Evolution and Future Directions of Water Use in Agriculture

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Types of land and water use in arid and humid zones

Arid zone

***Sakia* vs. CPI system** While flying over arid lands of the Nile delta fringe, Syria, and over the west coast of the Arabian peninsula, we can see some green circles indicating the CPI (Center Pivot Irrigation) systems that are operating down there. The CPI developed in the Great Plains in the Midwest of USA has been widely adopted in these arid zones. The green circles, 1-3 km in diameter, seldom stay at the same place for more than several years, but shift to other frontier lands after the CPI uses up deep groundwater, much of which consists of fossilized water that is never being replenished (Fig. 1).

Sakia, animal-driven wheel for lifting water from a shallow well or a ditch for just a few feet, is still in use in the same arid zones. Traditional *quanat* systems are also very widely used to collect replenishable groundwater from a distant aquifer. I have seen a bull walking down-slope beside a well pulling a rope at the

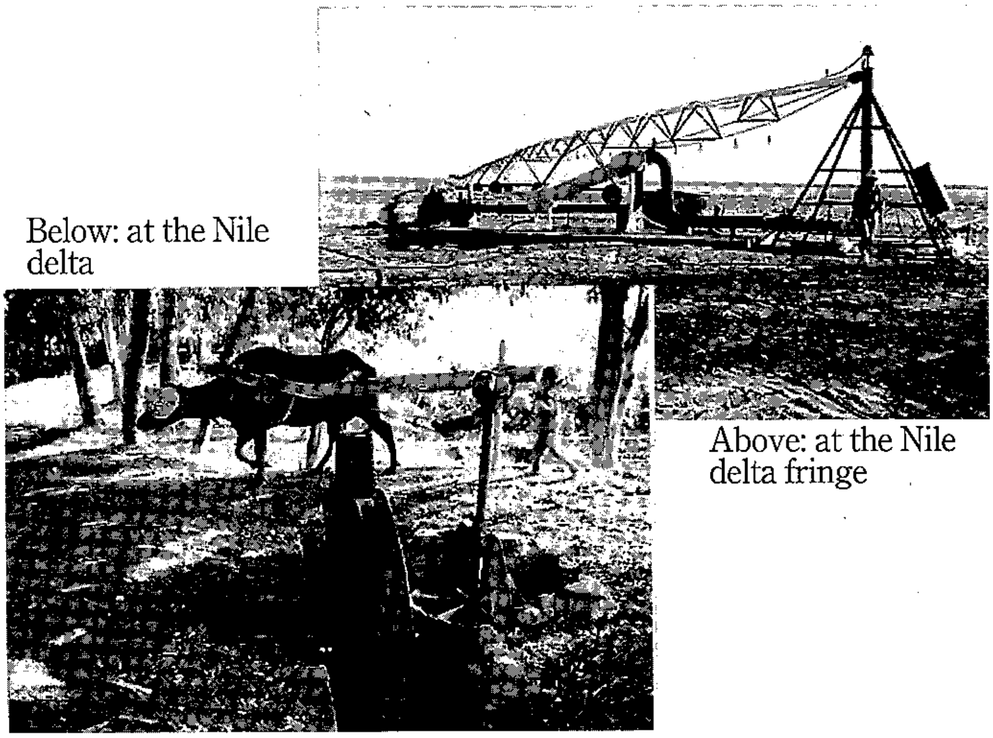

Fig. 1 Center-pivot irrigation (above) and *sakia* (below)

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end of which a leather water bag was attached, thereby lifting a small amount of water each time.

If the owner of a CPI system complains about the shortage of water, it is due to "greed" rather than need. If the owner of the CPI does not want to be blamed for exploiting very deep groundwater owned by nobody, namely owned by everybody, he must employ better water-saving irrigation, e.g. drip irrigation, even though it is much more costly.

Dry farming, savannization and water harvesting in arid zones In the vast central plateau in Turkey, wheat, barley and oats are grown extensively based on very traditional dry farming systems. Every time a farmer gets scarce and sporadic rain he does not waste time before rushing to his farm to rake the surface soil to preserve the soil moisture. He has to repeat this practice during the first rainy season. Wheat can be sown only in the following wet season so that it can extract the soil moisture retained from the last season in addition to the rain in the current season. The land that he owns is divided into two parts, one half is planted with wheat, leaving the other half fallow where after-the-rain raking is practiced. This is referred to as "the two-fields system". Actually, wheat areas in this region look like mosaics of planted and fallow bare lands.

Scientists are testing a method consisting of sowing wheat continuously using a sowing machine that can place the seeds at a prescribed depth, e.g. 5 cm, to ensure that the seeds use the soil moisture more efficiently. This innovation is expected to double wheat production by simply doubling the area to be sown every year. This new technology is environment-friendly.

It is our constant desire to change barren desert into green fields where milk and honey abound like in present day Israel. But, we have to be modest though, because we do not have enough water to use for the purpose. The concept of "savannization" is being advocated in the same country, Israel. In this innovation, traditional practices of water harvesting and collection are used, by providing border ridges. Selection of suitable trees and preparation for deep-rooted saplings must be ensured to make this promising venture successful (Fig. 2).

Fig. 2 Greening desert by "savannization" (Israel)

Humid zone

Engineering adaptation In less dry and rather humid zones, mainly in monsoon Asia, water use in ricelands has followed two distinctively different development paths. The rice landscape in Japan, located in the temperate monsoon zone, displays a condensed history that is "carved onto the land" (Furushima, 1967). Generations after generations of Japanese peasants developed ricelands by carving and cultivating land through their individual and collective labor, channeling stream water by building communal irrigation works and laboriously controlling the water conditions of their individual fields. This was mainly because the optimal duration of growth of the tropical plant, namely rice, was limited to five months from June to October. According to Takase (2001), the Japanese farmers had reached the "irrigation stage" at the end of the Edo era (1867). Based on these historical and communal initiatives, they developed a high-input and high-output rice cultural system. We define this system as "engineering adaptation", or "environment-formative" technology.

Agronomic adaptation On the other hand, in the humid tropics, farming systems have been less constrained by water conditions. Rice cultural system here has developed through adaptation to given water conditions, rather than exploiting scarce water or controlling excessive water. Farmers have selected, over centuries, better adapted rice strains. According to one estimate, in northern Thailand alone there used to be about 6,000 different strains. There must have been more than 20,000 different strains once cultivated in Thailand. The agronomic adaptation to the given environment can be found in various forms and types as follows (Kaida, 1991):

(1) Selection of a number of photo-period sensitive varieties of different magnitude to ensure flowering at prescribed times regardless of planting times, because rainfall at the planting time is so erratic.

(2) Selection of tall and late maturing (sometimes as late as 10 months) strains to stand with deep water, and on the contrary, dwarf and early maturing (sometimes as short as 3 months) strains to ensure growth during a short rainy spell in the water-thirsty hillsides.

(3) Direct seeding on dry bed is often practiced in non-irrigated fields to ensure germination under erratic rainfall patterns in the early rainy season.

