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Food Security in the Philippines

LIBORIO S. CABANILLA and MERLYNE M. PAUNLAGUI, *Editors*

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Water Management 2000: Not by Irrigation Alone

MAXIMO W. BARADAS and JOSEPHINE DG. MINA

Conventional thinking about agriculture revolved around the use of new varieties and fertilizers and pesticides without due regard to environmental inputs. This practice has placed the country among the lowest in the world in national average yields per hectare and/or the most expensive in unit production cost. Contrary to conventional thinking, flood and drought are nature's solutions to low food production. This chapter suggests that natural rainfall management can be a very effective and cheap alternative to the irrigation of rainfed areas.

CLIMATE CHANGE AFFECTS THE HYDROLOGIC CYCLE AND THREATENS FOOD SECURITY

Let us consider the hydrologic cycle in order to appreciate better the origin of the water problem and possible solutions, especially the nonconventional ones. The hydrologic balance of equation of land surfaces is:

$$P = ET + N + dm/dt \qquad (1)$$

where: P = precipitation (rainfall [R] and irrigation [I]);
ET = evapotranspiration (evaporation [E] from nonplant surfaces + transpiration [T] from plant surfaces);
N = runoff; and
dm/dt = change in soil moisture storage (time-rate of exchangeable soil moisture)

$$T = R + I - E - N - dm/dt \qquad (2)$$

There are four possibilities for getting enough water for transpiration. These are:

a) conserve rainfall [R];

b) irrigate [I] the crop;

c) reduce evaporation [E] and runoff [N]; and

d) combination of the above.

Conserving rainfall includes increasing soil moisture storage [dm/dt] for later use and collecting flood water from reservoirs for irrigation.

Irrigation water may come from farm reservoirs, tubewells, gravity irrigation systems, springs, and rivers.

Evaporation [E] is about 64 percent (378 millimeters [mm]) of total evapotranspiration (589 mm in 91 days) from lowland ricefields in the dry season and up to 78 percent (308 mm) of evapotranspiration during the rainy season at International Rice Research Insitute (IRRI) from 1966 to 1967 (De Datta 1981). Evaporation from lowland ricefields may be reduced by up to 80 percent with the aid of evaporation suppressants or monomolecular film.

The basic challenge in crop water management is to have enough water for transpiration [T] during critical crop development stages so that the crop will not be stressed and give high yield.

Annual total evapotranspiration [ET] in a humid tropical setting such as in the 46-square kilometer (sq km) Mabacan River watershed in Laguna is about 37 percent (700 mm) and runoff, around 63 percent (1,200 mm) of 1,900 mm average annual rainfall (Lettau and Baradas 1973). It is clear that proper rainfall (runoff) conservation can provide all the crop water requirement for transpiration even for the dry season crop.

Runoff may be reduced by increasing soil infiltration with levees or dikes, terracing, and reservoirs.

Climate change, which affects the hydrologic cycle, is often blamed for our water problem and its subsequent effect on food security. Global warming has been projected to increase evapotranspiration. Consequently, rainfall is projected to increase in some places resulting in possible flooding of low-lying areas, but rainfall will be deficient in other areas.

What some people want you to believe about climate change

Many people and the media, certainly, have used the terms "global warming" and "climate change" interchangeably. Studies on global warming due to increasing greenhouse gas emissions, particularly the doubling of carbon dioxide concentration, use the global circulation mathematical models (GCMs). The output of GCM models is simply a climatic scenario. This output answers the question: "What (will happen) if (e.g., carbon dioxide concentration is doubled?)" It does not predict climate. There is a lot of uncertainty about the model itself and the variable being put in, like doubling of carbon dioxide concentration. But the media have been reporting the scenario output of GCM models as future climate change. As C.T. Rubin and M.K. Landy (1993) put it, "Is it responsible (or even possible) to act on (global warming) predictions based on assumptions?"

Global warming is supposed to raise air temperature by as much as 7^{0}F over a 50- to 100-year period (White 1995). In addition to temperature increase, global warming could also cause sea-level rise and rainfall variability which could threaten food security. The Intergovernmental Panel on Climate Change (IPCC), based on their analyses and assumption of continuing trends in greenhouse gas emissions (GHGs), predicted a global sea level rise of 20 centimeters (cm) by the year 2030 and 60 cm by 2090 (Parry et al.). They predicted that even if GHG emissions were halted by 2030, the global sea level would continue to rise to 40 cm by 2100, levelling off a century or so later. They adopted for their report a 1.0-meter (m) sea-level rise (highest high tide).

What you should know about climate change

Weather is basically the instantaneous state of the atmosphere with respect to solar radiation, temperature, wind, precipitation, and humidity, among others. Climate, on the other hand, refers to the average weather conditions, including the extremes, in a given place.

Climate, like weather, is prone to fluctuations. In the 4.5-billion year history of the earth, several climatic changes have occurred. The First Ice Age took place 2.5 to 2.0 billion years ago. This was followed by the Warm Spell (warmer than today) 2 billion to 950 million years ago, even without the greenhouse gas emissions (GHGs) that we have today. Then came the Great Winter 950 to 650 million years ago and another Warming 650 to 70 million years ago when a great proliferation of life began (Christian 1993).

