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Review

Upper basin systems: Issues and implications for sustainable development planning in Malaysia

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The continuing demand for environmental resources in Malaysia in the next few decades of this century suggests the need for formulating, planning and the implementation of river basin development plans or programmes which is going to be even more complex in the future than it has been in the past. Complex socio-economic-ecological systems interact within the river basins and are affected by social, political and economic pressures from outside. Environmental impacts such as increased slope erosion, mass movements, sediment yield and decreasing water quality may be expected in the continuous development of the basin, and result from deliberate or inadvertent causes – the latter may be long -term and insidious. Basin managers, planners and administrators must recognize the potential risks of activity within the river basins; such risks vary (that is the impacts become magnified at certain times and in certain localities within the basins). Land clearing activities on the valley slopes especially for farming, urbanization, settlement and infrastructural development have created tremendous impact on the natural system dynamics of the river basins and its adjoining valley slopes and channel systems. In Malaysia new frontiers of development are needed to appease the voracious appetite of the development process and this would lead to the encroachment of more fragile and very sensitive ecosystems such as the upper basins of the major river systems in the country. Upper basin farming has been identified as one of the main reasons for the soil erosion and landslides in many of the major upper basin systems in Malaysia. This paper addresses the issues and challenges affecting environmental resource development in upper basin systems in Malaysia and the need for a comprehensive and holistic outlook towards drainage basin management in upper basin systems. This is because these regions are also new frontiers of development, which to a major extent creates tremendous impact on the highly sensitive high energy ecosystems of the basins.

Key words: Cameron highland regions, upper basin systems, highland regions, environmental degradation, sustainable management systems.

INTRODUCTION

Upper basin systems in Malaysia by virtue of their morphological forms, process response dynamics, habitat – ecosystem characteristics and spatial distribution are associated with the major highland regions of Peninsular Malaysia. The major highland regions identified are the (1) Upper Perak – Galas, (2) Upper Pergau, (3) Upper Kinta – Jelai, (4) Upper Jelai – Tahan, (5) Upper Selangor – Semantan, and (6) Upper Endau - Rompin river systems (Figure 1).

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These major upper basin systems drain the major highland regions of the Peninsular, including the *Titiwangsa* or Main Range which is the major highland region of the Peninsular.

Environmental degradation of upper basin systems is fast becoming a major environmental issue in Malaysia, primarily the result of the ongoing shifts in the exploitation and extensive development of the environmental resources there. Traditionally, the upper basin systems are utilized and developed for their water resources potential especially in hydroelectric energy generation, as for water supply to the agriculture and industrial industries and for domestic use downstream in the lowland and coastal regions of Malaysia. These traditional uses of upstream water require that the water resources availability of

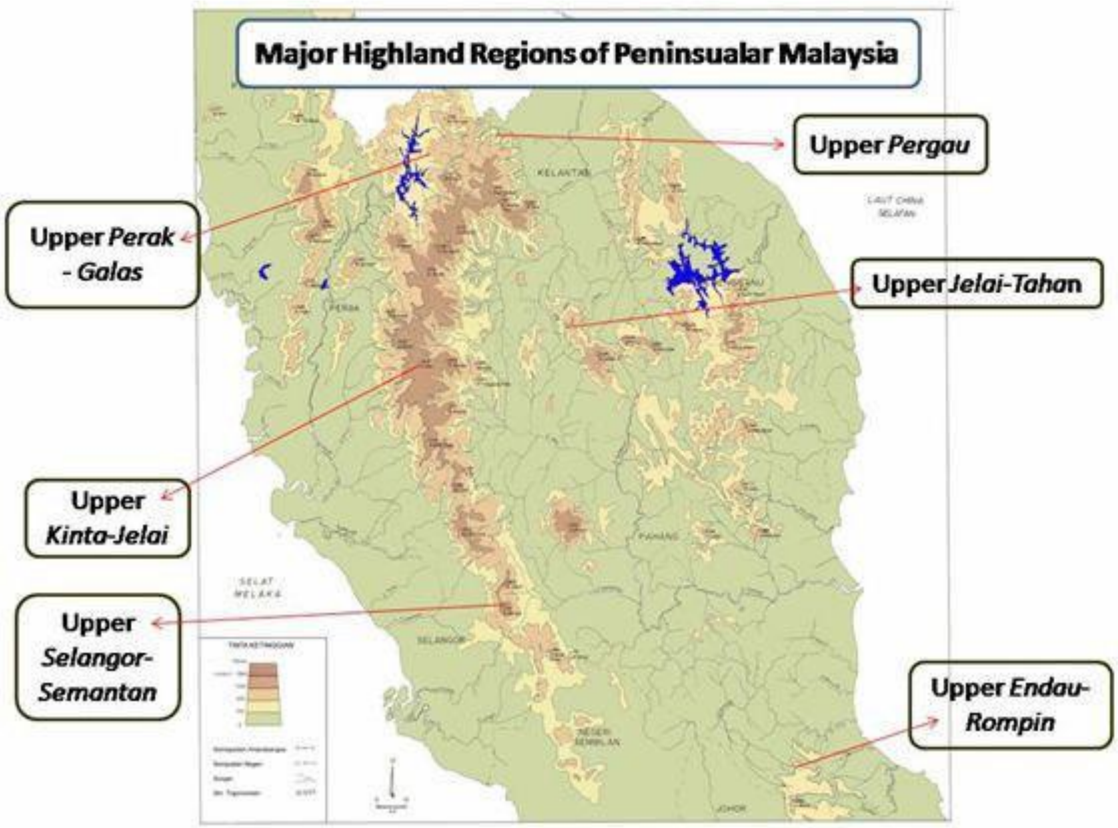


Figure 1. Major upper basin systems of Peninsular Malaysia.

upper basin systems is always in plentiful supply and in pristine quality.

