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URBANIZATION ON STREAM CORRIDOR ECOSYSTEM: CASE OF MEDA ELA & PINGA OYA TRIBUTARIES IN UPPER MAHAWELI RIVER, SRI LANKA

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Abstract: Impacts caused by urbanization on stream corridor eco-systems are enormous. In Sri Lanka stream corridors can be considered as one of the major sensitive eco system and that has been threatened by urbanization. Objective of this study is to analyze the stream corridor ecosystem stresses due to urbanization. Nature of the problem and impact in this study were analyzed through collected data from different types of surveys such as chain, vegetation, Solid waste, stream loads, water test, stakeholder interviews and observations. Ecosystem Stresses have been analyzed as follows: Private ownership (90%) of the stream corridor boundary lands and their activities are the major threat for the stream corridor ecosystem and created several impacts. Artificial modifications in stream corridors are the major problem created by land ownership close by the streams and it effected to structure and process in seven ways and affected 14 numbers of elements, parts and values in the stream corridor ecosystem. Stream dwellers waste handling behavior was identified as a second problem for the stream corridor it negatively effects ecosystem structure and process in four different ways and affected 12 elements, parts and values. Vegetation changes in stream corridor negatively affect to stream corridor structure in 2 ways and affected to elements and values in the stream corridor ecosystem. For sustainable stream corridor ecosystem the government give more power to relevant authorities to take legal actions for demarcate the stream corridor boundary line at least in urban premises and implementing some awareness programs in headwater catchments are recommended.

Keywords: artificial stream modification; stream corridor; solid waste; urbanization; upper Mahaweli River;

1. Introduction

"A stream corridor is an ecosystem that usually consists of three major elements; Stream Channel Flood Plain and Transitional Upland Fringe. Together they function as dynamic and valued crossroads in the landscape (Federal Interagency Stream Restoration Working Group, 1998)

There are more than hundred thousand kilometers of rivers and streams, along with closely associated floodplain and upland areas in Sri Lanka (Dissanayake 2014). The radial drainage pattern that carries surface water down from the high watersheds includes 103 distinct natural river basins that cover over 90 percent of the island. Mahaweli is the largest river (325 km) in Sri Lanka and it starts from central Highland. Its annual discharge is 7650 million cubic meters also has by far the largest catchment area (10327square km) covering one sixth of the country (Natural Resources of Sri Lanka, 1991). Agriculture, hydropower, day today water consumption, flora and fauna diversities and many other activities of the country mostly depend on this river and streams. Not only prior to the independence and but also After independence, as a result of the multipurpose development programs through accelerated Mahaweli development program was implemented, the land cover was considerably changed in the structure and composition. Lack of appropriate new settlement alternatives, vulnerability of ecosystem due to high intensity of rainfall and steep slopes, lack of integrated and coordinated land use planning are the reasons of rapid depletion of catchment resource base (Tschakrt. & Decurtins 1989).

This was further enhanced through the revised government policies moving towards a free market economy. Results of economic boom influence to increase settlement growth on vacant sensitive areas such as stream corridors (Dissanayake 2002, Chandrasekara and Gunewardene 2001). The consequences of human induced disturbances on stream ecosystem could be visible from end of the 20th century. River course changes (Dissanayake 2011) sediment load changes (Arnold 1996), changes of water quality (Abeygunewardene et.al 2011), extinct of biodiversity, environmental hazards are the major challenges in Stream corridors in Sri Lanka that have to be overcome. To overcome the massive environmental degradation due to plantation agriculture in head water catchments introduced some soil conservation strategies were introduced during the colonial period by the British.These approaches were not effective to control the degradation of highland watersheds. During The late 1970 the first holistic, broad- based watershed management projects were introduced by Mahaweli Authority and those projects lasted up to recent years (Gunewardene, 2003). Inability to set up sound education awareness programs, eco-friendly management mechanism with specific degradation level and lack of continuous evaluation and monitoring faults are the major issues to be solved in river catchment in Sri Lanka.

2. Research Problem

The Mahaweli River starts from the head Water Mountains, approximately half of the length of river flows through the wet zone steep slopes and moderate slopes, passing densely populated towns and activate resulting serious damages to the functions of the stream corridor ecosystem.

