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GIN AND NILWALA FLOOD CONTROL PROJECTS IN SRI LANKA

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ABSTRACT

Sri Lanka is an island with 2000mm average annual rainfall and maximum rainfall of 5500mm. Land area of 65519Mm^2 is divided into a wet zone of 22000Mm^2 by 2000mm isohyet. Heavy rainfall dropped into central mountains is drained to many reservoirs and hence it provides electricity in hilly areas. But the water drained to wet zone is not stored to produce electricity, other than in Kelani, Walawe river basins. A series of wet zone rivers are drained to sea with devastating floods. Lower Kelani, Kalu, Gin, Ben, Nilwala are the river basins with flood control projects. Gin and Nilwala basins were protected by specially designed flood control systems to protect drainage basins. **Unprotected areas of the river basins need life saving equipment such as life vests, small boats, provided for people living there**. Each village needs a flood warning system to inform people about the oncoming disaster. Upstream tanks are necessary for each stream.

Integrated effort is needed to get the benefits from these protected areas. The protected area predominantly meant for paddy cultivation. Hence farmers are instructed to use the available opportunity to cultivate the protected basins.

Quite contrary the paddy cultivation is not successful during the last 10 years. Drop in rice yields when compared with dry areas is one reason for the abandoning of cultivation. Rice price also drops due to government efforts to import rice and to bring down the cost of living of residents. The rice variety selected for these lands are traditional and not changed to high yielding hybrids. Bush growth is also not effective and one plant has only one shoot. But dry zone area develops nearly 32 shoots from one plant. The problems associated with the flood control projects are discussed in the paper.

It is useful to develop awareness program and to integrate the use of protected lands. Pumping is necessary to protect the houses and roads of the protected basin. It is useful to avoid housing in low levels.

It is useful to organize farmers and reduce pumping costs by planned farming. Breakdown in individual pumps is a serious trouble for the engineers. Electric pumps as well as diesel pumps develop faults, which are costly. Salinity gates are not durable. Low productive lands need crop rotation to recover the cost of pumping**.** Large areas suffering with floods and salinity problems are easily cultivated with polder techniques as in Indonesia. Many areas are abandoned. Abandoned areas of drainage basins needed a farming approach to recover the cost of maintenance as well as the use of the land. Relaxing state imposed rules to safeguard tenant ownership for cultivation is a best way of renovating cultivation.

Key Words: Flood Control, Environment, Soil subsidence

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INTRODUCTION

Sri Lanka is an island with 2000mm average annual rainfall and maximum rainfall of 5500mm. Land area of 65519Mm^2 is divided into a wet zone of 22000Mm^2 by 2000mm isohyet. Heavy rainfall dropped into central mountains is drained to many reservoirs and hence it provides power in hilly areas. But in wet zone only Kelani and Walawe rivers had reservoirs. Kelani and Kukule rivers are partly dammed.

Flood control measures were done by state agencies since 1919 with the flood control ordinance empowering the Irrigation Department for prompt action. A heavy flood affected Colombo City in 1916 and the then governor realized the need for an effective control of incoming floods. Kelani flood protection scheme was commenced under Irrigation Department. Major flood bunds with lock gates were constructed. River gauging at Hanwella and a flood warning system was organized. Rain gauging and flood forecasting was planned. Temporary closure of railway and main road at Kelaniya was designed to prevent spillage over the flood bund under heavy floods.

Kalu River in Western and Sabaragamuwa Provinces is another basin, which experience heavy floods. It has a flood control project at Ratnapura. Due to its narrow passage at Ellagawa the stagnation of floods lasted many hours. This fact led to take preventive measures for the urban area in the upstream. Kalutara city is at a higher level and Horana, Matugama towns were developed at the periphery of flood basin.

Gin River in Southern Province had a traditional development with floods. People harnessed the elevated flood level for transportation. Cultivation was planned to avoid onset of floods. Necessity of flood control was finally made into action in 1976. This plan provided flood bunds with a series of pump houses and low lift pumps. Drainage basins are separated to reduce flood accumulation.

Nilwala flood protection scheme in the Southern Province was completed in 1988. This was in line with Gin basin plan. The pumps were operated by diesel engines. A section of the plan to protect Matara City is yet to complete.

Ben River, which flows to West Coast with a low-level catchment, had flood protection bunds to protect paddy areas in Dedduwa Ranthotuwila with a control gate. Also it had saltwater exclusion gates. Coastal areas had salinity exclusion works in addition to flood control. Many gates were closed to prevent high tides and opened to release fresh water to the sea.