In ASEAN (1990), four basic designations related to duration for climatic variation were given:

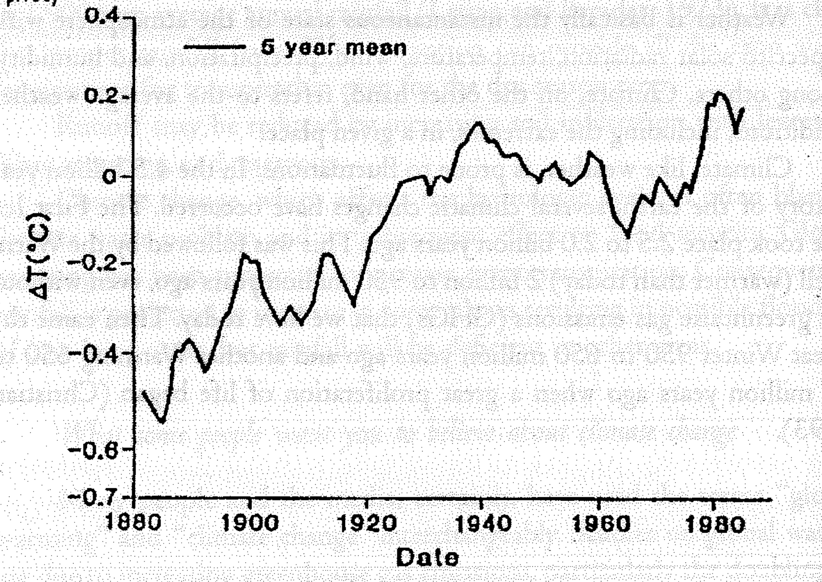
climatic iteration :	less than 10 years
climatic fluctuation :	10 to 1,000 years
climatic change:	10,000 to 1,000,000 years
climatic revolution :	over 1 million years.

Climatic iterations could be caused by terrestrial or air-sea interactions; climatic fluctuations by deep-ocean circulation or solar emission changes; climatic changes by the earth's orbital variations; and climatic revolutions by continental drift.

Twenty years ago, the literature on climate change revolved around global cooling resulting from volcanic eruptions and dust during droughts as in the early 1970s. In 1991, the eruption of Mt. Pinatubo resulted in global cooling. Today, much of the literature on climate change focus on global warming. How can there be global warming after just 20 years of global cooling (fig. 1)? If this is so, we have to redefine climatic change.

There is evidence that "weather anomalies in the last decade are not connected to the purported thinning of the ozone layer or a possible greenhouse effect but are more related to the cyclical shifts in atmospheric and

FIGURE 1: Mean air temperature change at 29 percent of the surface of the earth (*after* ASEAN 1990, p.136)

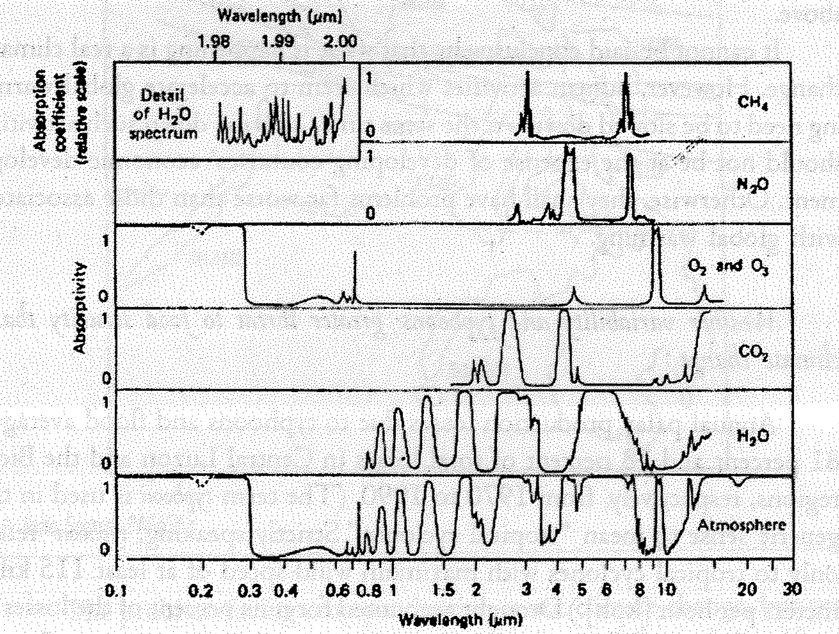


oceanic currents, known as the El Nino/Southern Oscillation" (White 1995).

Actually, the water vapor contribution to the natural greenhouse effect is about 70 percent (fig. 2) (although there is very little discussion about it in available literature on climate change). Thus, the effect of the greenhouse gases must be much less than 30 percent.

Studies about climatic change are often greatly misinterpreted. Figure 1 shows a typical finding that is expressed in temperature patterns during the past hundred years. Several features must be noted. First, these temperature values are from land-based stations that represent, at best, 29 percent of the global surface. The pattern also applies only to extratropical regions of the North Hemisphere which is about 48 percent of the earth's land surface. This means that fig. 1 shows patterns of only about over one-seventh of the earth. Strict statisticians will frown at such a very small sample.