Land transformations and development activities associated with traditional uses usually involve minimal change and do not involve large-scale land conversions, transformation and mechanization which are known to have caused serious and often irreversible obliteration of the drainage basin process - response regimes (Khairulmaini, 1999). In the case of hydroelectric power development, the sustenance of the drainage basins' natural hydrological regimes, which includes the slope and channel, subsystems are prerequisites for an effective basin management system. What this means basically is that water quantity and quality of the drainage basin systems needs to be sustained, as water quantity and quality are the driving requirements in sustaining power generation. Hydroelectric energy generation development in many parts of the country's upper basin systems usually affects environmental quality but with minimal impact on the upstream and downstream habitats and ecosystems.

The early exploitation of highland regions for agriculture (mainly rubber and oil palm) had little impact on the environment of the upper basin systems and downstream regions. Even highland tourism development for example, in its early stages of development had not much impact on the natural environment of highland regions. Environmental degradation during these early periods of upper basin development comes mostly from illegal logging activities.

Illegal logging occurs deep in the upper basin forests of most of the country's major river systems. The major impact of these activities is on the disruption of the upper basin hydrological cycle, the disruption of which would lead to soil erosion, slope failures, sedimentation, local climate changes and loss of populations of flora and fauna and a contraction of upper basin habitats and ecosystems. Soil erosion processes and slope failures would affect downstream water quality, channel sedimentation and the incidence of lowland flooding.

The turn of the new millennium, however witnessed rapid development of upper basin systems to cater for the booming eco-tourism in Malaysia, especially in West Malaysia. Intense urbanization, land transformation activities and the development of physical infrastructures imposed marked changes to the natural process - response regimes of the upper basin systems, especially in terms of changes to inherent processes, in terms of resultant types of processes, intensities (magnitudes) and frequencies of processes (Khairulmaini et al., 2003, 2006). In addition to this, the diverse horticultural practices of farmers of upper basin systems in order to meet market demand both locally and internationally have to resort to extensive use of fertilizers and chemicals to increase productivity and to develop the marginal unstable slopes of the upper basin systems. This excessive exploitation of the upper basin systems which in most cases occur unplanned and unchecked more than often disrupts the upper basin systems delicate hydrological balance and thus influences downstream river basin water quality and quantity. In Peninsular Malaysia, this development trend exhibits a dilemma. On one hand, there is a need to utilize upstream basin's water resources for continuous power generation and water resources demand of downstream activities, including the needs for rapid urbanization and commercial activities. However, on the other hand, upstream developments are becoming more intense and disruptive, as Malaysia moves into new frontiers of development, including also coastal zone development. Traditional agricultural development practices, for example, have been replaced by intense mechanization processes, and also much use of fertilizers and thus posed much changes to the natural process regimes of upstream basin systems (Chan, 2003; Choy, 2004). This problem becomes more acute as upper basin systems are generally high energy environments (by virtue of the steep valleyside slopes and river channel gradients) and under dynamic equilibrium conditions. Major land use transformation activities could disrupt this balance triggering the occurrence of rapid slope failures, ace-lerated soil erosion processes, sedimentation and rapid discharges within the hydro-geomorphological process - response systems within the basins. One of the major reasons why this shift in environmental resources development had occurred is related to the focus of development planning in the country.

There are generally 3 main focus of development in Malaysia. These are lower basin systems, coastal zones and upstream basin systems (highland regions) . The present pattern of development is now shifting more towards the coastal zones and upstream basin systems – highland regions, known for their very sensitive and fragile ecosystems. In the case of the upper basin - highland regions, they are also systems of potential high energy gradients kept in dynamic equilibrium through long period of adjustments and adaptation to the natural climatic regime there. The upper basin systems – highland regions are also water catchments areas and contribute also to hydropower generation in the country, and because of their pristine environmental characteristics have in recent years encouraged the rapid development of the tourism industry in the country. Urbanization and infrastructural development in upper basin systems associated with the tourism industry have created much impact to the fragile and sensitive ecosystems there. The last decade had witnessed much environmental degradation in upper basin – highland regions. The turn of the new millennium has witnessed a number of incidences that attest to the problems of environmental degradation in upper basin systems. New frontiers in land use developments associated with the tourism industry exert serious challenges to upper basin systems traditionally used for water resources deve-lopment and hydropower generation. When both of these conflicting development opportunities are being presented, the need for an effective drainage basin management system thus becomes a priority issue. This basin management system must be based on concerted effort towards sustainable development. Usually this form of management could not be divorced from an elaborate network of identifying, classifying and understanding of upper basin subsystems, their process response – regimes, the instrumentation and monitoring of the process-response changes, and to have the inputs given by all relevant stakeholders integrated in the decision making process attempts for future sustainable development of the region.

THE STUDY REGION: CAMERON HIGHLANDS UPPER BASIN SYSTEMS

The aim of this paper is to describe the emerging issues of environmental degradation in Malaysia’s upper basin - highland regions using the Cameron highlands region (CHR) as a case study (Figure 2). The CHR is located on the central part of *Banjaran Titiwangsa* (Banjaran = Mountain Range). The region is being drained by the Perak River system in the west into the Straits of Malacca. In the east the CHR is being drained by the Kelantan and Pahang river systems into the South China Seas. The CHR is located on the upper basin systems of these three major river systems and is generally more developed in the west than in the east.

However with the rapid exhaustion of land resources, the development focus has shifted towards the western part of the highlands. The CHR is still being developed for its water resources for hydroelectric generation, agricultural, industrial and domestic use downstream. The pattern and intensity of exploitation however has changed in the last half decade or so, as water supply issues are becoming more strained as a result of increasing demands. There would be serious conflict in the physical and chemical process regimes when drainage basins are developed for hydropower generation and at the same time exploited for its land resources. Hydropower generation usually involves minimal change and only disrupts upstream channel processes. However, land resource exploitations involve large-scale land conversions, transformation and mechanization and are known to have caused serious and often irreversible obliteration of drainage basin processes. Upstream tourism development for example, are often associated with intense urbanization and infrastructural processes that imposed marked changes