Kothmale multi purpose reservoir in the Mahaweli basin was planned to reduce flood threat in the down stream area. Major reservoirs can reduce the flood volume and water potential can be effectively used for irrigation and power generation. The downstream control measures are cheaper than upstream reservoir controls.

Water transport methods were adopted in 1770 and it was necessary to cut canals and link with the sea. Paddy lands in the vicinity were badly affected by salinity. It is said that Muthurajawela in Western Province was badly affected by the excavation of Hamilton-Dutch canal. Fresh water is a resource, which can be harnessed by agriculture. Upstream reservoirs were constructed where possible to detain water but failing that drainage options were taken. Ancient rulers advocated reuse of water after detaining in the dry zone. Excess of water in the wet zone could not be utilized in the nature of its destructive properties.

Mitigating measures taken against floods in the ancient days were preventive and houses were not erected in the flood basin. Agricultural activities were planned to avoid high floods in most areas and only one season was used for cultivation. Temples were constructed over elevated platforms because of floods. Flood Control Ordinance in Ceylon (Sri Lanka) was passed in 1919 and the duty was assigned to Irrigation Department. Kelani flood protection scheme

using flood bunds and lock gates was constructed. People settled over the Kelani flood bunds with unauthorized houses.
Flood bunds become barriers against lateral flow from local storm water discharges. Many environmental hazards are created by flood control actions. Proper designs in hydrology and hydraulics shall make the efficient plan. Economic conditions and sustainability of the system leads to further problems in time to time.
In many cases the environmental factors are not effectively considered in controlling floods. Cost benefit analysis mainly looked at agricultural productivity. Environmental Impact Assessment (EIA) was introduced recently for water resources projects. Therefore environmental assessment for flood control projects is not widely practiced as yet in Sri Lanka. The Gin Ganga project was completed in the year 1983 and has passed a significant time period to adequately reflect the changes due to the project. Nilwala project needs further development to incorporate an upstream reservoir to control a flood of 50year return period.

GIN BASIN

Gin Ganga is a river situated in the South Western Region of Sri Lanka. It drains an area of 960Mm^2 at the sea out fall, which is Ginthota. The river is 112.5km long, with its source reaching Abbey Rock (Elevation 1293m MSL). The river drains part of Southern Province and passes Udugama, Mapalagama, Agaliya, and Baddegama, Dodangoda and flows into the sea at Ginthota. The last stretch of Mapalagama to Gintota of the river is through flat lands. During rainy season floodwater inundates the Gangaboda Pattuwa and Galle Four Gravets (Bope-Poddala, Akmimana DS Divisions) in Galle District. The disaster caused by floods menaced 6200ha of paddy lands and 33000 people living in 6000 houses and affected transportation and communication in the lower basin. Nearly 216 000 people lived in the basin and 60000 people lived in the vicinity of floods in lower basin, PDR, GRP, (1975).
The Government of Sri Lanka in 1972 invited the Government of People's Republic of China to recommend a plan to control the flooding in the river basin. Chinese Engineers designed the flood control project. The Gin Ganga Regulation Project (GRP) was completed in 1983 by the joint assistance of Chinese and Sri Lanka Governments. Irrigation Department of Sri Lanka commenced operation and maintenance work in 1983. In 1972, about 22000 people living in 4000 houses occupied the project area below Agaliya. Gin Ganga project declared an unprotected area of 2540ha with 830 houses with 4000 inhabitants. Backwater effect inundates 78ha in upstream of Agaliya. Project occupies about 225 ha of paddy lands between flood bunds on both sides of river (PDR, GRP). Project included 6200 ha of paddy lands, which is 45% of the total. Electric pumps were provided to dispose drainage water from 3188ha of paddy lands. Another 1000ha of rainfed paddy lands in the upstream sub basins were unaffected and were taken as free from high scale flooding. 1740ha of Holuwagoda basin was drained by gravity. 800ha of marshy lands were reclaimed and converted as paddy fields in Diviturai.

HIDROLOGY

Gin Ganga basin mainly experiences southwest monsoon rains and floods are usually experienced during May - June. Floods also occur during the inter-monsoon period of October - November but to a lesser degree than the May-June monsoons. Average annual flow into the sea is about 1600 million cubic meters and the mean annual rainfall is 3048mm at Neluwa-Tawalama in mid catchment. Available records show that maximum stagnation of floods was for 30 days in May 1940 with a maximum discharge of 1400cumec at Agaliya, IDGauging,

(1940). Rainfall and river stage records are available from year 1928 onwards, PDR, GRP, (1975). The Irrigation Department maintains Agaliya, Bopagoda, Ratnapura and Tawalama gauging stations. Department of Meteorology maintains Galle meteorology station. Table 1 gives average annual values of data at respective locations in the vicinity.

