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Vision hidden behind the Design Features of Sri Lankan Ancient Irrigation Engineering Technology

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Abstract: Due to recent climatic changes taking place at global level, world is now heading for a disaster environmentally, unless some kind of a middle path is adapted in economic planning of future development projects. How to define a middle path in relation to economic development is a research need. Conventional Middle path is a person specific point of view and therefore the middle varies from person to person, from nation to nation and even politically within a nation. However the middle path meant in Buddhism for development is universal and common to all the living beings. Though the Buddhist middle path is conventionally explained in relation to spiritual development, material development focusing physical health is also stressed as a necessary pre-requisite for spiritual achievements. In order to understand this universally common middle path applicable to both spiritual and material development, design features of projects already implemented by the planners equipped with Buddhist Vision in its right spirit, could be used as an exploration ground. Irrigation Projects which have been sustained more than 2000 years and still functioning in some parts of Sri Lanka, designed using the AIT, is the best entry point for that exploration. This is also a timely need because the projects developed during the last century using Modern Irrigation Technologies (MIT) in Sri Lanka have already failed due to reasons such as water and soil pollution, human elephant conflicts and never ending dependency of farmers for fertilizer subsidies etc. In the proposed exploration, modern tools such as circular economic models as well as Buddhist guidelines related to ecosystems management for food production would be used to analyse the visions behind AIT which contributed to that long term sustainability. Recently introduced management effort known as Water Quota (WQ) to partially simulate outcomes of AIT by decentralising management aspects of canal networks designed using MIT, is also discussed.

Key Words: Cascade, Ecosystem, Middle Path, Ancient Irrigation Technology (AIT), Modern Irrigation Technology (MIT), Circular Economic Theory, Water Quota (WQ), Volumetric Impression.

1. Introduction

Production of healthy foods while assuring clean drinking water without any social and environmental conflicts was the basic vision of the Ancient Irrigation Technology (AIT). Whereas the vision behind the Modern Irrigation Technology (MIT) is to maximise mainly the individual Financial Gains of the end users, the human beings, by confronting with eco-system. In MIT, human being has also been assumed as the unbeatable species having a capacity to ignore the rest of the Flora and Fauna while confronting with the ecosystem to produce foods. Instead of confronting, the AIT had adapted a negotiation mode with the ecosystem in producing foods which were naturally healthy.

In reality, the Human Being is only a link among others in natural Ecological Cycle comprising of the rest of flora and fauna. Only difference is that the human species have the capacity to break it if they wish to do so. However, if one link of the cycle breaks, it is only matter of time to destabilize human In formulating the designs based on AIT, guaranteeing the right of existence of the rest of Fauna and Flora other than human had been perceived as long term vision. However, recently efforts have been made to respect other ecological components in the designs adapted in MIT, using tools such Environmental Impact Assessments (EIAs) before launching new projects. For an example, in those EIAs, fragmenting the eco systems into Farming/Human Settlement areas, Forest/Wild Life reserves, Elephant Corridors etc. using artificial boundaries are proposed as solutions. However, the assessing ultimate outcome of those projects in terms of financial gains of the human link, ignoring the impact on total ecosystems as a whole, still exists as the deep rooted vision of the MIT.

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1.1 Present situation

If one carefully observes with an open mind, the plight of large irrigation systems developed during the last century in the dry zone of Sri Lanka, it becomes obvious that the final outcomes of MIT have pathetically failed [1]. For an example, over the past 2 to 3 decades, about 23,000 main beneficiaries of irrigation projects of the Dry Zone of Sri Lanka have died and an estimated 69,000 have been diagnosed with water related Chronic Kidney Disease [2]. Since a death represents not just the loss of a loved one, but also often the loss of a family's main breadwinner, the consequences go beyond personal tragedy; families left in financial ruin, younger generation has been forced to give up farming. Rising crime rates is the natural result of this situation. Never ending Human Elephant Conflicts and never ending dependency of farmers on fertilizer subsidies to justify the feasibility of farming as a livelihood are other pathetic issues. For an example,, the financial provision made by the Government for the fertilizer subsidies amounted to Rs.2, 333,883 million or 1% of the total Government expenditure by the year 2016.[3]. In other words the beneficiaries of projects developed during last century using modern land use patterns adapted in MIT for agriculture are now living at the expense of the Tax Payers of the rest of the country.