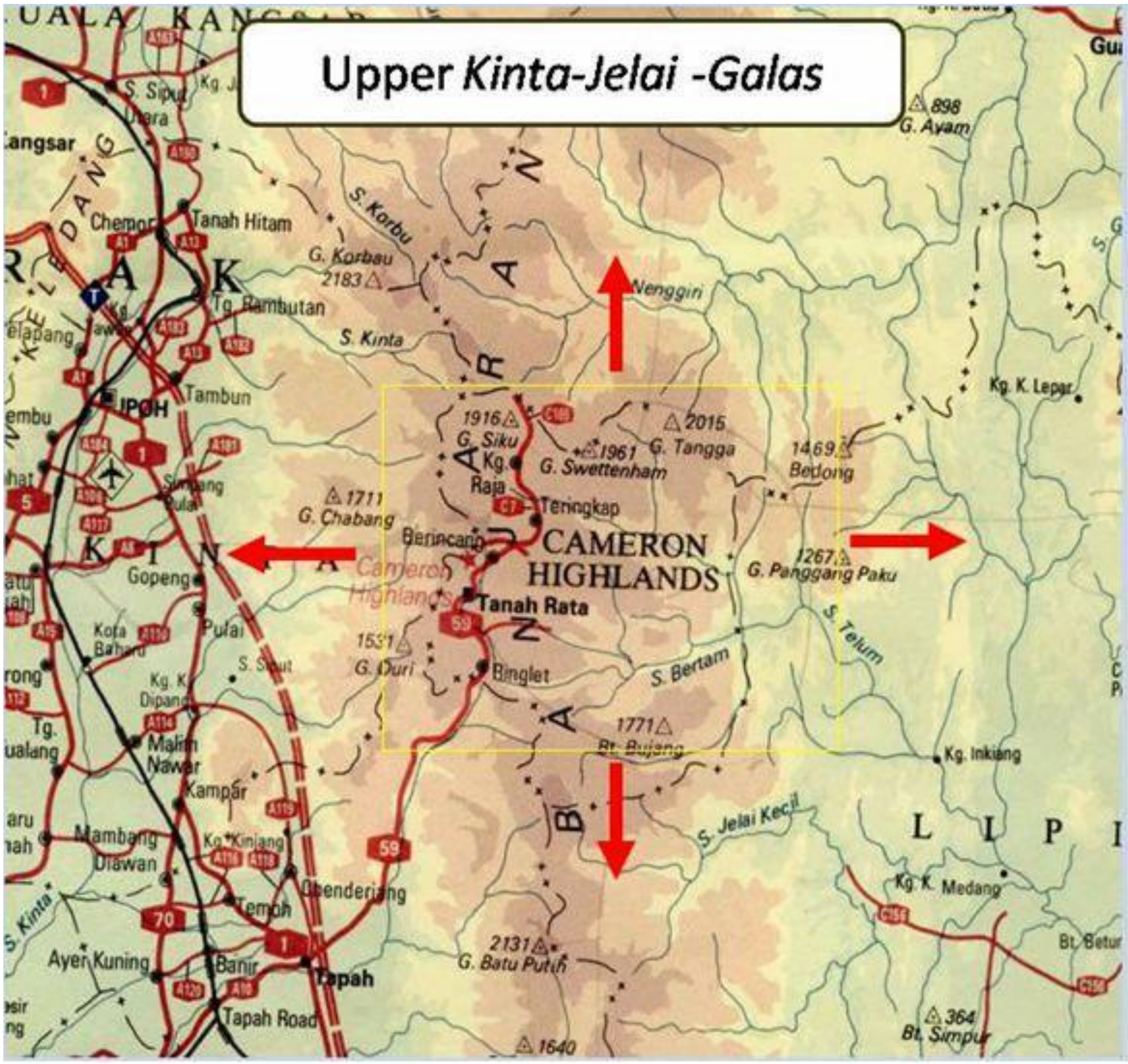


Figure 2. The Cameron highlands are located at the upper basin systems of major river systems.

to the process – response regimes of the region, especially in terms of changes to inherent processes, in terms of types, intensities (magnitudes) and frequencies of occurrence of specific processes.

In the case of hydropower development, the sustenance of the drainage basins' natural hydrological regimes, including slope and channel subsystems, are prerequisite to an effective basin management system. What this means basically is that water quantity and quality of the drainage basin systems are being maintained and thus also the driving forces behind power generation. However, excessive exploitation of land resources from the basins, through agriculture, urbanization and commercial forestry including eco-tourism developments can disrupt the basin's hydrological balance and thus influence water quality and quality. In Malaysia, this problem exhibits a dilemma. On one hand, there is a need to utilize upstream basin's water resources for continuous power generation and water resources demand of downstream activities, including the needs for rapid urbanization and commercial activities. However, on the other hand, upstream developments are becoming more intense, as Malaysia moves into new frontiers of development, including also coastal zone development. Traditional agricultural development practices, for example, have been replaced my intense mechanization processes, and also much use of fertilizers and thus posed much changes to the natural process regimes of upstream basin systems. This problem becomes more acute as upstream basin systems are generally high energy environments, thus the tendency for rapid slope failures, accelerated soil erosion and sedimentation to occur.

The turn of the new millennium has witnessed a number of incidences that attest to the problems of environmental degradation in the CHR. New frontiers in land use developments associated with the tourism industry exerting serious challenges to upper basin systems traditionally used for water resources development and hydropower generation. When both of these conflicting development opportunities are presented, the need for an effective drainage basin management system thus becomes a priority issue. This basin management system must be based on a concerted effort towards sustainable development. Usually this form of management could not be divorced from an elaborate network of identifying and classifying the upper basin systems, their process response - regimes, instrumenttation and monitoring their process-response changes, and the integration of all stakeholders role in decision making.