Changes in the natural flow regimes of the stream and major rivers are due to artificial construction within the most sensitive area of the waterways, resulting flood flows in the rainy season, extremely less water flows in the dry season, degradation of riparian and wetland habitats in broth in headwaters and lower catchments. Quality of water in streams as well as rivers is being degraded as a result of urban solid waste, nutrient loading and pesticides from urban, as well as farm runoff from the connecting canals are resulting in eutrophication of pools in streams and rivers and reservoirs are the critical issues in Upper Mahaweli stream corridors.

3. Objective

Objective of this study is to analyze the stream corridor ecosystem stresses due to urbanization.

4. Methodology

To identify the urban stream syndrome and the best management actions to conserve streams in different scale, the Mahaweli River structure and process is segmented in to 5 scales such as:

1. Mahaweli Catchment
2. Head water stream,
3. Corridors,
4. Reaches,
5. Points and lines

Within the upper Mahaweli catchment selected 3 head water streams and among that two corridors represent different urbanization levels base on population size and one stream selected less populated minimal disturb stream and it considered as a control stream corridor. Samples were taken from reaches scale as highly populated, average populated and less populated reaches within the streams and also from different point locations through collected the data in different ways.

Such as remote sensing and geographic information systems, chain survey, solid waste surveys, stream load surveys, water tests, questionnaire surveys with dwellers and interviews with both dwellers and officials.

5. Findings

In the development of a quantitative Stream Corridor Ecosystem Condition Gradient

(SCECG) model, weighted forty two number of impact attributes, through narrative decision criteria (Table 1) and used for assigning 42 attributes to SCECG levels as excellent, good, fair and poor and identify the statues of Upper Mahaweli stream corridors (Figure 1). In the SCECG, first four attributes that describe the artificial modifications of stream corridors and how it effects and affects the stream corridor ecosystem (A1-A4). Five attributes that describe changes of vegetation cover and its consequences (B5-B10). Twenty three (C-11 to C-35) attributes had been used to that describe the human behavior in the stream corridor and its effects and affects to the stream corridor ecosystem and seven attributes had been used describe institutional capacity for restoring the stream corridor ecosystem.

Table 1: Decision criteria for Stream Corridor Ecosystem Condition Gradient (Example)

Source: Dissanayake (2014)

Parameters	Decision criteria for Stream Corridor Ecosystem Condition Gradient (SCECG)			
Artificial modification	Excellent (1)	Good (2)	Fair (3)	Poor (4)
A.1 impervious surface within the stream corridor	Within the corridor pervious area more than 75%	pervious area 75%-50% impervious	pervious area 50%	impervious More than 75%

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Weighted SCECC table was converted in to one figure as stream corridor condition gradient (Figure 1) and found the conditions of three different stream corridors.

In Meda Ela out of 42 attributes 26 (62%) numbers shows 3-4 level of stress condition (fair to poor) while 16 (38%) attributes shows 1-1.9 level minimum stress condition (Figure 1) .

In Pinga Oya out of 42 attributes 24 (57%) numbers shows 3-4 level of stress condition (fair to poor) while 18 (42%) number of attributes shows 1-1.9 level minimum stress condition(Figure 1) .

In Heel Oya out of 42 attributes 7 (16%) numbers shows 3-4 level in condition (fair to poor) while

35 (84%) number of attributes shows 1-1.9 level minimum stress condition Figure 1.

SCECG was provided much guidance for identification of problems, effects and affects and how those impacted to the structure and process and the elements, parts and values in the stream corridors. Research base designed urban stream corridor stress network model (Figure 2) had given a clear picture about status of urban stream corridors for design restoration models to restore urban stream upper river Lanka counted in Upper

First and second level of the model was explained the problems of the stream corridor identified from the study (figure 2). Third level of the model was explained the stream corridor structure and process stress that was created due to the second level of problems. Forth level of the model was explained the affected parts and values stress in the stream corridor ecosystem. Fifth level of the model was explained institutional stress due to losing the natural balance of the stream corridor Ecosystem. Sixth level of the model was explained how political patronage influence to the different issues the research identified that the ownership of stream corridor boundary land is a major threat for the stream corridor ecosystem. More than 90% of the stream corridor boundary land belongs to the private dwellers and they handle the corridor activities and had created following problems common in urban stream corridors.