Now we cannot revert back to original land use pattern which was in existence before this century, because it is now too late. However, at least as a partial solution, an effort could be made for a paradigm shift in management aspects of already "developed" large scale irrigation systems constructed superimposing the existing Ancient Systems.

Main purpose of this paper is to introduce such management paradigm shift by analysing the basic vision behind Ancient Design which had been based on a Middle Path approach influenced by Buddhist Philosophy which was in existence from ancient time in Sri Lanka. Recently evolved development approaches at global level, such as Circular Economics [13] and the recommendations of United Nation Department of Economic and Social Affairs {17) also would be used in this effort.

2. Literature Review

Using eco system to produce foods in a negotiation mode with community participation can be achieved by decentralizing the management aspects of the canals designed using MIT. It was tried since 1988 in newly developed Mahaweli Areas [8, 9, and 10]. In 2000 those efforts were introduced in more systematic manner in System H of the Mahaweli Project under a World Bank funded Project called Mahaweli Restructuring and Rehabilitation Project (MRRP). Under the MRRP, a water management approach called Water Quota (WQ) was introduced to decentralize the operation of the Main Canals fed by the Kalawewa. In Mahaweli Systems these groups are called Distributary Canal Famer Organizations (DCFOs). There are about 60 such DCFOs in System H. Organizing farmers into medium level farmer groups similar to ancient villages was a natural result of that decentralization. In fact Villages of the Ancient Design are organizationally similar to those DCFOs. Only difference is that the Ancient Villagers had Stationary Water Bodies called Village Tanks and modern DCFOs have dynamic water bodies called Distributray Canals. In WQ approach, each DCFO were allocated a water volume in bulk or a quota at the beginning of cultivation seasons thereby equipping them with a Volumetric Impression about seasonal water availability to their individual command areas under the each Distributary Canal. Main Canal operation staff issues water flexibly according to demands of each DCFO ("On Demand" basis) and regularly updates the balance available in their quota for the rest of the cultivation season.

2.1Benefits of WQ Management approach

In conventional management approach, water is issued from the Main Canal according to pre-determined time tables. However in WQ approach water is made available "On Demand" basis similar to other public services like Drinking Water, Electricity etc., not at individual farmer level but to a group of farmers at DCFO levels. As a result of the WQ approach, agriculture productivity of lands where it was tried for the first time in System H of Mahaweli Project was improved by 30% while increasing farmer income by 36%. Cropping intensity was also increased up to 165% [5]. In 2002, WQ approach was recognized by the World Bank as the best water management approach suitable for South Asian Countries [4]. A technical paper published in IESL in 2004 highlighting the benefit of the new approach won the first prize in a competition conducted by International Water Management Institute. [6]. Latter in 2014, a program was

launched by ICTA to promote modern communication technologies such as SMS to create closed links between Main Canal Operation Staff and DCFO leaders to facilitate water availability flexibly as expected under WQ approach.[19] more reliably.

However irrespective of all these positive outcomes, WQ approach was not sustained as expected in some areas after retirement of the staff as well as the Farmer Leaders who were familiar with the WQ approach. According to an evaluation done by JICA [18] in 2011 in Uda Walawe area and recent studies done in System H [7], main reason behind this unsustainability is the lack of a vision about WQ approach among top management levels in irrigation sector.

One of the main purposes of this Technical Paper is formulation of a strategy for such Management Paradigm Shift through a vision change at national level using Ancient Village Tank Design as a tool. It is also expected that recent trends of various international funding source in promoting Ancient Tank Cascade approaches would also support this effort.