(4) Two extreme strains consist of floating rice and upland rice. So-called floating rice in the floodable zone has an ability to elongate not only plant's growing tips but also every internode, hence allowing a length of maximum 500cm at the rate of 20 cm a day following the rise of the water level. Upland rice is commonly sown on hill slopes in *swidden*-type farming.

Table 1 Agronomic adaptation

Varietal diversity of rice
* Maturity: 3 months to 10 months
* Height: 60cm to 500cm
* Photo-period sensitivity: from 0 to very significant
* Season: *aus, aman, boro* (in Bengal delta)
* Adaptability: From upland rice to floating rice

All of these diverse rice strains and cultivation methods have been developed, selected, screened and improved through generations of peasants' deep ecological knowledge and experience in the region.

Impact of "The Green Revolution" on Asian rice cultivation systems Since the mid-1960s, however, Asian ricelands had witnessed the rapid construction of modern irrigation systems. By the mid-80s, about 40 % of the total Asian ricelands had been blanketed with modern irrigation systems, of which about half had been built within 20 years since the mid-1960s. The prime motivation for modernizing rice culture that made this rapid development possible, was the confidence placed in the future of seed-fertilizer-irrigation technologies —-the Green Revolution—- advocated by IRRI (International Rice Research Institute) since the mid-1960s. IR-8, a high-yielding rice variety referred to popularly as "miracle rice" which was developed at IRRI in 1965, broke the ice. Irrigation was now considered to be a prerequisite to adopt this new seed-fertilizer technology. Without proper water supply at the right time in adequate quantity, all modern technology to secure high yield of this new strain, namely planting at optimal time, use of large doses of fertilizers and pest and disease control, would become too risky to apply (Kaida, 1991, and many others).

The impact of the Green Revolution can be evaluated from a different angle. Bangladesh, like many other Asian countries, has successfully introduced rice double cropping consisting of irrigated dry season boro rice and rainfed *aman* rice, which has contributed to increasing the self-sufficiency in their major food crops. Without the Green Revolution, Bangladesh could have been one of the countries that had failed to beat the harsh Malthusian problem.

Prior to the introduction of the irrigated *boro* rice in Bangladesh, however, a more diversified cropping system had been practiced traditionally; for instance in the floodplain, farmers lost no time after harvesting the main *aman* rice in November to December to sow mustard as a short-term maturing cash crop, and planted various *rabi* crops in the cool dry season, including legumes, and subsequently broadcasted either jute or aus rice depending on both continuous rainfall in the early monsoon season and soil fertility, replenished partly by preceding leguminous crops (Ando, 1994). With this diversified cropping system, even small farmers could be self-sufficient in food crops and other minor products including even small amounts of milk from cows that were fed on straw, corn and legumes grown on their own farm. However with the introduction of the simplified rice double cropping system, their subsistence economy, albeit meagre but more or less sufficient and sustainable, has been replaced by a cash economy. The Green Revolution technology is a scale-free technology. Nonetheless, in a cash economy, larger landholders must have gained much more from the Green Revolution than smaller ones. In this sense, this new technology was somehow scale-sensitive.

Ecotechnologies in land and water use in Asia

The "Green Revolution" technology has swept through almost whole rice-growing zones in Asia. Nonetheless, there still remain a number of "ecotechnologies" (Swaminathan, 1996) that have been nurtured by local farmers. In this chapter, several interesting examples of ecologically sustainable, time-tested, local technologies in relation to land and water use will be displayed.

1 Taxonomy of micro-topography and soils

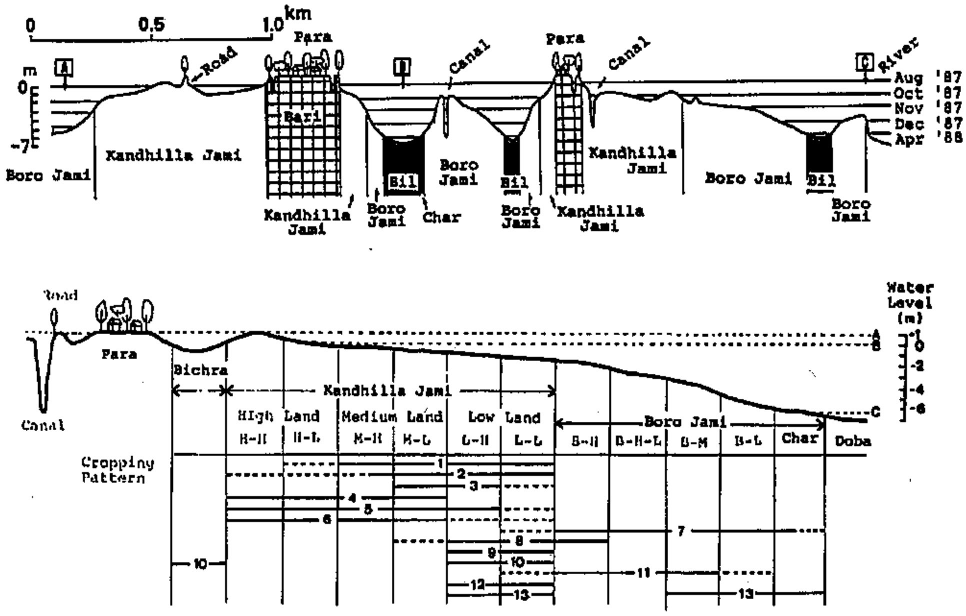
Local farmers do not possess any academic knowledge of topography and soil taxonomy. However, every slight difference in micro-topography and soil characteristics is more or less accurately designated using local names, which sometimes reflects the actual conditions as well as the corresponding scientific taxonomy. This is referred to as "local taxonomy of micro-topography and soils". A schematic cross-section of a gently sloping land on the fringe of "haor" in Bangladesh is shown here with both local and scientific, or rather mechanical taxonomy (Tanaka *et al.*, 1990) (Fig. 3).

2 Controlling acid sulfate soils in the Mekong delta

Since farmers know precisely the depth of the layer where jarosite appears, they scoop up uncontaminated surface soils to make ridges approximately 45 cm high and 80 cm wide. The ridges may remain unplanted in the early part of the first rainy season to ensure the leaching of acidity. First crop to be planted may be yam, followed by cassava or pineapple that are all relatively acid-tolerant. From the third season, the leached-out ridges, that are almost acid-free, will support any kind of crops including long yard beans, sugarcane, etc. (Chiem, 1994) (Fig. 4).

3 Replacing floating rice by rice double cropping system without controlling flood

The flood-prone gravel in the Mekong delta bordering Cambodia used to be planted with a single crop of floating rice, which occupies land almost for 9 months before being reaped in January. Since the introduction of *Doi Moi,* however, farmers have implemented double cropping of a pre-flood rice and a post-flood rice, completely replacing the floating rice. This drastic change has been accomplished without implementing any flood control measures. They know the growth habit of HYVs, which is non-photo-sensitive (Chiem 1994). While they normally live on safe river levees afar from rice field, farmers hastily move to their individual makeshift cottages built along canals and roads in the rice fields and reap the first pre-monsoon rice before submergence in rapidly rising water in the heaviest rainy month of August. Drying, storing and carrying their



Note: Maximum water levels in high flood years(A) and in normal years (B) ; and minimum water level in the dry season (C)

Nos. 1-13 indicate different cropping patterns.