FIGURE 2: Absorption spectra for various atmospheric gases (*after* Fleagle and Businger 1963 as cited in Rosenberg 1983, p. 35)



Second, these temperature values are based on some 100-150 stations worldwide. Most of these are located in or near urban areas and their heat islands. But from about the late 1930s to the early 1950s, most stations were located in airfields in rural areas — a cooler environment. Later, these airfields came under the influence of the heat island as the cities grew.

Another complication arises in the use of the term "climate change." Most studies focus on the temperature aspect, but few consider precipitation and even a fewer number deal with air mass variations. Only the latter can be called climatic studies, as distinguished from temperature and precipitation studies.

There is also the issue of "statistical illusion." Figure I shows a period of 100 years plotted against fractions of 1°C temperature change. What is 0.8°C over a hundred years? It cannot boil water, let alone melt the polar ice caps. This actual temperature change in the last 100 years is very far from the 7°F projected for the next 50 to 100 years (White 1995) mentioned above.

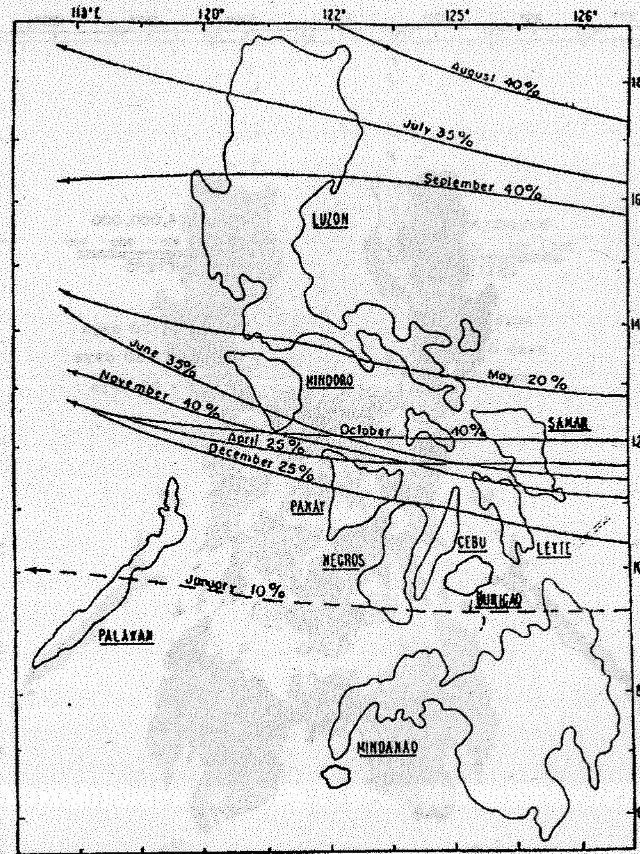
It cannot be said conclusively that what is happening is a real climate change. However, human activities which seem to accelerate global warming need to be slowed down. At the same time, slowing down such activities should not be at the expense of developing countries' economic development. Otherwise, they shall have problems far worse than those associated with global warming.

Weather variability and typhoons: greater threat to food security than climate change

Annual palay production losses due to typhoons and flood averaged 81 percent and 78 percent of total losses in Central Luzon and the Bicol regions, respectively, from 1970 to 1990. (The term *typhoon* is used in the generic sense to mean "tropical cyclones." Strictly speaking, *typhoon* refers only to tropical cyclones with maximum wind speed of at least 115 kilometers per hour [kph].) Drought accounted for nine percent of the losses in Central Luzon which has good irrigation systems, but 71 percent in Central Visayas and 62 percent in Western Visayas which have less developed systems.

Yet, farmers need not suffer yearly from typhoons. The average monthly tracks of these typhoons (fig. 3) are well known. They do not vary considerably over the years. These tracks respond to the atmospheric pressure distribution over the earth's surface resulting from the earth's revolution around the sun. Farmers simply have to avoid coinciding the critical stages in their crops' development with the expected arrival time of typhoons.