3. Comparison of the Land Use patterns adapted in AIT and MIT

Philosophy adapted in AIT which is a paradigm entirely different from the modern approach, can be illustrated using actual historical monuments in Major Irrigation Projects in the Dry Zone such as Kalawewa. Before Kalawewa Reservoir was built in the 5th century AD, the irrigable areas bordering Kala Oya was fed from small diversions across the river and by village tanks harvesting local rain falls. Latter Kalawewa Reservoir feeding the Yoada Ela was built by a King called Dhatusena by introducing a dam across Kala Oya. As a result, additional water became available for the village tanks in downstream areas bordering Yoda Ela. In addition, the Yoda Ela which is about 51 KM long also supplied water to Major City Tanks in Anuradhapura. When additional water became available from Kalawewa, what ancient designers did was increase the cropping intensity in lands irrigated by Village Tanks located along valleys crossing the routes of the Yoda Ela. (Fig.1). There were about 60 such village tanks located in valleys below the ancient Yoda Ela. Buddhist temples were also an essential in built feature of each Villages established under those tanks.

Grass grown in lands abandoned in the forest after Chena cultivation also had been ideal feeding ground for animal As a result of this type of land use practice, there were no conflicts between Elephants and the Human as experiencing today.

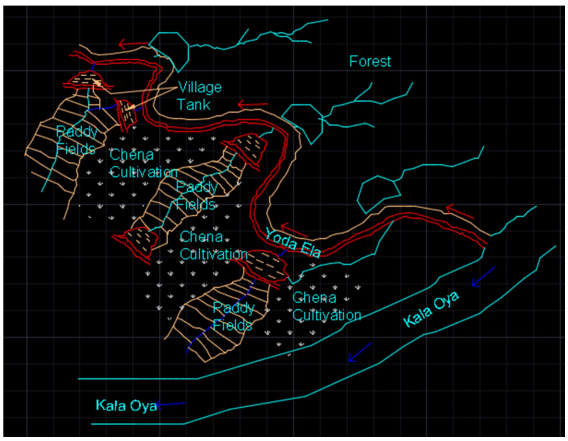

Fig 1: Land Use Design using AIT

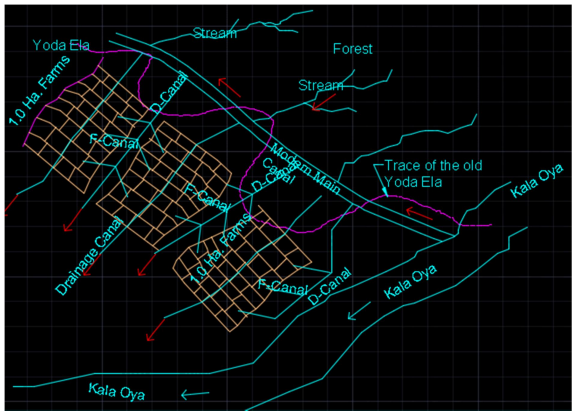

Fig 2: Land Use Design using MIT

In that design, rice was the main crops grown in valleys and protein rich foods were grown using a cultivation method called Chena in upland areas in between the valleys. Chena in its true spirit was an environmentally friendly cultivation method practiced without disturbing the soil and the forest covers beyond recovery. Special rain water harvesting tanks were also introduced within the forest areas to replenish ground water acquirer by harvesting local rains. Therefore, as a result of adaptation of AIT, whole of downstream areas had been transformed to an ecofriendly wet zone fed by Village Tanks rather than to a monotonous agriculture landscape fed by canals networks laid according to MIT. Ancient Village tanks also played the role of artificial Wetlands purifying water. In ancient design, there were no artificial boundaries fragmenting natural eco systems as recommended by EIAs of MIT.

In modern approach promoted by MIT, the Yoda Ela running along a contour was straightened to a sloping main canal and whole downstream irrigable area was transformed to a monotonous irrigated agriculture zone as shown in Fig 2. Main objective of MIT is to distribute water uniformly in maximum possible area. For that, the existing Village Tanks located in valleys were removed and a Canal network comprising of Distributary Canals originating from the Main Canal and Field Canals was introduced to spread water in downstream farming areas. Then the human settlement and farming areas are separated from rest of the eco system by fencing etc. according to guidelines recommended by EIAs.

3.1 Middle Path features of AIT

In contrast to approaches adapted by MIT, the AIT had assumed a middle path in dealing with local ecosystem to produce foods. Rather than confronting with eco systems by actions such as artificial fencing and wholesale clearing the forests for monotonous crop cultivation, AIT made a deal with the nature. Basic philosophy of development approaches adapted in ancient Sri Lanka was Buddhism which promotes the compassion towards living beings. As a result, the outcome of AIT was a win win situation for both Man Kind and Rest of the eco-system.