Fig. 3 Local vs. mechanical taxonomy of micro-topography

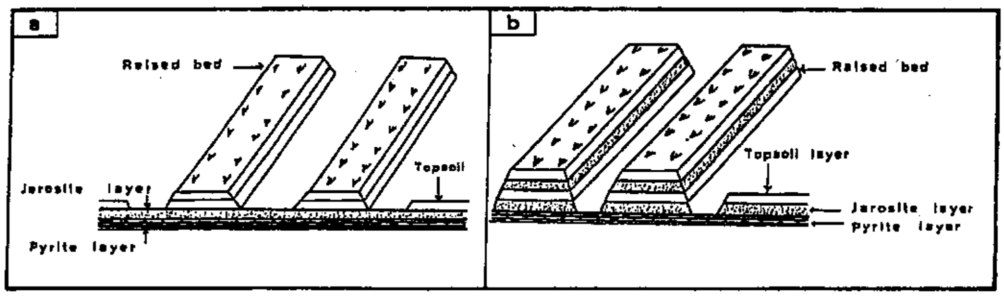


Fig. 4 Local technology using acid sulfate soils, Mekong delta, Vietnam Blocks of surface soils free from jarosite and pyrite are carefully heaped up to make low ridges on which acid-tolerant crops can be grown.

harvests are major problems (Kaida, 1995) (Figs. 5 and 6).

4 Intensifying small ditches along with major construction of canals in the Chao Phraya delta in the early 20th century

Many of the deltas in tropical monsoon Asia, typically the Chao Phraya, the Mekong, the Ayeyawardy, and the Cauvery deltas have been reclaimed into major ricelands through the construction of canals, which was implemented either by the government or private investors. The main canals provided the early pioneer settlers with drainage, water communication, banks on both sides on which to build their makeshift cottages, and safe drinking water for human and cattle. Once settled safely along the main canals, the hinterlands offered a great potential for becoming rice fields. The potential was actually realized by digging many small

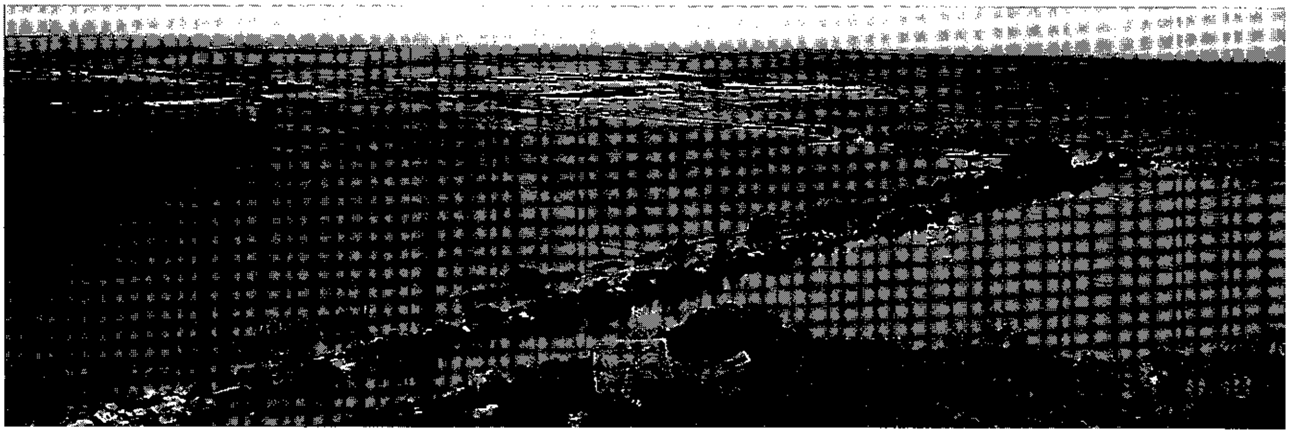


Fig. 5 Flood at Vietnam-Cambodia border, Mekong delta
In high flood, floating rice is seen growing in Cambodia (far back) while it is just an expanse of water in Vietnam.

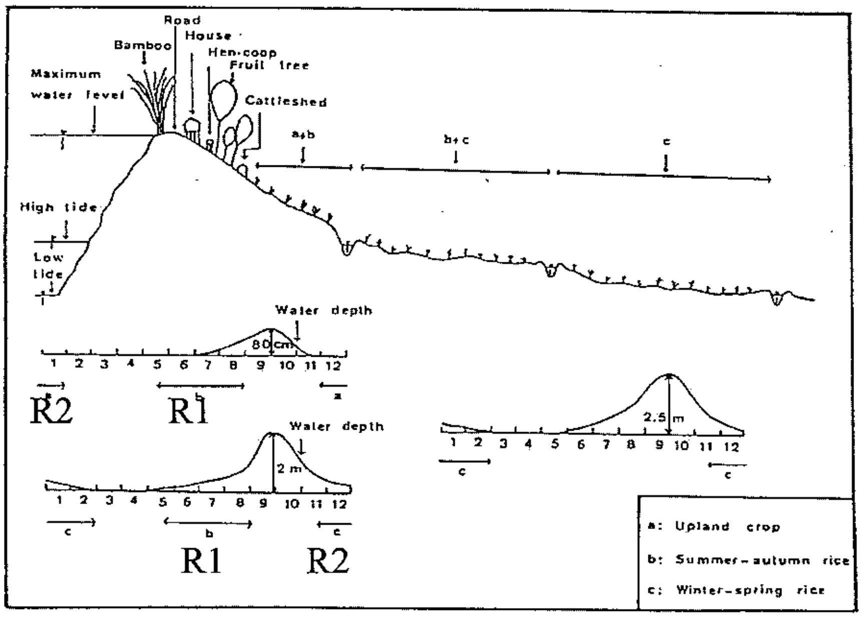


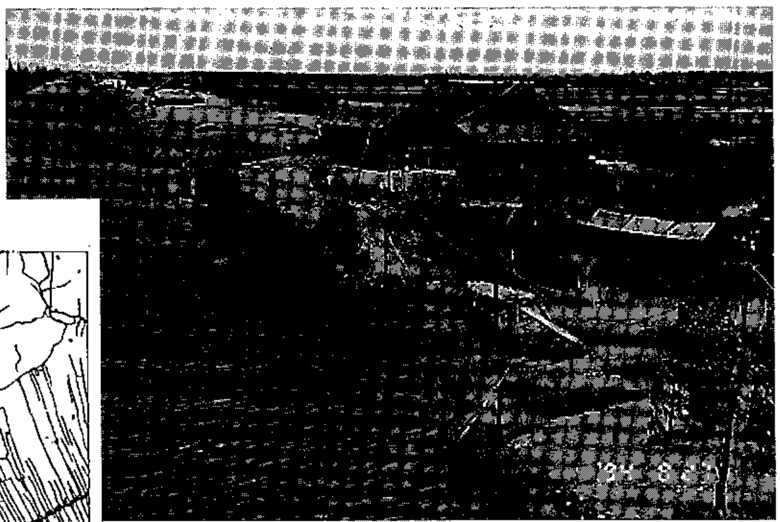
Fig. 6 Converting floating rice to double rice systems without flood control (Mekong delta, Vietnam).

comb-like ditches into the hinterlands without which one could not reach paddy lands. The only method of transportation was small boats going through the ditches. The digging was all performed manually by these early settlers (Takaya, 1987) (Fig. 7).