FIGURE 3: Mean monthly tracks of tropical disturbances over the Philippines



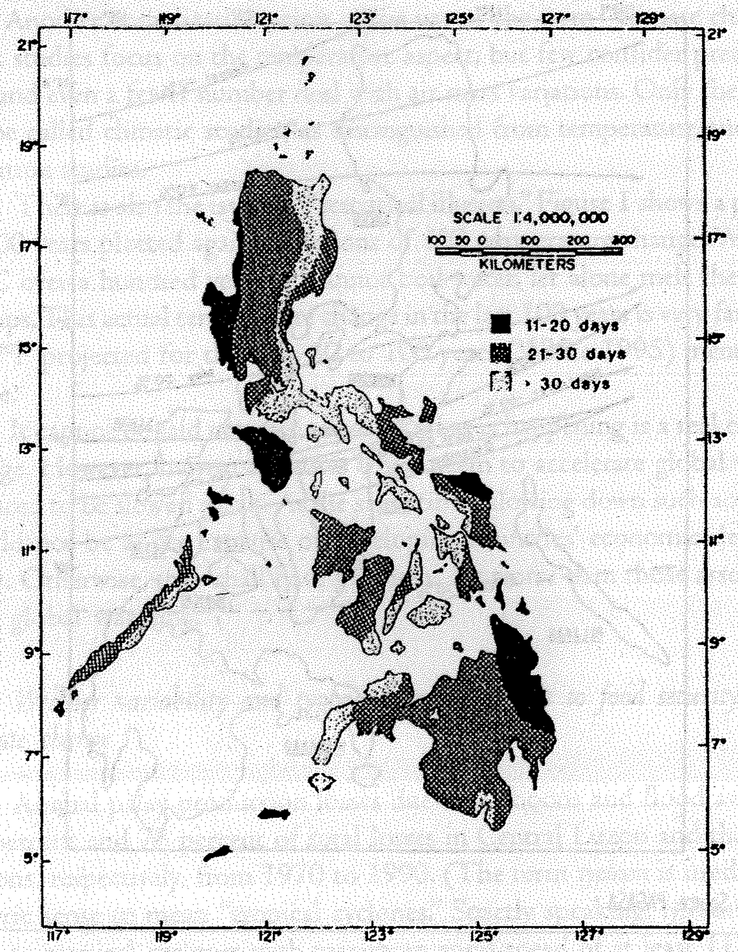
Data Source: PAGASA

The problem facing crop production is not climate change, but year-to-year or even day-to-day weather, particularly rainfall variability (figs. 4 and 5). Farmers can adapt to climate change which comes slowly.

FLOOD AND DROUGHT: NATURE'S SOLUTION TO LOW FOOD PRODUCTION

For a very long time, agricultural development depended on the breeding of new crop varieties, the use of more fertilizers and pesticides, and irrigation mostly for lowland rice. Climate was considered only as a hazard

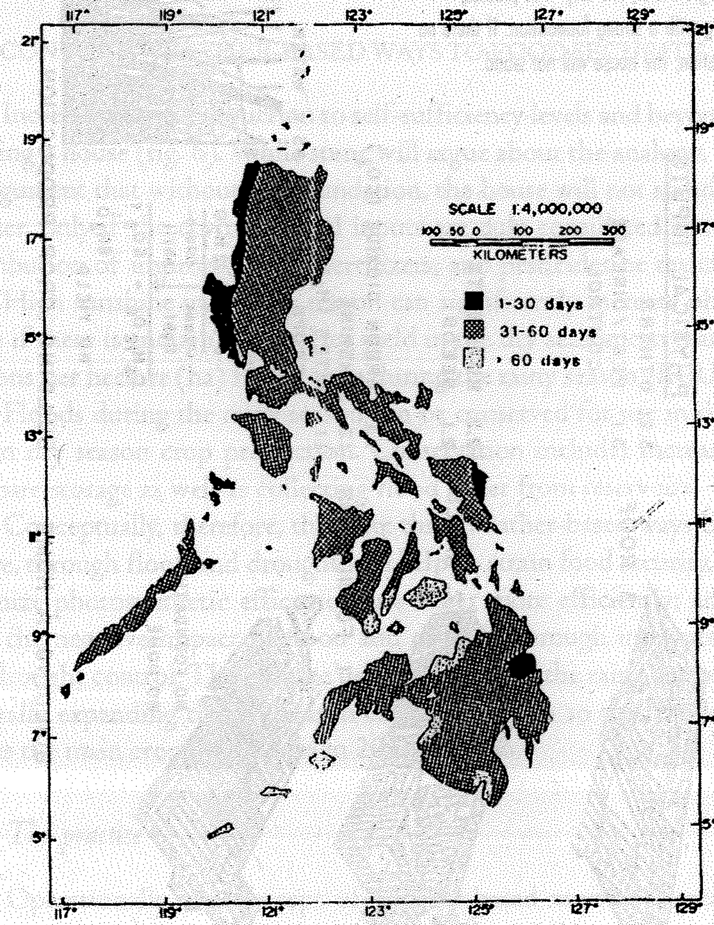
FIGURE 4: Variability of the onset of wetland rice growing season (Period needed to accumulate 200 mm rain after 31 March, *after* Boling 1991)



to agriculture and people seem to have been conditioned to think that nothing can be done about it. As mentioned above, this approach has put the Philippines among the lowest in the world in national average yield per hectare and/or the most expensive in terms of unit production cost. Why not consider the whole crop production system and manage climate to our advantage?