Also conflicts were not created like water scarcities at tail ends of the canals designed using MIT. According to MIT, famers should form organizations called Distributary Canal Organizations to share water in Secondary Level Canals. Those DCFOs are in fact similar to ancient villages but the water source (Canal) is dynamic. In ancient villages water source (Village Tank) is static. On the other hand ancient villagers had a Volumetric Impression about availability of their main water source visually. Such a design naturally promotes the cohesiveness among farmers using the Village Tank as the nucleus.

In AIT approach, promotion of the spirituality within the society also has been considered as an important need. That is why a Buddhist and Hindu Temple was also an essential component in built with each Village Tank in the ancient design. In the middle path approach applicable to food production according to Buddhist philosophy, health was considered as the ultimate profit and the mental happiness of the community was considered as the supreme wealth generated, from any development project [15]. In addition to solid tangible foods, Buddhists also believe in different kind of intangible mental foods which are also necessary for the existence of living beings [14]. Temples played the advisory role to control the quality of those mental foods thereby strengthening the cohesiveness and happiness among villagers. Therefore villagers, as their social responsibility treated monks as their best advisors [15] and maintained their livelihood by providing shelter and donating foods.

4. Circular Economics

According to recent studies, for every dollar spent on food, society pays two dollars in health, environmental, and economic costs. Half these costs – totalling USD 5.7 trillion each year globally – are due to the way food is produced [12]. The extractive, wasteful, and polluting nature of current food production costs the society as much as all costs related to food consumption such as obesity and malnutrition. These USD 5.7 trillion costs are a direct result of the 'linear' nature of modern food production, which extracts finite resources which is polluting, and harms natural systems. These USD 5.7 trillion costs are a direct result of the 'linear' nature of modern food production, which extracts finite resources which is polluting, and harms natural systems. Currently there is trend to divert to Recycling Economy to minimise wastes. However the recycling costs of some wastes such as Hospital. Wastes are very expensive. It is a big business in modern world. As a result developing countries are gradually becoming cheap dumping grounds for those expensive wastes as happened recently in Sri Lanka

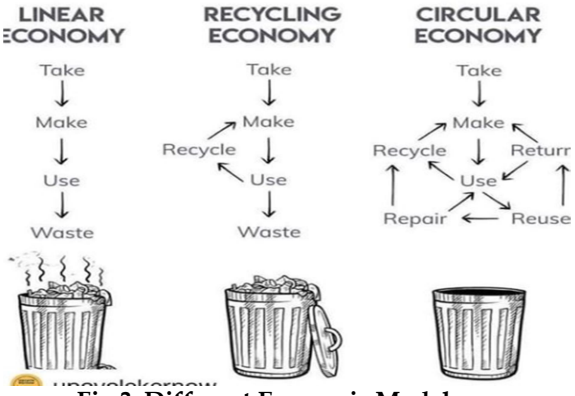

Fig 3: Different Economic Models

Circular Economy in the above sketch is a new approach yet to be adapted globally to address this issue. In the proposed exploration, circular economic models could also be used to analyse

the middle path vision behind AIT which contributed to its long term sustainability.

4.1 Basic Principles of Circular Economics [13]

1. A true circular economy is zero waste. Nothing is thrown away, because waste is designed out by making things for repair, disassembly and reuse.
2. Customers are no longer consumers, but users.
3. Things must be one or the other so that everything can be either reused or put back into nature. More complex objects should be designed to be dismantled so that they can be sorted into those two categories at the end of their lives
4. If this industrial cycle is to be sustainable, then the resource that powers it needs to be entirely renewable.

5 Qualities of outcome of AIT in resonance with Circular Economics

5.1 Guaranteeing Safety for Flora and Fauna within the agriculture landscape

In negotiation mode practiced under AIT in dealing with eco-systems to produce healthy foods, the compassion towards all the flora and fauna as promoted by Buddhism was a hidden vision. There is no such vision behind MIT. In AIT, human beings were treated only as users of natural resources and not consumers as promoted by MIT.

