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IMPORTANCE OF AQUA-TERRESTRIAL ECOSYSTEM AND DEVELOPMENT OF AN IFS MODULE IN WATER MONITORING, PRODUCTIVITY AND SUSTAINABILITY

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ABSTRACT

Water is one of the integral and key inputs of natural resources, endowed in India with a rich and vast bio-diversity. The quantity of water in the earth is fixed; only the form is changing time to time through different ways and means, amounting to about 1,384 million km^3, while, in India it is about 400 mham, should be conserved and used in a sustainable manner for its generations. Through project sources, suitable IFS (Integrated Farming System) model was developed utilizing aqua-terrestrial ecosystem through some need-based renovation programmes at farmer's level with the aim of developing multi-purpose production system in the regions. It created and facilitated for conserving runoff water during wet months, utilized properly through integration of "rice-cum-fish culture-cum-vegetables" for enhancing total productivity and livelihood development of rural farming community as well. In lands, plants (especially cocoanut on bunds or boarders), which produces from 4-5th year onwards, other trees plantation developed, especially on boarder areas, which will be valuable approximately after 25-30 years, and over all, utilized water of watershed basins as live-saving irrigation to adjacent arable crops done suitably and precisely. This system approach was economically viable, even to the resource-poor fish-farm families, exhibited >2.5 folds and it gained at its viable level of the regions. However, it needs more study and developing awareness for its sustainability.

Keywords: Water resources & utilization, aqua-terrestrial ecosystem, IFS model, crop-fish-vegetable/other plantations, economic stability and rural sustainability

INTRODUCTION

Water and its characteristics

The word 'water' has derived from the Latin word *'aqua'* and anything, which is associated with or growing or living in or near water, characteristically prevails aquatic in nature or otherwise any living or biological entity contents water, may be little or more. Water is the key and inseparable primary input that occurs on the earth in all three states, viz. (i). liquid (moisture), (ii). solid and (iii). gaseous (vapour) in various degrees of motion. Virtually, our country is endowed with vast natural resources in terms of land, water and bio-diversity.

Sources of water

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Truly precipitation is the prime source of water in the world. However, the nature gift us lot of water through many ways like rivers, dams, lakes, waterfalls, streams, rains and ground water. We, the people visualizing physically water in the different places, where it is in the form of stored for future use. Out of total rainfall, we are using only 10% water in a calendar year monsoon, which is a natural gift to the country with great diversity, and rest water flows to the river and to various others water resources. For the conception in depth, we can divide it into 3 main heads, as (1). Mountain water, (2). Land water and (3). Ocean water

Global water cycle

As per the Illustrated Oxford Dictionary (1998) - "The circulation of water between the surface of the earth and its atmosphere is driven by energy from the sun. Water vapour is lost from seas, rivers and lakes by evaporation and from plants by transpiration. The rising vapour cools and condenses into droplets of water, which forms clouds. Carried by the wind, clouds continue to absorb water until saturated, when the water droplets falls as rain, hail or snow (precipitation). In this way water is redistributed around the planet". The quantity of water in the earth is fixed; only the form is changed time to time in its natural consequences through its different ways including natural calamities (Fig. 1).

Quantity of Water

World scenario

Water is the key and integral input of the world, which is the most abundant compound of all living organisms. More than 70 per cent of the earth's surface is covered with water. The total resources of the earth in solid, liquid and gaseous forms are presented in Table 1. The total water resources of the earth are about 1,384 million km^3. About 97.16 per cent of total water in the world occurs in the oceans as salt water. Only 2.60 per cent is fresh water. The water in the oceans has a salt content over 3 per cent and is not fit for direct use by humans, many plants, livestock's or in the industry. High costs, high-energy requirements and associated environmental degradation limit the possibility of mass desalinization except small quantities for domestic use. Even in the near future, there is no possibility to extract economically large quantities of fresh water from the seas (Reddy and Reddy, 1997).