Tab. 1 Average Annual Values of Rainfall, Evaporation, Specific Yield of Flow, Run Off, Peak Flow, Water Quality

COMPONENT	STATION	ANNUAL VALUE	REMARKS
Rainfall	Tawalama Galle	3048mm 2380mm	1901/65 Average 1901/65 Average
Pan evaporation	Ratnapura Ratnapura	1210mm 1140mm	95/96 65/96 Average
Run off Rainfall	Tawalama Tawalama	911MCM 3580mm	Run off 95/6 Rain fall 95/96
Specific yield	Tawalama	0.68	1995/6
Volume estimated	Ginthota	1600MCM	1901-1965 average
Peak flow	Agaliya	1400cumec	Peak flow May 1940
River water quality	Wakwella	Salinity, iron	River water quality

GIN BASIN DEVELOPMENT

Gin Ganga basin is fairly well developed in agricultural pursuits. The upper reaches are planted with tea, rubber, coconut and cinnamon. Rubber predominates in the lower areas. Paddy lands are in lowland pockets, all along the river amounting to about 14,133ha, PDR, GRP, (1975). About half of paddy lands, situated in the low lands, suffer from periodical floods, ECIR, (1968). The tea plantations are said to contribute to the sediment in water currents. Paddy fields lose finer sediments. Mountains in mid basin also said to have low vegetation due to erosion. The new short rooted bud tea plantations with high foliage reduced the erosion after 1970, Soil, (1994). Low- lands in the basin are about 15% and most are paddy lands, which were concentrated in the lower basin. The cash crop plantations in high lands are about 34 % cultivated with tea, cinnamon and rubber. Domestic areas are cultivated with coconuts and vegetables. About 25 % of the basin is under jungles. Project area had 40% paddy, 20 % rubber, 10 % tea and others in the lowest section. In the upper project area 31% paddy, 30% tea, 30% rubber, 5% gardens and 4% scrubland are available, ECIR, (1968). The soil map of Sri Lanka shows red yellow podzolic soils from Udugama to Kimbi ela and red yellow podzolic soils with well-developed laterites and their drainage associates from Kimbi ela to Galle, Panabokke, (1967).

Gin Ganga flood plains possess clay deposits, which are used for pottery, brick and tile making while using the same land for paddy cultivation. Sugarcane was also cultivated in the low lands. Vegetables and green leaves are cultivated mostly near Labuduwa, Ukwatte villages.
Sand mining from the riverbed was a long time practice among the villagers. This was accelerated due to cement mortar brick production. Though bamboo plants are found along banks the erosion can be observed during high flows.

Problem of Gin Ganga flooding was considered as the first and foremost environmental hazard of the district. Government budget allocations for flood relief activities included food and lodging services for the displaced persons. Daily river flow gauging at Agaliya was commenced in 1940 by the Hydrology Division of Irrigation Department. River stage was recorded from 1928 onwards. Since then the highest flood had been the one recorded in May 1940, which amounted to 1400 cumecs. This storm was widespread in the wet zone of Sri Lanka. Heavy rainfall in the basin initially creates flooding in Mapalagama area. Then it moves down to Agaliya area in a significant stagnation due to narrowness of the section. Wakwella area is then affected by heavy flooding, which usually lasts for more than a week. People make use of boats for urgent travel and transport needs. Social and economic damages were very high as the people face enormous difficulties including loss of life and property. Schools remained closed during floods. A significant effect was the rejection of entire area for future development. Flood basins are used for paddy cultivation but fertilizer is not added due to high risk of flooding in many areas. As a result the crop is not thriving to a maximum level. Average yield is 1-2 tons/ha for paddy.

The land closer to important places like roadways, markets, schools, temples are in demand for building construction but could not be utilized solely due to flood inundation. The area produced tea, rubber, and coconut products for export market in British period but now demanding more space for village expansion due to high population. Two storied houses were constructed in flood plains to escape from wetting in ground floor. After various investigation studies, ECIR, 1968 & PDR, GRP, (1975) the plan proposed by the Government of China was executed to control the Gin Ganga flooding which was completed in year 1983. Agaliya to Mapalagama section of the basin was excluded for the final design and took as a buffer zone.