5.2 Guaranteeing a healthy food plate

Land used designs adapted by AIT produced not only rice under irrigated conditions but various other nourishing food varieties generating from numerous assets of the landscapes, such as fruits, medicinal plants, Bee honey and fish.. The consequences of the newly created monotonous landscape in modern design consisting mainly paddy are well reflected by the present day to day meal plate of our farmers, as shown in Fig 4.

In agronomic practices promoted by AIT, there was no need to apply agrochemicals as fertilizers because the Eco System within the Soil itself functions as an Organic Fertilizer Factory. In that factory, earthworms play the role of labour, free of charge for fertilizer production. However in modern approach, earthworms have extinct because of chemical fertilizer.

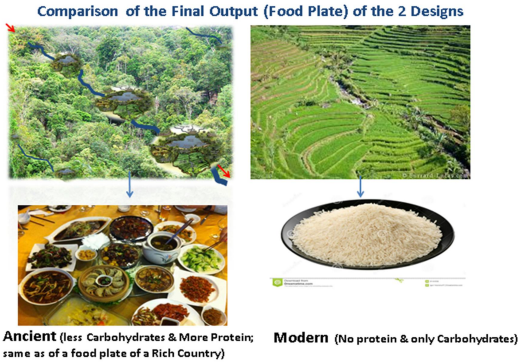

Fig 4: Comparison of quality of the Food Plates produced using AIT and MIT

As a result of the ground water aquifer also get polluted beyond use creating situations where the farmers have to pay for drinking water as shown in Fig 5 while ancient famers enjoyed clean drinking water directly from wells

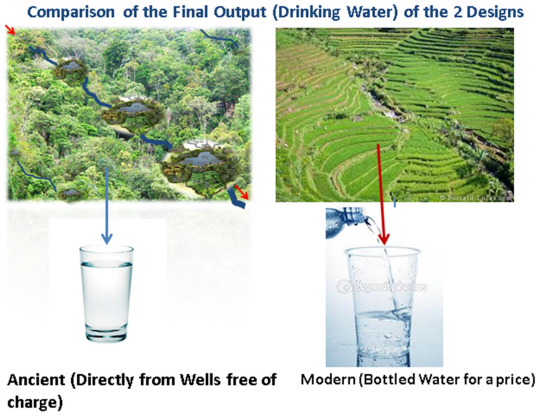

Fig 5: Comparison of the impact on quality of water due to adaptation of AIT and MIT

In the AIT approach, nothing is thrown away, because waste is designed out by making things for reuse.

5.3 Guaranteeing the sustainability in natural resource base

Water resource in the world is not depleted. It is not gone out of atmospheric space. Issue is that it is not available just where it is needed. This is because of the lack of capability of holding the locally available rain water for the rest of the year. Minimum organic content of the soil to retain water should be at least 2%. However presently it is only 0.05% in 25% of the land area of Indian subcontinent. Hidden reason behind the incapability of the soil to retain water is the removal of forest cover because of unplanned human interventions in catchment areas of water bodies and streams.

AIT addressed this issue by introducing Village Tanks to capture local runoff water which otherwise loss where and when it is needed. Also the Forest cover in catchment areas of those tanks was not disturbed beyond recovery while practicing Chena cultivation producing protein rich foods, according to agriculture practices promoted in AIT.

5.4 Guaranteeing the long term sustainability for newly introduced infrastructure

Circular economics treat human beings as only one user of the ecosystem rather than main consumer as assumed in conventional economic approaches. For an example, in the user mode adopted in ancient time, even the materials used for housings had been biodegradable and therefore recyclable. It was not due to lack of technical skills. Bricks and Tiles made by burning soil beyond recovery had been allowed to use specifically for temples construction only. Though cement was in existence, it was not used to build structures such as irrigation tanks. All water storage facilities including major dams were built only with earth because earth dams naturally become a part of the nature. Another noteworthy engineering feature of the AIT is that the need for hard concrete structures to control water flows along water conveyances was minimum. For an example, the Ancient Main Canals called Yoda Ela functioned as an elongated shape water tank known as Level Top Canal (LTC) in modern terminology. LTC running along a contour automatically stores water when there is no downstream irrigation demand from it. Therefore its management was fully decentralised. Natural streams crossing its path were used to convey water from LTCs to Village Tanks constructed as a chain called cascade along those streams. In such water conveying system, the concrete structures such as Regulators and Drops across the water conveyances are not needed. Logic behind this ancient vision was that the communities emerged after construction of new projects should not be allowed to depend on infrastructure subjected to decay with time. In modern systems, rehabilitation of structures and manmade canals is necessity at least for every 25 years.

