Review

Water management issues and problems in Africa

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Abstract

An enquiry into pressing issues in contemporary water resource management in Africa reveals an extensive, well-researched and heavily debated literature. This paper strives to reveal this through a brief discussion of four prominent issues or 'problems' in contemporary water resource management across Africa; integrated water resource management involving decisions about allocation; health, domestic water and sanitation; agricultural water management; and climate change. The first three represent policy arenas that are complementary to each other, but to some extent are also competing in terms of donor focus. The fourth is an emerging contextual issue that is helping to refocus and renew efforts in water management. The most significant dimension of these issues of water resource management in Africa today may be the degree of interdependence that exists between the four issues and therefore in the difficulties and hard choices associated with deciding which to prioritize. In addition, as with many contemporary issues spanning environment, culture and geography, water resource problems in Africa are characterized by a complex overlap between environmental, socio-economic, political, financial and technical viewpoints and concerns.

Integrated Water Resource Management

A Framework for Planning and Policy

Integrated water resources management or IWRM currently serves as the foremost entry point into water resources in Africa. The effective management of freshwater resources in Africa involves satisfying the often divergent needs of the environmental, sociocultural and political sectors. These disparate players are routinely engaged in an ongoing exchange to achieve the sustainable and equitable allocation of a finite water supply. Issues of equitable allocation in Africa are severely complicated by naturally occurring water variability and dynamic political and geographic divides, which result in the need for transboundary collaborations. IWRM has emerged as the most significant 'framework' shaping strategic level approaches to water resource management in Africa [1]. Defined as 'a process which promotes the co-ordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems' [2], IWRM recognizes the river basin as the lowest appropriate level for policy development and resource management (river basin management or RBM).

In Africa, the United Nations Environmental Programme (UNEP), a leading proponent of IWRM (echoed by the Global Water Partnership and the EU Water Facility), recognizes 59 transboundary basins covering approximately 60% of the continent, crossing innumerable cultural, political and geographic boundaries and actively supporting many divergent users. Africa's basins are under increasing demand from growing urban populations and an agricultural sector striving to meet the demands of economic development in an environment of increasing climatic variability related to global climate change. The cultural, political and geographic complexity inherent in the management of shared water resources is being further exacerbated by changing political boundaries, policies and priorities, international and intranational conflict, poverty, population migration and inadequate distribution capacities. IWRM is one of the foremost frameworks for addressing this array of water-centred challenges in Africa and a method by which these issues can be theoretically set aside in the best common interests, enabling the inclusion of all stakeholders to determine allocation patterns.

Problems with Complexity, Trade-offs and Implementation

In its normative form, IWRM is a participatory management framework to incorporate the interests of all stakeholders in policy development that will optimize the use of the limited supply of freshwater and manage demand, while ensuring equitable and sustainable access to quality water for all. Although the literature cites political, economic and sociocultural issues related to the participatory power of vulnerable populations, such as women, the poor and smallholder farmers, the full contributory participation of these remains problematic [3, 4]. Historical attempts to prioritize stakeholder and livelihood concerns in the face of a naturally uneven distribution of water across the region have resulted in broad allocation disparities [5, 6]. Admittedly challenging, and in many cases revealing political biases, progress with IWRM has been slow [7].

The science that feeds into decision-making is culturally determined, and thus it is by no means certain that the causes of hydrological change and the solutions will be readily agreed among divergent stakeholders [8]. The literature suggests that conflict can be avoided through collaborative management frameworks, revealing in transboundary resource management opportunity for cooperation and benefit sharing among previously divergent and/or minority stakeholders. Examples of this include the Nile Basin Initiative and the Zambezi Basin Authority. A growing body of evidence indicates that if the risks posed to all users are clearly defined in a scientifically sound manner, they can be used to create actionable programme plans that meet the needs of all. In this regard, participation is critical to the success of IWRM by increasing technical and institutional capacities and building stakeholder confidence in multinational collaborations [6, 9–11].

