		Nov-66	4.09	15.36	11.27	6.91	1.63	3.33	0.48
		Nov-67	5.72	20.96	15.24	9.18	1.66	4.29	0.47
		Dec-67	12.64	68.08	55.44	27.17	2.04	12.47	0.46
		Dec-69	3.56	19.52	15.96	8.56	1.87	4.73	0.55
		Dec-71	5.17	20.18	15.01	8.89	1.69	4.62	0.52
		Jan-73	10.29	71.04	60.75	28.46	2.13	13.62	0.48
		Jan-75	12.50	67.05	54.55	31.50	1.73	11.85	0.38
Lit Ruaha at Mawande	<i>Q98(R/M)</i> 0.00-2.42 <i>Q98(CV)</i> 0.00-0.55	Dec-61	9.73	117.75	108.02	45.33	2.38	27.67	0.61
		Dec-69	3.29	24.83	21.54	7.99	2.69	4.97	0.62
		Jan-70	8.26	66.08	57.82	34.25	1.69	19.20	0.56
		Jan-73	8.00	135.03	127.03	43.79	2.90	22.38	0.51
		Dec-73	4.57	44.01	39.45	15.37	2.57	8.89	0.58
		Dec-77	4.70	55.77	51.08	16.94	3.02	14.52	0.86
		Mar-79	52.14	230.21	178.07	72.52	2.46	31.34	0.43
Urobo at GNR	<i>Q98(R/M)</i> 0.00-5.45 <i>Q98(CV)</i> 0.00-1.40	1964*	0.00	2.20	2.20	0.20	11.16	0.35	1.75
		1965*	0.00	1.62	1.62	0.03	50.13	0.13	4.09
		Mar-64	0.05	2.20	2.15	0.49	4.41	0.72	1.48
		Mar-65	0.01	1.62	1.61	0.18	8.85	0.36	1.98
		Dec-65	0.00	0.03	0.03	0.01	5.81	0.01	1.72
		Nov-75	0.16	3.99	3.83	0.90	4.26	1.37	1.52
		Dec-75	0.16	2.63	2.47	0.31	7.85	0.46	1.45
Lit Ruaha at Iwawa	<i>Q98(R/M)</i> 0.00-1.93 <i>Q98(CV)</i> 0.00-0.56	Dec-63	6.00	32.24	26.24	11.25	2.33	6.32	0.56
		Mar-65	8.17	50.74	42.57	21.95	1.94	12.32	0.56
		Nov-66	1.43	8.43	7.00	3.07	2.28	1.89	0.62
		Dec-69	0.88	10.74	9.86	4.40	2.24	2.85	0.65
		Nov-70	2.52	25.72	23.20	3.90	5.96	4.15	1.06
Ndembera at Madibira	<i>Q98(R/M)</i> 0.00-2.67 <i>Q98(CV)</i> 0.00-0.79	Nov-61	0.65	3.66	3.01	1.07	2.82	0.84	0.79
		Jan-62	0.28	80.64	80.36	31.67	2.54	24.81	0.78
		Feb-62	1.49	25.42	23.93	8.46	2.83	8.24	0.97
		Apr-62	9.56	63.15	53.59	19.72	2.72	13.75	0.70
		Jun-62	1.75	33.03	31.28	7.11	4.40	10.73	1.51
		Dec-63	2.62	40.90	38.28	11.61	3.30	11.42	0.98
		Mar-64	4.63	32.27	27.64	14.33	1.93	11.29	0.79

* refers to annual statistics where the total case showed suspicious

Fig.7 shows a time series (1981-1997) of discharge statistics in 'Kimani' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal Dec 1997 as suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.7 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 4.07 (~R/M) and 0.00 to 1.19 (~CV) respectively (Tab.2). Combinedly the discharge in Nov 1985 and 1992, Dec 1986 and 1991, and Feb 1987 are outside of those variability domains (Fig.7) and thus the corresponding discharge data of these particular year-months along with the suspicious point in 'Kimani' station were considered to be outliers (Tab.2) in 1981-1997 time series.

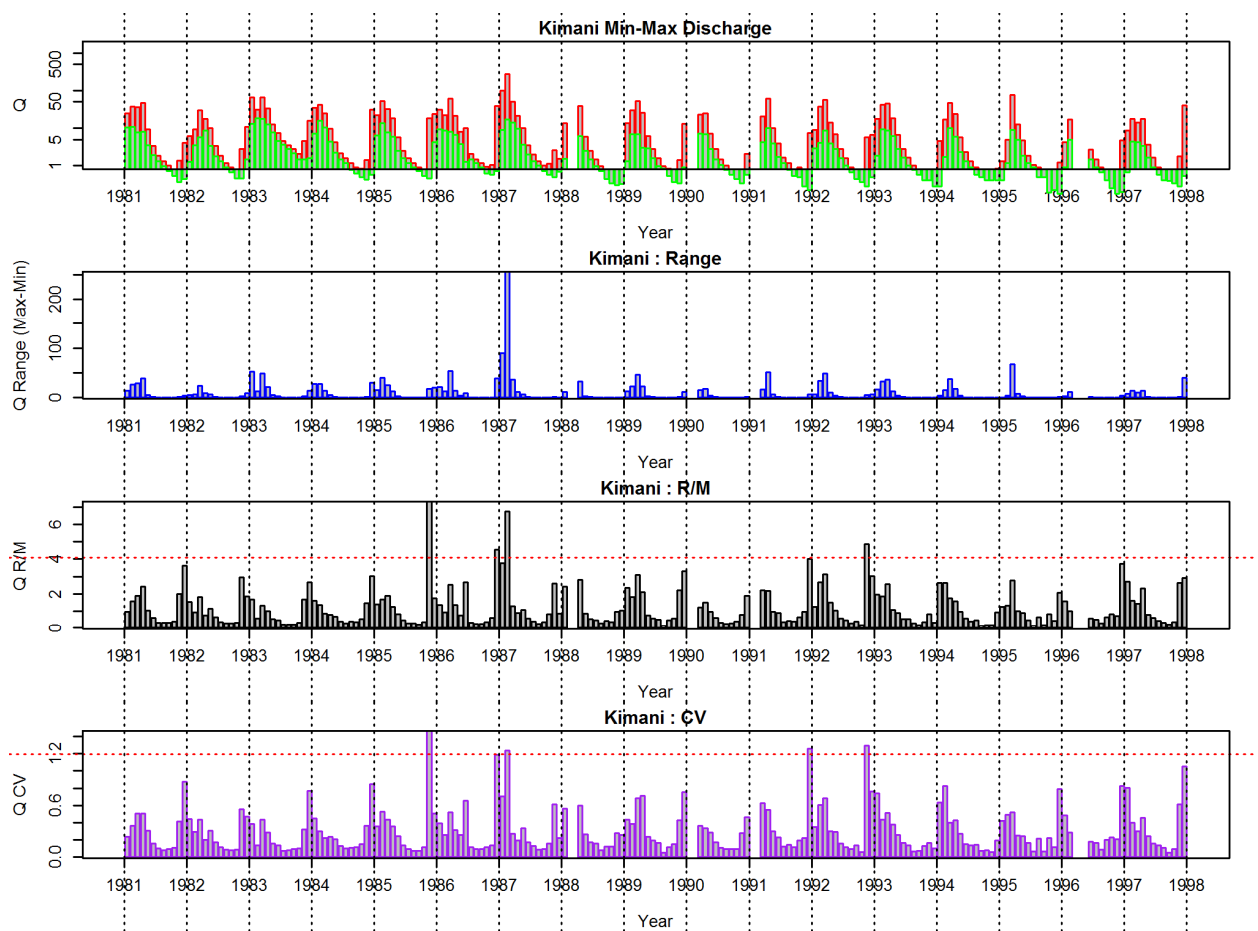


Fig.7 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Kimani' station under Ruaha sub-basin

Fig.8 shows a time series (1981-1997) of discharge statistics in 'Ndembera at Ilongo' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal Dec 1998 as suspicious data point within the general discharge pattern. Furthermore, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.8 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 2.81 (~R/M) and 0.00 to 0.84 (~CV) respectively (Tab.2). Combinedly the discharge in Oct 1993, Nov 1981, 1985 and 1989, and Dec 1991 are outside of those variability domains (Fig.8) and thus the corresponding discharge data of these particular year-months along with the suspicious point in 'Ndembera at Ilongo' station were considered to be outliers (Tab.2) in 1981-1997 time series.

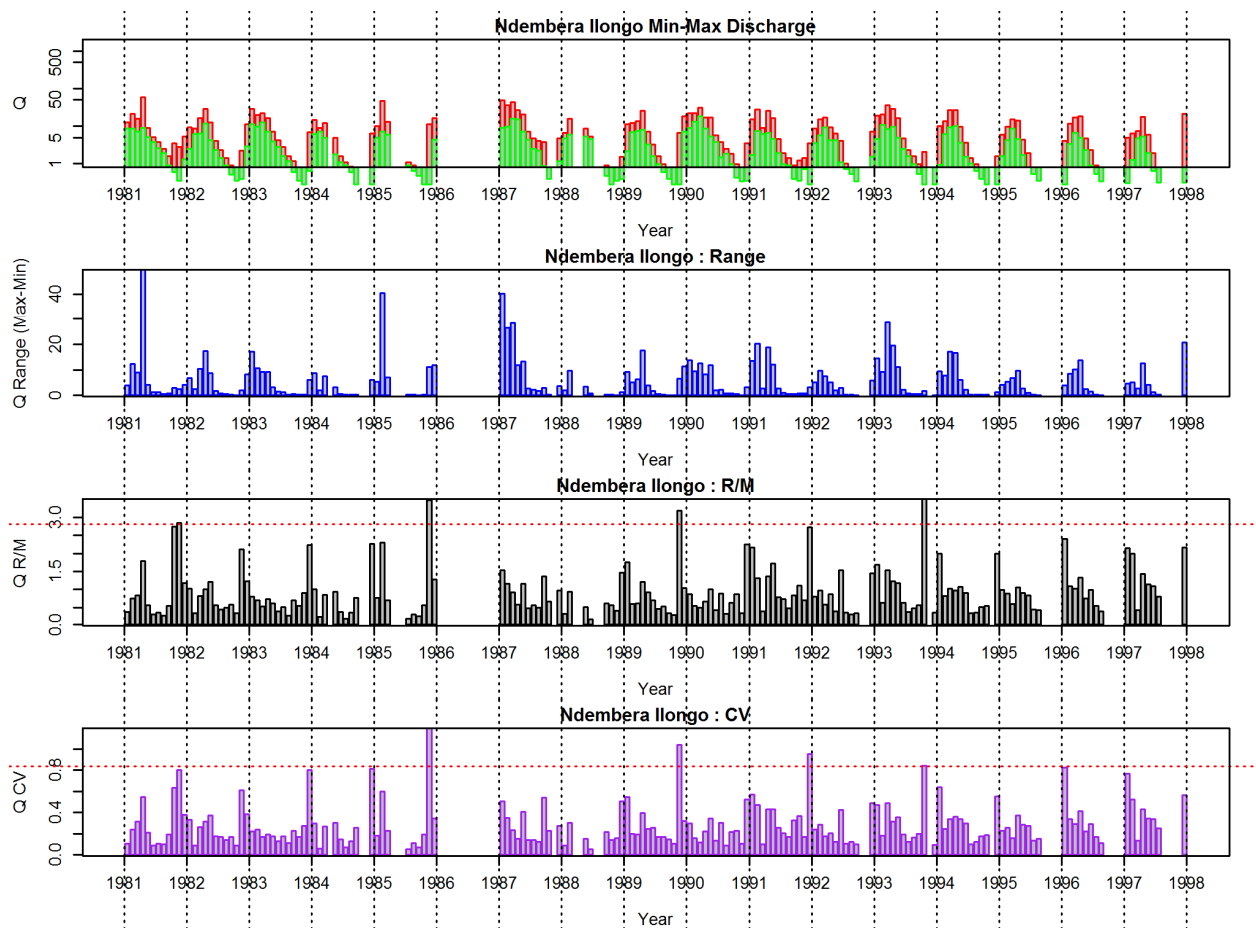


Fig.8 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Ndembera at Ilongo' station under Ruaha sub-basin

Fig.9 shows a time series (1981-1997) of discharge statistics in 'Little Ruaha Ihimbu' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.9 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 1.64 (~R/M) and 0.00 to 0.46 (~CV) respectively (Tab.2). Combinedly the discharge in Nov 1982 and 1992, and Dec 1996, and Jan 1994 and 1997 are outside of those variability domains (Fig.9) and thus the corresponding discharge data of these particular year-months in 'Little Ruaha Ihimbu' station were considered to be outliers (Tab.2) in 1981-1997 time series.