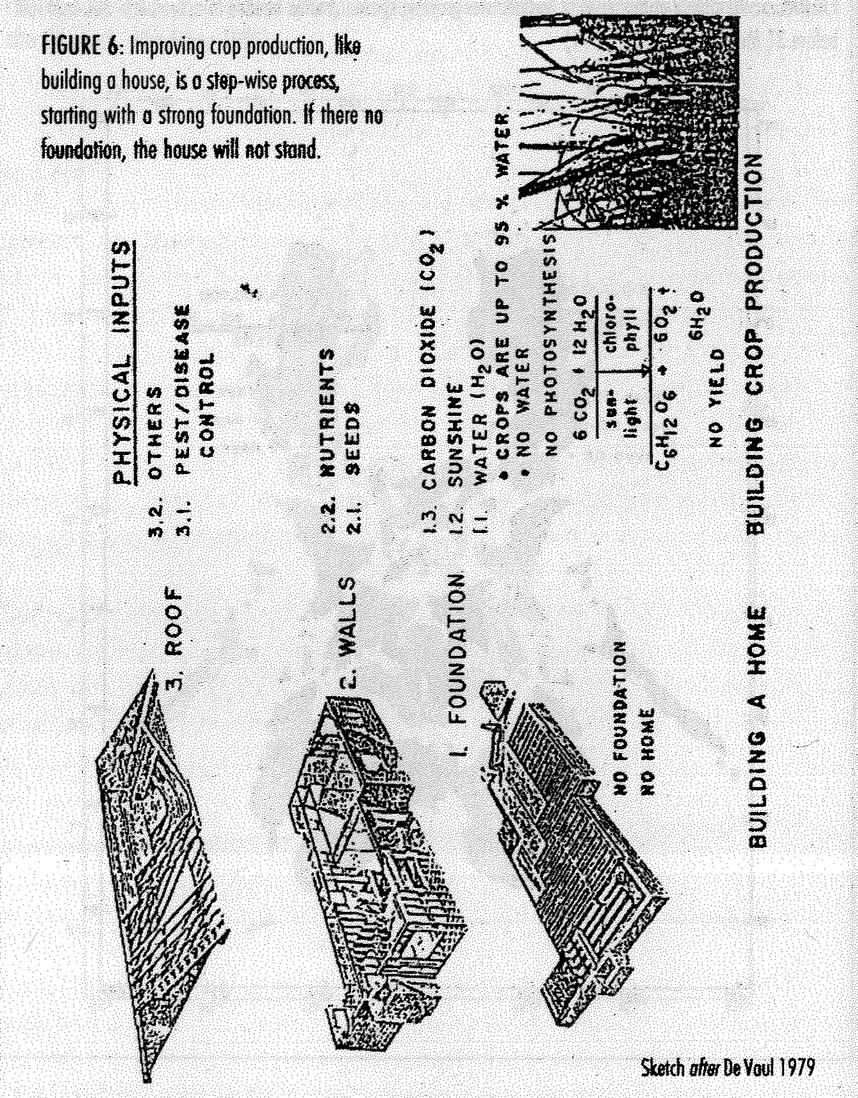
Agricultural policymakers, program implementors, and even some academicians do not seem to appreciate the low crop production potential of

FIGURE 5: Variability of the onset of wetland rice growing season (Period needed to accumulate 300 mm rain before 31 March, *after* Boling 1991)



keeping the rainy season as the main cropping season. Due to cloudiness in the rainy season, there is little sunshine available for photosynthesis. There are more weeds since water is everywhere. Pests abound due to more alternate hosts and the pesticides are washed off by rain. Due to high humidity, high incidence of diseases occurs. Inputs and harvests are difficult to transport to the farms and market, respectively, due to poor road conditions. Grain crops are also difficult to dry.

FIGURE 6: Improving crop production, like building a house, is a step-wise process, starting with a strong foundation. If there no foundation, the house will not stand.



Sketch after De Vaul 1979

During the dry season, sunshine for photosynthesis is abundant and other conditions are more favorable for high crop production. There are fewer weeds and pests and less diseases. Transport of crop production inputs and harvest is easier even in third-class roads. Grain drying is not at all difficult.

But water is insufficient during the dry season. Considering that crops need water and sunshine to produce high yield in addition to sufficient

nutrients, why not promote technologies that increase soil moisture storage, save the floodwater, and use the high sunshine during drought (actually dry season) to increase crop production and annual farm employment?

THE CONCEPT: WEATHER-BASED WAYS TO FOOD SECURITY

Increasing crop production to self-sufficiency levels and beyond is like building a house (fig. 6). While some will argue about the analogy, there is no argument that without the foundation, the house will not stand. In like manner, only if the environmental inputs are duly considered can the full contribution of improved seeds, fertilizers, and pesticides be realized.

High sunshine in the dry season can significantly increase photosynthesis if there is enough water. Rice yield in the dry season can reach up to 2.2 tons per hectare (ha) higher than during the rainy season (IRRI 1975).

Floods during the rainy season can be conserved for use in dry spells and in dry season crop production. Conservation includes increasing soil moisture storage as well as collecting flood water from reservoirs.

Conceptually, therefore, there are three weather-based ways by which nature, through flood and drought, can help us attain food security, namely, optimize photosynthetic efficiency; use water more efficiently; and minimize the negative impact of flood and drought through integrated flood and drought control. They can be used both during the rainy season and in gradually expanding the dry season crop production so that the latter becomes the main cropping season in 20 years or so.

The practice

Operationally, the concept of weather-based ways to increase food production boils down to sunshine harvesting, rainfall harvesting, and integrated flood, soil sediment, and drought control.

Optimizing photosynthetic efficiency (sunshine harvesting). Photosynthetic efficiency (PSE) is basically the energy equivalent of dry matter produced by a given crop at harvest divided by the total solar energy received from planting to harvest in the field in which the crop is grown (Baradas 1994a). Table I shows the actual and potential photosynthetic and water use efficiencies of various cropping systems. Only about one percent, or even less, out of a potential 10 percent (based on total incoming solar radiation), is converted to yields in our farms. Since the photosynthetically active radiation (PAR) is only about half of the total incoming solar radiation, some say that PSE should be based on PAR. That simply means doubling the present and potential PSE.

The denominator of the PSE equation, which is total solar radiation received from planting to harvest, can be "manipulated" through agronomic practices. Not enough work has been done using this approach to increase yield relative to breeding new varieties. Basically, the agronomic approach involves either of the following or both: a) reducing the total value of solar radiation received by the planted area from planting to harvest; and b) getting the crop to intercept most, if not all, of whatever radiation is received in the field.