Examples of additional complexity are evident in intersectoral collaborations to balance land and water development with environmental preservation while protecting human health. The literature suggests the need to allocate water resources to the agricultural sector to increase production levels to meet the food needs of an increasingly urbanized population [12]. Paradoxically, while increasing urbanization suggests an improvement in quality of life, it also indicates increased demand on both the environment and existing institutional capacities, which, when overstressed, may fail, manifesting in increased risks to human health [6, 13, 14]. Additionally, the literature indicates that while agricultural irrigation programmes are intended to foster economic and food programme self-sufficiency for Africa's most vulnerable populations, these programmes often conflict with sustainable management concerns, environmental protections and compromise the future insurance of basic quality of life benefits [15, 16].

Currently emerging is a literature which suggests that the quality of the environment is the emergent result of the interactions between humans and the environment. This argument explores a dynamic, mutually influential relationship between environment and human society. Ongoing research seeks to improve understanding of the extent to which the manifestations of this complex engagement are controllable and to employ this as the basis for more flexible resource management frameworks [10, 17–19].

New Legal Frameworks and Sustainability

In the past 10 years, a remarkable effort to review and refine water legislation has taken place in different countries in Africa. South Africa has been held to be one of the foremost proponents of proactive water policies designed to ensure a basic water right, improve the management and allocation of water and reduce transboundary and cross-sectoral conflicts to reduce the economic burdens of sustainable water resource management programmes on debt-ridden nations [3, 20]. Although the overall benefit of these reforms cannot be discounted, the extent of cultural and political tolerance for change has been questioned, as the existence of well-established power structures and embedded cultural scepticisms continue to mute the potential of new initiatives [13, 21].

Full implementation of IWRM programmes has been simultaneously bolstered by governmental commitment to operationalize water legislation and constrained by their respective capacity limitations [6]. Just as water supply and population demands vary, technical and infrastructural capacities differ in condition and design intent, hindering a full and efficient utilization of available water resources, regardless of the extent of commitment. The literature suggests a direct linkage between good governance, national economic strength and existing infrastructure. These basic proficiencies are necessary to improve water delivery and sanitation infrastructures, which have been greatly complicated by scalar issues related to population growth and urbanization. Increases in urban demand have placed additional stress on already inadequate utility and wastewater infrastructural systems [22]. This has become particularly critical in regions where urban sprawl has resulted in unplanned township areas with inadequate water infrastructures. Attempts to expand services have been further confounded by inadequate tariffs, usage monitoring and fee collection capabilities [3, 21]. The literature suggests that changes such as improved consumer education, legal protections, technological improvements and subsidization versus taxation, and increased smallholder participation, are important conditions in the sustainability and capacity of water programmes and infrastructure projects [6, 23–25].

Health, Water and Sanitation

Introduction

Human health issues and their relationship to water resource management are becoming an increasingly important debate. Health is linked to a daily intake of clean water, and hence to the deployment of provisions such as a basic water right, microscale technologies in accessible locations, to provide water for personal hygiene and safe wastewater management to reduce or eliminate the spread of infectious disease [22]. This is particularly true for vulnerable populations already coping with issues of poverty, water stress and/or water scarcity and infectious disease.

Connections with Public Health and Diseases

The HIV/AIDS crisis in parts of the African continent has become an issue that is changing the way in which water resources are managed. The high mortality rate associated with the pandemic is projected to have a dramatic influence on capabilities at all levels for water allocation and management. This change demands that new and/or ongoing IWRM programmes remain flexible to adjust to fluctuations in population, ensuring that allocation accurately reflects the current water demands of each community. Additionally, dramatic changes in socio-economic resilience may reflect indirect challenges, such as the ability of heavily impacted communities to pay for water access and sanitation that must be met by changes in funding and subsidization. Lesser concerns have been raised involving the risks posed by loss of the workforce. Concerns suggest the loss of technically skilled workers may limit national capacities to develop and operationalize critical programmes and that losses in the manual labour force may potentially delay completion of water access and sanitation projects [6].

While remarkable advancements have been made to ensure the provision of basic water services, basic sanitation services have not paralleled this progress. This is due, at least in part, to purely scalar issues as governments struggle to meet the growing and changing demands of a rapidly urbanizing population while attempting to extend severely limited infrastructural capacities to critically vulnerable rural populations. The quality of water, dependent both on origination source and treatment methods, is directly linked to the condition of public health, particularly for vulnerable populations such as those with HIV/AIDS [26]. The assurance of clean, fresh and reliable water supplies to health care facilities, such as hospitals, is also a key component. Research indicates the need for a more adequate and reliable supply of quality water to such facilities as well as the supply of quality freshwater for drinking, personal hygiene and sanitation are equally important in the reduction of the spread of infectious diseases, including malaria and HIV/AIDS, and promote general good health and well-being throughout communities [27].