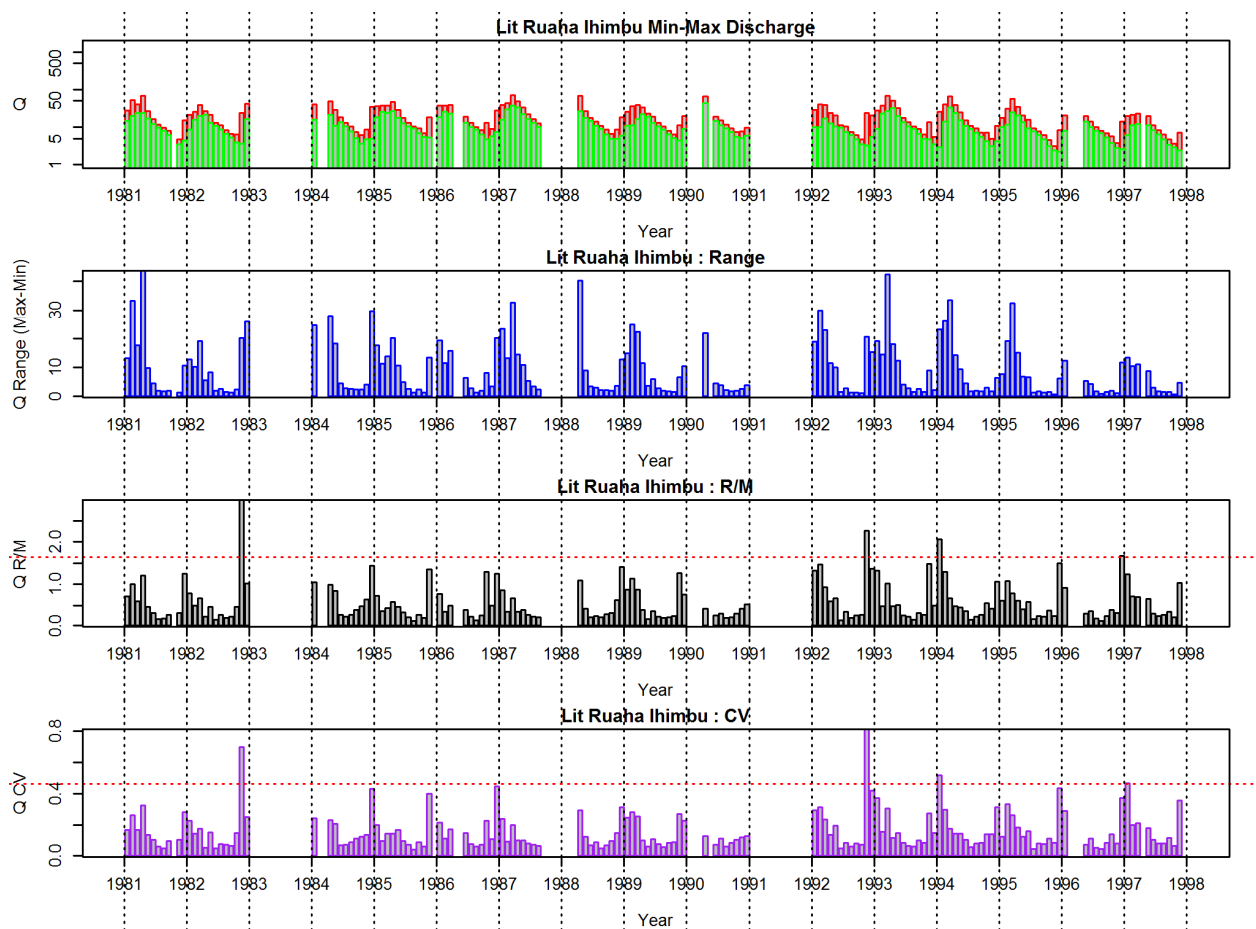


Fig.9 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Little Ruaha at Ihimbu' station under Ruaha sub-basin

Fig.10 shows a time series (1981-1997) of discharge statistics in 'Mtitu' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.10 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 2.36 (~R/M) and 0.00 to 0.61 (~CV) respectively (Tab.2). Combinedly the discharge in Jan 1991, Mar 1992, Apr 1988 and 1989, May 1983, and Jun 1988, 1996 and 1997 are outside of those variability domains (Fig.10) and thus the corresponding discharge data of these particular year-months in 'Mtitu' station were considered to be outliers (Tab.2) in 1981-1997 time series.

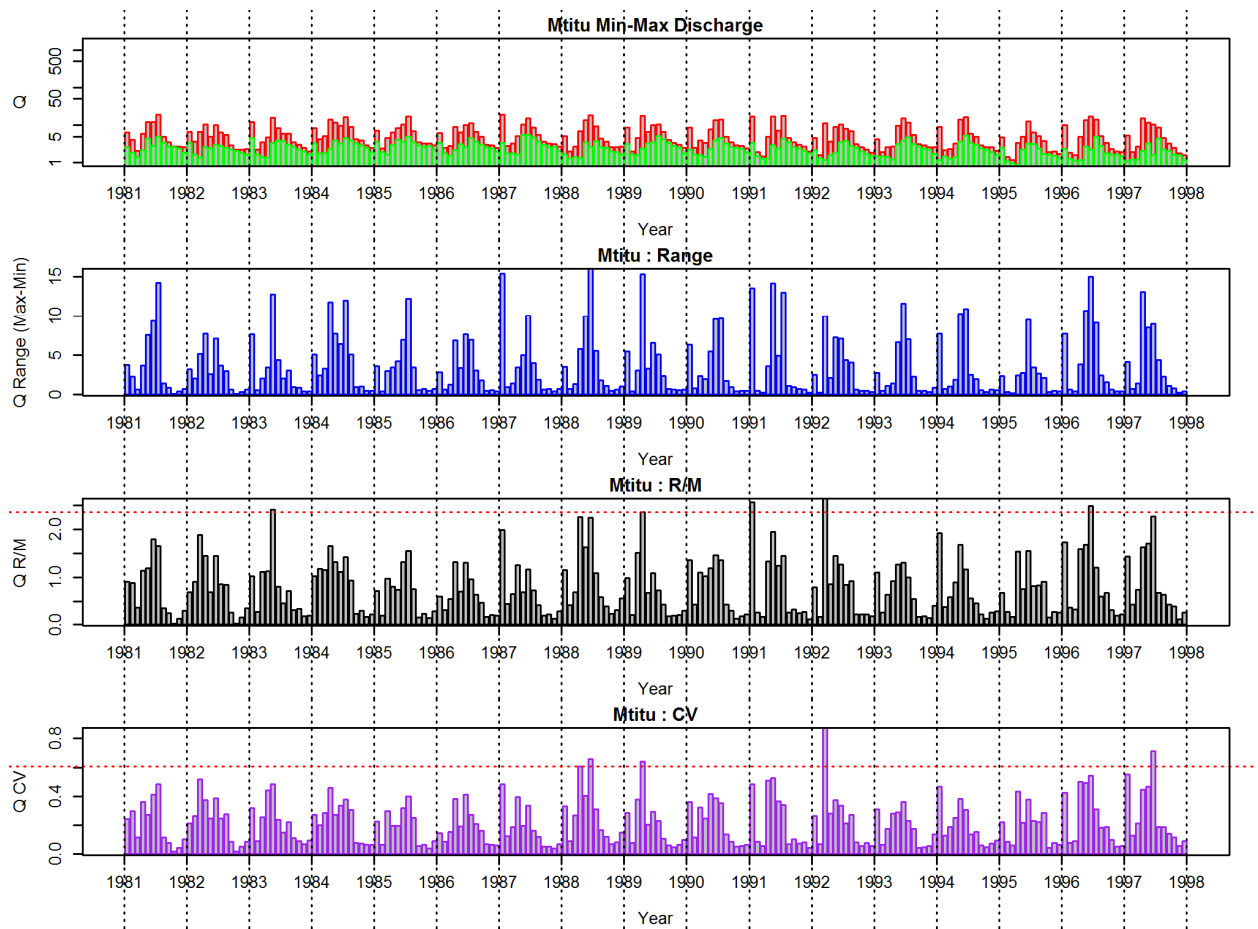


Fig.10 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Mtitu' station under Ruaha sub-basin

Fig.11 shows a time series (1981-1997) of discharge statistics in 'Lukosi at Mtandika' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal Jul 1995 as suspicious data point within the general discharge pattern. Furthermore, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.11 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 2.35 (~R/M) and 0.00 to 0.52 (~CV) respectively (Tab.2). Combinedly the discharge in Mar 1981, 1988, 1992, 1996 and 1997, Jul 1995, and Dec 1998 are outside of those variability domains (Fig.11) and thus the corresponding discharge data of these particular year-months along with the suspicious point in 'Lukosi at Mtandika' station were considered to be outliers (Tab.2) in 1981-1997 time series.