5.5 Guaranteeing a Conflict Free O&M

Because of Village Tanks, water management had been decentralized to village levels. For an example there are about 60 such decentralized management units (Tank, Village and Temple) along Kalawewa Yoda Ela along its 51 KM route. In managing water, each Village enjoyed the availability of water in bulk from Yoda Ela independently. Yoda Ela itself was an elongated canal with very mild slope or in other words was an elongated shape water storage tank. As a result farmers were fully aware of available volume of water for the season. There were no head and tail end conflicts among farmers as very commonly encountered in sloping main canals designed according to MIT. Because of its sloping nature, the operation of the Main Canal designed based on MIT is fully centralized and farmers have to depend on rigid time tables decided by Main Canal Operator to receive water at their farm gate. Because the main water source is located far away from farms there is no any kind of Volumetric Impression about water availability among farmers during the cultivation periods. On the other hand the Volumetric Impression about the availability of water is inbuilt in Village Tank systems naturally encouraging farmers to save water and maintain the tank and its infrastructure voluntarily as a group. This group is called Village. However in contrast, in modern systems, the government authority has to force the farmers to do the maintenance of canals or else charge a fee.

5.6 Role of the professionals

Professionals who designed irrigation systems according to AIT delivered their services as professional farmers rather than subject matter specialists. There were no professionals technocrats of AIT, having academic qualifications as now days. According to the vision of AIT, irrigated agriculture is a combination of an Art and Science guaranteeing healthy foods for human being, in negotiation with the eco-system. Skills and knowledge related to AIT were transferred from generation to generation through village leaders. However this vision has now been pathetically changed as a result of perceiving the farming as a business according to the designs generated from MIT. As a result of this misconception, hidden links are being emerged even between Food Industry and Pharmaceutical business. There is tendency of transforming even the professionals responsible for health sector into agents of companies which promote genetically modified high yielding crops requiring chemical fertilizers. For an example, presently 3 international companies [16] control 60% of the shares globally in Insecticide and pesticide market. At the same time they also sell the drugs for

diseases like cancer which is caused by insecticides and fertilizers such as Glycophosphate which destroys biodiversity in agriculture landscapes. As a result, in times to come, the farms developed using MIT might transform to gambling places of those international companies to earn profit using the ecology of the country and health of local farmers as their bets. Therefore there is a need to equip professional involved in irrigation sector with knowledge related to ecological issues taking place at global level.

6. Proposed Solution to simulate the outcomes of AIT using designs features adapted by MIT

Middle Path adapted in AIT is a different paradigm from modern approach in irrigation sector. It is similar to difference between ancient medical systems in health sector called Ayurweda and the modern Western medicine. However it is possible to combine any two paradigms. For an example, in the case of medicine, recently developed Medical Engineering is used by Ayurwedic Doctors to diagonise various illnesses in order to recommend the right Ayurveda Medicines [20]. In the case of Irrigation sector also recently introduced water management approaches such as Water Quota (WQ) explained in Para 2.1 could be made more user friendly in efforts to simulate the outcomes of AIT, using modern Canal Automation methods adapted in MIT. In parallel to those efforts, recently proposed recommendations of agencies such as United Nation Department of Economic and Social Affairs [17] could also be used to strengthen the links between two paradigms. Those guidelines relevant to Irrigation Sector in Sri Lanka are as follows.