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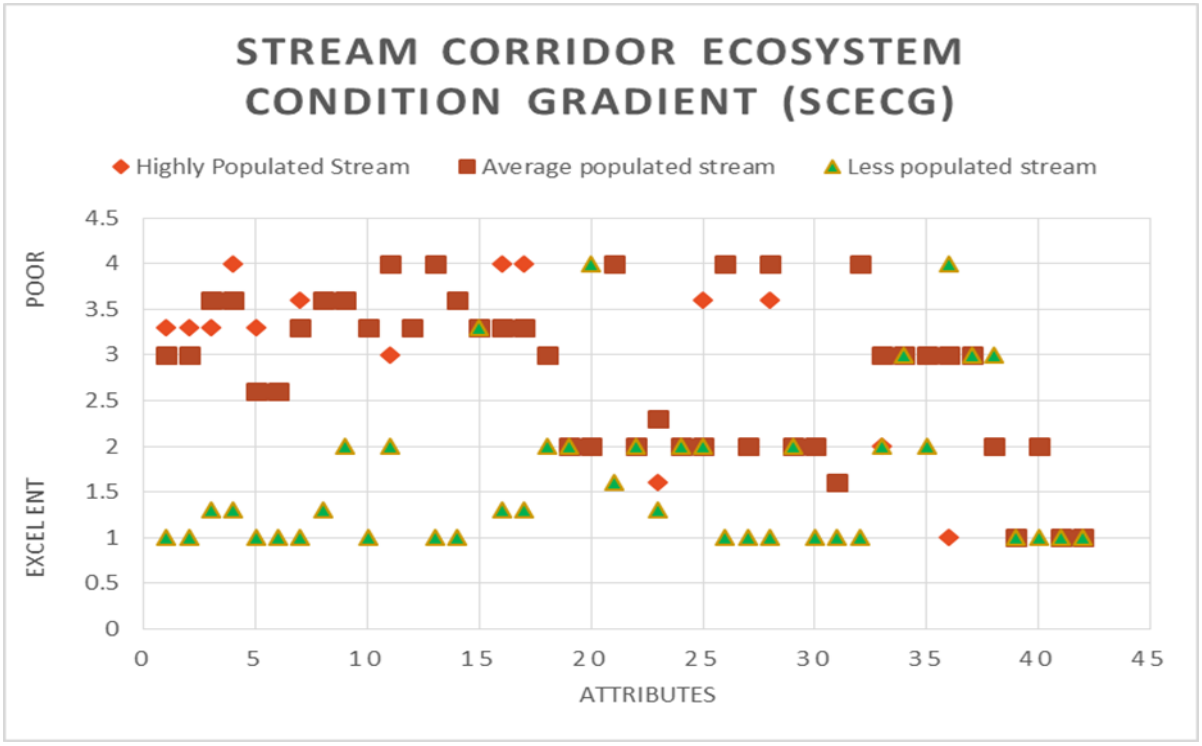

Figure 1: Stream Corridor Ecosystem Condition Gradient (SCECG) Source: Dissanayake (2014)