The closely interrelated nature of public health issues and water, and the inherent political potential for power imbalances between divergent stakeholders, further justify the need for demand reconciliation at the subcatchment level. The use and allocation of water must be approached in a cooperative way allowing for economic, ecological, social and political trade-offs between shared users as conflicts over scarce resources can be better resolved when a high level of interdependence exists among the involved parties [6, 9]. IWRM has been employed successfully to draw stakeholder communities together in the definition of scientifically sound plans that include sanitation and public health, hygiene education and facility upgrades. A critical component in the effort to elevate awareness of the connection between water and public health has been international and regional governmental support in strategic discussions, such as the World Summit on Sustainable Development 2002, and World Water Forum 2003, to increase funding and improve sanitation infrastructure to ensure hygienic water [28]. Additionally, low-tech and cost-effective methods to improve hygiene and sanitation have been introduced into communities at risk, including education, exposure of water to sunlight, chemical treatments, water filtration and boiling [16, 22, 27].

Interconnections with Other Water Management Problems

The issue of human health is closely interrelated with the issues of transboundary water resource management. The transboundary nature of many shared freshwater resources is expected to manifest in power struggles over the use of water upstream and resulting impacts on downstream water supply and water quality. Upriver utilization of waterways for damming, irrigation, transport and waste and chemical/industrial disposal can exacerbate issues of scarcity and/or pollute freshwater supply downstream, leading to systemic potential for disease for downriver residents [9, 26].

Additional human health risks are expected to arise related to the ambient temperature increases and water supply variability caused by global climate change. Although heavily debated, research indicates that water temperatures will rise as ambient temperatures rise, resulting in an increase in water-borne pests and bacterial disease. As well as predicting an overall increase in aridity, projections reflect an increase in incidents of high precipitation, resulting in flooding events. Africa, resulting in flooding. Flooding and standing water can reduce the quality and safety of already limited freshwater sources vital to the prevention of water-borne disease, particularly diarrhoeals, in poverty-stricken and compromised populations, such as those with HIV/AIDS. Paradoxically, allocation issues may become more complicated as ambient temperature increases are also projected to exacerbate drought and climatic variability in some regions, which may increase agricultural and human demands on available water supplies. Any reduction in food production could increase the susceptibility of already vulnerable populations to disease while reductions in allocation to agriculture could limit progression towards food self-sufficiency and also impact human populations [25, 27]. Interdisciplinary management frameworks are being looked as ways to balance increasing stress on water resources and contributing watersheds and mitigate related health risks to water-dependent populations at all levels [6, 14].

Within the frame of human health and climate change, agricultural irrigation becomes increasingly important as a way to ensure a reliable supply of water to support agricultural food production necessary for the African population. Research suggests contradictory findings, in that irrigation increases the spread of infectious water-borne disease, such as malaria, and that these increases occur only in areas where transmission is already unstable owing to other factors, such as little or no immunity to malaria parasites. Some evidence suggests that irrigation does not change the transmission pattern of malarial disease in stable transmission areas and in fact suggests a reduction in infection in these areas as a result of an increase in wealth in agricultural communities enabling better sanitation, protection methods, such as bed netting, and medical interventions, such as anti-malarials. As with many water issues in Africa, attempts to perform effective empirical research on this area have given rise to complexity, driving the need for more effective research methods such as before and after comparisons of malarial infection levels in villages prior to and after the establishment of irrigation systems [15].

Associated with these interconnections are questions on how to tackle the divergent concerns of IWRM and the Millennium Development Goals (MDG) coming out of the Johannesburg World Summit in 2002. With the MDG No. 7, the countries of the world pledged to reduce by half the proportion of people without access to safe drinking water and basic sanitation. Although this has to occur within a larger framework of water resources management, the latter concern is poorly captured by the MDGs, which in turn creates a lack of emphasis for tackling urgent poverty concerns related to inadequate RBM. Also associated with these gaps are governance dichotomies regarding how best to finance IWRM (largely via standard international aid) and the health and sanitation MDG (a mixture of aid, globalized capital and utilization of private water companies). Perhaps an indication of these tensions and of the difficulties achieving appropriate governance structures to deliver the MDGs has recently been demonstrated by the case of City Water in Dar es Salaam [29].