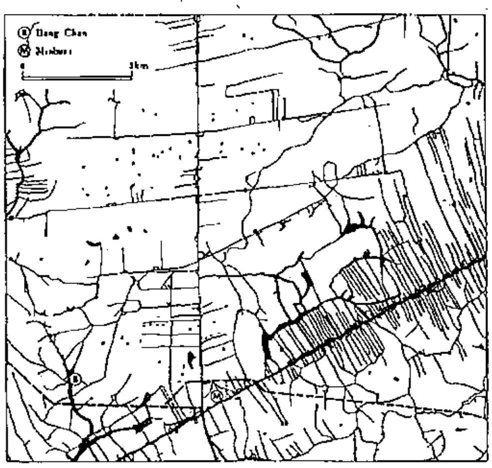
5 Poldered complex garden culture

In many of the Asian deltas where fresh water is readily irrigable and drainable, poldered complex garden farming flourishes, like in the lower Chao Phraya delta (Kaida, 1991), active delta in the Mekong (Chiem, 1994, Kaida, 1995) and major parts of the Zhujiang delta in southern China (Kaida, 2000). A part of a farmer's rice land, about 1 acre, is poldered by building high dikes at four sides, high and wide ridges, 60cm high and 4m wide will be dug-out on which banana may be planted with various fruit saplings of commercial value. Near the homestead along a canal, where tall coconut trees are planted to provide comfortable shade, a few fish ponds may be dug to rear some fishes for home consumption. The ditches between the ridges can also be used as fish ponds for home consumption and for sale in markets, too. The banana grove will provide, in several years, dense green foliage of fruit trees. The most basic requirement for this complex land use is the easy irrigation and drainage from and to the adjoining canal (Fig. 8).

In the case of Vietnam, one or two head of pigs are reared, whose excrements provide fish meal, and in turn, scooped-out mud from the bottom of pond will be dressed on the ridges to fertilize fruit and vegetables. This complex land use on the basis of material recycling is named VAC, and VACR if rice is included, in Vietnam. In the case of the Chao Phraya delta, Kaida designated the system as "rice-fish-poultry-fruit complex" garden (Kaida, 1987) (Fig. 9).



Plain of Reeds, Mekong delta



Chao Phraya delta in 1910s

Fig. 7 Early settlement for rice cultivation
Banks of canals provide homesteads for pioneer settlers. Main and lateral canals were the lifeline not only for cultivation and transportation of rice, but also for their living and sustenance.

6 Sumatra's transmigration canals

Here is a set of two maps showing canal systems for reclaiming dense coastal jungle in South Sumatra, Indonesia (Fig. 10):

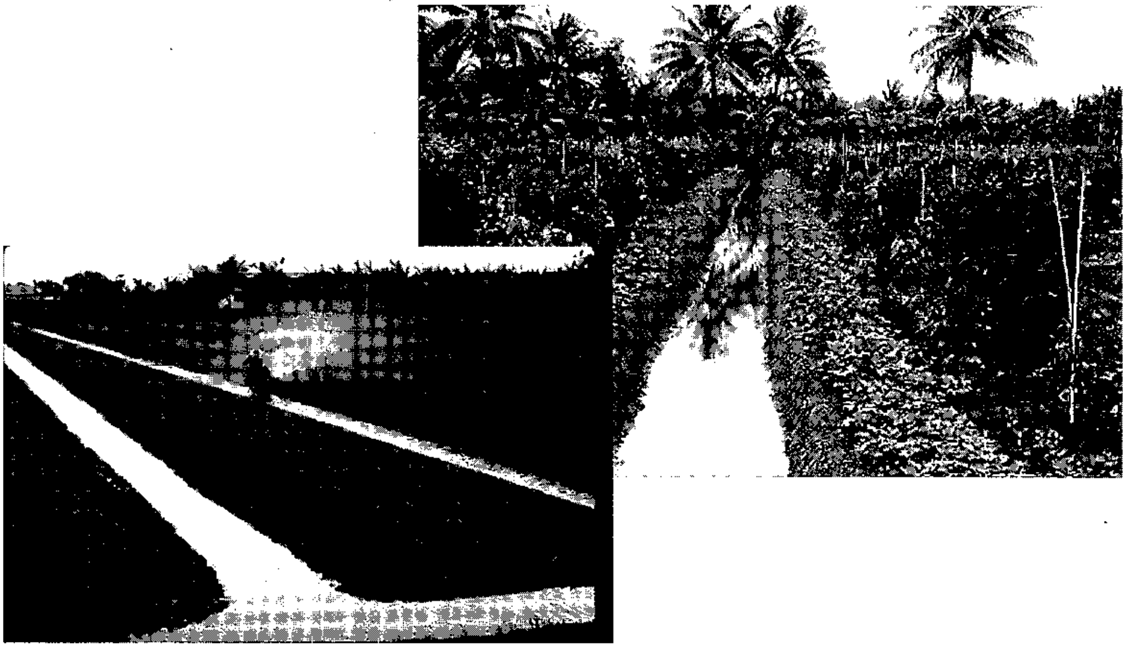


Fig. 8 "Rice-fruit-fish-poultry complex" in the Chao Phraya delta, Thailand.