The CHR is morphologically and structurally an upper basin system; part of the major drainage system of the Sungai Bertam is situated on the Main Range of Peninsular Malaysia. The average elevation of the CHR is ~ 1180 m and the highest peak in the basin is Gunung Brinchang (~ 2032 m). Most of the CHR is underlain by granite. Granites weathering has contributed to the development of very shallow soils on the valleyside slopes. The soils are generally heterogeneous in texture, very friable and loosely formed. These characteristics describe the high erodibility of the slope materials in the CHR. Rainfall records of the last 50 years do not show yearly variability. Rainfall is generally very high with minimum values of 1800 mm to maximum values of 3000 mm. These very high rainfall values contribute to the development of numerous tributary systems of the upper basins. The high and frequent rainfall patterns contribute towards the high erositivity of the CHR. The major drainage systems of CHR include Sungai Telom, Sungai Plaur, Sungai Terla, Sungai Kodol, Sungai Kial, and Sungai Bertam. The river systems are also being managed and manipulated (diversion works) for hydroelectric power generation in the CHBPB. These include the two major hydroelectric schemes in the region – the Cameron highlands hydroelectric schemes and the Batang Padang schemes, the power stations are those at Kampung Raja, Kuala Terla, Robinson Falls, Habu, the Sultan Yussuf, Sultan Idris II or Who and at Odak power stations.

LAND USE DEVELOPMENT AND ENVIRONMENTAL EFFECTS

Man can manipulate and modify the water-sediment balance of the CHR through the activities of various landuse practices (Figure 3). These activities in general disrupt the natural process -regimes operating at the scales of the basin systems, and the valley side slopes and channel subsystems. For example, urbanization in the CHR greatly affects the natural drainage of the Sungai Telom Basin thus influencing the water and sediment discharge of the basins. Landuse activities such as crop cultivation and associated management practices on the valleyside slopes could govern the process regimes there. Here, soil production and soil removal becomes crucial in influencing the water-sediment balance on the slopes. When dealing with indirect change, the problem is to determine how much alteration of runoff and erosion conditions in extra-channels areas is necessary to produce a given type and amount of channel adjustment.

Land use change can take on various forms but in the CHR, a two–phase process could be distinguished, a period of forest clearance for purpose of cultivation and urbanization. A major result of forest clearance is accelerated slope erosion and rapid slope failures on the valleyside slopes, associated with a dense network of gullies and mass movement processes and an increase in sediment supplied to adjoining basins. Much of these sediments are stored temporarily on lower valleyside slopes as colluvial deposits or as alluvium in flood plains and channels. The conversion of forest to cultivated lands also affects runoff characteristics. The channel systems can also be affected by man. Dams, for example, disrupt the flow of energy and matter in channels. Upstream local base level is raised to position at which the water surface intersects the original bed, the maximum rise in height being determined by the crest of the dam spillway. With a reduction in capacity and competence for transport, a depositional wedge is constructed and channel gradient locally lowered.

Although aggradation seems to take place rapidly at first, its upstream extent may be limited or long delayed. Upstream influences are variable, depending on the sediment transport characteristics and the height of the dam relative to the pre-existing profile of the stream. Most work has been concerned with the downstream effects of reservoir construction, of which two have been widely reported, a reduction in the magnitude of flood peaks and a marked decrease in sediment discharge. However, in term of power generation, water quality and quantity upstream of dams are very important.

The land use pattern in the CHR is shown in Table 1. In general there is a shift in landuse patterns towards agriculture developments and urbanization. Indirectly these land use changes are associated with the emerging importance of the tourism industry.

The progressive increase in land use changes from forests to agriculture and urbanization has a direct impact on the rainfall—runoff relation. The effect could be seen for selected river systems of the CHR. The shift in landuse can also be seen to influence an increase in the annual runoff -sediment load of selected river systems of the CHR. There are a more than 140 – fold increase in the sediment load of the basins (Choy, 2003). The increase sediment load can also be observed to have serous impact on the reservoir systems in CHR. Sediment data of the Ringlet Reservoir show a gradual increase in