Agricultural Water Management – Irrigation and Rainfall Harvesting

Introduction

There are three interrelated debates on how agricultural water sector can be revised to meet divergent rural, environmental and urban sector concerns. Firstly, there is the subject of expansion of irrigation via new donor investments. Secondly, there is an argument that rainfed agriculture should improve its management of soil and rainwater. Thirdly, it is suggested that that utilization savings should be made in irrigation because of the inefficient use of water in that sector. Estimates of efficiency depend on type of system and measurement, and range from 35–75%, that if improved can increase available water supply and ease allocation conflicts. Related to this is the argument that key sectors, such as smallholding irrigation, should be assessed by measures of economic efficiency to establish fair allocation and investment levels. Although the quantifying aspect of this approach helps inform policy and management frameworks and drive technological improvements, it has been noted that the use of economics alone may put critical issues of equity at risk and fail to comment sufficiently on the institutional reforms necessary to underpin allocation shifts [3, 4].

A New Irrigation Expansion in Africa

A number of organizations (e.g. World Bank [30] and FAO [31]) are currently strongly expressing a desire to put irrigated agriculture at the centre of economic rural development, agricultural livelihoods and food security, whether this be from a donor, government or research point of view [32]. This desire is being expressed at both national and continental scales [33, 34], with the New Partnership for Africa's Development (NEPAD)'s Comprehensive African Agricultural Development Programme (CAADP) being one of the most important policy instruments for engaging with such growth [35, 36] and the African Water Facility being another (see [33]). With regard to donor and national government interest, although some political players seem to see unalloyed benefits with irrigation, the Commission for Africa [37] cautiously outlined a framework by which 3–4% growth per annum might be supported. The need for careful planning and implementation has been outlined by others as well [38] which encapsulates basic questions such as the relative emphasizes placed on the formal, informal or private sectors in terms of how such an expansion, believed to be an increase of 5–10 million ha in the next 10 years, will occur and sustain itself [39].

A Continuum Between Rainfed and Irrigated Agriculture?

The future of irrigation funding may depend on arguments that seek to integrate and render obsolete any distinctions irrigation management and rainfed farming – although protagonists of this may wisely consider the non-linear complexity of large irrigation systems beyond 100 ha in size. In theory, IWRM again is a viable management framework which makes planning and guidance possible at the whole land and water system and which prominently includes indigenous expertise/adaptation methods in the development of drought-resilient farming systems [40, 41]. Rainfall harvesting has been investigated from an economic perspective, giving promising results that indicate that not only is rainfall harvesting economically beneficial to the livelihoods of smallholding farmers but also that it enables the cultivation of crops that would not otherwise have been sustainable under normal climatic conditions [42]. This topic is also directly linked to the issue of climate change, which, as noted before, is expected to lead to both increases in rainfall and increases in drought. How this will play out for the consequences of risk perception by farmers of a more widely varying weather system (given that fields with harvesting technology may either be flooded or left arid) has yet to be observed. Under increased climate variability and differing circumstances related to markets and livelihood choices, it is farmers who will choose to opt for or decline rainwater harvesting techniques rather than donor and scientist protagonists who hold such favourable views of its potential.

Rainfall, if managed correctly, may manifest concomitantly as a benefit to the overarching economic conditions of the smallholder and the region, creating potential for new agricultural markets in arid regions increasingly stressed by climate change and natural variability [43]. In the scale range from rainfall capture for a single tree or small field up to coalesced irrigation within a catchment, donors and scientists should reflect carefully on whether removing boundaries between categories of systems will gain much insight for useful policy-making.

Irrigation Efficiency and Productivity

Though a range of practices can be found, irrigation is not generally seen as efficient, estimated at less than 50%, due to irrigation methods such as flood irrigation. In addition, water loss and inefficiency in urban areas has also been estimated at 50%, due primarily to inadequate regulation and infrastructural capacities [3, 44]. Although such figures must be viewed with suspicion as efficiency measurement is rarely accurately conducted [45], there is general agreement[1] that efficiency improvements could increase the availability of water to ease strained allocations to other sectors [12].