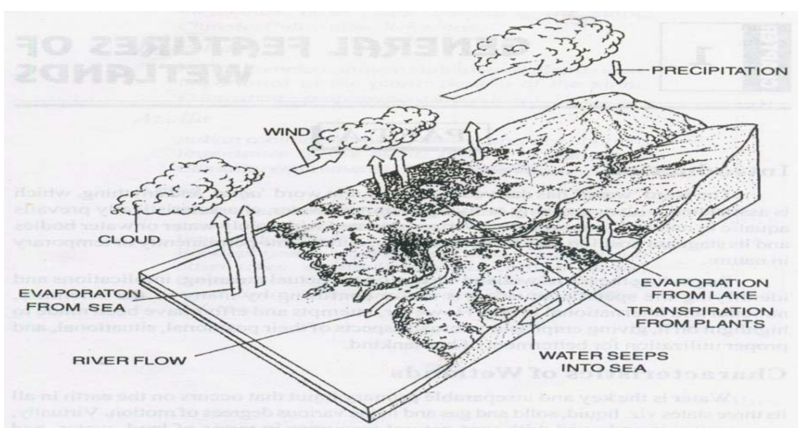

Fig.1. Global water cycle

Table 1. Water resources of the earth in solid, liquid and gaseous form

Resources	Form	Quality	Volume	Percent of total

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			('000 km³)	
Oceans	Liquid	sl	1,348,000	97.16
Polar ice caps, ice-bergs and glaciers	Solid	f	27,820	2.01
Ground water and soil moisture	Liquid	f	8,062	0.58
Lakes and rivers	Liquid	f	125	0.009
Lakes and rivers	Liquid	sl	100	0.007
Atmosphere	Gas	f	13	0.0009
Total			1,384,120	100.00

Sl : salt water, f : fresh water, Source: Baugartner and Reichel (1975)

Water resources of India

India is blessed with a good amount of rainfall receiving in a given year. But these is a great variation in regional distribution of rainfall from <100 mm in extreme arid part of western Rajasthan to highest rainfall regional region (>10,000 mm per annum) in Cherrapunji and adjoining *Khasi* hills of Assam and Meghalaya in the country (Table 2). However, on the basis of availability of annual rainfall in an area, the regions may be classified accordingly –

Table 2. Based on the availability of rainfall the zone/ region / area may be divided broadly

Sl. No.	Regions	% of cultivated area	Rainfall received mm/annum
1.	Arid	25	<250
2.	Semi arid	30	250-500
3.	Sub-humid	20	500-1000
4.	Humid	11	1000-1500
5.	Wet	9	1500-2000
6.	Very wet	5	>2000

However, on an average the country's annual rainfall is about 1194.0 mm or round about 1200 mm, which amounting or quantity (volume) of 400 million hectare meter (m ha m). Actually, we can estimate the total volume or quantity of rainfall that carries in the different resources, source in the country etc. based on this average rainfall value :- There are two types of estimation ---

1st Method of estimation :

i) The country's annual rainfall is about 1194 mm. The country's geographical area is 329 million ha

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Therefore, total rainfall in India = 1194 mm x 328 m ha

= 391632 million ha mm

= 391.632 m ha m or 392 m ha m

This may be rounded off 400 m ha m including snowfall.

ii) **2nd Method of estimation :**

Generally our rainy months occurred 4 months in a year, staring from June to September. Our Bay of Bengal of Bengal branch of monsoon current carries moisture about amounting to 770 m ha m and Arabian Sea branch monsoon current carries about 340 m ha m. So, total monsoon moisture carries by both the sources = 770 + 340 = 1110 m ha m.

On an average 27.5% moisture carried by monsoon current, which is precipitated as rainfall in the country.

So, total rainfall = $1110 \times \frac{27.5}{100}$

= 305.25 m ha m

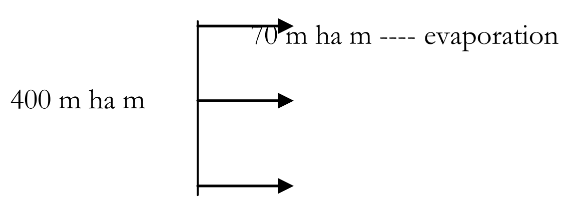
For remaining 8 months, the precipitation is in the order of 100 m ha m. Therefore, the total rainfall according to the calculation = 305.25 + 100 = 405.25 m ha m or round about 400 m ha m. On an average, 130 days in a year is wet days in our country. Out of which, 75 days have rainfall <2.5 mm. It moisten a few mm of the top soil and than it evaporates rapidly. Rest 55 to 60 days have rainfall >25 - 30 mm, which is affected soil-environment in different ways. The amount is sufficient for saturated the upper and sub-soil column, if it is in optimum quantity. If this rainfall is more than optimum need, then the surplus amount may be added or will act as ----

i) Ground water contribution,
ii) Flow downwards & admixture with the adjoining river, tributaries, channels, low-lying areas and
iii) Ultimately adds with the sea water.