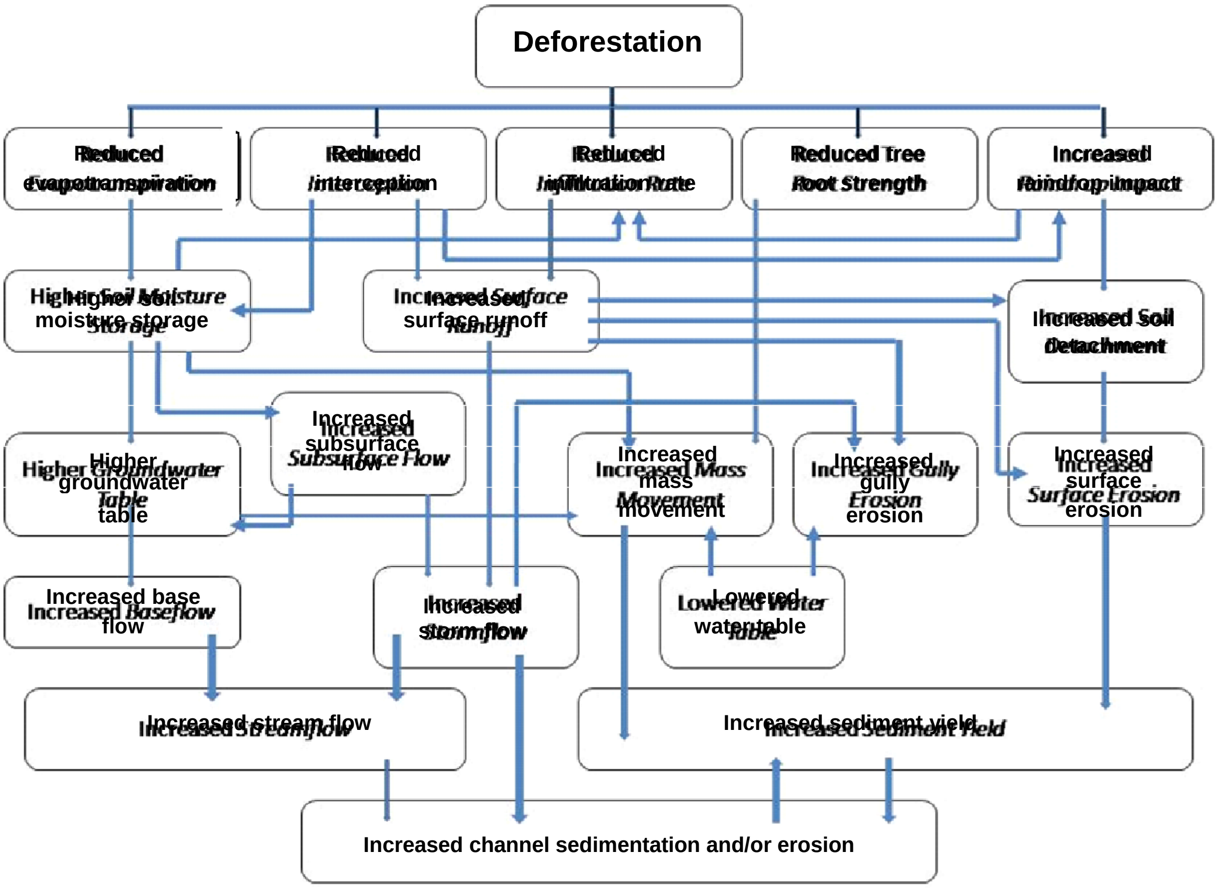


Figure 3. Landuse development and its impacts on upper basin process response systems.

Table 1. Landuse changes in the CHBPB.

Landuse	Year				
	1947	1974	1982	1990	1997
Telom catchment (km^2)					
Forest	103.8	96.6	90.4	90.3	74.1
Agriculture cultivation	5.5	8.0	13.2	13.4	28.9
Tea plantation and orchards	1.1	5.6	6.3	6.2	6.3
Urbanisation	0	0.2	0.5	0.5	1.1
Upper Bertam catchment (km^2)					
Forest	19.5	16.5	16.2	15.9	15.4
Agriculture cultivation	1.9	3.0	2.2	2.4	2.9
Tea plantation and orchards	0	0	0.1	0.1	0.1
Urbanisation	0	1.9	2.9	3.0	3.0
Lower Bertam catchment (km^2)					
Forest	43.8	30.0	29.2	29.1	28.1
Agriculture cultivation	2.6	3.8	9.7	10.2	14.7
Tea plantation and orchards	4.8	16.3	10.6	10.1	6.5
Urbanisation	0	0.4	1.0	1.1	1.2
Lake and pond	0	0.7	0.7	0.7	0.7

Source: UM-TNRD, 2000.

sedimentation in the reservoir since its construction. The measured deposits increased linearly over a period from 1965 to 1984, after which the sediment deposition rates increased drastically. The measured deposits make up a total volume of more than 3 million m^3 for the year 1998 and more than 3.5 million m^3 for the year 1999. Sedimentation reduces the storage capacity of the reservoir which has increased drastically from 10.9% in 1984 to 46.3% in 1998 and then to 52.7% in 1999 (UM-TNB, 2003; TNB, 2000). To check the high siltation rate of the reservoir, systematic sediments excavation program has been initiated by TNB since 1984. Despite the sediments excavation program, the annual sedimentation rate increases drastically from a value of around 20,000 – 50,000/m^3/year before 1984 to reach a high value of around 25,000 m^3/year in 1990, 1991 and 1998. The annual sedimentation rate is ~ 430,000 m^3/year for 1999. The reduction of the reservoir storage capacity would have serious repercussions on future power generations of CHBPB and its contribution to the national Electricity Grid. Apart from sedimentation, the intense vegetables and horticultural farming activities in the CHBPB is also heavily laden with nutrients and pesticides. These expectations are confirmed with the rapid algal growth in the reservoirs, and the resultant process of eutrophication (Plate 7). Decreasing chemical quality of the reservoir waters are envisaged to also contribute to water loss, thus decreasing power generation through time.

SUSTAINABLE UPPER BASIN MANAGEMENT SYSTEMS

A sustainable approach towards highland management must be adopted for the CHR. This is because water resource quantity and quality are prime issues of concern in hydropower generation – in terms of energy generation and sustenance. As it is, the runoff-sedimentation records show that the problem has reached critical levels and are escalating in CHR. This would have serious impact on hydropower generation in the future and the aspirations of the country to become an industrialized nation in 2020 seriously challenge.

Furthermore, water resources supply to increasing demands downstream especially for agriculture, industrial and domestic use would be compromised if the degradation of water resources quality and quantity at the source areas are not addressed. Highland management systems must incorporate the drainage basin management approach to planning landuse changes make sense because, (1) the drainage basin is a readily defined functional unit established by physical relationships which encompass the key interrelationships and interdependences of concern to both land and water managers, (2) the approach is holistic linking upstream and downstream areas, and the chain of cause and effect relationships related to the hydrological process regimes, and (3) the drainage basin is a convenient unit for analysis that overlaps and integrates the professionals involve in basin development. Thus the drainage basin provides a basis for organizations and disciplines to interact. Drainage basin management and planning may also be seen as a way of integrating use of natural resources and of increasing levels of human wellbeing. Drainage basin management and planning must be made a tool in state policy matters, especially those dealing with landuse changes. This approach recognizes the variety and types of changes which are likely to cause severe environmenttal impact in the basin. Such spatial linkages between effect and impact of development in a basin are shown in Figure. In general, a working model of drainage basin management to planning landuse development describes a number of step process (Gibbs, 1986). These are summarized as below:

1) Identification of drainage basin subsystems as fundamental development planning units.
2) Drainage basin management as a process.
3) Drainage basin management as a planned system.
4) Drainage basin systems as structured components
5) The overall conceptual framework of the basin integrating process, activities and component system.

Highland regions are upper basin systems (Figure 4). Highland regions have specific process – response systems (these include the slope and channel subsystems) but influence the process – response systems of downstream basin systems. Demarcation and understanding the process – response systems dynamics of upper basin systems should be prerequisite to landuse development planning of highland regions.

Highland regions (upper basins) as management tools

Each drainage basin subsystem has its own sets of process response dynamics (Figure 5). Changes to these processes – response regimes would give rise to specific environmental degradation issues.

Highland regions (upper basins) as planned systems

Identification of environmental issues leading to a number of step processes to manage the problems arising within the highland regions (Figure 6).