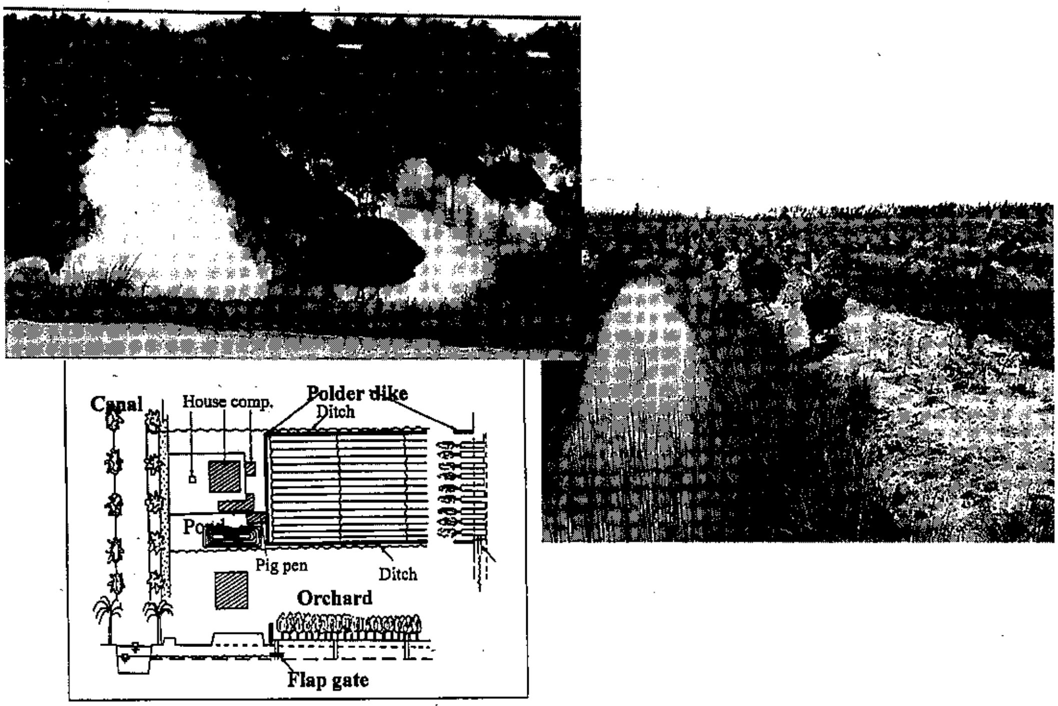


Fig. 9 "Rice-fruit-fish-poultry complex" farming evolving in the Mekong delta, Vietnam.

(1) Local, shallow canal system to reclaim rice fields along an active river and coconut grove inland. First, a small and shallow ditch approximately 2 m wide and 60 cm deep may be dug out by manual labor. The ditches will be enlarged by natural erosion caused by rushing-in and out current induced by a large tidal range reaching about 2 m in the adjoining river. Paddy fields established along the active river may be irrigated and drained by "tidal irrigation" (*pasan-surut*). Peaty soils in the hinterland will become coconut groves owing to the acidity of the water leaching in the ditch (Tanaka, 1986).

(2) Deep canals excavated by modern machines to ensure drainage allowed to accommodate organized and state-sponsored transmigrants from Java. The latter model has been shown, in many cases, to be unsustainable because deep drainage irreversibly desiccated the peat layers, resulting in peat loss and acidification (Kaida, 1979). Many of these ricelands that were productive at the early stage are now being abandoned.

7 Southern India's cascade tanks

From the lower slopes of the Deccan plateau to the rivers in the plain in southern India, a series of cascade tanks have been used for a long period of time, since the 2nd century. The shallow tanks store irrigation water for downstream use, and every tank bottom itself becomes rice fields when water recedes. The tank floor, after water has receded, becomes a browsing ground for herds of cattle. This corresponds to the traditional land- and waterscapes in southern India, which contrast with the square sacred ponds attached to every temple in the same region. Probably, the bimodal rainfall patterns in this region ensure efficient use of this cascade tank system (Fig. 11).

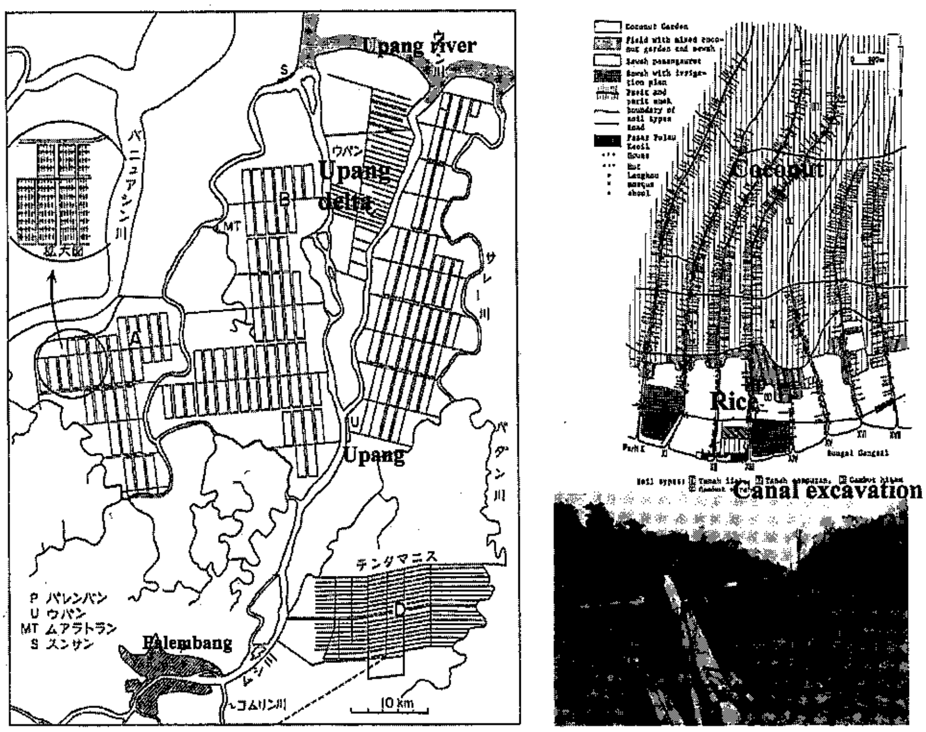


Fig. 10 Two different modes of coastal peat-swamp development on Sumatra Island, Indonesia A large and geometrical layout of drainage canals alignment in a state-sponsored trans-migration project vs. shallow drains dug by spontaneous settlers to use swamplands for coconut groves.

8 Combined use of surface and groundwater in northern India

It is surprising to observe that irrigation canal command areas of the famous Ganga Irrigation Systems almost exactly overlap STW-irrigated tracts. This is because tertiary or quarterly canals in the lower reaches are not capable of conveying the appropriate amount of water at the right time. Farmers install dug-wells or STWs driven by motors to suck groundwater which may be constantly replenished by seepage from the canals. In the areas out of the canal command, the same intensive, diverse and intricate cropping as in the command areas is practiced. Kaida has designated this practice as "domestic response to foreign impact", in praise of local farmers' wisdom in making the best use of the conditions given to them (Ueda and Kaida, 1994; Kaida, 1997) (Fig. 12).