However, if the situation is in severe form, particularly within a short time, then this excess water may create flood situation even sometimes in unprecedented form.

Water availability in the country

So, the total availability of water in the country is about 400 m ha m. This amount of water is utilized in different ways or forms round the year. On the basis of calculation, the total evaporation (loss) to the astrosphere is about 70 m ha m out of 400 m ha m. The other utilizable sites are :



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115 m ha m ---- run off

215 m ha m ----- infiltrate into the soil.

Total surface flow in India

Irrigation commission of India (1972) has placed the total surface water flow in the country is about 180 m ha m through the major rivers including tributaries system in the country. The sources are as follows :

i) 115 m ha m contribution from rainfall,
ii) 45 m ha m as regenerated flow from ground water as assessed from river flow during non-rainy months and
iii) 20 m ha m brought in by streams and rivers from catchments lying outside the country (Bangladesh, Pakistan and China).

Utilization of surface flow

The total surface flow of water (180 m ha m) in the country is utilized through different ways, as follows:

1) 15 m ha m is utilized through diversion works and direct pumping (RLI),
2) 15 m ha m is stored in various reservoirs and tanks and
3) 150 m ha m goes to the sea and some adjoining countries.

This amount and forms is vary from time to time and year to year. This picture is not rigid one.

Soil moisture and ground water recharge

On the basis of permeability of soils in different regions and rainfall pattern, it has been estimated that for the country as a whole about 12.5% of the total precipitation infiltrates to the ground water table, then,

$$\frac{400 \text{ m ha m} \times 12.5}{100} = 50.0 \text{ m ha m}$$

We know that of the total amount of water in the country through rainfall is 400 m ha m, of which about 215 m ha m infiltrates in to soil. Out of 215 m ha m about 50 m ha m percolates to the water table through soil stratum and rest 165 m ha m is retained in the soil column as soil moisture. However, the total ground water of the country has been estimated as 67 m ha m, which is counting from the different ways / source.

67 mham → 50 m ha m --- from precipitation or rainfall
→
→ 5 m ha m ---- as flood flow

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12 m ha m ---- from irrigation system

Utilization of ground water

The total ground water of 67 m ha m is utilized though various ways ----

1) 13 m ha m extracted from various uses,
2) 45 m ha m regenerated into rivers and
3) 9 m ha m is used or loss for E_T (evapotranspiration) and raising of ground water table.

In near future with the full exploitation and development of water resources, it is expected to be about 85 m ha m.

Loss or utilization of water as transpiration

For maintaining turgidity, metabolic etc., a reasonable quantity of water is essential through the plants system. Major part is lost through the ways of transpiration. However, the amount of transpiration from different source is about 110 m ha m, as follows:

i) Irrigated crops --- 13 m ha m
ii) Non-irrigated crops --- 42 m ha m
iii) Forests and other vegetations ---- 55 m ha m

On full development, it will increase to 125 m ha m.

Potential Utilization of Water Resources

During 1976, the total utilization of water in the country was only 10% of the water resources; it is likely to rise to about 26%. However, with improved technology and adaptation in future years, it is expected to increase over 30%.

Reasons for low utilization of water resources

The causes low utilization of water resources in India, are –

i) Rainfall in a limited time, ii) Construction of dams and watersheds, iii) Scarcity of arable land adjoining river basins and iv) Short length in between river and sea.

i) **Rainfall in a limited time**

The rainfall in most part of the country is confined to a few months in a year and sometimes, occurrence is scanty may be long or short time and sometimes heavy rains may be within short time. If it more within short time, then surplus rain water will flow downwards and maximum river flow will occur during that period. As the rainy season's flows can not be fully utilized during this short period, water has to be stored artificially in the reservoirs for subsequent use. *In situ* utilization is comparatively low from the sources during that time.

ii) **Construction of dams and watersheds**

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Construction of suitable dams or reservoirs or watersheds are one of the mitigation options for storage this surplus rain water in a place. So, in suitable sites dams or reservoirs can be built for large storage of rain water. But these are very limited in the country, even it is non-functioning of the existing system due to so many causes. Some major rivers in the country do not have enough storage capacity for completely harnessing the river flow during rainy season.

iii) **Scarcity of arable land adjoining river basins**

Scarcity to arable land in some river basins leads to unutilized large quantity of river water in many adjoining river places. e.g. for the enormous size of the river *Brahamaputra* its valley in Assam is quite narrow having a mean width of only 90 km, i.e. not enough adjoining land to irrigate and

iv) **Short length in between river and sea**

Similarly, because of their short length to the sea, the west flowing rivers of south India (*Tapi* river), offer only limited scope for further development for irrigation.