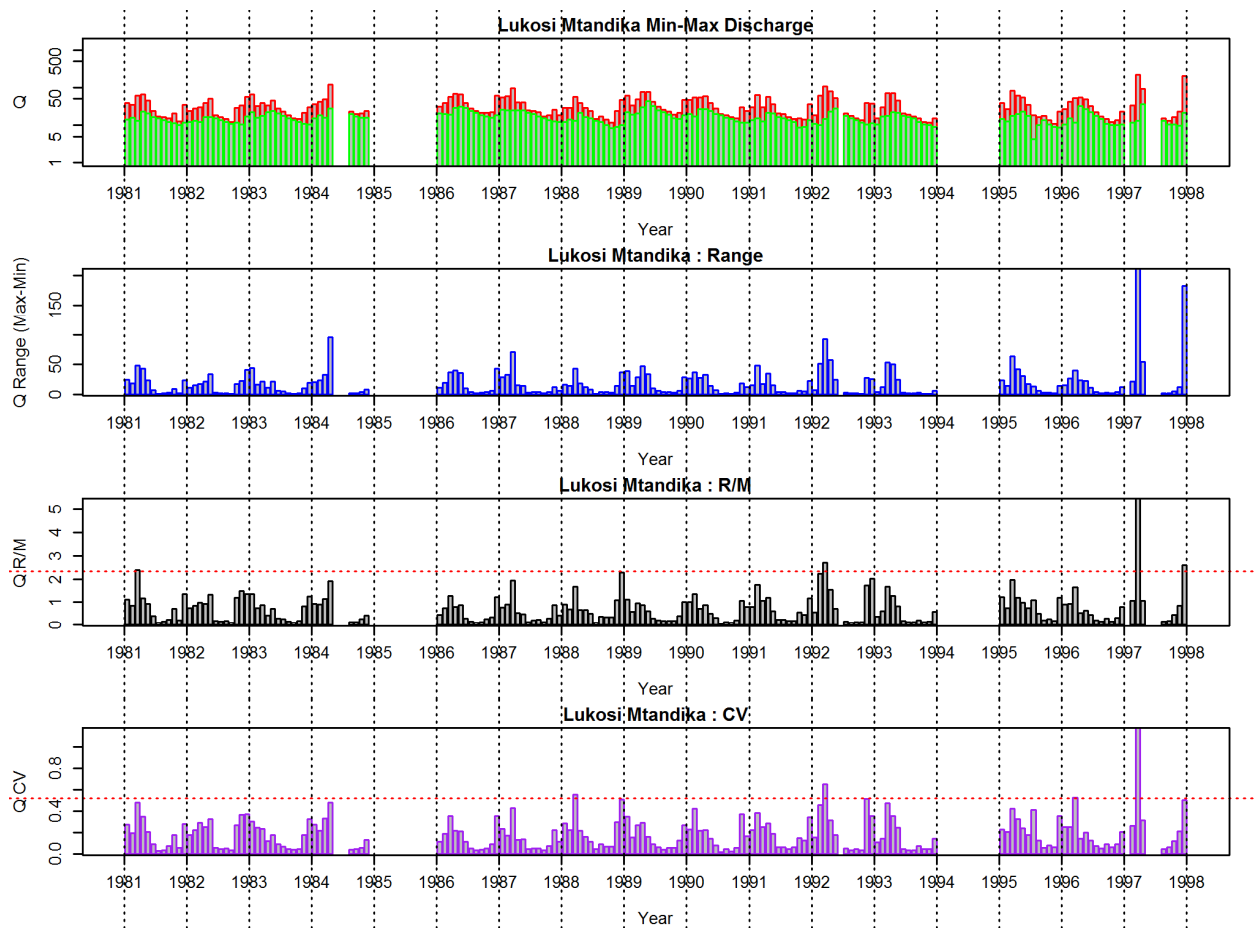


Fig.11 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Lukosi at Mtandika' station under Ruaha sub-basin

Table Ann-III.2. Outliers with descriptive statistics in '1981-1997' series of Ruaha sub-basin

Station	P(0.98)	Outliers	Min	Max	Range	Mean	R/M	SD	CV
Kimani		Nov-85	0.47	18.67	18.20	2.50	7.29	3.65	1.46
	<i>Q98(R/M)</i>	Dec-86	0.73	39.75	39.02	8.61	4.53	10.19	1.18
	<i>Q98(CV)</i>	Feb-87	17.38	272.74	255.36	37.91	6.74	46.94	1.24
		Dec-91	0.22	7.39	7.17	1.79	4.01	2.25	1.26
		Nov-92	0.28	5.75	5.47	1.12	4.87	1.46	1.29
		Dec-97	0.55	40.00	39.45	13.55	2.91	14.27	1.05
Ndembera at Ilongo		Nov-81	0.35	2.79	2.44	0.86	2.84	0.69	0.80
	<i>Q98(R/M)</i>	Nov-85	0.28	11.38	11.10	3.20	3.47	3.82	1.19
	<i>Q98(CV)</i>	Nov-89	0.28	6.73	6.45	2.03	3.17	2.11	1.04
		Dec-91	0.28	3.58	3.29	1.21	2.73	1.15	0.95
		Oct-93	0.28	2.11	1.83	0.52	3.50	0.44	0.84
		Dec-97	0.32	21.12	20.80	9.63	2.16	5.40	0.56
Lit Ruaha at Ihimbu		Nov-82	3.64	23.76	20.12	6.74	2.99	4.71	0.70
	<i>Q98(R/M)</i>	Nov-92	3.22	23.87	20.65	9.14	2.26	7.42	0.81
	<i>Q98(CV)</i>	Jan-94	2.96	26.13	23.17	11.26	2.06	5.81	0.52
		Dec-96	2.58	14.34	11.76	7.06	1.66	2.63	0.37
		Jan-97	6.13	19.52	13.39	10.85	1.23	5.05	0.47
Mtitu		May-83	2.98	6.00	12.74	4.20	2.41	2.56	0.48
	<i>Q98(R/M)</i>	Apr-88	3.76	9.32	5.74	5.09	2.26	1.55	0.61
	<i>Q98(CV)</i>	Jun-88	2.47	3.61	16.00	2.82	2.25	4.66	0.66
		Apr-89	5.21	10.28	15.36	6.94	2.37	4.16	0.64
		Jan-91	3.38	16.96	13.58	5.29	2.56	2.56	0.48
		Mar-92	3.53	10.66	9.97	5.63	2.64	3.29	0.87
		Jun-96	1.79	3.34	15.04	2.25	2.48	3.30	0.54
		Jun-97	2.11	3.23	8.98	2.56	2.27	2.83	0.71
Lukosi at Mtandika		Mar-81	13.00	60.94	47.94	20.03	2.39	9.62	0.48
	<i>Q98(R/M)</i>	Mar-88	13.24	56.41	43.17	25.75	1.68	14.29	0.55
	<i>Q98(CV)</i>	Mar-92	14.52	107.31	92.79	34.34	2.70	22.41	0.65
		Jul-95	4.20	18.16	13.96	12.85	1.09	5.31	0.41
		Mar-96	11.78	52.07	40.29	24.42	1.65	12.88	0.53
		Mar-97	13.00	223.63	210.63	38.67	5.45	45.33	1.17
		Dec-97	21.46	204.22	182.76	70.04	2.61	35.10	0.50

Fig.12 shows a time series (1998-2013) of discharge statistics in 'Great Ruaha at Salimwani' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal Dec 2011 as suspicious data point within the general discharge pattern. Furthermore, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.12 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 3.07 (~R/M) and 0.00 to 0.80 (~CV) respectively (Tab.3). Combinedly the discharge in Dec 2003, 2006, 2009 and 2013, and Mar 2001 are outside of those variability domains (Fig.12) and thus the corresponding discharge data of these particular year-months along with the suspicious point in 'Great Ruaha at Salimwani' station were considered to be outliers (Tab.3) in 1998-2013 time series.

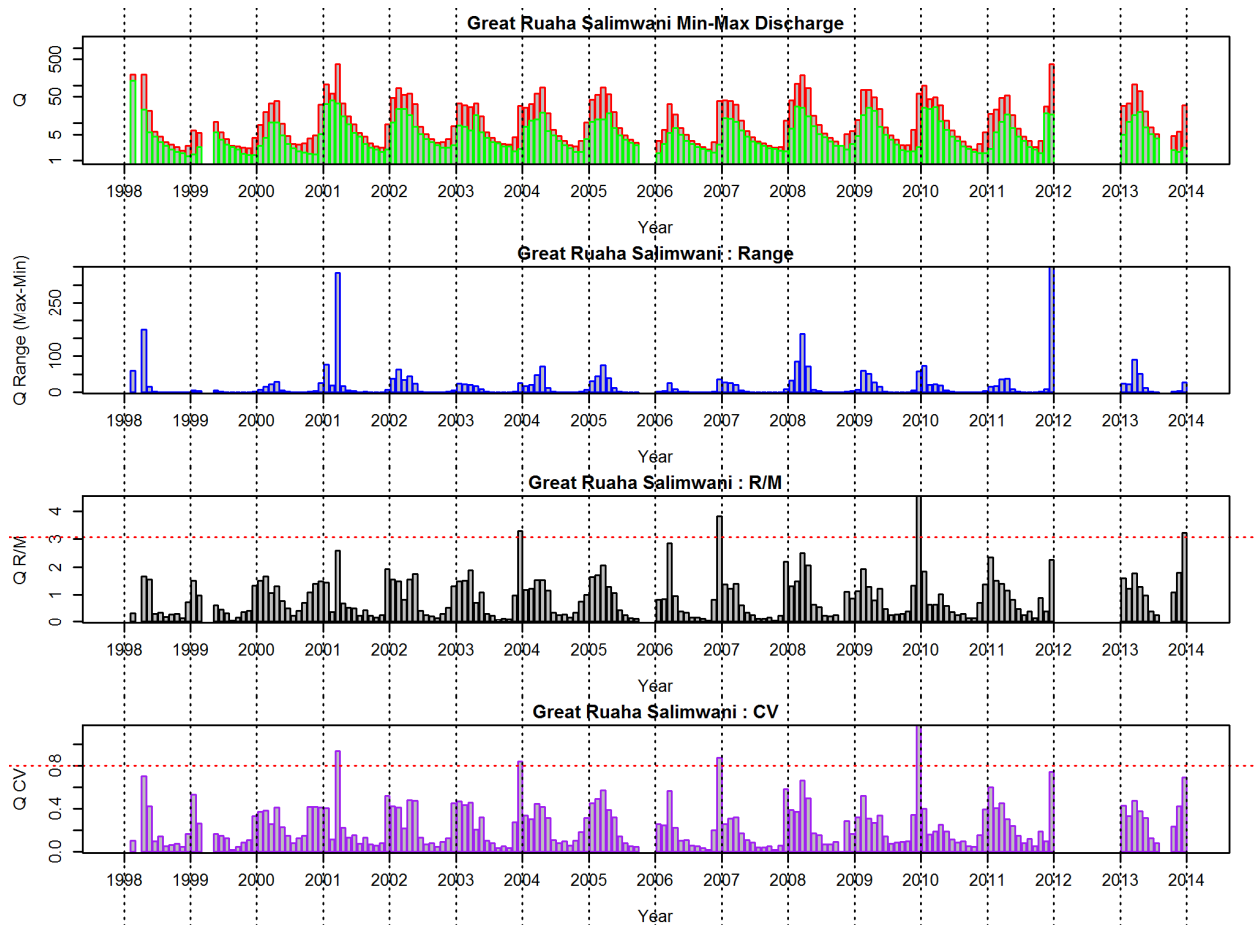


Fig.12 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Great Ruaha at Salimwani' station under Ruaha sub-basin

Fig.13 shows a time series (1998-2013) of discharge statistics in 'Kimani' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal Oct 2011 as suspicious data point within the general discharge pattern. Furthermore, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.13 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 5.70 (~R/M) and 0.00 to 1.32 (~CV) respectively (Tab.3). Combinedly the discharge in Mar 2004, and Apr 2001, 2004 and 2009 are outside of those variability domains (Fig.13) and thus the corresponding discharge data of these particular year-months along with the suspicious point in 'Kimani' station were considered to be outliers (Tab.3) in 1998-2013 time series.