One practical way to reduce total solar radiation received, from planting to harvest, is to shorten the crop duration in the field. This means transplanting, for example, rice seedlings when they are older (up to 40 days old for 105-day varieties), but the seedbed technology must be improved (to minimize root damage which delays maturity) and foliar fertilizer applied before and after transplanting.

Another possible measure to reduce total solar radiation received is to induce the crops to flower earlier than usual, perhaps through the use of growth regulating chemicals. In the case of rice, only the top four or five leaves contribute largely to grain yield, but the crop produces 14. If this can be reduced to 10 through early flower induction, the crop cycle shall be significantly shorter than 90 days. A 60-day cycle implies up to five crops per year in continuously-irrigated areas.

Increasing solar radiation interception means closer spacing, multiple cropping, and transplanting of older seedlings. That crops can convert to food only the solar radiation that their leaves actually intercept is often overlooked.

Rainfall harvesting and increasing water use efficiency. Rainfall harvesting has been practiced by many farmers especially in arid and semi-arid regions. Although the practice of collecting flood water from rain has yet to be promoted extensively, the Bureau of Soils and Water Management (BSWM), including the Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD), has already performed some demonstrations of the process. What needs to be promoted more are the crop cultural practices which increase soil moisture storage and minimize evaporation losses.

Crop water use efficiency (WUE) is closely related to PSE. It is the unit weight of harvested yield per unit weight of water used to grow the crop (Baradas 1994b). As shown in table I, there is room to increase WUE

TABLE 1

Actual and potential photosynthetic and water use efficiences

Cropping System	Photosynthetic Efficiency[1] (%)	Water use efficiency[2] (kg dry matter/ ton water)
Subsistence		
Average	0.04 - 0.1	0.04 - 0.12
Best	0.08 - 0.2	0.10 - 0.24
Ranch Farming		
Average	0.10 - 0.2	0.12 - 0.24
Best	0.20 - 0.4	0.24 - 0.48
Intensive		
Average	0.25 - 0.35	0.30 - 0.42
Best	0.60 - 1.0	0.72 - 1.2
Experimental		
Season	0.80 - 1.5	0.96 - 1.8[3]
Week	1.5	1.8
Day	2.0 - 4[4]	2.4 - 4.8
Theoretical		
Upper Limit	8.0 - 10.00	9.6 - 12.0

1. Based on total incident solar energy on the farm, therefore including energy falling on water surface, bare ground and/or weeds.

The values can be almost doubled if only the visible portion of incoming solar radiation is used as the basis for calculation. The photosynthetically active radiation is in the visible portion which constitutes roughly 45 percent of the total spectrum. Note also that the figures given refer only to the economic yield, such as grain for rice. The other plant parts which were produced also by the photosynthetic process, like stem, leaves, and roots, are excluded.

2. Assuming 60 percent conversion of solar energy to latent heat.

3. Values of 1.39 for continual soil saturation (1.0 cm) and 0.63 for deep (15 cm) continual flooding in 91 days have been reportec for IR8 at IRRI, Los Baños, Philippines, 1968 dry season (De Datta and Williams 1968).

4. Actual values of 3.35% for IR8 rice in Los Baños (Norcio 1970) and 3.0% for sorghum in USA (Begg 1965) have been reported.

Data Source: Lemon 1969

up to 10 times. Among the technologies that can be used, singly or in combination, to increase WUE by using less water are:

a) irrigating crops as needed during the reproductive stage;

b) barely saturating ricefields instead of keeping 10-cm standing water, unless water is plentiful, but controlling weeds by other means like pulling them, using rotary weeder, stepping on weeds in lowland ricefields to submerge them, etc.;

c) placing irrigated areas side by side to minimize evaporation resulting from advection of energy from intervening dry areas;

d) transplanting older seedlings to shorten crop duration in the larger fields, but improve seedbed technology to minimize root damage (Mina 1996) or use foliar fertilizers before and after transplanting;

e) transplanting other crops besides rice and vegetables (Mina 1996) instead of seeding them directly in the field, where labor and/or mechanization allows the practice economically;

f) plastering ricefield levees or dikes often with mud or insert plastic sheets around the levees to minimize seepage;

g) using drip principle in irrigating upland crops;

h) irrigating alternate furrows of row crops to minimize percolation;

i) mulching crops, like garlic, with rice straw or other suitable locally available materials to minimize evaporation and control weeds;

j) using windbreaks to reduce windspeed and evapotranspiration; and

k) avoiding off-barring and hilling-up for dry season row crops to minimize evaporation.

Integrated flood, soil sediment, and drought control. The current practice of building dikes to throw flood water quickly to the sea is an irrational flood control measure under Philippine conditions. Instead, reservoirs can be used to hold flood water back. This approach will not only control flood and minimize loss of soil sediments to the sea, but also provide irrigation water for drought control.