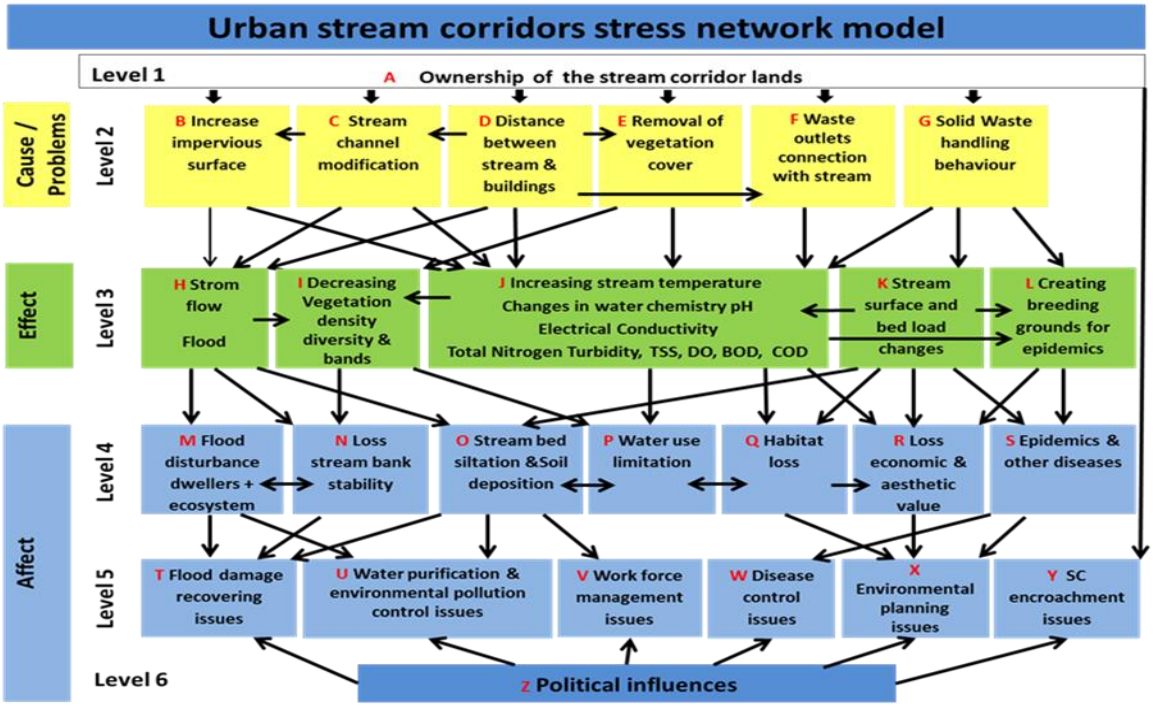

Figure 2: Urban stream corridors stress network model Source: Dissanayake (2014)

stream corridors as well as other urban and semi urban streams in Upper Mahaweli River; it effected to stream corridor structure and process in 5 ways, and affected 14 number of elements, parts and values in the stream corridor ecosystem.

Stream dwellers disposal of solid waste and waste handling behavior was identified as a second problem of the stream corridor and it effects ecosystem structure and process in 4 different ways and affected 12 elements, parts and values in the stream corridor ecosystem.

Vegetation changes in stream corridor effected to stream corridor ecosystem structure in 2 ways (Figure 2 Level 3 I and J) and affected to 3 numbers of elements parts and values (Figure 2 Level 4 N,O and P) in the stream corridor ecosystem.

When analyzing the network model it was found that artificial modification problem had an impact and changed the stream mophometry (Landscape) in stream corridor ecosystem in three different ways it impacted to total catchment increasing the impervious surface, impacted to stream channel as channel modification and impacted to stream channel, flood plain and upland fringed.

It was also founded that Three different problem faces were affected to change the ecosystem structure in seven different ways (see figure 2 level 4 M to S): increasing impervious surface was led to change the stream process: storm water flows and flood hazard especially in Meda Ela and Pinga Oya and also effected to change the process of stream water chemistry.

Stream channel modification problem affected to change the stream corridor process creating smooth and thick surface effect to storm waters and floods and also contributed to change the stream water process.

Buildings close to the stream problem affected to storm water and flood effects change the stream water chemistry as well as supported to increase other problem as generate close proximity to waste waters. It also disturbed to the stream corridor structure removing vegetation for construction work. This network was clearly identified from stream cross sectional surveys.

Artificial stream corridor modification effects affected to change the structural and process parts, elements and values in different ways. Earth filling, excavation, mixing and sealing of soil for roads, paving areas and for buildings effected water balance. Narrowing stream widths and concreting stream bank is very common in highly and average populated reaches in stream corridors and its leads to increase the water velocity. The study identified storm water and floods was affected to the people, their properties and their happiness, flood eroded stream bank and lose the stream bank stability and increased siltation in the stream bed. Stream surface covered bridges and concreted slabs prevent sun light reaching the stream and creates an unfavorable living environment for the aquatic species. The problem further was affected to institutional party creating issues such as flood damage recovering issues, water purification and environmental protection issues.

When analyzing SCECG and the network model it was found that waste handling behavior created impacts to change the stream corridor ecosystem in two different ways (Problem F and G). It change the stream water chemistry (structure). If stream containing high concentration of toxic materials or high temperatures, low dissolved oxygen or other chemical characteristics are inappropriate level stream health will be in bad condition. As many other studies similar to this study identified, also confirmed artificial constructions on very close proximity to the stream channel poor controls of erosion lack of riparian shading, excessive sources of nutrients oxygen demanding waste from urban waste, waste water outlets and storm water pollution resulted in degradation of the physical and chemical conditions in the streams and exerted undesirable impacts on stream corridor eco system and it was

clearly visible from consequences due to modification ,consequences of land use changes and consequences of stream water pollution .