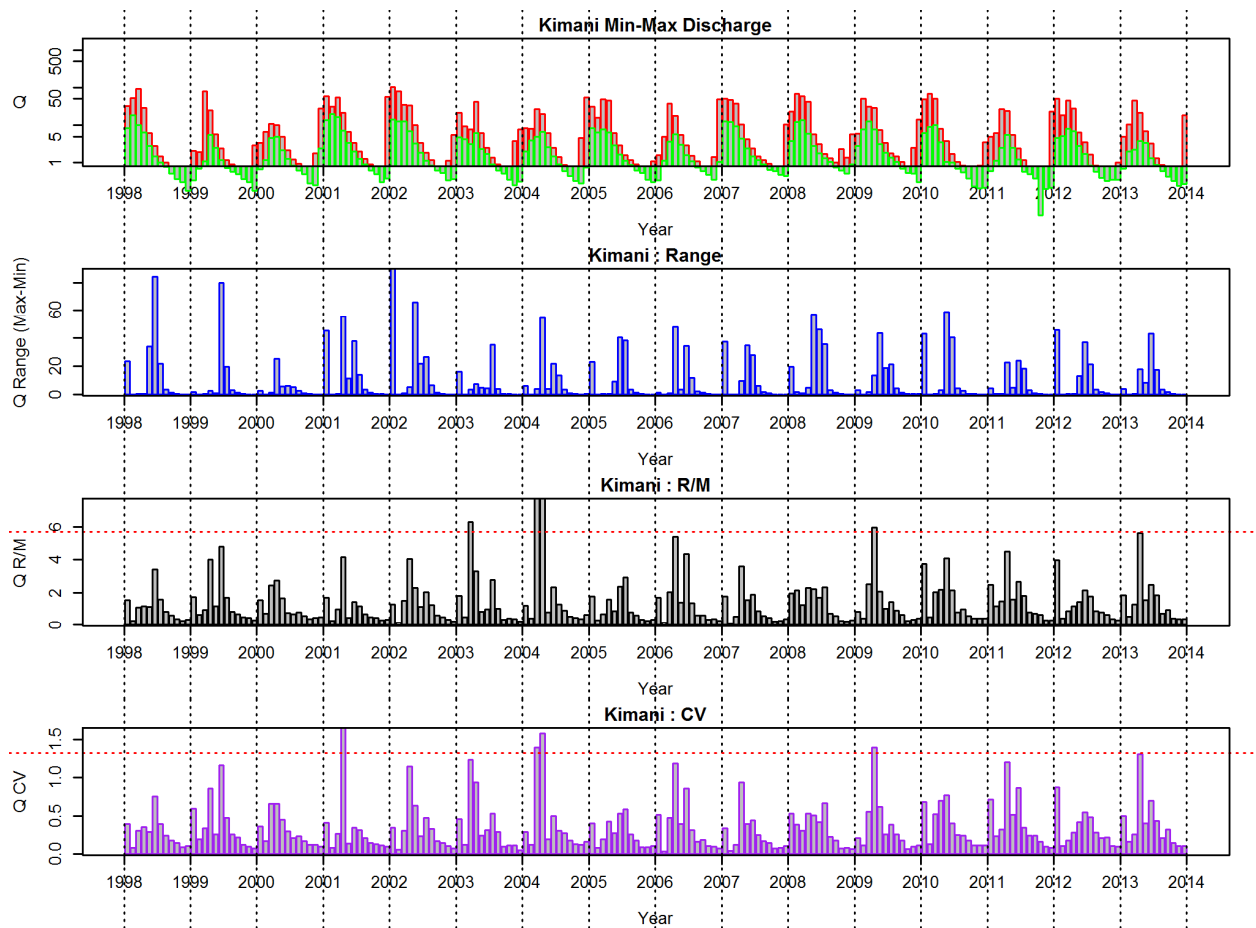


Fig.13 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Kimani' station under Ruaha sub-basin

Fig.14 shows a time series (1998-2013) of discharge statistics in 'Mbarali at Igawa' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.14 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 4.88 (~R/M) and 0.00 to 1.00 (~CV) respectively (Tab.3). Combinedly the discharge in Nov 2013, and Dec 2003, 2004, 2005 and 2009 are outside of those variability domains (Fig.14) and thus the corresponding discharge data of these particular year-months in 'Mbarali at Igawa' station were considered to be outliers (Tab.3) in 1998-2013 time series.

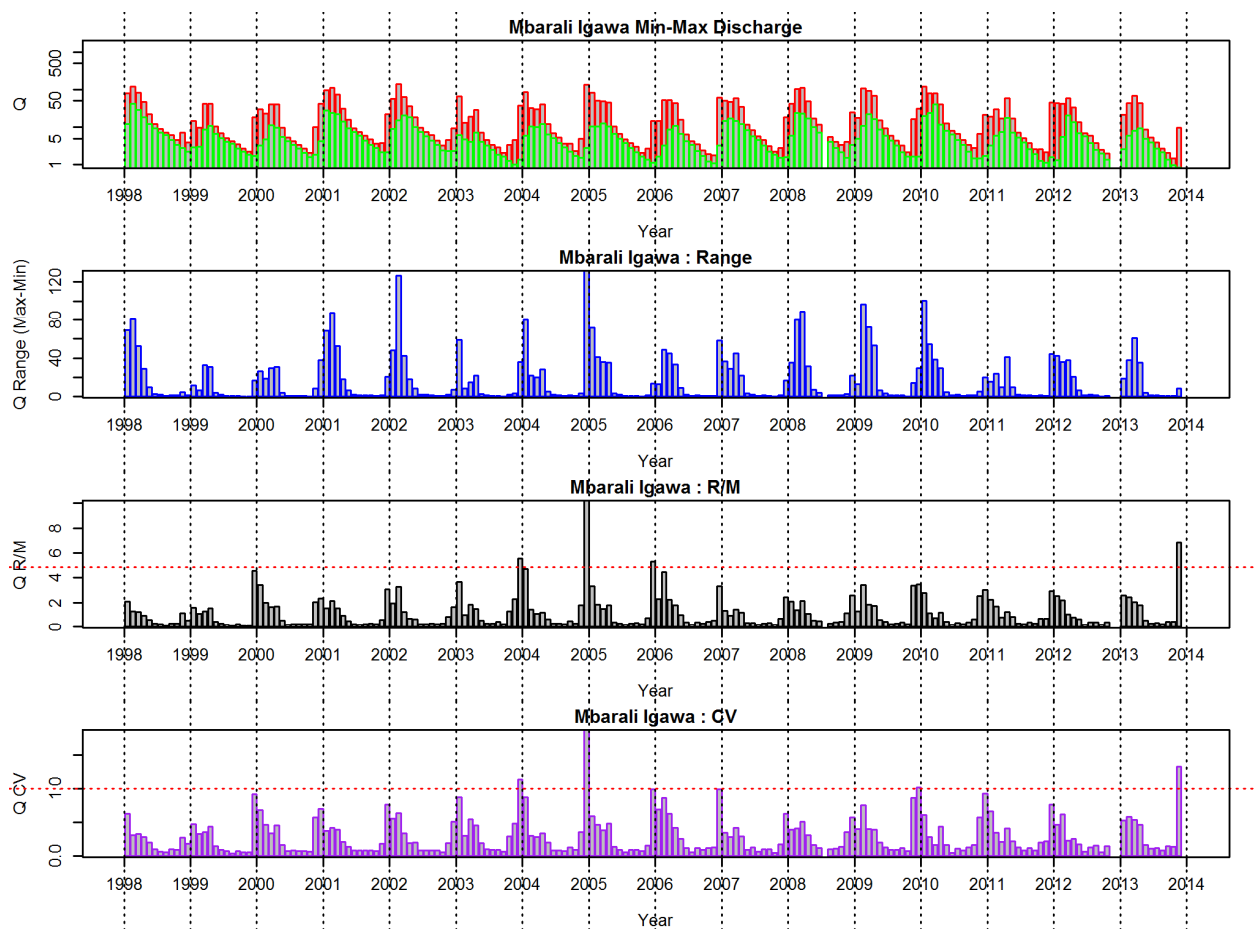


Fig.14 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Mbarali at Igawa' station under Ruaha sub-basin

Fig.15 shows a time series (1998-2013) of discharge statistics in 'Ndembera at Ilongo' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.15 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 3.54 (~R/M) and 0.00 to 1.15 (~CV) respectively (Tab.3). Combinedly the discharge in Nov 2000, 2006 and 2009, and Dec 2002, 2007 and 2011 are outside of those variability domains (Fig.15) and thus the corresponding discharge data of these particular year-months in 'Ndembera at Ilongo' station were considered to be outliers (Tab.3) in 1998-2013 time series.

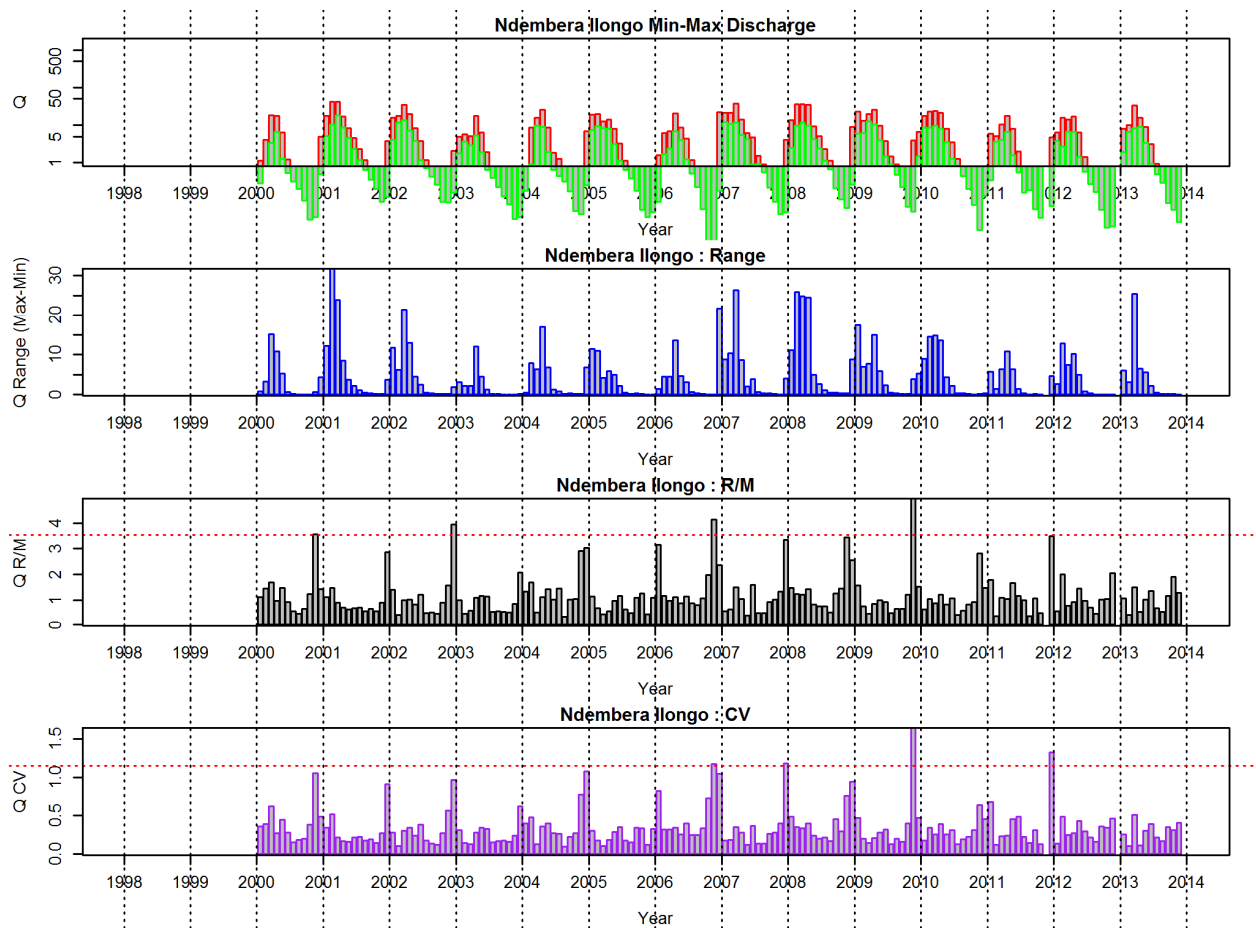


Fig.15 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Ndembera at Ilongo' station under Ruaha sub-basin

Fig.16 shows a time series (1998-2013) of discharge statistics in 'Mtitu' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.16 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 2.06 (~R/M) and 0.00 to 0.61 (~CV) respectively (Tab.3). Combinedly the discharge in Nov 2000, Dec 2006 and 2007, and Mar 2009 and 2012 are outside of those variability domains (Fig.16) and thus the corresponding discharge data of these particular year-months in 'Mtitu' station were considered to be outliers (Tab.3) in 1998-2013 time series.