- **Organized small and medium farmers:** WQ was introduced with the objective of decentralizing water availability "On Demand" basis to group of farmers about 300 under each distributary canals in large scale irrigation projects. Those organizations, called Distributary Canal Organizations (DCFOs), could play a role of medium scale farmer groups. Those groups enjoying the newly introduced WQ facility guarantee the water availability "On Demand" basis. As a result they could negotiate with private sector more confidentially for joint venture agro business because they have volume based water rights also in addition to area based land rights.
- **Define goal on human nutrition rather than more production:** Performance of each Farm Units could be monitored in relation to their productivity while guaranteeing the healthiness of ecosystem in agriculture landscape. For an example Organic Farming with the participation of private sector companies having proper market channels with cities become a possibility for Farmer Organizations. This potential automatically promotes the ecofriendly cultivation in large scale irrigation projects.
- **Insist on transparency in measuring result:**

As a result of WQ approach farmers become constantly aware the availability of water on a volume basis and all the measurements while managing water would be done by officials responsible for managing the Main Canals in large scale irrigation projects jointly with DCFOs. Under WQ approach both parties become manageably responsible for each other on quantitative basis. The Volumetric Awareness created due to WQ approach would also be very useful in tackling conflicts situations on water rights arise between Farmers and other stakeholders such as Water Board, Electricity Boards etc. This awareness is also very relevant in sharing water during water scarcity periods especially because of lack of clearly defined Water Policy in Sri Lanka.

- **Motivate and Reward:**

When farmers are equipped with Volumetric Impression about their water rights in addition to land rights, younger generations naturally get motivated to do agriculture. Also the Performance levels of Managers who manage irrigation systems (For an example Block Managers in the case of Mahaweli System) could be measured because each Manager can be allocated a fixed volume of water for the cultivation season. Therefore their management efficiencies could be measured based on Rs earned for the country per unit volume of water, thereby creating an opportunity to introduce performance based incentives system for them.

7. Summary

In adapting Modern Irrigation Technology (MIT) for designing large scale irrigation projects in Sri Lanka, existing land use pattern of ancient irrigation systems in the Dry Zone of Sri Lanka has been damaged to a cetain extent. This is due to the lack of the vision as explined above about the design approaches adapted in Ancient Irrigation Technology (AIT). At the

same time, country is now heading for an environmentally unsustainable situation due to recent climatic changes taking place at global level. Therefore there is a critical need to explore alternatives in planning and managing modern development projects. Vision behind the designs adapted for projects using Ancient Irrigation Technology (AIT) which have sustained more than 2000 years and still functioning could be used as exploration ground to find such alternative.

One noteworthy management feature of Dry Zone Ancient Village tank systems was that it had provided a Volumetric Impression among users on continuous basis about the limitation of water availability for their day today use for agriculture as well as for domestic use. This impression motivated the users to save water both quantitatively as well as qualitatively by protecting associated eco systems. Recently introduced water management approach called Water Quota (WQ) is a similar effort to introduce Volumetric Impression among farmers in areas developed by Mahaweli Authority using MIT. Though it is not a carbon copy of AIT, it was observed that WQ management approach also motivated the farmers to save water as a group by maintaining canal network voluntarily and by adapting proper on farm rain water harvesting methods. As a result of the WQ approach, cropping intensity was also increased up to 165% [5].

8. Conclusions

Land use designs which had promoted by MIT is a crabon copy of large scale irrigation projects in countries like US. Productivity of most of those farms dedpend on chemical fertilizers. On the other hand the land use design adapted by AIT promoted eco friendly organic agriculture.. At the same time, theere is a need to promote Organic Agricuture specially in view of recently emerged health issues in Sri Lanka. For an example, over the past 2 to 3 decades, an estimated 69,000 people in agriculture areas in the Dry Zone have been diagnosed with water related Chronic Kidney Disease [2]. However, now we cannot revert back to original land use pattern adapted by the AIT, because the farmers are already settled for decades in newly developed areas. However at least a paradigm shift in management aspects of already developed large scale irrigation system could be introduced as a strategy to simulate the outcome of AIT to a cetain extent Recently introduced WQ approach sucessfully adapted in some Mahaweli Areas, is a possible option for a such management paradigm shift. In parallel to this effort, recommendations of United Nation Department of Economic and Social Affairs promoting organic agriculture. also could be implemented while using principles of recently introduced circular economic theories to gurantee long term sustainability in using natural resources for development works.

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