Land-Water Linkages in Rural Watersheds Electronic Workshop

18 September – 27 October 2000

Case Study 21

A quantitative treatment on the influence of catchment features, based on GIS, on fish production in Sri Lankan reservoirs

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The work presented was carried out in Sri Lanka (5-9°N; 79-82°E), which is purported to have a high density of reservoirs, concentrated in the dry zone (receives less than 187 cm of annul rainfall). Reservoirs in Sri Lanka are very diverse in size, age, some dating back nearly 2000 years, hydrology, use and catchment features.

The reservoirs are the mainstay of the Island's inland fishery which provides the main source of animal protein to the rural poor. The fishery is artisanal and is characterised by three main features; the main stay of the fishery is the exotic cichlid species *Oreochromis mossambicus* and *O. niloticus*, the gear used is uniform (gillnets of 8 to 12 cm mesh) and the crafts are non-motorised canoes operated by one or two persons (De Silva , 1988).

The current study was based on nine perennial reservoirs, thought to be representative of large perennial reservoirs in the Island. For each reservoir, fishery data (total catch, species composition and size, number of boats operating, amount of gear used, etc) were obtained over a two year period, for at least 20 days in each month. This data were supplemented with limnological data such as conductivity, total phosphorous and nitrate, and chlorophyll a, collected once every second month, at three stations for each reservoir. Conductivity, total phosphorous and nitrate are all indices of nutrient availability, which in turn are known to influence natural productivity, in particular the primary productivity of a water body. These parameters, either singly and or in combination with morphometric features of water bodies have been used previously to develop empirical models that relate to fish production in water bodies. Chlorophyll a is a measure of primary productivity in a water body.

Land-use maps for each of reservoir catchments (topo sheets; 1:50 000; Department of Surveys, Government of Sri Lanka) was used for digitising the land-use patterns (ARC/INFO, version 3.4D+), when 16 land-use patterns were evident, of which nine could be considered to be significant in area (> 5% of the total catchment, at least in one reservoir (Table 1).

TABLE 1
The percentage area of the nine, main land-use types of the catchments of the reservoirs studied. Only land-use types which are greater than 1% of the catchment for at least one reservoir are included; CA- catchment area; Ch- Chena (shifting cultivation land); Fc- Forest cover; Gl- Grasslands; Hg- Home gardens; Pl- Paddy land; Pn- Plantations (coconut, rubber and tea); R- Rock; Sl- Shrub land; Wb- Water bodies (reproduced from De Silva *et al*., 2000)

Reservoir	Land-use types (% of catchment)										
	Area (km^2)	CA (km^2)	Ch	Fc	Gl	Hg	Pl	Pn	R	Sl	Wb
Badagiriya	4.86	340.3	13.1	21.6	0	2.4	2.5	1.6	0.1	54	4.7
Chandrikawewa	4.39	213.8	51.4	1.5	1.2	28.1	5.4	7.2	0	3.7	1.6
Kaudulla	27.13	362.1	0.3	54.8	0	1.0	0.6	23.2	0.1	19.2	0.9
Kiriibbanwewa	3.66	24.8	39.2	6.1	0	2.4	0	0	0	47.3	5.0
Minnneriya	25.5	217.1	1.9	53.0	0.2	3.8	3.7	1.7	0.1	35.2	0.5
Nachchaduwa	17.85	591.7	16.2	14.3	0	8.6	15.2	1.8	1.2	34.8	8.0
Nuwarawewa	11.99	67.0	28.7	2.4	0	32.4	10.9	0	0	22.4	3.2
P. Samudra	26.62	57.65	0	62	2.1	7.1	1.0	0	0.2	27.0	0.6
Udawalawe	34.15	1108.0	25.6	25.7	3.0	8.4	4.9	14.9	0.4	14.3	2.9

GIS have been previously used in fishery and related studies, such as for salmon habitat evaluation (Lunetta *et al*., 1997), monitoring water quality parameters for inland fisheries and/or aquaculture (Harrington *et al*., 1992; Egna, 1994), effect of aquaculture development on mangroves (Terchunian *et al*., 1986), etc. However, investigations on influences of watersheds/ catchments on fishery and/or fishery related parameters are relatively scarce. For example, Webb and Bacon (1999) studied the Dee River catchment in Scotland with a view to managing its salmon fishery, Vehanen and Riihimaki (1999) indicated of the influence of shore land use patterns on water quality ad fish yields in Finnish impoundments, and Nakasone and Kuroda (1999) established a relationship between water quality in irrigation reservoirs and land use of the watersheds.

Based on the catch statistics and reservoir catchment land-use features a number of statistically significant ($P<0.05$) regressions were derived. It was evident that the extent of forest cover and shrub land, either singly and or in combination, and in relation to reservoir capacity or reservoir surface area were the most determining factors on the fish yield in the reservoirs (Table 2). The above catchment features were also correlated significantly to limnological features, discussed previously, of the reservoirs, all of which are known to influence fish production, either directly and/or indirectly. It is hypothesised that the extent of forest and shrub cover has the greatest influence on the nutrient run-off from the watershed, which in turn influences the primary productivity of the water body, and thereby the fish yields. In essence those water bodies which have watersheds with high forest and shrub cover, in proportion to their surface area and capacity, should expect to be more productive, and result in better fishery output.

TABLE 2
Results of regression analysis between the ratio of extent of the land types forest cover (FC) and shrub-land (SL) to reservoir surface area (RA) and /or reservoir capacity (RC) to fish yield (FY= kg $ha^{-1}yr^{-1}$). (reproduced from De Silva *et al.,* 2000)

Statistical Relationship	r	P
FY = 0.027 FC/RC + 72.86	0.81	<0.01
FY = 10.972 FC/RA + 56.13	0.81	< 0.01
FY = 3.123 (FC + SL)/ RA + 70.31	0.76	<0.02
FY = 0.007 (FC + SL) /RC + 81.73	0.73	< 0.05
FY = 3.91 SL/RA + 79.31	0.70	< 0.05
FY = 0.009 SL/RC + 85.30	0.70	< 0.05

RA, FC, SL are in km^2; RC- km^3

The present study has shown the importance of the land use pattern of the watershed on fish production, which often forms the livelihoods of significant number of rural poor. It has shed light on the possibilities of utilising GIS to formulate yield predictive models in inland waters, providing a useful tool for effective management. Most of all the study demonstrates the need to have a holistic approach to the management of fisheries, that involves all stakeholders of the whole watershed, a point stressed at a recent workshop on reservoir fisheries management (De Silva 2000).

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