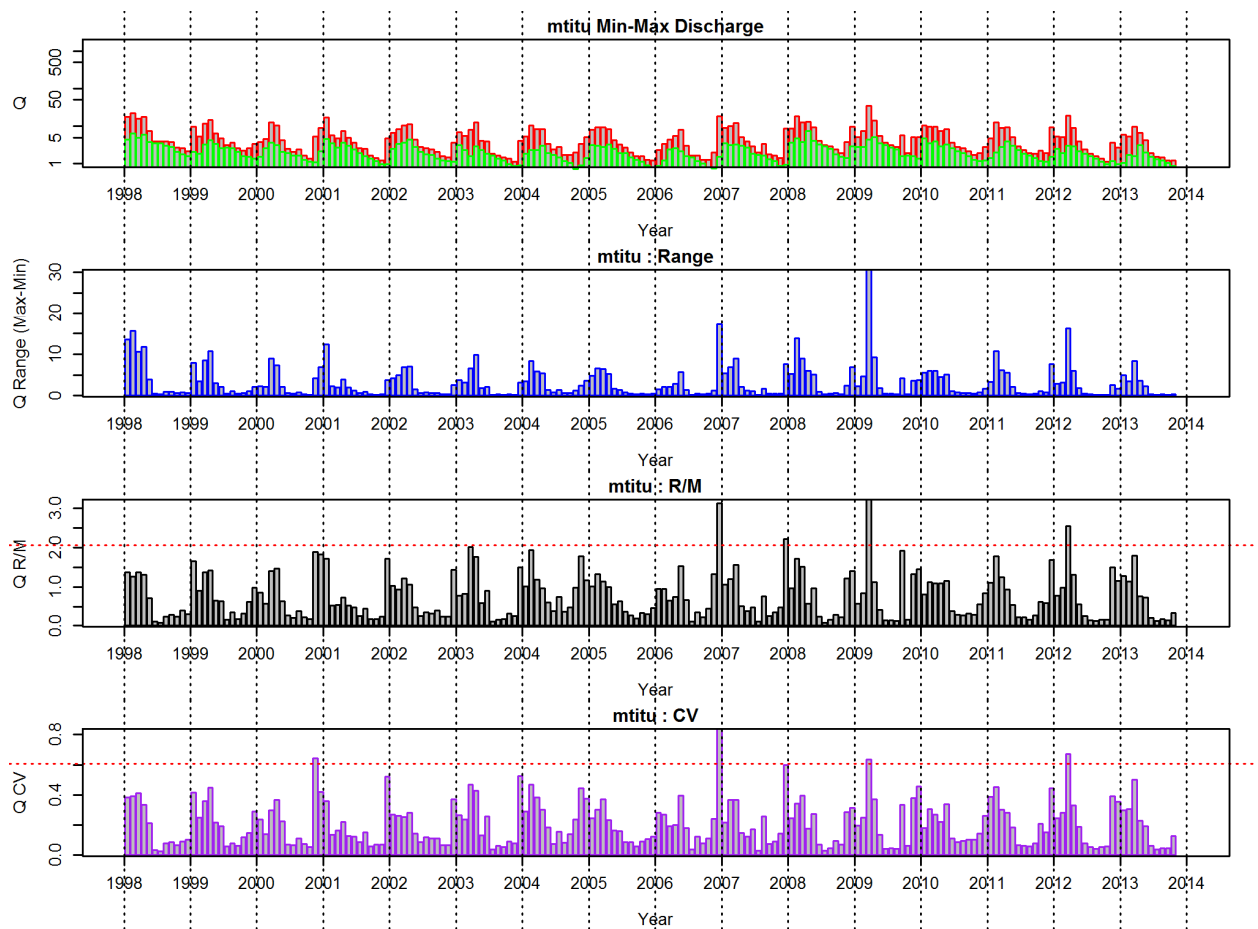


Fig.16 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Mtitu' station under Ruaha sub-basin

Fig.17 shows a time series (1998-2013) of discharge statistics in 'Little Ruaha at Mawande' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal Nov 2005 and Dec 2005, 2013 and 2014 as suspicious data point within the general discharge pattern. Furthermore, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.17 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 2.96 (~R/M) and 0.00 to 0.80 (~CV) respectively (Tab.3). Combinedly the discharge in Nov 2000 and 2006, and Dec 2000, 2001 and 2006 are outside of those variability domains (Fig.17) and thus the corresponding discharge data of these particular year-months along with the suspicious point in 'Little Ruaha at Mawande' station were considered to be outliers (Tab.3) in 1998-2013 time series.

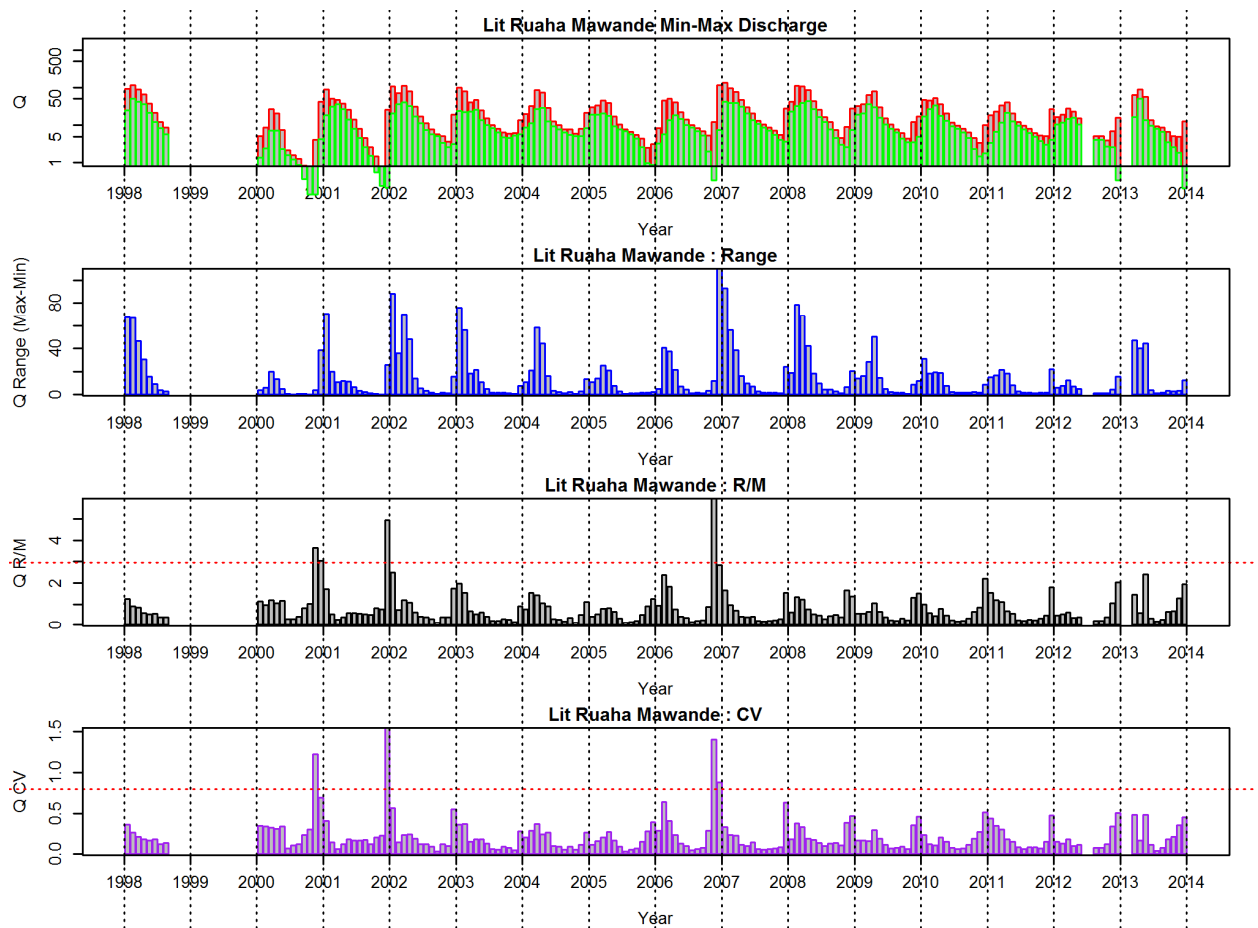


Fig.17 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Little Ruaha at Mawande' station under Ruaha sub-basin

Fig.18 shows a time series (1998-2013) of discharge statistics in 'Little Ruaha at Makalala' station under Ruaha sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.18 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 2.74 (~R/M) and 0.00 to 0.76 (~CV) respectively (Tab.3). Combinedly the discharge in Oct 2000, Nov 2000, 2003 and 2013, and Dec 1999 and 2006 are outside of those variability domains (Fig.18) and thus the corresponding discharge data of these particular year-months in 'Little Ruaha at Makalala' station were considered to be outliers (Tab.3) in 1998-2013 time series.