A simple but promising vegetable production technology is the "floating gardens" in swamps (like Candaba Swamp in Pampanga) or simply in flooded areas during the rainy season. They can also be used in rivers to replace the problematic water lily. The practice involves preparing floating beds (possibly bundled rice straw or other grasses), attaching them to stakes to keep the bundles in place, but allowing them to move up or down as the water rises or recedes, putting soil from the bottom of the swamp on top of the beds, and planting vegetables on them. Fertilizer may be applied as needed by the crop. The flooded area or swamp shall provide subsurface irrigation to the crop. Tomatoes, leafy and viny vegetables like squash, watermelon, muskmelon, bitter gourd (ampalaya), and white gourd (upo) have successfully been planted this way in other countries. Leafy vegetables, tomatoes, and melons may be covered with mosquito netting to avoid spraying pesticides that may contaminate the water.

A related technology which is used in other countries involves developing alternating (1.0 m wide – or more) dryland and submerged areas. Upland crops include vegetables and grain crops. Lowland rice and/or fish is grown in submerged areas. A basic version of this technology which can be expanded is the practice of some farmers to grow vegetables on the bunds, dikes, or levees of their fields. A highly developed version of this technology is used in the Netherlands where large drainage channels (about 3.0 m wide by 3.0 m deep) enable upland crop production in otherwise submerged fields.

IRRIGATION: WHAT FARMERS DO AFTER WASTING RAINFALL

Irrigation is a sound practice to control drought and produce more food especially in the dry season. It is interesting to note, however, that much of the quantity of water provided by irrigation was already supplied earlier by natural rainfall but was not properly conserved, hence the title of this section.

The above situation is like the proposal to pump water from Laguna de Bay somewhere between Sta. Cruz and Pagsanjan, Laguna. The water shall then be purified, chlorinated, and pumped back to Metro Manila. Much of that chlorinated water will be used only to flush toilets (biggest domestic use of water), wash clothes and vehicles, and water gardens. Much of that water actually fell earlier as rain over Metro Manila, but was not collected there. Instead, it was allowed to drain to the streets and get polluted as it went down to Laguna de Bay. How far has the Philippines 2000 master plan changed this thinking or default behavior?

The high cost of irrigation development and maintenance

Current figures on the development of gravity irrigation systems range from about PhP70,000 to PhP150,000 per hectare. Shallow tubewells which are being promoted now by the DA cost around PhP20,000 to PhP30,000 per hectare although private drillers appear able to cut down the cost considerably.

Rehabilitation of run-down irrigation systems costs nearly as much as the development of new ones. Maintenance cost is also high.

Water distribution problems in large irrigation systems

Social problems abound in the distribution of water in large irrigation systems largely because demand for water cannot be met. Outsiders will find it hard to understand, for example, why farms at the tail-end of the system may have water but those upstream have none. Often, farmers use influence or simply threaten irrigation personnel to provide water to their farms when they want it. There are also cases when farmers resort to illegal subsurface connections to the irrigation canals.

RAINFALL MANAGEMENT: CULTURAL PRACTICES TO WATER PLANTS THE NATURAL WAY

If natural rainfall management practices are promoted, food can be produced in significantly greater quantities even with a limited irrigation development budget. The farmers will themselves implement these measures at minimal cost ; government will have to bear only the cost of promoting rainfall management practices.

In South Africa, for example, they can average 1.9 tons per ha of corn from 49 mm of rain throughout the growing season using rainfall management practices (Martin 1988). In the Philippines, dry season corn produces knee-high crop and zero yield from 100 mm of rain.

Some practices used to manage natural rainfall and produce reasonable yield under drought conditions in South Africa are: (a) zero runoff; (b) near-zero evaporation; and (c) rainfall multiplication. These are applicable in the Philippines for dry season crop production.

Zero runoff

Soil ripping/subsoiling is one method for zero runoff. A subsoiler attached to a tractor cuts the soil at selected intervals and depth (around 50 cm or deeper) so that most or all of the rainfall will be absorbed by the soil.

Levees/dikes and "underground" plastic dams for upland crops will keep the rain from running off, thus, increasing infiltration.

TABLE 2

Sample afternoon weather forecast and rice farming advisory (*after* Baradas 1992)

Filename: A: ——————
(1st 7 characters of Station Name to be printed)
Date: ——————
a b c d e
AGROMET CODE: P 1 3 2 1 3
AGROMET CODE DEFINITION:
a1. Sky condition: CLEAR
b3. Maximum Air Temperature (ºC): > 32
c2. Maximum Relative Humidity (%): 70
d1. Windspeed (knots): < 10
c3. Soil Moisture Condition: DRY

Rice farming operations wihch may be done by farmers:

1. Land preparation (ploughing/harrowing/rotavating)

2. Seeding (with dry seeds)

5. Spraying (pesticide/foliar fertilizers), ground application

6. Spraying/dusting (pesticide)/fertilizing), by aircraft

8. Irrigating (flooding method)

10. Hårvesting/Threshing

11. Cleaning/Sundrying grains

Near-zero evaporation

Soil, crop residue, and/or plastic mulching will keep evaporation close to zero in upland farms. Using evaporation suppressants or monomolecular films can reduce evaporation by up to 80 percent in lowland ricefields with standing water. The materials used have at least 16 carbon atoms per molecule, are nontoxic, and environment-friendly.

No off-barring and no hilling-up for row crops also reduce evaporation by minimizing the soil surface exposed to the atmosphere.