Water in crop production

Water is a prime natural resource and important input for assured agricultural production. In absence of it, crop production is drastically hampered, sometimes crop may total failure, even other management variables are in optimum in the field. It has been observed through different experimentation that the yield of a crop may be doubled or even more if water supply is in (i) proper time (ii) with proper quantity. This proper time with required quantity may be performed either through natural rescores like precipitation or through artificial means of irrigation. It may be concluded that water will continue to be the principal key factor in mitigating climatic constraints, enhancing agricultural production systems and ultimately augmenting farmer's income, in future as well.

Irrigation Potentiality

Recognizing the vital role of water as a critical input in crop production, huge investments have been made in the last decades since independence for harnessing water resources for various uses including agriculture. Irrigation at present accounts for nearly 84% of water requirements. In future, non-irrigation requirements will be growing faster and still by 2025, the irrigation will account for 73% of the total water requirements of the country.

Water potentiality of humid to very wet regions

These regions broadly included the regions of humid, wet and very wet, where rainfall potentiality is high enough. It ranged from 1000 to >2,000 mm, but somewhere it is >10,000 mm per annum. Due to prevailing of soil characteristics, geomorphic situations and climatic condition there is a greater chance to accumulate more water in depressed low-lying situations, invariably after satisfying *in situ* demand of the soil. Moreover, it accelerates due to prevailing of more number of depressed saucer-shaped areas like oxbow lakes (*mauns, chaurs, jheels, beels, baors, nayanjali* etc.) predominant in Indian subtropics, which has been intersected by the main river system and it's so many tributaries (*The Ganges, Brahmaputa, Padma, Mahanadi, Mahananda, Ichhamati, Churni, Jalangi, Rupnarayan* etc.), mostly in Indo-Bangladesh regions.

Like arable or terrestrial land system, wetlands are also equally important for (i) conserving runoff water, (ii) cultivation of aquatic crops, (iii) fish culture, (iv) integration of fish-cum-aquatic crops, (v)

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recharging of ground water, moreover (vi) it maintains and sustained for ecological balance in the area. So, wetland has a greater role for all concerning including its sustainability in the areas.

What is wetlands ?

Wetlands are the places where the two great natural components that cover our earth - land and water - wet and mingle to support life forms that are often different from those that dwell only on land or only in water". Or in otherwords, "wetland is an area of land where the water level remains near or above of the surface of the ground for most of the year. Simply, "The wetlands are land transitional between terrestrial and aquatic system where the water table usually at or near the surface or the land is covered with shallow water". Moreover, this definition includes several attributes, which are:

i. At least periodically the land must support predominantly hydrophytes,
ii. The substrate is predominantly hydric soil and

The substrate is non-soil and is saturated with water or covered by shallow water sometimes during the growing season of each year.

Indian scenario

India receives a total precipitation of about 400 million hectare metres (m ha m) annually, which is recycled through its various forms (utilization, stored and wastage), much is lost through evaporation and runoff, equalling 70 m ha m and 180 m ha m, respectively. Hardly around 150 m ha m enters the soil. Of the total runoff of 180 m ha m from the different places, the country has been able to harness about 20 m ha m or so in major and minor irrigation projects. Quite a sizeable amount i.e. 160 m ha m of precipitation flows through major rivers and its tributaries into the sea (Singh, 1998).

However, a sizable area (25-30%) in the coast and north-eastern plains of India is exposed to waterlogging during peak-wet months and the duration of such submergence depends upon the topographical situation of lands and textural class of the soil. This situation predominantly faces in such aquatic bodies, categorically termed as '*low-lying flood plains including back water swamp',* situationally called lakes, ponds, oxbow lakes, depressed estuary, deltaic alluvial plain etc. that commonly known as *Jheel, Beel, Tal, Maun, Nayanjali, Pools* etc. Theses are of different sizes and are of different forms in nature.

These zones comprises of mostly flat alluvial plains intersecting with the main river system (*The Ganges*, *Bramhaputra, Mahanadi, Krishna, Cauveri* etc.) and its so many tributaries of various forms, canal, low-lying areas subject to frequent waterlogging and flood making them swampy, particularly during peak rainy months. The quantity of water in the earth is fixed; only the form is changed time to time in its natural consequences through its different ways including natural calamities.