NILWALA GANGA BASIN

Nilwala river basin lies mainly in the Matara District. The river flows south and the drainage area is 975 Mm^2. The longest path of the basin begins near to Deniyaya of Gin basin. Paninkanda hill is in this basin and a solar battery rain gauge station was mounted there to transmit precipitation records directly to Matara office, which controls the flood protection in the lower basin. This was now withdrawn due to terrorist activities. The northern part of the basin is mountainous and possesses high rainfall of 3000mm annual average but the lowest point of Matara has only 1990mm. The 2000mm isohyet, which defines the limit of wet zone passes through the basin.

The basin comprises Hulanda oya, which joins at Akuressa with the Nilwala River. Kirama Ara in the left bank joins the river below Akuressa. Part of the Nilwala catchment is augmented to Urubokka oya, which drains to Tangalla. This augmentation is relieving the burden of a high flood and it feeds the Muruthawela reservoir. Part of Kirama Ara is augmented to Kirama Oya. Digili Oya and Kadawedduwa oya are left bank streams joining in the last 7mile stretch of the river.

Kirala kele is in the right bank of the basin, which is boggy and marshy and the land is in the same level with the sea. Several attempts were made to develop Kiralakele area during the last 100 years but only in 1988 the area was isolated by flood bunds and a pump house was provided to evacuate drainage water in to the river at Thudawa. A large area was separated as the unprotected area including the road from Thudawa to Bandattara. New Bridges were erected across passage of the river and the river is dredged. Old gravity drainage canals were closed.

NILWALA BASIN DEVELOPMENT

Kadawedduwa oya in the left bank was protected by flood bunds along the bank. A pump house is provided to evacuate storm water from the protected basin. This area protects 1500ha from floods. This sub basin is in arid sector and it was successful in paddy cultivation. The drought in 2001 provided necessary heat to the crop and it yielded more than 5T/ha. Kiralakele area protects 3000ha of paddylands. This Kiralakele is a big marshy area. Several canals were cut to direct the drainage water to the pump house but the water is stagnating due to low head. Area closer to the Matara city is now protected from flooding due to the flood bunds and hence the scheme was successful in the city limits. 2000ha of paddylands in the Kiralakele is now abandoned due to acidity development in exposed half bog soils.

Seasonal variation of rainfall also creates difficulties in drainage. Shortage of water in the second half of crop season becomes a major problem for farmers. The drought situation in 2001 reduced the water availability without giving a higher crop yield. They demand supply from upstream of river in to paddy tracts. This will automatically increase the pumping hours of drainage water through the pumps. To reduce the drainage volume a large gravity outlet is planned with a new gate. Acidity development is due to exposed half bog soils, which contains iron and aluminium and receives sulphate from trapped seawater and finally forms acid sulphate called jarosite. This acidic water is harmful to animals equally. Acid sulphate situation reported first time in Sri Lanka only after the creation of flood bunds in 1990. The project protected 650 houses in the protected area. It also declared an unprotected area of 2800ha. Farmers in this open land cultivate their paddylands at a risk of getting destroyed. However there is no drainage problem for them.

DISASTERS

The design of main line of Nilwala flood bunds was planned for 1969 flood level, which corresponds to 10 year return period with closer banks but the flood came in May 2003 became more serious (50year flood) and it inundated all the upstream towns and villages. Kirama Ara basin drainage reached the river at first and it overtopped the bunds and released water to Kiralakeke area. Heavy flood entered the area inundating all the paddylands. Pumping was not sufficient to remedy the situation and at two places the bunds were cut open to drain stagnant water. This breach of bunds caused damages in the protected basin. Protected areas were subjected to additional threat after 13 years and it collected dead cattle and other creatures in the highly turbid drained water, which remained at 2.5 m level when the river dropped to 1.5m after 7 days of the flood. 63 lives were lost in the Nilwala basin and only 4 persons drowned.