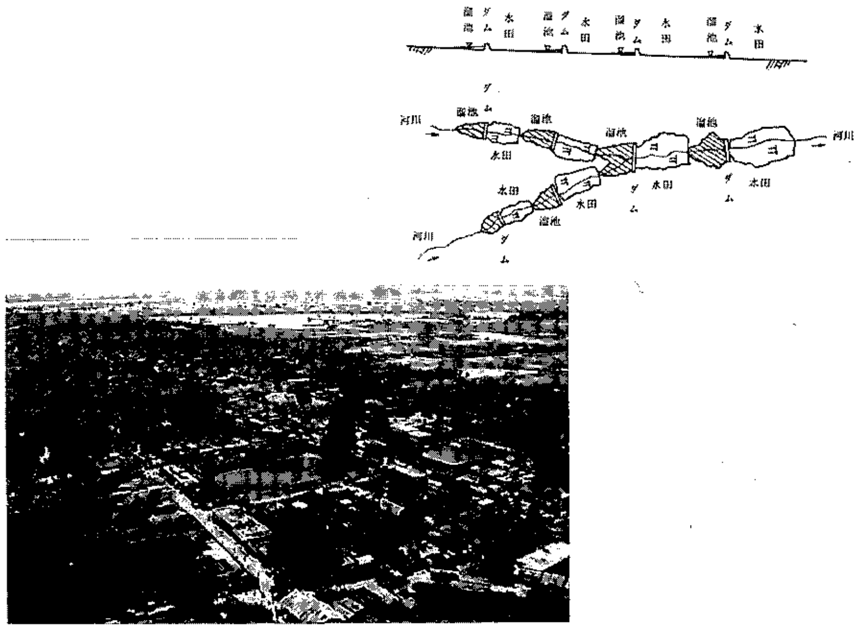


Fig. 11 Southern India's cascade tanks for irrigation (background) and temple sacred ponds (foreground).

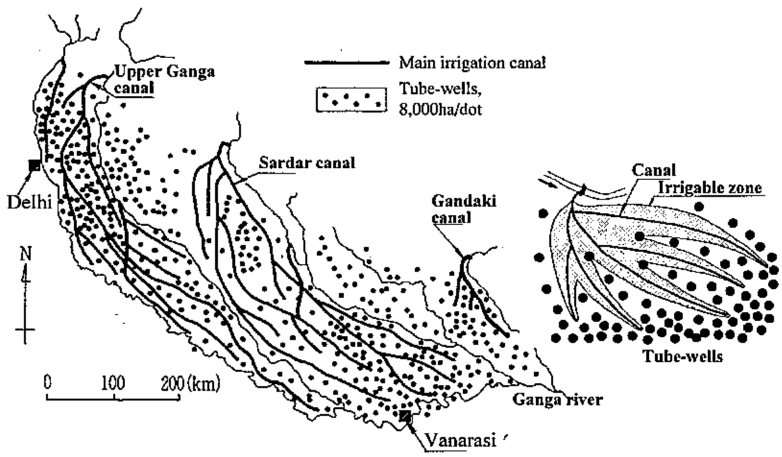


Fig. 12 Combined use of canals and groundwater in northern Indian plains Water distributed to a large region by the giant canal networks is actually used at field level through SDWs (shallow dug-well) or STWs (shallow tube-well) sunk in the individual farms.

Irrigation types corresponding to the physiographic setting of ricelands

Irrigation types corresponding to the physiographic setting of ricelands are presented in Table 2.

Table 2 Eight major types of irrigation corresponding to physiographic setting

Types of irrigation	Physiographic setting
Rain-fed	Plain
Tank irrigation	Plain and plateau
Controlled stream diversion irrigation	Intermountain basin, fan and volcanic foot-slope
Tube-well irrigation	Plain (Gangetic Plain)
Lifting irrigation from controlled creeks	Lower delta
Semi-controlled gravitational canal irrigation	Major part of upper delta, plain
Water conservation	Floodplain in delta
Tidal irrigation	Coastal plain

Note: Listed in the order of area covered by each type of irrigation.
Source: Kaida, 1991

Future trends of land and water use in agriculture

Future types of irrigation in monsoon Asia

In my personal view, in tropical and subtropical monsoon Asia, the types of irrigation of ricelands will become as indicated in Table 3. About half of the ricelands will still remain unirrigated , because of either the non-availability of water, or high costs of installing new irrigation systems.

Table 3 Types of future irrigation and associated land use in monsoon tropics

Types of irrigation and land use	Area
Rainfed	50 %
Controllable irrigation Controlled stream diversion irrigation ("Irrigation water running through homestead woods and gardens into rice land behind") Gravitational canal irrigation ("Rice estate") Tube-well irrigation ("Multiple cropping on the basis of individual lifting irrigation") Tank plus dug-well irrigation Lifting irrigation from controlled creek ("Rice, fish, fruit and poultry complex")	35 %
Water conservation ("Floating rice and fish culture")	15 %

Source: Kaida, 1991

Thirty-five percent will be under controlled irrigation of various types, while the remaining 15 % will be under loose water control, namely, under deep water conservation, mainly in the present floating rice area. The zone will serve as water retarding basins to absorb drained water from controlled irrigation areas. The control of flooding in the floodplains in the delta, though feasible mainly from the standpoint of engineering, may not be a wise alternative. Costs would be high, and it might threaten the delicate water balance. The floodplain makes a better contribution by serving as a water conservation area, where floating rice and fish can be grown safely.

Future trends of land and water use in agriculture

Overall, future trends of land and water use in Asian monsoon zones would be, in my personal view : 1) individualizing irrigation, 2) selective irrigation for diverse cropping patterns, 3) landscaping irrigation, 4) communalizing water use planning and implementation, and 5) regionalizing irrigation for combined rural and urban water management.

1 Individualizing irrigation for intensive and diversified cropping

Agricultural technology is basically the individual farmers' technology. Irrigation technology alone has been considered to be communal, collective, and often governmental by many engineers, and naturally the ethics of communalism and collectivism was encouraged for proper operation of gravitational canal irrigation systems. Always the concern among irrigation specialists was how to develop communal and regional organizations to operate and maintain the irrigation systems more efficiently.

The modernization of irrigation facilities has largely been motivated by the introduction of modern high-yielding rice varieties since the late 1960s, and improved irrigation has in turn given greater freedom in selecting rice varieties and combining crops grown in ricelands almost throughout the year. The modern rice varieties were particularly suitable for adoption as major component crops in multiple cropping systems, in part because of their higher yielding potential than their local traditional counterparts. In addition, their photo-period insensitivity and short maturity allowed them to be easily incorporated into the original cropping patterns.

In the case of a small tank irrigation system in the dry zone of Sri Lanka, the efficiency of irrigation delivery in the dry season was sometimes found to be as low as 40 %, with the remaining water being wasted down the field channel. Despite the many engineering and organizational deficiencies that remained to be overcome, it was found that the major cause of the loss was the complicated, multiple cropping patterns adopted by individual farmers. Given a block of ricelands in which a certain percentage is planted to non-rice crops, the right amount of irrigation water calculated for water requirement for various crops cannot be delivered properly, because the physical dimensions of the canal and field channel networks are designed for the full irrigation of rice-land, which requires much more water than mixed cropping. A remodeling of the whole irrigation system may be required to meet the various water requirements of individual field plots and blocks in terms of amount and timing.