Technological solutions have yielded efficiency increases through implementation of shorter season varieties, improved in-field water control, and, were feasible and economically viable, changes to irrigation technology and methods such as micro-irrigation (drip systems), and general productivity improvements improving agricultural outputs, or ‘more crop per drop’. Research suggests a shift towards research of previously underutilized methods such as the use of saline water, more efficient rainfall water harvesting/redistribution and wastewater recycling and reuse as untapped ways to maximize efficiency and productivity. Emerging techniques and/or improvements to existing methods include ‘gravity-fed formal irrigation schemes, collector wells, boreholes and deep wells, hydraulic ram pumps, hand pumps for sand extraction and water from shallow wells’ [21]. Additional improvements in productivity are recognized in improved planning of water use, such as better alignment between irrigation water use, natural rainfall cycles and closer adherence to water scheduling, regulation and allocation policies developed by planners, users and other stakeholders [47–49].

Analyses to establish levels of efficiency and productivity in the agricultural sector take various forms and include livelihoods perspectives and economic measurement. Livelihoods perspectives explore efficiency and productivity improvements through the lens of a necessary agricultural intensification for food supply, while supposedly meeting water scarcity concerns and the cultural and material needs of smallholding farmers [49, 50]. The primary assumption of the livelihoods approach is that farming methods and water used for smallholder agricultural irrigation are efficient from an individual’s level, but less so from a collective or river basin level. In some cases a troubling paradox is noted between improvements in efficiency or methods at the smallholder level and the resolution of more complex overarching issues such as improved national capacities and infrastructures, reduced allocation and scarcity conflicts, food production self-sufficiency, and the reduction of environmental stress [51]. While solutions at the lowest level are critical to improve the understanding and performance of all sectors, these improvements should be recognized as components contributing to the character of larger issues rather than the cause of these issues. IWRM is recognized as an analytical framework with the potential to address the interrelated nature of these many critical concerns. Research suggests a shift in approach from one of top-down ‘scientific’ interventions that stress mandatory smallholder participation, to mutually informing frameworks that fully maximize the potential of both overarching shared priorities and management and the

[1]See for example the Vientiane Statement produced by the International Forum on Water and Food in Vientiane, Laos, November 2006 [46].

underlying methods successfully employed by local users [52]. This suggests that a more adaptive, flexible approach to IWRM resolutely focusing on problems found may have more utility [53]. Additionally the scalar nature of these issues is recognized when the level of analysis for efficiency and productivity shifts from the smallholder/plot level to the regional or watershed level, making evident the connections between the input and output of smallholder/plots to the health and allocation demands on the catchment-wide water system [54]. It becomes vital to step back from management at the smallholder/plot level, through irrigation, to a broader perspective that considers the connections and uses between all sources of water.

Climate Change and Resource Variability

Introduction

At the highest level of analysis, global climate change forms a formidable backdrop to complex contemporary water resource management efforts in Africa. African nations are recognized as being particularly vulnerable to projected global climate changes as a result of an inherent high reliance on rainfall and runoff to feed freshwater resources and watersheds that support diverse livelihoods and inadequate human, infrastructural and institutional capacities to enable adaptation to change. Additional contributions to the overarching issue are national predisposition for water stress/scarcity, high reliance on rainfed agriculture vital for food production, economic and population shifts, and projected intensified response by naturally and regionally variable climatic conditions to global climate change stressors such as drought and the El Niño Southern Oscillation (ENSO) [25].