Highland regions (upper basins) as structured components

The proposed conceptual framework for drainage basin

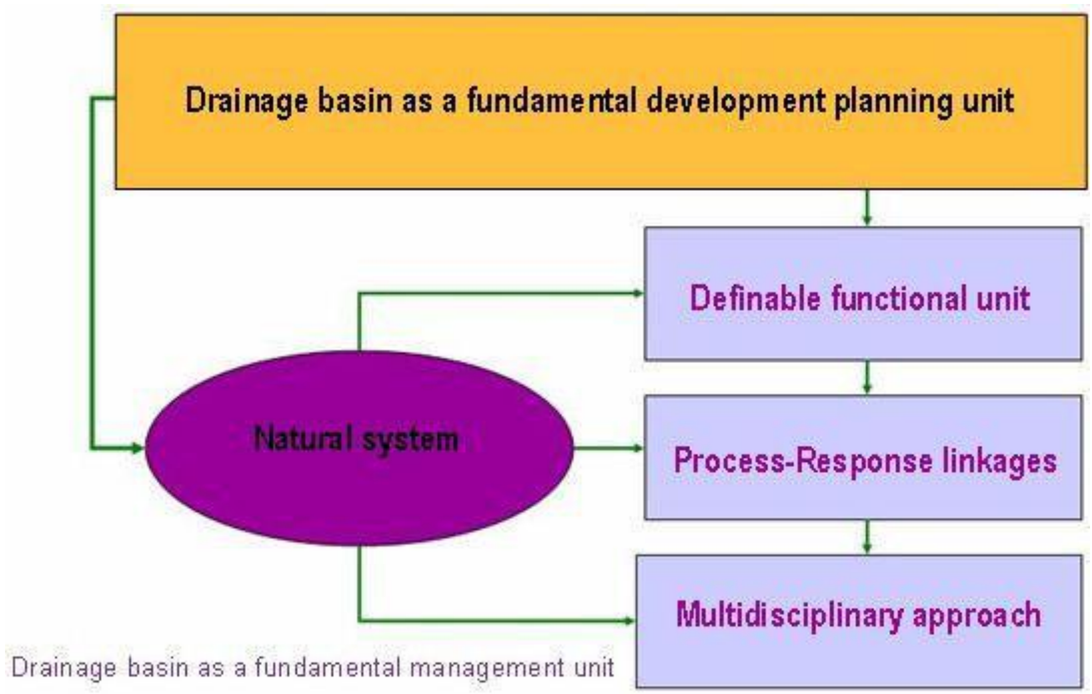


Figure 4. Highland regions are upper basin systems.

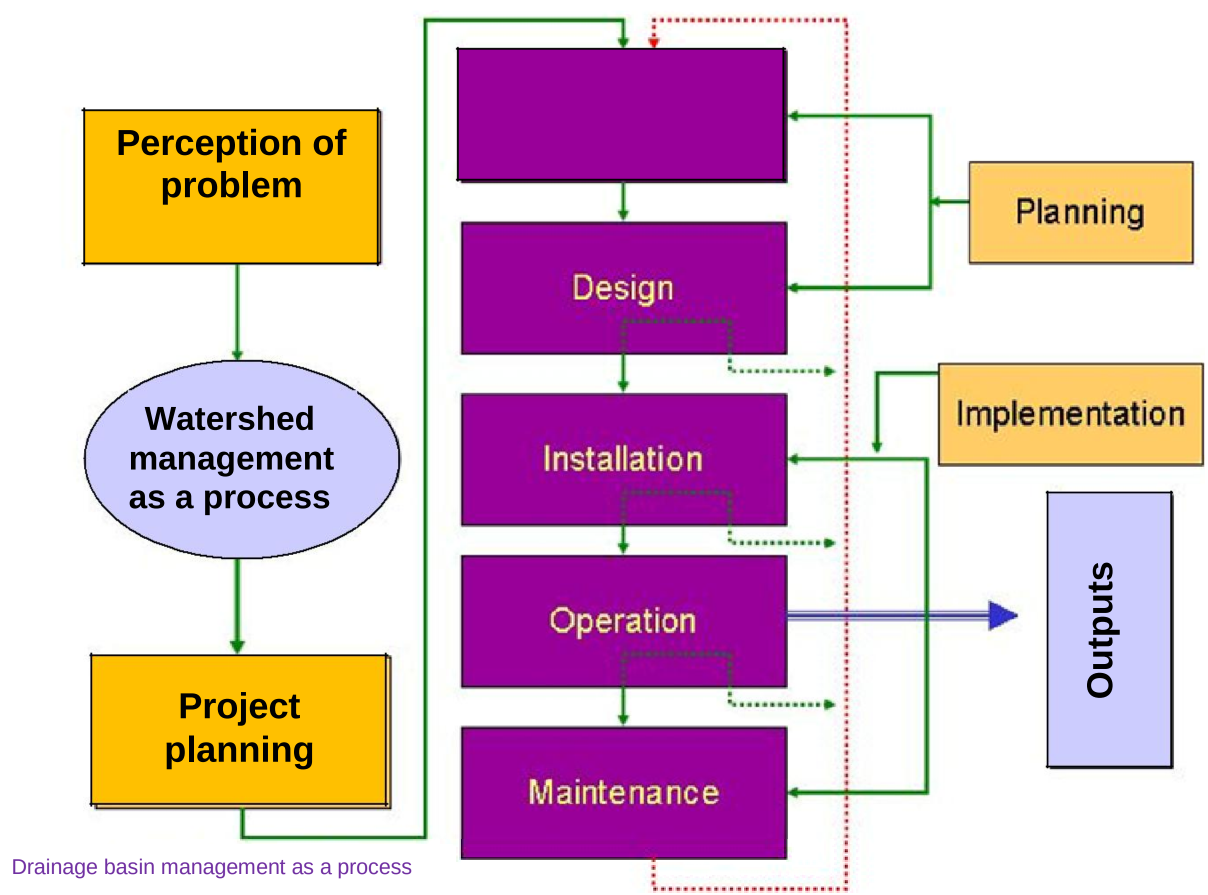


Figure 5. Management process in highland regions.