Importance of wetlands - at a glance

i) Survival of human civilization is inextricably linked with wetlands,
ii) Wetlands sustain economic stability to hundred millions of people,
iii) On a short time scale, wetland is useful as sources, sinks and transformers of a multitude of chemical, biological and genetic materials,
iv) Wetlands clean the polluted water, prevent flood and recharge ground water aquifer,
v) It provides a unique habitat for a wide variety of flora and fauna,
vi) The swampy environment of the carboniferous period produced and preserved many of the fossil fuels on which we depend now,
vii) James (1995) has rightly termed wetland as *'Natures kidney'* because of the natural functions they performed,

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viii) Rice, fish, other food and non-food crop production is derived from wetlands,

ix) The development and management of wetlands are an important part of the integrated watershed management plans,

x) Wetlands are immensely valuable in terms of economics and quality of life, and

xi) A vast area of coastal wetland is very significant today for conservation of mangrove forests as well as wildlife when environmental pollution is a burning question of the world.

Classification of wetlands

Based on geomorphic situation, topographical condition, textural class of the soil, water retentive capacity and water quality including chemical nature, wetlands broadly be classified into two major groups viz. 1. Inland wetland, and 2. Coastal wetland. More or less these are the natural phenomenon exists everywhere in the earth. Categorically, in regard to water quality, inland wetland bodies possess the fresh water, while, salt water with its varying degree in coastal wetlands system.

WETLANDS

Inland wetland	**Coastal wetland**
e.g. Swamp	e.g. Marine
Marsh	Estuarine
Bog	Riverine
Fen	Palustrine
Peatland	Lacustrine
Muskeg	Deltaic Islands
Wet meadow	Coastal low lands
Chaur land	
Tal land	
Diara land	

Distribution of wetlands

It has been presented in table 3 and 4, particularly about the divergence of different types of wetlands in the world, India and West Bengal. Although it may vary year to year in the country and in the state, more

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precisely in the eastern part of the country due prevalence of low-lying situations as well as accomplished with humid and sub-humid climatic condition.

Table 3. Coverage of wetlands at a glance

Place	Area
World	855.8 million ha
India	23.5 million ha (may be extended >40.0 m ha)
West Bengal	5.25 lakh ha

(Source: Maltby and Turner, 1983 and Anonymous, 1986)

Table 4. Wetlands in state of West Bengal

Sl. No.	Types	Areas ('000 ha)
i.	*'Beel'* or almost permanent water bodies	31
ii.	Inundated areas	44
iii.	Marshy areas	43
iv.	Saline affected areas of *Sundarbans*	400
v.	Wetland areas near the reservoir or wetland beside the dam	6.5

Source : Anonymous (1986)

Wetlands – Its proper utilization

Practically, farmers' are using these vast wetlands as per their traditional need, which are not always agro-ecologically suitable, subject to vacant oftenly without any proper use.

Not systematically, but in scattered way these swampy, fertile, productive wetlands are utilized occasionally by the associated farmers' for the production of nutritious and popular aquatic food crops, economically viable non-food crops, medicinal, aquatic fodder-crops and other important aquatic plants including bio-fertilizers. However, over all production of the system and the economic outturn is not at all encouraging due to technical back up and financial stringency. In fact, this fertile and productive soils of wetland can effectively be utilized following proper agro-techniques for better production, which may turn economically viable for the rural sector of the people (Puste, 2004), viz.

Wetland crops

A. Aquatic food crops
   i. Deep water rice (*Oryza sativa* L.)
   ii. Deep water rice cum fish culture
   iii. Water chestnut or *singhara* (*Trapa bispinosa* Roxb.)

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   iv. Makhana or gorgon nut or fox nut (*Euryale ferox* Salisb.)
   v. Taro or *pani kachu* or *jal kachu* (*Colocasia esculenta*)

B. Aquatic food cum ornamental plants
   i. Lotus or padma (*Nelumbium speciosum*)
   ii. Water lily or saluk (*Nymphaea* spp.)
   iii. Royal water lily (*Victoria amazonica*)

C. Aquatic non-food economic crops
   i. Matreed (*Cyperus* spp.)
   ii. Shital pati (*Clinogyne dichotoma*)
   iii. Hogla (*Typha elephantina*)
   iv. Rattan palms or cane (*Calamus* spp.)
   v. Shola (*Aeschynomene aspera*)

D. Aquatic fodder crops
   i. Para grass or water grass (*Brachiaria mutica*)
   ii. *Coix* or gurgur grass (*Coix* spp.)