Several measures can be applied to cope with maldistribution of water. The first is the improvement of "hardware", e.g. by linking several tank irrigation systems in series or in parallel in order to minimize the overall loss of water, in a way adopted in many of the traditional tank systems in the dry zone of Sri Lanka. The second is the refinement of "hardware and software", e.g. by operating a very intricate tertiary irrigation network through an operational organization which allows the famous "rotational irrigation" practiced in parts of Taiwan. The third measure, described earlier, is to use shallow wells dug in individual field plots to collect groundwater seepage from the tank in order to supplement erratic surface delivery. This regulation by individual use of dug-wells may also be applicable in large gravitational irrigation systems where water delivery tends to be erratic and unreliable. Instead of the wells, a group of small regulating ponds could be used to temporarily store rainfall and excess water delivered through irrigation canals, thereby greatly improving irrigation efficiency. These measures are all directed toward the individualization of irrigation.

2 Individualizing irrigation for individual farm operations

An increasing number of farmers are now seeking nonagricultural and off -farm job opportunities, resulting in part-time farmers. In Japan, this trend requires extra capacity and a more flexible operation of gravitational canal irrigation systems as more and more farmers demand water supply only over the weekends when they can work in their fields. Furthermore, they have been requesting very flexible water delivery systems through pressurized pipelines, where water can be tapped fully at any time just as city people tap water from the water system at any time. Elsewhere in Asian countries, more and more farmers install STWs so that they can obtain water on demand. In Pakistan, along the main and lateral water conveyance canals, a number of STWs are installed to secure water uptake on demand at any time. It is difficult, however, to distinguish this innovation from water "stealing". The communality of their operating canal network is increasingly becoming a burden to the water users, who are not available in the villages as before. As indicated in the Hindhustan plain, individual STWs installed in the irrigable tracts of the canal command supplement the surface canal irrigation systems. This trend of using the induced groundwater through individual STWs will become more and more common.

We can now request irrigation engineers to plan and design systems, from the first place, compatible with the combined use of surface and groundwater, and also compatible with mixed communal and individual handling of the water delivery.

3 Landscaping irrigation

Many of the traditional Japanese irrigation systems in fans had multiple uses before being channeled into the ricelands: the clean water diverted from a weir ran first through the settlements, providing water for such domestic uses as washing vegetables for marketing, rearing carp and other fish, washing household utensils, washing clothes, and fire-fighting. Water and the irrigation landscape were kept clean for these minor uses. Many of them, however, have been abandoned with the "modernization" of the past 30 years, resulting in polluted water and "poor" irrigation landscapes. Modern rationalism in the planning of irrigation has bypassed the multiple water uses, and considered single purpose of efficient irrigation. Only recently has the concept begun to be reconsidered from the standpoint of creating and improving the waterfront landscape and enhancing the recreational utility of irrigation facilities.

Ms. Tomiyama, a renowned critique on water-related culture and environmental conservation, writes the following poetic phrases while showing a beautiful rural scene at Asuke, Aichi, Japan, which was photographed by the famous photographer, Shinzo Maeda: (Fig. 13)

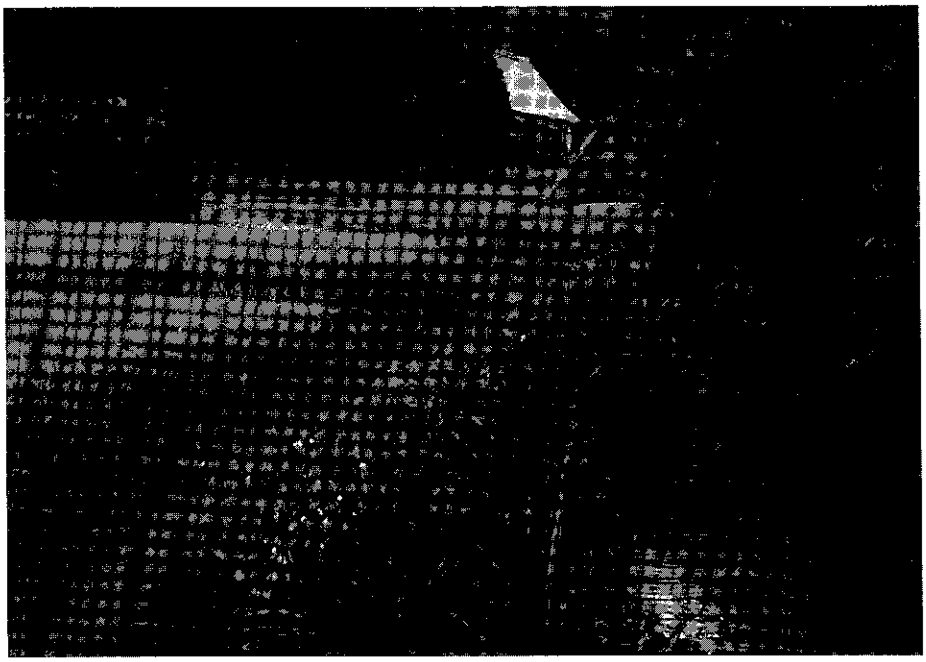


Fig. 13 A brook in spring, Japan.

Streams in the homeland have surely flowed like this since rice first was grown in the Yayoi Period. Such channels, as the songs say, teemed with crucian carp and loach and were home to schools of killifish. Waterways like this once were as much part of the lives of children as the songs they now sing. In the twinkling of an eye, the clear brooks, which from the upland to the seashore, flowed to every corner of our land, have all but disappeared. A single generation of neglect has wasted what was maintained for millennia. We need to restore the pure water of hometown streams and make them everywhere flow into the lives of children again. To do this we all have to support the farming families who manually labor to maintain the land and water (Calendar, September 2001).

Since the early 1990s, the Japanese engineers have attempted to adopt the "biotope" concept which had originated in Germany, being backed up by citizens' movement to *restore* what Ms. Tomiyama advocated above. The engineers are now trying out what they claim "near-natural" engineering to restore the secondary nature with which we had been endowed plentifully before we "modernized" farming practices and rural infrastructures, especially irrigation and drainage[1].

We have many lessons to learn in this respect from the small irrigation systems in Southeast Asia. Irrigation networks in the volcanic foot-slopes in central Java and in Bali, for example, are all designed to serve multiple purposes. The water runs down through settlements and homestead gardens and is used for watering gardens, daily washing and bathing and other purposes, then runs into the ricelands behind the homestead forests and gardens. I have been fascinated by this multiple use of irrigation water and people's ingenuity in making engineering structures and works a part of the "landscape", infusing the natural and man-made landscapes into one. I consider this "irrigation water running through homestead woods and gardens into the ricelands behind" as a typical and desirable irrigation landscape in small fans and volcanic foot-slopes (Fig 14).

4 Communalizing rural development plans and implementation for people's participation

In many of the ODA-related agricultural and rural development projects in developing countries, a group of engineers, both from the country of origin and foreigners, may be employed to make plans from scratch, design and supervise the implementation of a project. They normally start their jobs by making maps where necessary, installing rain and water gauges to collect hydrological data, drilling test bores for groundwater prospect, sampling soils to determine the soil characteristics based on the FAO and other scientific schemes. This routine work is more or less standardized and may be applied even to small-scale agricultural and rural development. I would say, particularly for the case of rural development, that all this professional routine tends to preclude possible participation of local farmers in the planning stage, thus alienating the project from the local people.

