

# SUBAK SYSTEM IN BALI, INDONESIA



Japan International Cooperation Agency (JICA)



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SUBAK SYSTEM IN BALI, INDONESIA

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## PREFACE

Bali is supposed to be one of the paradises remained now in the world because of its natural scenery and traditional culture ingeniously colored by Hinduism.

And at the same time, Bali is a unique existence from the standpoint of the system of water use for paddy field, as well as known by the name of Subak, in which water has been managed quite democratically for many centuries, and technical matters have been smoothly harmonized with the Hindu religion.

The Subak system should be studied more in detail carefully than ever and be made applicable to modern water management coupled with improved practices of farming.

The paper was prepared through the authors' survey in Bali, who sincerely hope that it will promote better understanding of the Subak system in the field of irrigation and drainage.

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## I. Indonesia's Geographical Position

Indonesia is an archipelago, consisting of about 3,000 islands and isles, spread over a territory as vast as that between two coastal lines of the USA. It stretches out from the isle of Sabang, the northwest tip of the archipelago to West Irian (Meranke), in the east, covering an area of 5 million square kilometers.

Surrounded by three oceans, the South China Sea, the Indian and Pacific Oceans, Indonesia boast of having a favourable situation as a buffer territory connecting two continents, Australia and Asia. This situation makes Indonesia a point of junction of traffic roads leading to all parts of the world. The principal islands in Indonesia are five in number: Sumatra, Java, Kalimantan, Sulawesi and West Irian. Scattered in between are the small islands varying in size from a tiny islet of several square kilometers to an island as big as Sri Lanka.

Indonesia's 120 million inhabitants are not equally divided into islands that make up the archipelago. Java, the smallest of the "Big Five" leads in the density of population with 76 million people. It is even one of the most densely populated areas in the world; the average is about 500 persons per square kilometer for the whole island while the really thickly populated parts are inhabited by an almost 600 persons per square kilometer.

Sumatra, three times as big as Java, is second in population although it does not count more than 21 million inhabitants, or one-fourth of Java's population. The, follows Sulawesi (1 1/2 times as big as Java) with about 9 million people. Kalimantan, the second largest island of Indonesia (4 times the size of Java) has about 5 million inhabitants and West Irian, the biggest of the five is the least densely populated with 3 million inhabitants.

Flung across the equator, Indonesia is a tropical country with a tropical climate. Like other tropical countries, it has only two seasons - the wet and the dry. Generally, the former lasts from October till May and the latter from June till October.

Rainfall varies from island to island. On the top of the list is Kalimantan with an average rainfall of 3,300 mm per year. The eastern part of Nusa Tenggara (formerly called Lesser Sunda Islands comprising Bali, Lombok, Timor, Flores, Savu, etc.) which consist mainly of low lying plains has the least average of rainfall; the record is about 1,200 mm per year.

Indonesia is rich in natural resources. The agricultural products include rice, rubber, tea, tobaccos, cinchona, paper, etc. while the minerals exploited include oil, tin, coal and gold. Indonesia is the World's largest product in cinchona bark.



## II. Indonesian Cultures

There are over three hundred different ethnic groups in Indonesia, each with its own cultural identity, and more than two hundred and fifty distinct languages are spoken in the archipelago. Religious beliefs, too, are varied: nearly all the important world religions are represented, in addition to a wide range of indigenous ones. Economic adaptations include such differing modes as seminomadic shifting cultivation, sage gardening, small-holder rubber tapping, irrigated rice farming, highly capitalized plantations for export crops, small itinerant peddling, large-scale commerce, cottage industry and modern manufacturing. Forms of community also vary, from small isolated villages to huge modern cities; the many different types of kinship systems include matrilineal, patrilineal, and bilateral patterns; while the traditional political structure range from tribes to kingdoms.

Nevertheless, not everything in Indonesia is diversity, and some generalizations can be made. Most of languages belong to a single linguistic family, the Malayo-Polynesian, that is, their share may close cognate words and have highly similar grammatical structures. About ninety-five percent of the Indonesian's profess Islam alongside local indigenous religious beliefs, while an even earlier layer of Hindu-Buddhistic thought provides a further basic for cultural similarity over much of the area. The tenacious indigenous religions which merge with rather than merely surrender to Islam, Hinduism, or Christianity appear to be all of the same general species. Economic adaptations, though various, can be veiled down to a few representative types, and the same can be said of community forms.