E. Aquatic medicinal plants
   i. Brahmi (*Bacopa monnieri*)
   ii. Kesuti or keshori (*Eclipta alba*)
   iii. *Ipomea* or swamp cabbage (*Ipomea aquatica*)
   iv. Talmakhana or kule khara (*Hygrophila auriculata*)
   v. *Enhydra* or helencha (*Enhydra fluctuans*)
   vi. Indian pennywort or thankuni (*Hydroctyle asiatica*)
   vii. *Marsilea* or susni (*Marsilea quadrifolia*)
   viii. Water cress or swamp forest (*Nasturtium officinale*)

F. Aquatic aromatic plant
   i. Bach (*Acorus calamus*)

G. Aquatic weed cum plants of organic and biofertilizers
   i. Water hyacinth (*Eichhornia crassipes*)
   ii. Duck weed or taka pana (*Pistia stratiotes*)
   iii. Jal jhangi or Hydrilla (*Hydrilla verticillata*)
   iv. Azolla or pana (*Azolla pinata*)
   v. Algae

The production yield and its potentiality is so important (Table 5) and also are equally important to the common markets and locals *bazaar*, mostly preferred by the rural and urban people. All the aquatic crops (food, non-food commercial) are covering a reasonable area in the different agro-zones of this sub-continent and gaining importance day by day. But, in the country very limited works on improvised agro-techniques have been so far done on the utilization of these underutilized crops, although these would have immense importance for developing in water harvested basins as well as to make it more productive and sustainable in nature. These have great importance, particularly in the north-eastern part of the country due to prevailing of humid to sub-humid accomplished with sub-tropics in nature, which is really congenial for growth and development of these aquatic crops.

Table 5. Yield potentiality of different wetland crops

Description	Average production /yield (ha^{-1})
A. Food Crops :	
Deep-water paddy (*Oryza sativa* L.)	2.5 – 3.5 t ha^{-1}

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Water chestnut (*Trapa bispinosa* Roxb.)	7.5 - 10.0 t ha^{-1}
Makhana (*Euryle ferox* Salisb.)	2.5 - 3.0 t ha^{-1}
Taro (*Colocasia esculenta*)	75 t $ha^{-1}yr^{-1}$ (as *lati*); 18,750 pieces t $ha^{-1}yr^{-1}$ (corm + cormels)
Cocoyams (*Xanthosoma sagittifolium*)	30-45 t ha^{-1}
Water-lily & Lotus (*Nelumbo* sp.)	40,000 – 50,000 ha^{-1}
B. Non-food Commercial Crops :	
Matreed (*Cyperus tegetum*)	2,250 bundles of mattable sticks ha^{-1} (1st cutting in Sept-Oct); 1,500 bundles ha^{-1} (2nd cutting in Feb-Mar); 2,250 bundles ha^{-1} (3rd cutting in Jun-July), respectively.
Hogla (*Typha elephantina*)	500 bundles of mat ha^{-1}
Sitalpati (*Clinogyne dichotoma*)	750 mats ha^{-1} in 1st cutting; 1125 mats ha^{-1} in 2nd cutting and 3000 mat ha^{-1} in 3rd cutting, respectively
Shola (*Aeschynomene aspera*)	It is available in the hat or in market in bundle basis (2.0-2.5 m circumference of 0.75 - 1.5 m length). Single harvesting : 175-225 bundles and multiple harvesting 225-275 bundles ha^{-1}

Development of Integrated Farming System Model on "Rice-cum-fish culture-cum-vegetables" for productivity and livelihood development utilizing aqua-terrestrial ecosystem

Objectives

1. Proper utilization of aqua-terrestrial ecosystem, particularly which are waste or unused in nature,
2. For enhancing productivity per unit area per unit time
3. For generating income and livelihood development that are sustainable in nature, particularly for small and marginal group of farming community.

System approach

Implementation steps at sites :

- Survey and Layout of the area for implement
- Need-based manipulations of areas (earth works etc.), viz.
  - Development of existing watershed ponds for rainwater conservation & recycling,
  - Layout & shaping of wetlands as per situation (shallow, medium and deep),
  - Development of aqua-terrestrial ecosystem (IFS models),
  - Development & Installation of watering system etc.
- Adaptation of field crops including fishes
  - Adaptation of improvised agro-techniques in respective areas,
  - Utilization of almost all the essential inputs in time and quality materials (seeds & fingerlings, plant foods & feed materials and need-based bio-degradable protection measures) and

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- Time to time monitoring, analysis, harvesting and marketability are to be emphasized for better return and economics.