TABLE 3

Sample morning weather forecast and maize farming advisory (*after* Baradas and Mlenga 1988)

Filename: A: A ___________
(1st 7 characters of Station Name to be printed)
Date : ___________

a b c d e
AGROMET CODE: A 1 2 1 1 1
AGROMET CODE DEFINITION:
a 1. Sky condition: Fine/Practically clear
b 2. Minimum Air Temperature(oC): 11-18 (Cold to Cool)
c 1. Maximum Relative Humidity (%): <75
d 1. Windspeed (knots): <10 (Light)
c 1. Soil Moisture Condition: Wet (water drips when handful of soil is squeezed between fingers)

Maize farming operations which may be done by farmers:

5. Spraying pesticide

6. Harvesting

7. Sundrying

TABLE 4

Format of desirable cultural practices for rice at seeding, vegatative, and reproductive stages depending on whether the soil is dry, moist, or wet

	Soil moisture condition		
Crop Stage	Dry	Moist	Wet
Seeding			
Vegetative			
Reproductive			

Windbreaks (crop stubbles, crops of various heights, trees, and artificial materials) also reduce evaporation and transpiration significantly from crop surfaces.

Rainfall multiplication technologies for dry season cropping

These technologies simply increase the amount of natural rain available to the crop. In effect, by reducing the area planted to the crop and using the rainfall collected in the whole area for the planted section, rainfall is multiplied. For example, if 100 mm of rain which fell on 1.0 ha is used to irrigate only 0.25 ha, the effective rainfall is multiplied four times, or 400 mm. The rainfall of 100 mm can only produce 1.0 ha of knee-high corn crop without any ear but 400 mm on 0.25 ha can produce 1.0 ton of corn.

Wide row spacing (2.3 m between rows in South Africa against 0.75 m between rows in the Philippines) and high density planting within rows are some ways to multiply the effective rainfall for the dry season crop.

PROSPECTS OF WEATHERWISE FARMING

Weather-based decision-making for pest and disease management

In plant pest and disease management, there is a triad concept. The pest or disease will develop if there are pests in significant number or there is virulent pathogen; crops are at a susceptible stage; and there is a favorable environment host. Knowledge of the triad concept facilitates pest and disease management.

Weather-based decision-making for water management and crop production

As in the case of pest and disease management, the weather is also a very important factor in water management. The amount of water for irrigation, for example, can be objectively determined from the measured or estimated evapotranspiration since the last irrigation and/or rain. This ensures high water use efficiency of the crop.

Damage to crops due to weather can be minimized by developing cropping patterns based on climatological probabilities of the occurrence of significant weather. The cropping pattern should be such that the critical crop development stages do not coincide with unfavorable weather such as a typhoon (fig. 3). The sensitive stage should preferably coincide with favorable weather such as the reproductive stage of rice coinciding with high sunshine.

After the cropping pattern is set, the performance of day-to-day farming operations should be based on synoptic weather forecasts and corresponding advisories for farm operations like what PAGASA has been issuing initially for Central Luzon and the Bicol region. Tables 2 and 3 suggest, for example, the various rice and maize farming operations which may be done by farmers depending on the stage of development of their crop.

It will also be very useful to tabulate, as in table 4, the desirable cultural practices to follow for each crop development stage, depending on whether the soil is dry, moist, or wet. Dry soil crumbles and is hard to press between fingers. Wet soil drips. The condition of moist soil is somewhere between those of dry and wet.

Weather-based rainfall management, applied research and demonstration centers

Everything discussed in this chapter will not help farmers nor contribute to food security unless farmers see and learn more about them first in regional rainfall management promotion and demonstration centers. A promising arrangement for the centers is joint funding and operation by the appropriate offices of the DA, Department of Science and Technology (particularly the PAGASA) and the PCARRD, and the state colleges and universities of agriculture.

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Potential of On-Farm Reservoir Use for Increasing Productivity of Rainfed Rice Areas

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Nearly half of the world's ricelands is rainfed (Greenland 1984). The erratic rainfall pattern limits the productivity of rainfed areas; for most of these areas, rice can be produced only in the wet season (WS), but rice yields are low due to suboptimal input use and aberrant weather (Mandac and Flinn 1984). As a consequence, rainfed farms are generally worse off than irrigated farms. Their economic conditions are unlikely to improve until alternative technologies to minimize their dependence on rainfall are developed.

In the Philippines, where 41 percent of the total cropped area is rainfed, some farmers have been harvesting rainfall and runoff from adjacent fields and storing the water in on-farm reservoirs (OFRs). They use OFRs to supplement rainfall for the wet-season rice and to grow a second irrigated rice crop in the dry season (DS). However, very little is known about OFRs technology although it had been used for more than 25 years.

A 1986 survey conducted in six villages of the provinces in Central Luzon, Philippines – Tarlac, Nueva Ecija, and Bulacan – reveals that use of OFRs is a viable technology for farmers in those areas. OFRs store rainwater for intensive rice production. Approximately 7.8 percent of the land is used for reservoir construction, which for the 68 owners interviewed averaged 2,500 square meters (sq m) in area, and 2.6 meters (m) in depth. An OFR provides supplemental irrigation to the entire ricefarm (average farm size of 3.3 hectares [ha]) in the wet season and meets the water requirements of about 40 percent of the farm for growing rice in the dry season.