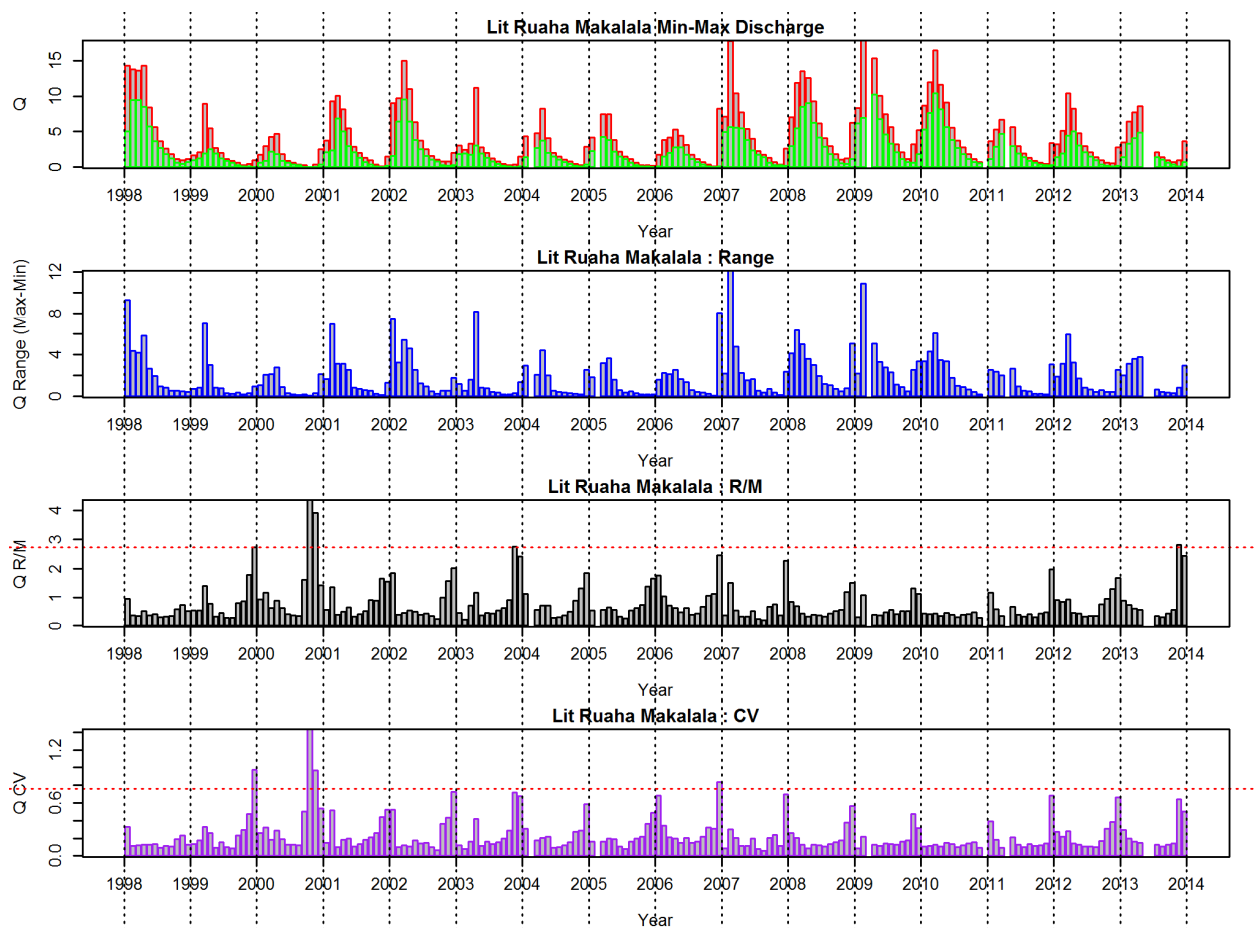


Fig.18 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1981-1997' in 'Little Ruaha at Makalala' station under Ruaha sub-basin

Table Ann-III.3. Outliers with descriptive statistics in '1998-2013' series of Ruaha sub-basin

Station	P(0.98)	Outliers	Min	Max	Range	Mean	R/M	SD	CV	
Gr. Ruaha at Salimwani		Mar-01	33.96	367.08	333.12	128.37	2.59	120.29	0.94	
	<i>Q98(R/M)</i>	0.00-3.07	Dec-03	2.11	28.57	26.46	8.05	3.29	6.75	0.84
	<i>Q98(CV)</i>	0.00-0.80	Dec-06	2.70	39.32	36.61	9.61	3.81	8.41	0.88
			Dec-09	2.33	61.09	58.76	12.95	4.54	15.22	1.18
			Dec-11	17.33	367.35	350.01	155.40	2.25	115.89	0.75
			Dec-13	2.28	29.62	27.35	8.48	3.22	5.88	0.69
Kimani		Apr-01	7.26	21.31	55.50	11.93	4.17	21.95	1.65	
	<i>Q98(R/M)</i>	0.00-5.70	Mar-04	4.99	26.95	4.23	9.42	7.70	0.77	1.40
	<i>Q98(CV)</i>	0.00-1.32	Apr-04	6.60	20.02	54.48	10.33	7.70	11.14	1.58
			Apr-09	7.62	28.92	13.65	14.77	5.96	3.19	1.39
			Oct-11	0.04	0.42	0.59	0.32	0.66	0.15	0.16
Mbarali at Igawa		Dec-03	1.36	37.44	36.08	6.53	5.53	7.44	1.14	
	<i>Q98(R/M)</i>	0.00-4.88	Dec-04	2.83	134.28	131.45	12.91	10.18	24.17	1.87
	<i>Q98(CV)</i>	0.00-1.00	Dec-05	1.16	14.49	13.33	2.51	5.32	2.49	0.99
			Dec-09	1.67	30.93	29.25	8.38	3.49	8.59	1.03
			Nov-13	0.86	9.60	8.74	1.28	6.84	1.70	1.33
Ndembera at Ilongo		Nov-00	0.04	0.62	0.59	0.16	3.56	0.17	1.05	
	<i>Q98(R/M)</i>	0.00-3.54	Dec-02	0.16	2.07	1.91	0.48	3.94	0.47	0.97
	<i>Q98(CV)</i>	0.00-1.15	Nov-06	0.00	0.09	0.09	0.02	4.14	0.03	1.17
			Dec-07	0.05	4.06	4.01	1.20	3.35	1.42	1.18
			Nov-09	0.05	3.90	3.85	0.78	4.94	1.28	1.64
			Dec-11	0.07	4.80	4.73	1.36	3.49	1.79	1.32
Mtitu		Nov-00	1.11	5.30	4.19	2.21	1.90	1.41	0.64	
	<i>Q98(R/M)</i>	0.00-2.06	Dec-06	1.54	18.74	17.20	5.51	3.12	4.61	0.84
	<i>Q98(CV)</i>	0.00-0.61	Dec-07	0.95	8.61	7.66	3.44	2.23	2.06	0.60
			Mar-09	4.40	34.91	30.51	9.49	3.21	6.04	0.64
			Mar-12	3.00	19.23	16.23	6.38	2.54	4.29	0.67
Lit. Ruaha at Mawande		Nov-00	0.15	4.09	3.94	1.08	3.66	1.32	1.23	
	<i>Q98(R/M)</i>	0.00-2.96	Dec-00	4.31	42.66	38.34	12.62	3.04	8.74	0.69
	<i>Q98(CV)</i>	0.00-0.80	Dec-01	0.21	25.78	25.56	5.17	4.94	8.00	1.55
			Nov-05	0.97	2.53	1.55	1.70	0.92	0.47	0.28
			Dec-05	0.86	3.14	2.27	1.82	1.25	0.72	0.39
			Nov-06	0.35	12.08	11.73	1.97	5.95	2.77	1.41
			Dec-06	7.45	117.23	109.78	38.52	2.85	33.82	0.88
			Dec-12	0.34	15.86	15.52	7.67	2.02	3.89	0.51
			Dec-13	0.21	12.59	12.38	6.34	1.95	2.85	0.45
Lit. Ruaha at Makalala		Dec-99	0.02	0.97	0.95	0.35	2.73	0.34	0.97	
	<i>Q98(R/M)</i>	0.00-2.74	Oct-00	0.00	0.05	0.05	0.01	4.35	0.02	1.43
	<i>Q98(CV)</i>	0.00-0.76	Nov-00	0.01	0.34	0.33	0.08	3.91	0.08	0.97
			Nov-03	0.05	0.38	0.33	0.12	2.76	0.09	0.72
			Dec-06	0.11	8.20	8.09	3.30	2.45	2.76	0.84
			Nov-13	0.15	0.97	0.83	0.29	2.83	0.19	0.64

Fig.19 shows a time series (1961-1980) of discharge statistics in 'Lumemo' station under Kilombero sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.19 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 5.57 (~R/M) and 0.00 to 1.11 (~CV) respectively (Tab.4). Combinedly the discharge in Jan 1961 and 1970, Mar 1980, and Apr 1975 and 1978 are outside of those variability domains (Fig.19) and thus the corresponding discharge data of these particular year-months in 'Lumemo' station were considered to be outliers (Tab.4) in 1961-1980 time series.

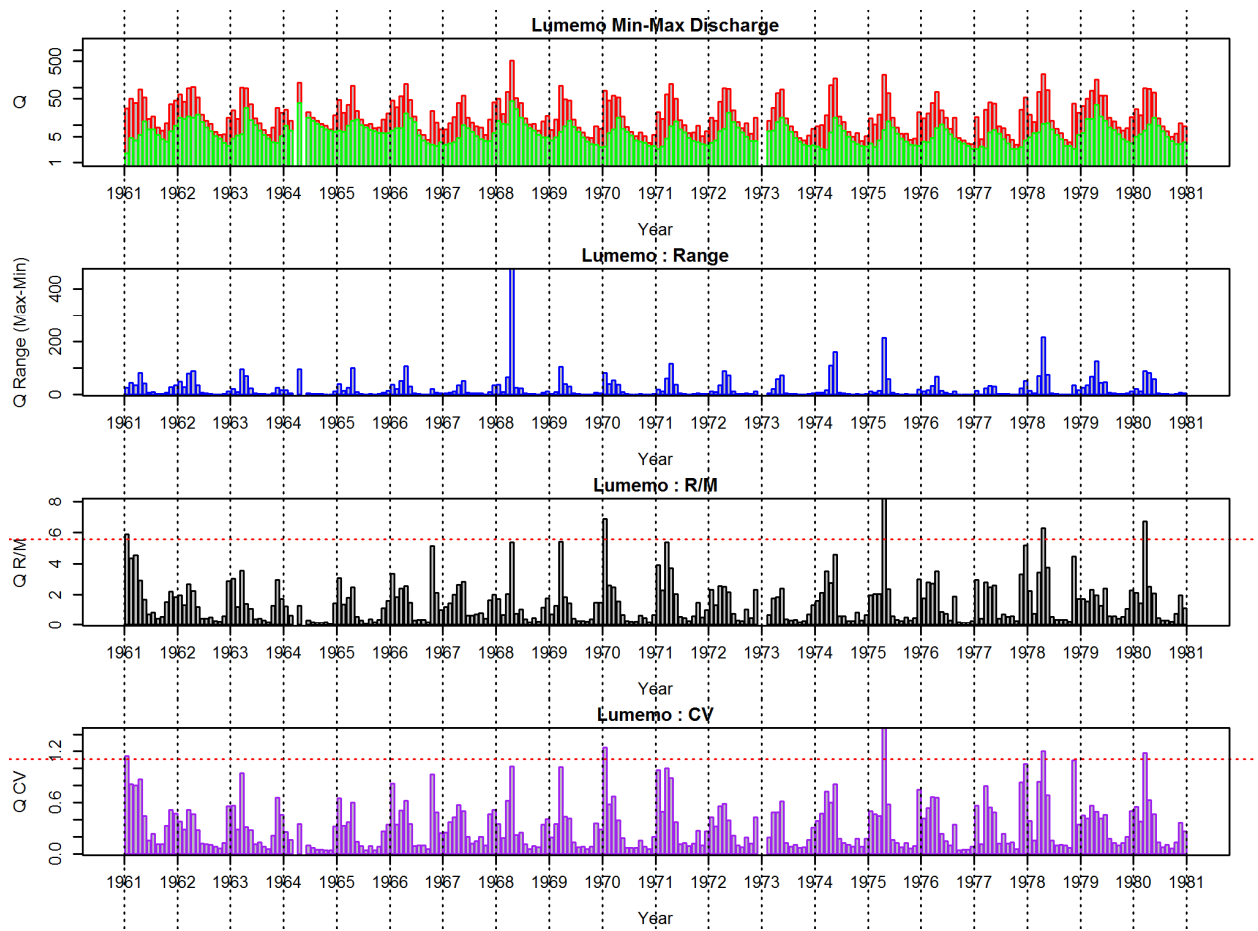


Fig.19 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1961-1980' in 'Lumemo' station under Kilombero sub-basin

Fig.20 shows a time series (1961-1980) of discharge statistics in 'Hagafiro' station under Kilombero sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.20 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 2.54 (~R/M) and 0.00 to 0.67 (~CV) respectively (Tab.4). Combinedly the discharge in Nov 1967 and 1969, Dec 1965, 1966, 1969 and 1971, and Mar 1962 are outside of those variability domains (Fig.20) and thus the corresponding discharge data of these particular year-months in 'Hagafiro' station were considered to be outliers (Tab.4) in 1961-1980 time series.