A diagram (Fig. 3) indicates the local taxonomy of micro-topography drawn by the local people, in comparison with a somewhat modern but mechanical standard classification scheme. In this case, the local taxonomy is not necessarily superior to its modern counterpart, but it is sufficient to serve the purpose of planning rural development. Likewise, farmers have their own taxonomy of local soils in simple, ordinary words, which is normally sufficient, or even better than the standard, scientific classification schemes, to serve the purpose.

Another diagram (Fig. 15) shows a sample of so-called rural hydrology, indicating the directions of flood flows and *banga* (washed and eroded points in road and flood embankment). This map has been drawn using (1) foot, (2) a bicycle, or at best a motorcycle, (3) eyes to see the reality, (4) ears to listen to what the local

[1] Journal of the Japanese Society of Irrigation, Drainage and Reclamation Engineering discusses the "biotope" in the special issue dedicated to this topic, in vol.69, number 9, September 2001.

Fig. 14 Bali's *subak* weirs and their guardian shrines
Subak **weirs, large and small, are always associated with their guardian shrines. These artificial structures are fused completely into the environment.**

➢Water map through local people's eyes
➢Equipment required: Either foot, bicycle or motor-cycle; eyes to see, ears to listen to; and soft mind to interpret what people say.
➢Base map: *mouza* map
➢Encourage people's participation from planning stage.

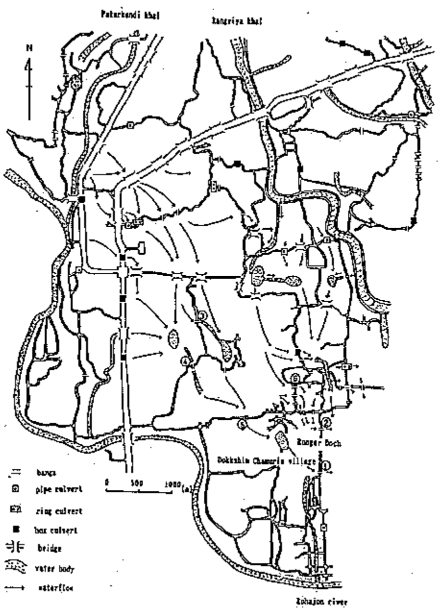


Fig. 15 Rural hydrology
A water condition map, generated on the basis of local people's observation and information, assures people's participation when local micro-infrastructure schemes are planned and designed on it.

people say, and (5) flexible mind to try to intrepret how local people evaluate the situation. Neither tools nor scientific equipment may be required to draw this type of local-scale resources maps (Uchida *et al.*, 1995). Through the process of making the "rural hydrology" map, engineers will be able to rouse public interest in the forthcoming project, and enhance local people sense of ownership. In my own experience, by the time when the simple map was completed, a consensus had already been reached as to which *banga* should be refilled and reinforced and which bridges should be repaired, or where new bypass roads and bridges should be installed, etc. I would refer to this process as "communalizing" project planning process to ensure local people participation in and the ownership of a local development project.

In the case of the northern India's Ganga Irrigation System which was shown earlier, if engineers had carried out field studies and noticed the ubiquitous dug-wells and STWs used conjunctively with the canals, they might have come up with an alternative concept of designing this combined system in the first place, rather than persuading local people to organize themselves into irrigation users' associations to better manage the canal system. Where a workable irrigation association does not exist at this moment within a very traditional irrigation system such as this, it will never be organized in future. People know that it will not work. In this case, individual irrigation by way of combined use of canal and groundwater is the very "communal" way of using water.

5 Regionalizing irrigation for combined rural and urban water management

Urban encroachment is taking place almost everywhere in the rural regions. In most areas, the increased run-off and drainage loads following urbanization are dumped into the existing irrigation and drainage systems. Likewise, polluted drainage from urbanized districts is generally discharged into the existing irrigation and drainage systems. Being overwhelmed by the increased inflows and contamination, many of the Land Improvement Districts (LID)[2] in heavily urbanized districts have given up the responsibility and entrusted the municipality with the regional water systems. Some active LIDs, however, have used this opportunity to integrate the regional drainage into their irrigation and drainage network based on a contract with municipalities or townships with the outlay of necessary public budget.

Many of the ponds for irrigation are less used in the urbanized districts, but they must be maintained to avoid breaking. This is becoming a big burden to the LIDs. Many of the ponds are being transferred to municipality or township, and are being improved and used as suburban recreational areas. Some active LIDs can also take part in the recreational and entertaining enterprises with the best use of their assets of ponds and running waterways. In general, water users' associations, such as the LIDs in Japan, are most qualified to operate and maintain regional water systems as they have full expertise of handling water and are very cautious about water contamination. They should be entrusted and provided with necessary budget for operation and maintenance of the regional water systems. Water users' associations would better be geared to manage regional water resources.

At one time in the history of modern Japan, respective water users made individual projections of future water demand by extrapolating the current trend of often over-estimated demands. New users in the industrial and domestic water supply sectors have asked for more water, while the irrigation sector never abandoned its traditional vested rights to the water in the river basin. New sectors had no other choices but to build reservoirs in the upper reaches. Avoiding high-cost water supplied from the "public sector", many industries have developed their own water-recycling systems, while the irrigation sector has continued to release almost two-thirds of its water demand downstream through modernized irrigation and drainage networks[3]. This has resulted in, eventually, over-investment in the so-called "public works", leaving a large volume of unused water

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[2] In Japan, conventional irrigation and drainage systems have all been operated and maintained by the "land improvement district" (LID). This is an institution almost equivalent to an irrigation association, or irrigators' association, elsewhere.

in the reservoirs.

In the arid zone, too, CPI operators (I am using the terminology CPI and *sakia* symbolically) ask for more water, and the industrial and domestic water supply sectors will force their way, while *sakia* wheels as ever. Arithmetic sum of their future demand projection will become very high. Scarce water available in a basin must be shared among the different users either through free market or communal manipulation. In the free market, *sakia* must disappear first because of its inefficiency, followed probably by the fossil groundwater in deep aquifer. If all of those concerned do not want the water resources to be extinct and contaminated to an irreversible extent, a regional institution to manage water resources must be established. The rule to operate the institution should be much tighter in the arid regions than in the humid regions. The arid region has a much smaller margin to water crisis leading possibly to environmental catastrophe.

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[3] In ordinary irrigation and drainage systems of paddy lands, about two-thirds of the water taken-in from a river at the diversion point return to the same river farther downstream either through seepage or open drainage channels. Modern facilities enhance this cycling of water. Moreover, in Japan, irrigation demand is decided on the basis of drought years that recur every 10 years. In normal years, excessive water simply runs down the irrigation channels, or water is not taken in full amount.

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