Working Plan

To realize the significant importance of these valuable aquatic crops including rice, an income generated IFS (Integrated Farming System) model on **"Rice-cum-fish culture-cum-vegetables"** utilizing 1.0 ha unit area of aqua-terrestrial (land) was developed, in which rice (and/or other aquatic food, non-food commercial, food-cum-ornamental plants may be considered giving equally importance), fish and prawn was cultured during wet season in the low-lying field, and *kharif* (summer) and winter vegetables, fruits like papaya and coconut was also developed on field bunds or adjacent land system. Watermelon or other trailing type crop was also considered after harvest of rice. Such a system not only gives good productivity and cash return to the farmer but also provided employment opportunity to the farm family round the year (Table 6).

Due care, however, was taken not to use the chemical plant protection measures as far as possible but was used bio-degradable and/or organic pesticides. As a matter of fact in lowland rice system, insecticides hardly work because of standing water remaining up to heading stage of rice, which greatly dilutes the concentration of pesticides. However, a pest tolerant rice variety [Sabita (cv. NC 492)] along with the common and major carps like Catla, Rohu, Mrigal, besides freshwater to giant prawn species (*M. rosanbrgi* and *N. malcolmsonil)* are compatible with lowland rice.

Approximate Specific Area for the system

A. Aquatic or wetland system (60%) i.e. 0.60 ha and

B. Terrestrial or land system (bund and adjacent land) at about 40% i.e. 0.40 ha.

Approximate specific area was provided for this model, like – (i) for aquatic or lowland or wetland system (65%) i.e. 0.65 ha and (ii) for terrestrial or land system (bund and adjacent land) at about 40% i.e. 0.35 ha was provided. However, to other individual farmer's level this area may be different, depends on the availability of land under this system.

Table 6. Utilization of aqua-terrestrial ecosystem vis-à-vis production potential and economics of rice-based IFS system (1 ha unit)

Item	Actual cost (INR)	Annual depreciation @ 5% on actual cost (INR)	Annul interest @ 12.0% on actual cost (INR)
I. Fixed Capital Cost (INR)			
Earth Work	30,000.00	1,500.00	3,600.00
Sub-Grand Total			**35,100.00**
II. Variable Operational Cost (VOC)			

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1	Rice	10,000.00
2	Crop after rice (watermelon)	5,000.00
3	Fish and prawn	15,000.00
4	Vegetable on pond bund or adjacent areas	
	a) *Kharif* (summer) vegetables	5,000.00
	b) Winter vegetables	6,000.00
5	Horticultural plantation crops/trees :	
	a) Papaya (150 female plants)	3,000.00
	b) Banana 100 plants (both green and ripening type)	5,000.00
	c) Coconut 50 plants (production starts from 5th year) for plantation & subsequent maintenance	6,000.00
	From 5th year maintenance for 50 coconut plants (INR 200/- per plant)	10,00,.00
	TOTAL	**55,000.00**
Interest on VOC @ 12% per annum for half of the period		6,600.00
Sub-Grand Total		**61,600.00**
GRAND TOTAL		**96,700.00**
GRAND TOTAL including coconut maintenance		**1,06,700.00**

So, total annual investment: (Fixed capital cost + VOC + annual interest on VOC) = INR 96,700.00 & INR 1,06,700.00.

III. Returns

Crops	Area (sq. m)	Produce (kg)	Av. rate (INR kg^{-1})	Total value (INR)
Rice				
a) Grain	6,500	2,750	14.00	38,500.00

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b) Straw	6,500	5,350	2.00	10,700.00
Fish	1,300	1,019	80.00	81,520.00
Prawn	8,000	180	300.00	54,000.00
Crops after rice (watermelon)	6,500	8,000	5.00	40,000.00
Vegetables on bund or adjacent lands				
a) *Kharif*	500	950	12.00	11,400.00
b) Winter	600	1,800	10.00	18,000.00
Horticultural crops				
a) Papaya (150 female plants)	300	3,000	10.00	30,000.00
b) Banana plantation 100 plants (both green and ripening type)	500	100 per pl	8.00	40,000.00
c) Coconut 50 plants (from 5th year)	300	150 per plant	10.00 per coconut	75,000.00
Gross annual income (from 1st to 4th year)				**3,23,850.00**
Gross annual income (from 5th year onwards)				**3,98,850.00**