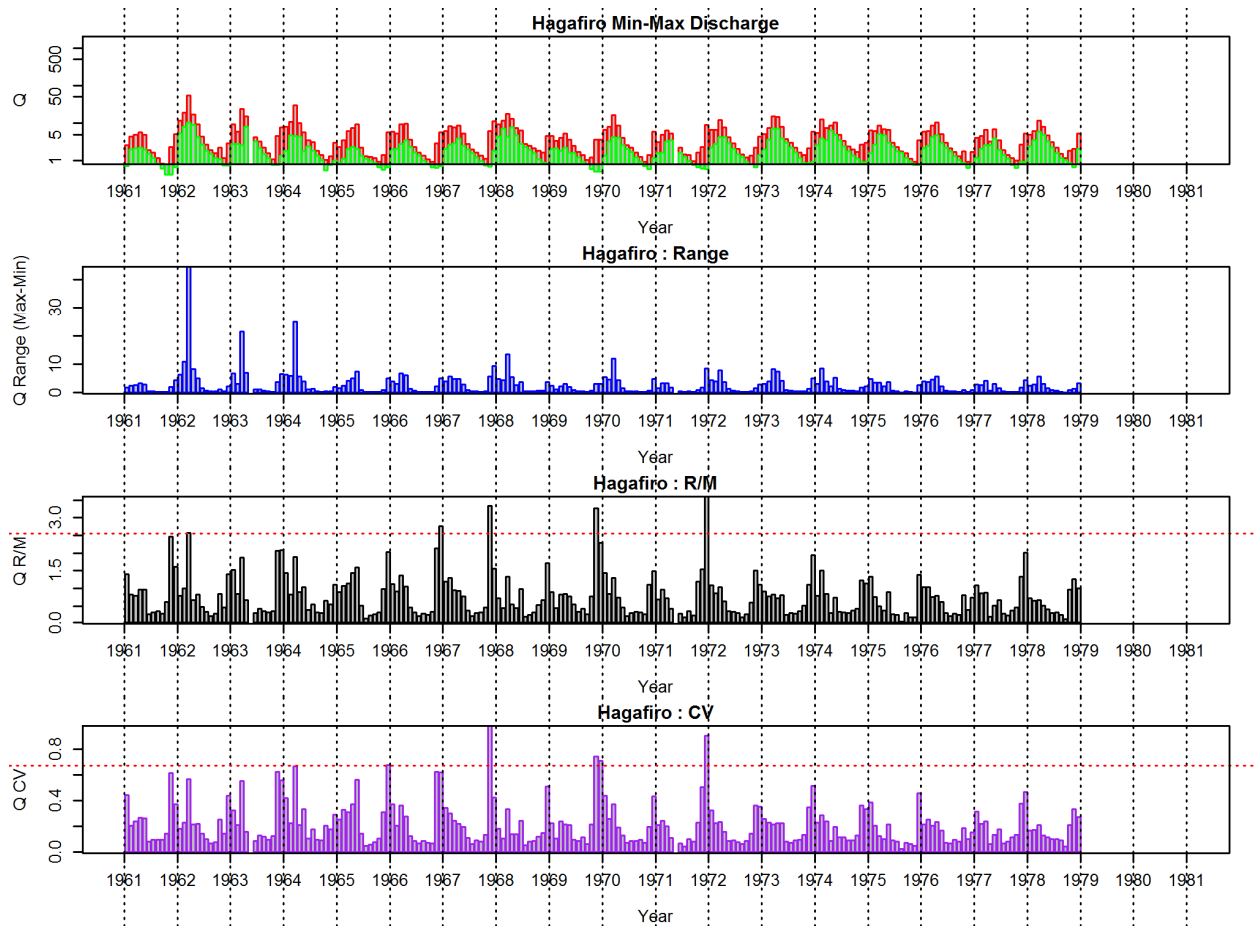


Fig.20 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1961-1980' in 'Hagafiro' station under Kilombero sub-basin

Fig.21 shows a time series (1961-1980) of discharge statistics in 'Mpanga' station under Kilombero sub-basin where monthly min-max discharge and range distribution over the period reveal no suspicious data point within the general discharge pattern. However, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.21 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 2.73 (~R/M) and 0.00 to 0.61 (~CV) respectively (Tab.4). Combinedly the discharge in Oct 1971, Nov 1961 and 1963, Feb 1974, Mar 1971, 1972 and 1974, and Apr 1971 are outside of those variability domains (Fig.21) and thus the corresponding discharge data of these particular year-months in 'Mpanga' station were considered to be outliers (Tab.4) in 1961-1980 time series.

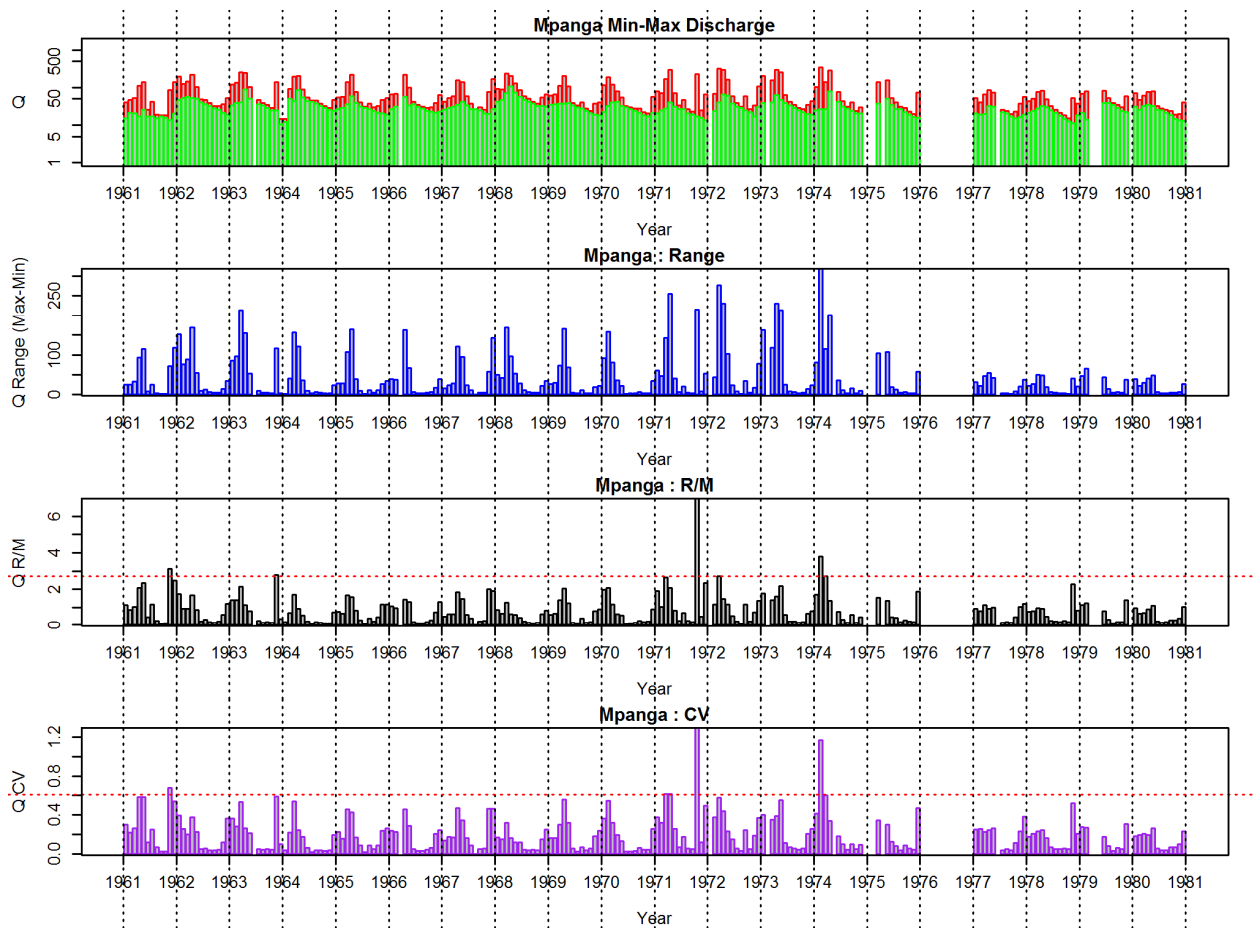


Fig.21 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1961-1981' in 'Mpanga' station under Kilombero sub-basin

Fig.22 shows a time series (1961-1980) of discharge statistics in 'Mnyera at US Taveta Mission' station under Kilombero sub-basin where monthly min-max discharge and range distribution over the period reveal Jul 1978 as suspicious data point within the general discharge pattern. Furthermore, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.22 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 2.05 (~R/M) and 0.00 to 0.72 (~CV) respectively (Tab.4). Combinedly the discharge in May 1968 and 1978, Jun 1977, Aug 1967, and Dec 1978 are outside of those variability domains (Fig.22) and thus the corresponding discharge data of these particular year-months along with the suspicious point in 'Mnyera at US Taveta Mission' station were considered to be outliers (Tab.4) in 1961-1980 time series.

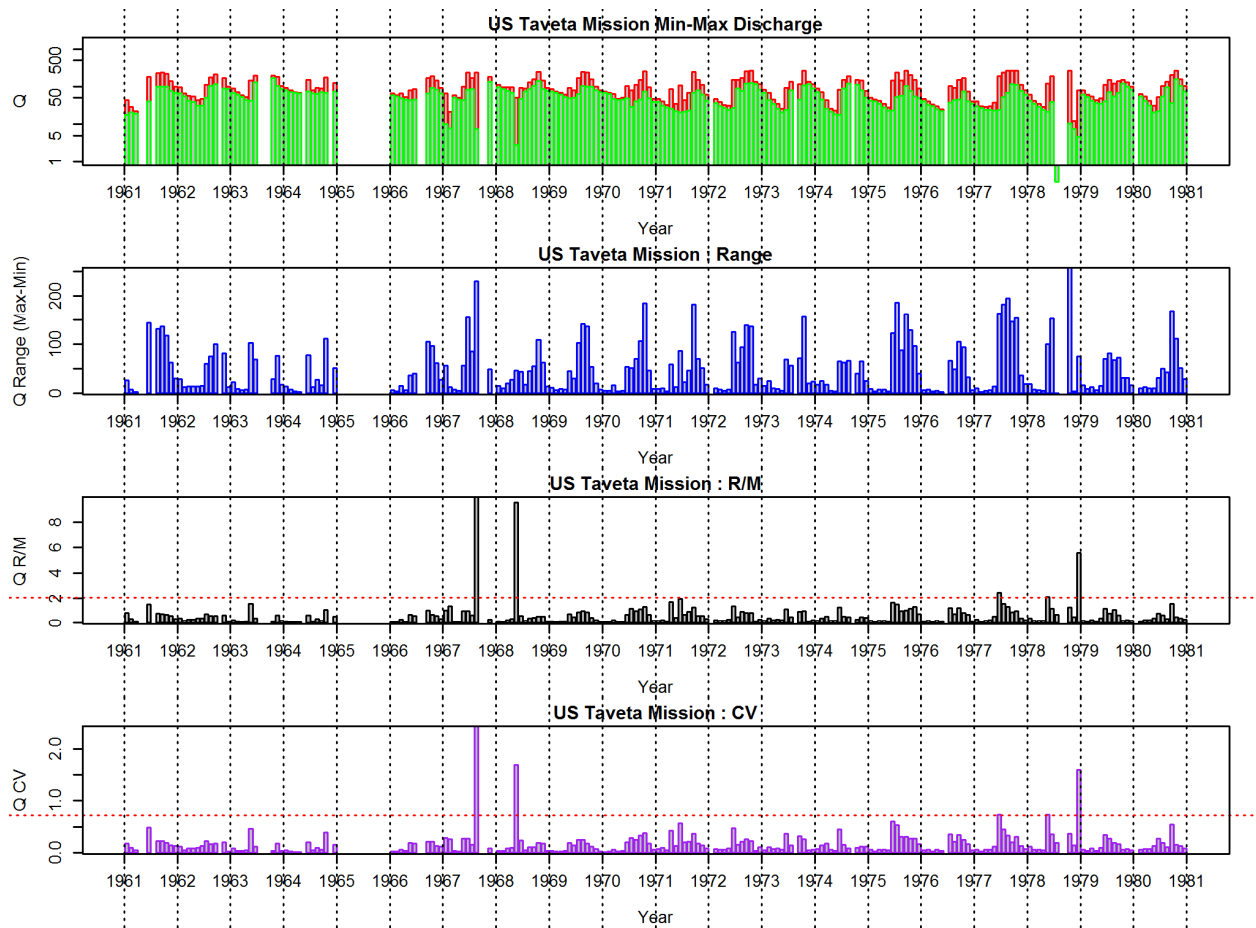


Fig.22 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1961-1980' in 'Mnyera at US Taveta Mission' station under Kilombero sub-basin