DISASTER IN MAY 2003

In the island 235 lives were lost in this disaster and many lives were lost due to earth slips in the residential hill slopes of Kalu basin. Ratnapura area of upper Kalu basin was badly affected by high precipitation. The sudden soil wetness, developed in the jungle bared tea lands, could not resist sliding forces of the slip circles. The rainfall, which was 338mm intensity showered in the full moon Wesak day as a result of monsoons developing in to a cyclone over the southwest corner of Sri Lanka around Ratnapura. The resulting overland flow drained along Gin Ganga, Nilwala Ganga, Kalu Ganga, Kukule Ganga, Kirama Oya, Urubokka Oya, Walawe Ganga creating excessive flow stages. The damages wiped out towns and villages destroying the infrastructure facilities of roads, telecom, houses, offices, drinking water supply, electrical

distribution network and bridges in the valleys. Displaced citizens were accounted to 150,000 families. 31 000 houses were damaged. Rescue parties safe landed 155 people who were hung on to trees. Medical attention and food was given to the needy with international aid at this hour of disaster. Gin basin recorded 16 deaths and 3 of them were in Niyagama in the unprotected area of Gin Project.
Drowned cases were more in Gin and Kalu basins due to unexpected floods in the unprotected river basins.
Overland flow filled few reservoirs in Hambanthota District including Muruthawela and Uda Walawe. Ratnapura in the north of Nilwala basin recorded 227mm rainfall in 3hours, which was the cause of major break down in communication.

Gin Ganga flood bunds were designed for 1967 flood at Agaliya. May 2003 flood was bigger than that but it was nicely controlled with in the flood bunds with the action of spreading half the volume in the mid way unprotected area of Nagoda Gonalagoda area. Sand mining has controlled bed levels below the designed levels. Timely opening of sea outfall controlled gravity drainage in Holuwagoda canal.

DISCUSSION

Flood protection in the drainage basins is the most important activity. Awareness programs can control deaths due to high flow. Skill in swimming is a necessity for people to recover the life in case of drowning. Life saving ability is needed to rescue others. Teaching classes are needed for children in the wet zone. Monsoons are receiving in May with heavy floods lasting 10 days and the people are ready to deploy timber boats for transporting. Sudden rise of water levels are due to intense precipitation, which is unexpected as in 2003, which had 50year return period. Life vests, climbing towers, hanging ropes, emergency boats are necessary for each house in the unprotected area. Villagers are keeping electronic and electric goods and books and many other valuable items in the modern society at a risk of getting wet. Rich persons possess more perishable goods than poor. Upstream reservoirs are now proposed in the wet zone to store water for future use. Trans-basin diversion is suggested for long time but due to lack of financial aid it was not realized. Stored water is used to generate power and the fresh water is an invaluable resource in the dry period. Sri Lanka drains half of wet zone water directly to the sea.
Long-term flood protection projects are maintained by Irrigation Department. In addition diversion projects supply water to paddy tracts by control gates. The gate is manually operated to close to store water for diversion. Excess water is spilled down the stream. When the devastating floods are expected due to heavy precipitation it is the practice to open all the anicut gates to prevent damage to the paddy tract. This will result in heavy floods in the down stream areas. Usually floods are coming in the middle of the cropping season. It is the duty to protect the crop. Warning signals are necessary to avoid damage. Many anicut schemes are unproductive due to lack of water, salinity, rat attack, crab damage, poor soil quality and weeds. Rekawa Lagoon is receiving low inflows and hence proposed recreational activity is reduced.

GIN BASIN PROTECTED AREAS

Electric pumps are operated to evacuate storm water during flood hours or high base flows in the river-side. 3044ha are protected successfully. Some farmers face drainage problems due to soil subsidence. Some areas are abandoned due to low base flows. Some farmers willfully do

not crop. Poor farmers abandon cropping due to economic reasons. Cattle damage paddy tracts. Canal blocks cause water-logging. Farmers assure yala and maha crops with high yields after 1983.

GIN GRAVITY DRAINAGE AREA

Holuwagoda basin 1000ha is abandoned from 1992 due to subsidence and poor drainage. Widened Kepu ela provides drainage path but it is controlled by salinity intrusion.

NILWALA PROJECT

Kadawedduwa sector is well cropped but Kiralakele 1800ha is abandoned. Poor drainage, soil subsidence, acidity development, water stress due to low base flows and lack of funds to run diesel pumps frequently, are the negative factors.

NILWALA UNPROTECTED AREA

May 2003 devastating flood has caused submergence of Hulandawa, Akuressa, Malimboda areas by 10m. Residents never expected this height of flood lift as they were living for the last century. Residents feel that damaging Kiralakele protected basin by cutting bunds is a measure to reduce floods as it happened before 1990. Three times they tried to cut flood bunds. This property damage can be avoided by a proposed Bingamara reservoir in the upstream of the project. Inundated lands will be compensated. Storing valuable freshwater is useful for 4500ha paddylands and providing drinking water to Matara and to generate power. Part of Kiralakele marshes also can be used for a storage tank. Residents in unprotected area oppose replacement for a tank bed but at last they drowned by heavy floods. Digili oya tank is proposed as it has low inundations of villages.