1 USD = INR 46.00 (INR – Indian Rupee)

B-C ratio over the system or specific system :

1st year to 4th year :

Cost of cultivation : INR 96,700.00

Gross monetary return (GMR) : INR 3,23,850.00

So, net profit (NP) of the system : INR 3,23,850.00 – INR 96,70.00 = INR 2,27,150.00

So, B-C ratio of the system = $\frac{2,27,150.00}{\quad}$ = 2.349 or 2.35

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96,700.00

<u>5th year and onwards</u> :

GMR : INR 3,23,850.00 + INR 75,000.00 = INR 3,98,850.00

For coconut maintenance on and from 5th year onwards INR 10,000.00

So, Cost for the produce : INR 96,700.00 + INR 10,000.00 = INR 1,06,700.00

NP of the system : INR 3,98,850.00 – INR 1,06,700.00 = INR 2,92,150.00

$$\text{So, B-C ratio of the system} = \frac{2{,}92{,}150.00}{1{,}06{,}700.00} = 2.738 \text{ or } 2.74$$

(GMR - gross monetary return, NP - net profit and B-C ration - benefit-cost ratio)

Outcomes of the project :

1. Through project sources, it has been possible for development of need-based, excavation, renovation and cleaning of waste wetlands in the agro-zones, which is imperative for the ecosystem for water conservation, restoration and recycling it *in situ* and subsequent use in adjacent terrestrial land system for vegetables and other plantations,
2. Establishment of plants (especially cocoanut on bunds or boarder areas), which is producing and will produce approximately from 5th year or onwards, will increase productivity and economically benefited,
3. Other tree (timber) plantation has been done, especially on the bund or boarder areas, which will be valuable approximately after 25-30 years as a resourceful revenues to the farming community and
4. Over all, utilization of water in watershed may be available as live-saving irrigation to arable crops, is important.

CONCLUSION

As water is the key and integral elements of natural resources, it would obviously be utilized in precise and wise way for the benefits and sustainability not only in the country but also in the world, either may be ground, surface and/or wetland sources. In the country, in addition with this, vast wetland ecosystem may effectively be utilized through the cultivation of so many aquatic valuable underutilized crops, fish variables which not only valued to human beings but also imperative for the upliftment of resource poor rural economy as well, who are inextricably linked with the system.

Besides, wetlands are continuously enriched by adding large quantities of biomass, enriched in sequence, should be used this enriched biomass effectively for the production of arable crops as well as improvement soil nutrient status in consequence in the zones. Wetlands are highly exploited and sufficient commercially exploitable species and aquaculture make the wetlands more valuable (aquatic crops, fish and other food and non-food crops, value-added products are derived from

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wetlands. Substantial quantities of fuel and materials for weaving and thatching are also obtained from wetlands. Wetlands provide water for domestic and industrial consumption and in arid regions provide water for irrigation. The development and management of wetlands should form an important part of the integrated watershed management plans. A vast area of coastal wetlands is very significant today for conservation of mangrove forests as well as wild life preservation, when environmental pollution is a burning question around the world. Yet wetlands are truly disappearing at an alarming rate with the expansion of civilization,- needs study, developing awareness for its sustainability.

REFERENCES

Anonymous (1986) *In*: Indian Agriculture in brief. *Geographical Magazine* 55 (21st ed.), pp. 12-17.

Baugartner, A. and Reichel, E. (1975) The world water balance. Elsevier Scientific Publishing Co., Amsterdam.

James, E. J. (1995) Managing the wetlands and their watersheds. *Yojana*. 39 (182), pp. 43-50.

Maltby, E. and Turner, R. E. (1983) Wetlands of the World. *Geographical Magazine*, 55 :12-17.

Puste, A. M. (2004) In: *Agronomic Management of Wetland Crops*, published by Kalyani Publishers, Ludhiana, India during 2004.

Reddy, G. H. S. and Reddy, T. Y. (1997) In: *Efficient Use of Irrigation Water*, published by Kalyani Publishers.

Singh, R. P. (1998) Rain water management : Principles and Practices, Chapter 5, In: *50 years of Agronomic Research in India*, published by Indian Soc. Of Agronomy, New Delhi.