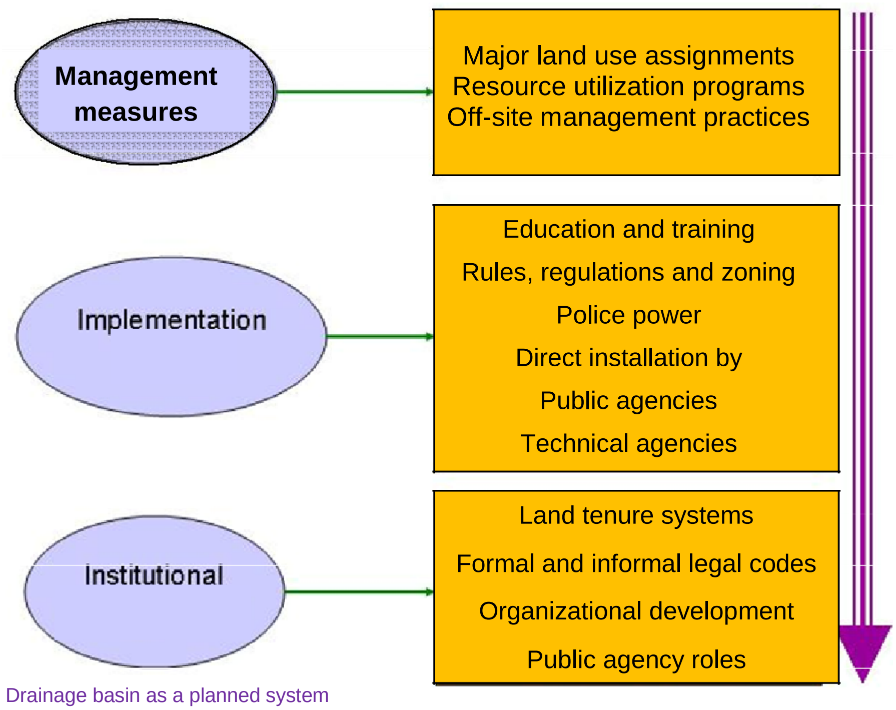


Figure 6. Highland regions as planned system.

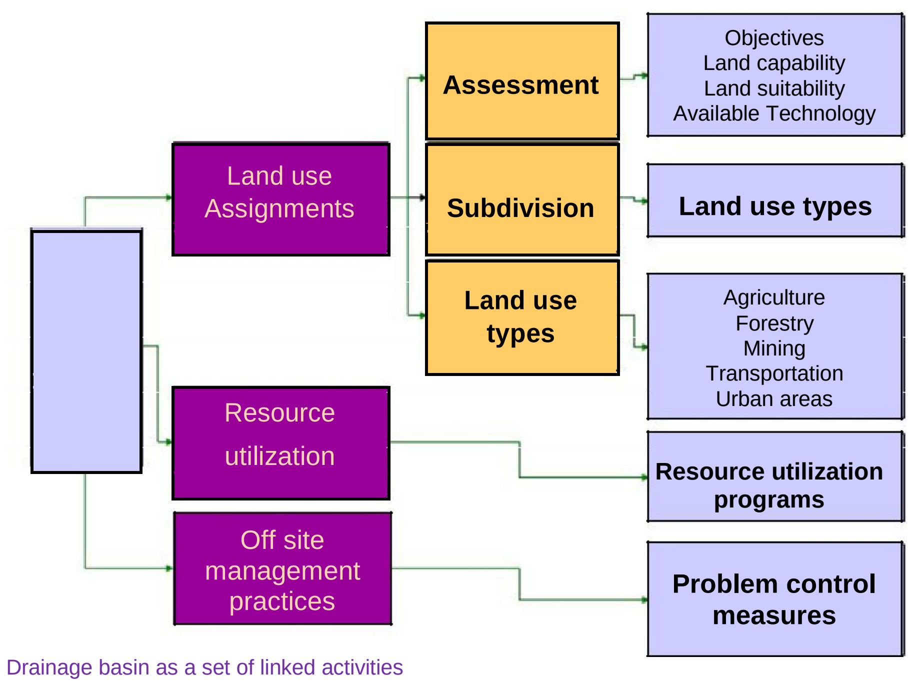
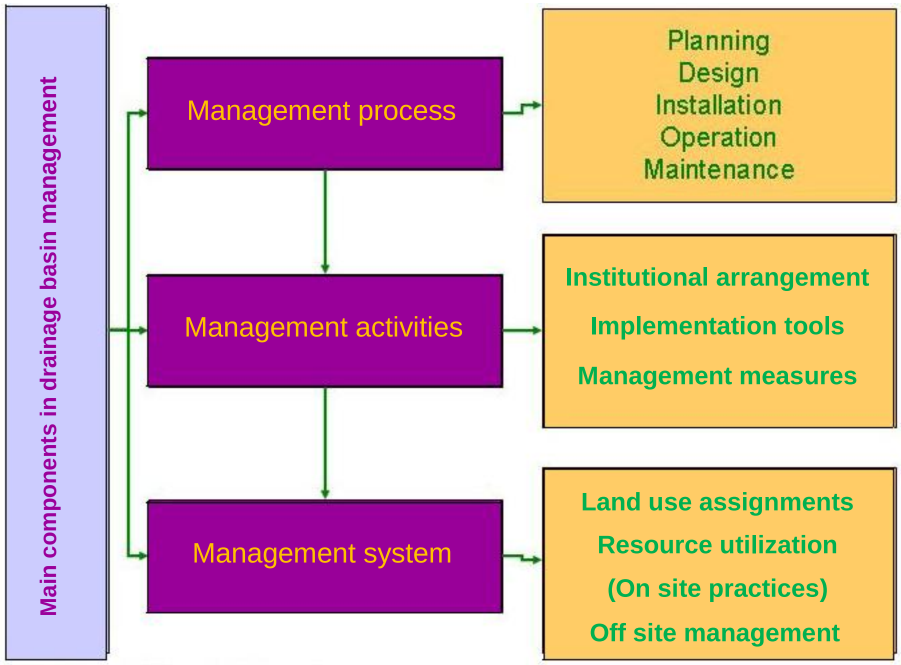


Figure 7. Highland regions as a structured process.