SOCIAL ISSUES

A. Land Issues

Galle paddy landowner gets 20% crop yield but Matara owner gets 50% as the yield was high in Matara. In 1958 Paddy lands act reserved the tenant ownership and owner got only 25% of the crop yield. This is a benefit to the Matara tenant. But the aim of the act was to improve productivity. Some landowners dropped the possibility of tenant farming. In the Agrarian services act the commissioner has the power to allocate barren lands to tenants for a definite period. Shortage of base flows damage the running crop but as a result further increase in land use cannot be guaranteed. Banana introduction is also considered for some areas. Cattle damage is not prevented. Cattle owners live in the same village. Acid water is harmful to cattle. Low income from paddy is due to rising cost of labour, machinery, fertilizer and chemicals. Cheap rice is imported from India. Younger generation is not willing to continue farming as the diseases like lepto-spirosis is spreading. Wet zone crop yield is around 2T/ha where as dry zone gets 6T/ha. This is due to high bushing in the plant with more heat. Water stress and iron toxicity reduces yield. Yield was good after flood controlling for five years. Soil nourishment was reduced after flood control Seneviratne, (2000).

B. Polder development

Abandoned drainage basins are fairly large in size. Holuwagoda and Kiralakele are protected areas of 2500ha size. Large areas are best to fight insects, pests and weeds but inundation and

low water conditions damage the area. Hence poldering smaller areas using a small pump to evacuate excess water, is a better solution. A ring of bunds can protect the area with a surrounding canal to drain storm water. Such areas can be cropped with rice, reeds and banana. Reeds withstand salinity in coastal areas.

Lack of funds for repair of existing structures and machinery is a reason for failure of maintenance. Diesel pumps in Nilwala very often damage due to wear and tear. Life span of a machine expires needing new machines. But there is no replacement. Diesel is a fuel imported at a rising cost.

FARMER ORGANIZATIONS

Branch canals of all schemes are controlled by farmer organizations. Many farmers reside closer to the tracts but as the lands are not profitable to sustain a living, farmers migrate to towns and Colombo city to get better facility and opportunities. Farmers need incentives to continue cropping. Timing of land preparation and seed broadcasting is very important in saving water. Any farmer who delays land preparation needs more time at the end of the season and hence requests more water or more pumping hours. Hence control activities in pumping are dependent on farmers. At the same time houses constructed near the pump houses are frequently subjected to inundation. They always request pumping, which is costly and could be avoided. Construction of houses near low water line has to be prohibited. Maintenance of drainage canals with the help of farmers shall be done annually. If it is neglected poor drainage is the ultimate result. At present drainage canals are the responsibility of farmers.

CONCLUSION

1. Rejuvenation of drainage activity needs sustainability of flood control activities. Kelani, Gin, Nilwala projects need continuous-financing as they are already maintained. It is the duty of the farmer and the state to attend to day to day maintenance needs to make the task simpler without allowing it to aggravate into a big problem.
2. Unprotected areas are highly populated and hence needed preventive measures. Possible storage tanks are necessary to store water for future use and for possible augmentation. The body of a drowned person reaches the sea if there is no reservoir in the way. This is very harmful and many lives can be recovered otherwise. Tanks can solve wet zone problems of low fresh water in dry spells for drinking and agriculture. Rubber dams are some times useful in low elevations.
3. Unused lands can be used as storage tanks. Kiralakele acidity development can be reduced by a new tank storage.
4. Farmer organizations need to integrate to increase cropping intensity and reduce cropping time to reduce pumping hours. Early farming practice reduces damage to the crop.
5. Legislation changes are necessary to encourage landowners for farming.
6. Crop rotation and using high yielding varieties are suggested.
7. Electric pumps are better than diesel pumps. Nilwala pumps need conversion to electricity. Additional pumps are needed to Kiralakele and Holuwagoda to avoid water-logging. Polder development can be introduced to abandoned areas.
8. Awareness programs are necessary to train swimming and life saving. Boats have to be ready in all villages. Life vests are needed for every house.

9. Augmentation of rivers to send excess water to dry areas is necessary. Upstream reservoirs satisfy the need of drinking water and irrigation. Reuse of brown water drained to sea from reservoir projects can be used by pumping in to another tank.

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