Stream load changes (process) had impacted to increase siltation in the stream bed (elements), habitat loss (elements), loss of aesthetic values, and increase the epidemic breading grounds was identified in this study. Geomorphic processes are the primary mechanisms for forming the drainage patterns, channel, floodplain, terraces (Stream corridors) and catchments. Sediments are the major character of stream and it closely related with the movement of stream water. Fine sediments intrusion in to the stream corridor from non-point sources stream bed gravel can reduce permeability and intra gravel water velocities, thereby restricting the supply of oxygenated air and also controlled the process of pools and riffles in head water streams. This situation clearly revealed that tones of demolition debris had been dumped in to the less populated stream corridors especially with road accessed highly and average populated stream corridors negatively affects to the aquatic biodiversity and its clearly revealed from the stress network analysis.

SCECG and the network model was found to influence vegetation cover changing problem effect to change the stream corridor structure, decreasing the vegetation density, diversity and vegetation bands, and it was also effect to water structure and affected to parts and value such as habitat loss stream bank stability, habitat, water use limitation and economic and aesthetic values. It also creating institutional issues such as environmental planning, punitive issues **(Figure 2)** Whether it was a single issue impact scale will be the most highest.

Riparian vegetation changes was causing to lose numerous patterns and functions in stream corridor ecosystem as identified by many researchers as well as this study also found the facts in stream corridor ecosystem. A remarkable riparian vegetation cover loss can be identified in highly populated reaches in Meda Ela and Pinga Oya. In that respective stream corridors comprised with totally concreted or poor vegetation diversity and very poor vegetation bands. Loss of ground cover in the watershed and stream corridor led to decreased infiltration and increase runoff, leading to higher flood peaks and additional runoff volume. Reduction in base flow and increase in storm flow can result in formerly perennial stream becoming intermittent or ephemeral. That situation very clearly identified from the stream dwellers perceptions about 20 years ago regarding conditions of the stream.

Such corridors mostly covered with introduced species and mono plants species can live under extreme environmental conditions (temperature, soil, chemical parameters etc.). It reduces food availability affects stream temperature and disrupts sediment nutrient toxin uptake from surface runoff.

Typical riparian vegetation diversity and vegetation bands with well grown canopy could identified in the less populated stream (Heel Oya) as well as in less populated reach in average populated stream corridors (Pinga Oya). They very clearly correlated with elevation, gradient, availability of sunlight and other geographical factors. It also acts as a filter for sediment and control pollution from upland areas, it provided habitat for many species in that ecosystem, shade for the water cool and help to protect the bank stability. The critical situation was that highly and average populated stream corridors vegetation band damaging percentage is very high and it's mostly covered from concrete.

Relationship between slope and height of the vegetation and disparities between highly populated and less populated stream corridors also very important focal point identified in this study. In steep slope corridors height of vegetation is very low compare to with average slope corridors. Such characteristics cannot be identified in the highly and average populated stream corridors. When planning for re planting

attention should be given to the above factors.

6. Conclusion

It was found that there are many problems induced by humans: artificial stream modification, changes of land use in stream corridors, human behavioral activities such as solid waste handling, water pollution and restoration capacities were evaluated, using forty two (42) different attributes. To evaluate the attributes in stream corridor condition level was taken at internationally accepted standards; tropical research accepted stranded as well as local indigenous knowledge. The findings of this study provided sufficient data base to evaluate the states of Upper Mahaweli head water stream corridors in Sri Lanka. Research findings based on stream corridor ecosystem condition gradient (SCECG) provided sufficient direction to identify the statues of Upper Mahaweli stream corridors.

In highly, average and less populated streams condition were represented by SCECG and level is 2-3 level (Good to poor). It was observed that less disturb streams like Heel Oya SCECG level is 1-2 (excellent to good): where the stream corridor is recovering rapidly, and active restoration is unnecessary and even detrimental. Urban stream corridors in Upper Mahaweli River are being gradually converted to almost urban waste cannels and this was identified in this study at different scales

For sustainable stream corridor ecosystem for Sri Lanka the government should give more power to relevant authorities to take legal actions for demarcate the boundary line of the stream corridors at least streams passing by urban premises. The process will be difficult but awareness will be much benefitting.

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