Data Management and Scenario Modelling

In dealing with the complexity and potential vulnerability of African environments, resources and populations to climate changes, integrated regional resource management plans are relied upon to provide valuable insights into the ongoing development of more robust action plans. Critical within these frameworks is the propagation of technical assistance to train local staff in contemporary assessment methods, planning and intervention approaches. Technological methods, particularly geographic information systems (GIS)-based visualization and earth system modelling, and electronic information sharing via web and data exchanges contribute to sustainable programme development, enhanced partnerships and cooperation across diverse stakeholder working within the climate constraints [6]. Yet at a more basic level, such models and modalities are vulnerable to the all too common issues of data quality. Complex issues that span environmental, sociocultural and political sectors pose a challenge for linear technological solutions made even more problematic by claims arising from the seemingly indeterminable distinction between changes related to climate change and those related to natural climatic variability [55] and new land use patterns. While modelling efforts are based on the most credible scientific information available to the researcher at the time, the resulting models and scenarios are highly sensitive to both researcher bias and the programmatic assumptions of the chosen model and data sets. Addressing bias by a more public deliberative approach may require that these scenarios are presented side by side to reveal the entire range of potential outcomes for a particular enquiry [25, 56]. It is worth repeating though that scenarios are frequently underpinned by data sets which suffer an aforementioned lack of empirical quality, necessitating a reversion to less than useful historical averages [55, 57, 58]. These issues cause scientists to remain conservative in their assertions of the certainty of modelled outcomes. Acknowledgement of the limitations of modelling in the communication and use of research has become vital given its significance in the development of appropriate interventions, adaptation and policies [55]. Caution is advised to ensure that technological solutions are appropriate in cultural and economic setting in which they are employed [21].

As highlighted elsewhere, sufficient technical expertise has become an essential factor in integrated assessment methodologies, such as integrated coastal zone management (ICZM) and IWRM. Sound scientific and socioeconomic analyses are relied upon to define risks shared by divergent users of water resources, establish baseline measures and assess progress. Technical support and propagation is a key interest in the United Nations Framework Convention on Climate Change (UNFCCC), which has contributed support and funding to improve the capacity of African nations to perform baseline, scientifically sound greenhouse gas emissions (GHG) assessment, to assess vulnerability and to develop and share long-term mitigation and adaptation strategies [25, 56, 59, 60]. Many integrated programmes are broadening participation through the use of the web, sharing data via CD-ROM and reducing the potential for conflict by increasing the transparency of programmatic activities by encouraging open access to planning, monitoring results and documentation [11]. The level of advancement of these technical methods ranges from fairly simplistic, such as document sharing across the web and the use of global positioning for site location, to the extremely complex in the creation of multidimensional and temporally dynamic GIS models [25, 55].

Conclusions

The inherent complexity associated with contemporary water resource management in Africa has been illustrated in the preceding discussion of the key themes of IWRM; health, water and sanitation; agricultural water management; and global climate change. Many interrelated environmental, socio-economic, political and technical issues challenge attempts to manage water resources at the regional level including transboundary resource issues, conflict, human health issues, national capacity, efficiency and productivity, scarcity, variability, global climate change and sustainability. IWRM has emerged as the current approach through which these elements can be approached to achieve the goal of sustainable and equitable allocation of water – although the efficacy of the responses now needs to be put under close scrutiny, particularly as it attempts to marry with parallel efforts to develop water resources for agriculture and ongoing challenges related to water and sanitation.

In this regard, within the overarching framework of IWRM, research reflects trends towards improvements in agricultural irrigation methods through the collection and more efficient use of runoff and rainfall, and the more efficient use of allocated freshwater resources to improve the performance of shared water resources. Environmental concerns are being further incorporated into strategic programmes to avoid future degradation of water resource, such as salinization, which may in turn further strain already taxed water resources [3, 10, 11, 39]. Technological advancements play an influential role in the achievement of this goal, with trends suggesting an increase in the reuse of waste/saline water in the future [61], and the use of computerized modelling and temporally dynamic scenario development to improve understanding, planning and decision-making. Scientific and technical expertise is recognized as a key element to strengthen national capacity in these fields, and should be prioritized more resolutely than at present.

How to best manage closely interdependent and dynamic economic, environmental, social and cultural elements to achieve sustainable and equitable access for all to freshwater resources remains an active and open-ended question, with a variety of responses being tested [18, 62]. A leading methodology, IWRM, draws in key attributes of a relevant response; a cooperative element that draws in stakeholders from all levels; increased inclusion of bottom-up resource management methods and indigenous expertise; environmental protection for long-term sustainability; and flexibility enabling management and service providers to respond to user demands within a context of the temporally dynamic geographic, economic, health and public/private sector dynamics of African nations. If united with governmental and political commitment and international assistance under a scientifically sound and technologically advanced framework, these considerations will contribute to a more sustainable and comprehensive approach to water resource management in Africa.

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