Fig.23 shows a time series (1961-1980) of discharge statistics in 'Mngeta' station under Kilombero sub-basin where monthly min-max discharge and range distribution over the period reveal Feb 1974, Mar 1974 and 1977, Apr 1970, and Sep 1966 as suspicious data points within the general discharge pattern. Furthermore, the percentile (0.98) line at range-by-mean (R/M) and coefficient of variation (CV) statistics in Fig.23 indicates that 98% daily discharge data lie within a month-wise variability from 0.00 to 6.18 (~R/M) and 0.00 to 1.20 (~CV) respectively (Tab.4). Combinedly the discharge in Nov 1977, 1978 and 1979, Dec 1978, and Mar 1980 are outside of those variability domains (Fig.23) and thus the corresponding discharge data of these particular year-months along with the suspicious points in 'Mngeta' station were considered to be outliers (Tab.4) in 1961-1980 time series.

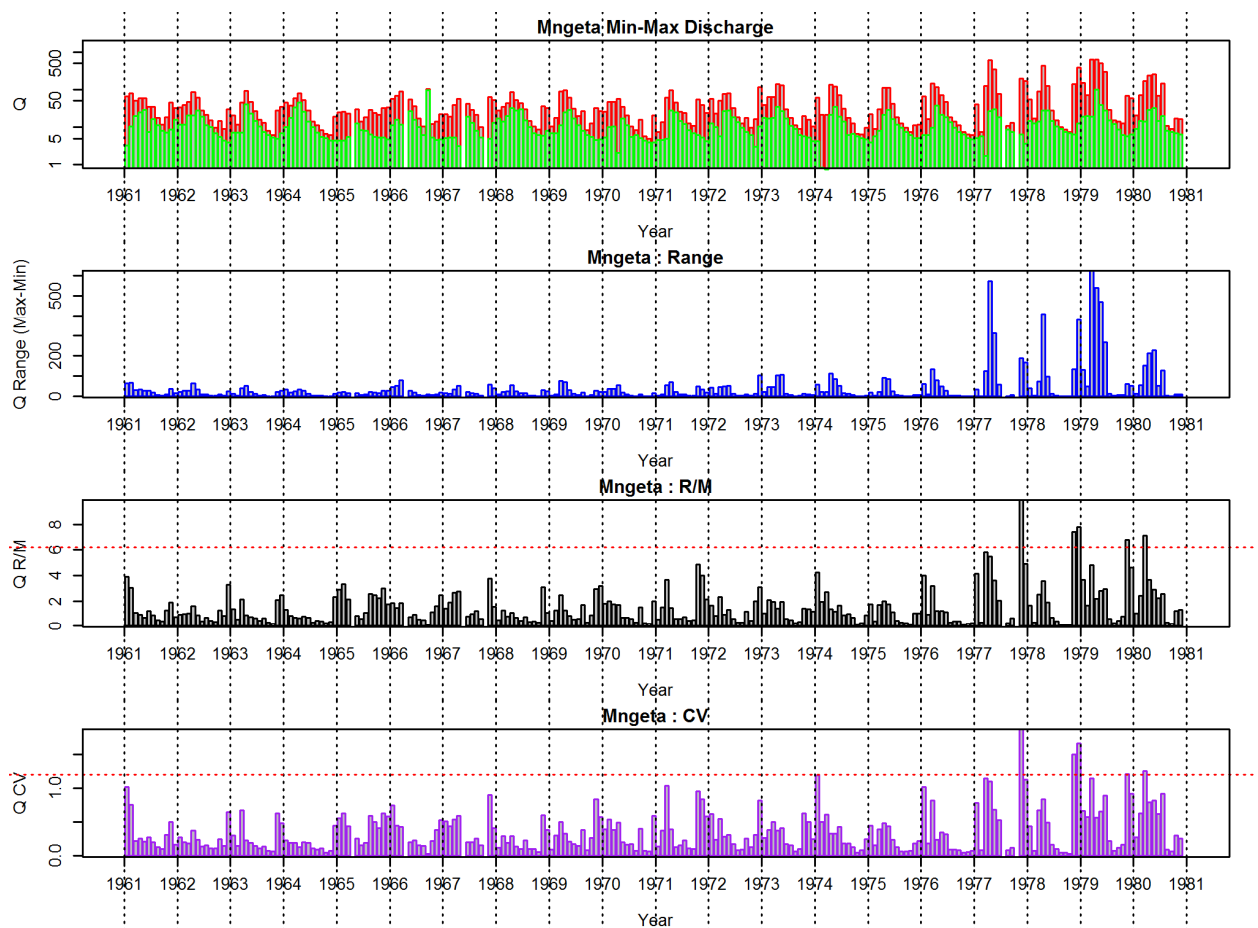


Fig.23 Top to bottom order: min-max discharge, range, range-divided-by-mean (R/M), and coefficient of variation (CV) over the time series '1961-1980' in 'Mngeta' station under Kilombero sub-basin

Table Ann-III.4. Outliers with descriptive statistics in '1961-1980' series of Kilombero sub-basin

Station		P(0.98)	Outliers	Min	Max	Range	Mean	R/M	SD	CV
Lumemo			Jan-61	1.81	27.55	25.74	4.38	5.88	5.02	1.15
	<i>Q98(R/M)</i>	<i>0.00-5.57</i>	Jan-70	2.74	83.29	80.55	11.68	6.90	14.54	1.24
	<i>Q98(CV)</i>	<i>0.00-1.11</i>	Apr-75	7.56	221.21	213.66	26.11	8.18	38.45	1.47
			Apr-78	10.89	227.69	216.80	34.48	6.29	41.53	1.20
			Mar-80	7.20	95.55	88.35	13.13	6.73	15.55	1.18
Hagafiro			Mar-62	10.47	54.94	44.47	17.29	2.57	9.81	0.57
	<i>Q98(R/M)</i>	<i>0.00-2.54</i>	Dec-65	0.68	5.77	5.09	2.50	2.03	1.69	0.67
	<i>Q98(CV)</i>	<i>0.00-0.67</i>	Dec-66	0.73	5.76	5.03	1.82	2.76	1.13	0.62
			Nov-67	0.69	6.27	5.58	1.67	3.34	1.63	0.98
			Nov-69	0.51	3.61	3.10	0.95	3.26	0.71	0.74
			Dec-69	0.51	3.67	3.16	1.38	2.28	0.98	0.71
			Dec-71	0.60	9.14	8.54	2.38	3.59	2.15	0.90
Mpanaga			Nov-61	13.43	85.30	71.86	23.01	3.12	15.59	0.68
	<i>Q98(R/M)</i>	<i>0.00-2.73</i>	Nov-63	25.13	140.78	115.65	41.59	2.78	24.45	0.59
	<i>Q98(CV)</i>	<i>0.00-0.61</i>	Mar-71	27.66	169.88	142.22	53.55	2.66	32.87	0.61
			Apr-71	40.36	295.60	255.24	123.25	2.07	75.49	0.61
			Oct-71	17.24	232.59	215.35	30.92	6.96	39.87	1.29
			Mar-72	40.91	317.75	276.84	101.33	2.73	58.76	0.58
			Feb-74	27.14	345.27	318.14	84.00	3.79	98.04	1.17
			Mar-74	27.14	142.57	115.43	42.29	2.73	25.41	0.60
US Taveta Mission			Aug-67	7.48	237.42	229.94	23.10	9.95	56.08	2.43
	<i>Q98(R/M)</i>	<i>0.00-2.05</i>	May-68	2.85	49.96	47.11	4.95	9.52	8.36	1.69
	<i>Q98(CV)</i>	<i>0.00-0.72</i>	Jun-77	23.78	188.04	164.27	67.25	2.44	49.26	0.73
			May-78	21.45	121.66	100.22	48.43	2.07	35.62	0.74
			Jul-78	0.30	0.59	0.29	0.42	0.70	0.08	0.20
			Dec-78	4.51	79.70	75.19	13.45	5.59	21.50	1.60
Mngeta			Sep-66	94.90	104.00	9.10	99.91	0.09	2.79	0.03
	<i>Q98(R/M)</i>	<i>0.00-6.18</i>	Apr-70	2.08	57.68	55.60	32.51	1.71	16.10	0.50
	<i>Q98(CV)</i>	<i>0.00-1.20</i>	Feb-74	0.85	21.69	20.84	10.81	1.93	5.39	0.50
			Mar-74	0.75	21.69	20.94	7.74	2.70	4.73	0.61
			Mar-77	1.70	125.50	123.80	21.22	5.83	24.37	1.15
			Nov-77	6.30	195.60	189.30	19.16	9.88	35.77	1.87
			Nov-78	6.30	140.10	133.80	18.09	7.40	27.09	1.50
			Dec-78	12.70	391.40	378.70	48.56	7.80	80.50	1.66
			Nov-79	5.63	68.26	62.63	9.21	6.80	11.16	1.21
			Mar-80	14.00	166.90	152.90	21.55	7.09	27.07	1.26

Table Ann-III.5. Completeness of Cleaned Discharge Data

Station	% complete
<i>Time Series: 1961-1980</i>	
1. Great Ruaha at Trace	96.08
2. Lit Ruaha at Ihimbu (61_80)	86.15
3. Lit Ruaha at Mawande (61_80)	85.68
4. Urobo at GNR	82.68
5. Lit Ruaha at Iwawa	92.79
6. Ndembera at Madibira	82.87
<i>Time Series: 1981-1997</i>	
7. Kimani (81_97)	94.29
8. Ndembera at Ilongo (81_97)	91.03
9. Lit Ruaha at Ihimbu (81_97)	81.55
10. Mtitu (81_97)	86.61
11. Lukosi at Mtandika	86.35
<i>Time Series: 1998-2013</i>	
12. Graet Ruaha at Salimwani	92.56
13. Kimani (98_13)	77.90
14. Mbarali at Igawa	74.65
15. Ndembera at Ilongo (98_13)	96.09
16. Mtitu (98_13)	80.51
17. Lit Ruaha at Mawande (98_13)	85.80
18. Lit Ruaha at Makalala	97.38
<i>Time Series: 1961-1980</i>	
19. Lumemo	95.14
20. Hagafiro	82.75
21. Mpanga	96.32
22. US Taveta Mission	84.89
23. Mngeta	93.28