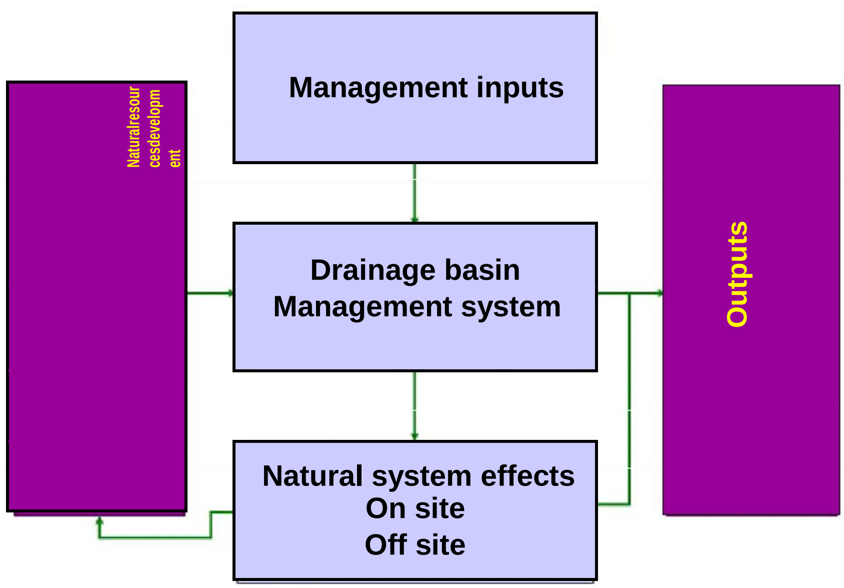
management is both a diagnostic and planning tool, which is based upon the disaggregation of management into three complimentary dimensions (Figure 7):

a) Management as a process, involving elements of planning, design, installation, operation and maintenance (Figure 8).



Main component in drainage basin management

Figure 8. Major components of highland management systems.



Drainage basin management as a process – output system

Figure 9. Highland regions as process–response systems.

b) Management as a system of management measures, implementation tools, and institutional arrangements (Figure 9),
c) Management as activities for which specific tasks are required (Figure 10).

The conceptual framework thus projects a systematic appraisal and structured approach towards development of environmental resources. However, it must be stated here that implementing this structured approach needs a radical shift in drainage basin developments. One major

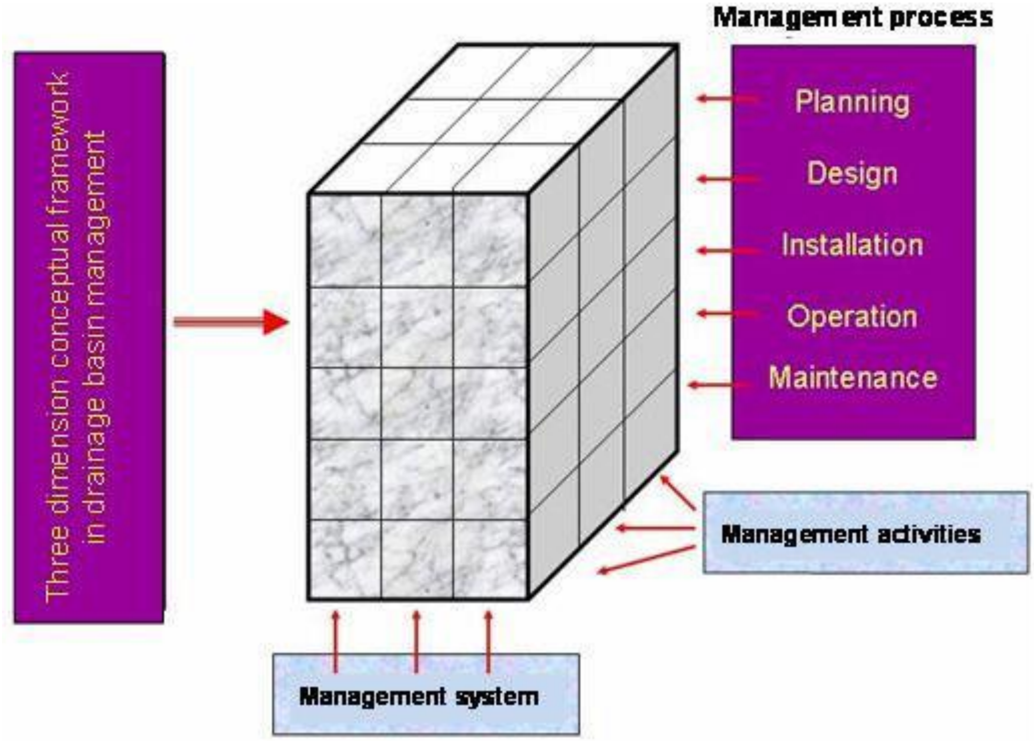


Figure 10. Integrating framework of highland management systems.

constraint is that it does not conform to the development policies of the state stakeholder whose major objective is economic development and to increase the state GDP (Gross Domestic Product). It is for this same reason that the tourism industry is becoming more important in upper basin systems. Unless there is a radical shift in state development policies, upstream developments such as at CHR would continue to create conflict between environmental sustenance (for example quality and quantity of runoff) and environmental degradation (landuse developments).

CONCLUSIONS

The CHR provides one of the major hydropower sources for West Malaysia. Being a natural upstream basin, it provides the ideal setting for hydropower generation. However, state policies, aspirations and ignorance could also lead to bad development practices and severe environmental impacts. The tourism industry capitalizes on the pristine environment of the CHR and the pull of traditional agricultural practices. These have led to intense urbanization and related infrastructural developments which have led to serious impact on the natural systems process-response regimes such as the problem associated with rapid slope failures, soil erosion and sedimentation. One way to overcome this is to implement a sustainable basin management approach that incorporates the understanding that drainage basins are functional and dynamic entities. This approach must not be divorced from an elaborate network of basin instrumentation and monitoring which should also be charted for the whole basin. State policies should then be integrated within this overall appraisal of the drainage basin dynamics.

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