Most Indonesians are peasants of one sort or another, that is, there are small scale independent farmers who have some contact with commerce in goods and in ideas from the cities. Few are so isolated as to be economically self-sufficient and unaware of cultural differences and of social change. At the same time, few are commercial farmers in the sense of systematic production for ever increasing net profits. The highly capitalized plantations for export crops employ only a small portion of the total Indonesian population; most of the rest are subsistence farmers, cultivating their own land and selling part or all of their produce into urban market networks, but for personal livelihood alone.

The basic special contours of Indonesia's social and cultural landscape have been influenced historically by the countries' geographical setting of innumerable mountainous islands ranging the calm Java sea. The coastal perimeters of the islands have culturally much in common because of the frequency and ease of contacts among them; but inland peoples, cut off from one another by tropical forests and precipitous land masses, display widely diverging cultural forms. The interior regions are of two very general ecological types: first, these parts



where extensive irrigated rice terraces can be maintained primarily in the great river plains and volcanic slopes of central and eastern Java and Bali, and to a lesser extent in scattered pockets elsewhere in the other islands; and second, these areas where topography, soil, or rainfall patterns make wet-rice (lowland paddy) difficult and necessitate shifting farming or other economic adaptations.

The geographical distinctions are reflected in three broad types of Indonesian societies; the strongly Hinduized inland wet-rice areas; the trade oriented, deeply Islamic coastal peoples; and the mainly pagan tribal groups of the mountainous interior regions. The three categories only crudely and tentatively summarized the basic forms underlying Indonesian diversity; nevertheless, they provide a convenient framework for descriptive exposition.

The first category, the wet-rice growers of inland Java and Bali, comprises nearly half of the total population of Indonesia. The inland villages are sprawling and densely settled, and it is here that population pressures are rapidly becoming unmanageable. In the not-so-distant past there were fairly large kingdoms in Central Java and in South Bali. The culture of the inland peoples, although it is very distinctively their own, derives strongly from India of the first millennium, although Java acquired an important overlay from Islam after the fourteenth century. Both peoples stress formal etiquette and the proper recognition of status distinctions between aristocrat and commoner; spiritual and social refinement are highly admired. The arts-dance, music, drama, literature are intensively cultivated. Of the two islands, Bali is the more traditional, for its indigenous social structure still functions today. The Javanese peasants are what might be called "posttraditional," for the combined impact of Islam and colonial commercial development broke the tight integration of its traditional social structures, but did not produce a modern institutional system of the types found in Europe or contemporary Japan. The Javanese community, unlike most of these elsewhere in Indonesia, is almost "suburban" in its lack of distinct social boundaries and the near absence of institutionalized internal groupings. Moreover, the Javanese landscape is characterized by a thick scattering of large urban centres.

The second social type, the Islamic coastal peoples, includes such widely scattered groups as the Malays of Sumatra and Kalimantan and the Makassares of South Sulawesi. The key to their similarities lies in their common history of participation in the international spice trade of the fourteenth to nineteenth centuries. At nearly every harbour in the archipelago there grow up a community of highly heterogeneous composition - Malays, Javanese, Makassares, Moslem Indians, Arabs, Portuguese, English, Dutch, Chinese, and others-governed loosely by a local Moslem sultan. Ethnic heterogeneity and a commercial orientation remain significant characteristics of the coastal peoples. Islam and

a number of cultural patterns associated with it, such as respect for religious learning and law, and certain types of music, dance, and literature - is the most important unifying element. Many of the towns of twentieth-century Indonesia outside Java have crystallized around these former trading kingdoms, with the development of the modern governmental apparatus both increasing their ethnic heterogeneity and giving now civil-servant status to the local royalty.

The immediate rural hinterland of these Islamic coastal towns, outside of Java, is usually a sparsely populated region, with fishermen, craftsmen, coconut tenders, commercial gardeners, and wet-rice farmers living near the town, and shifting cultivators (still of the same coastal culture) located in the nearby hills. Beyond these hills, in the mountainous interiors, are the pagan tribal groups discussed below. While in the past the harbour sultans sometimes claimed these tribes as subjects and forcibly exacted tribute from them in the form of produce and slaves, the two worlds, coast and interior, had actually little to do with one another. This was in marked contrast to the Islamic market towns of Java, which were founded at an early date along that island's northern coast and which had strong and intricate relationships with the high civilization in the interior.

The tribal groups, classed together as the third category, display a very wide range of cultures. This grouping includes the Toradja Sulawesi; the Dayak of interior Kalimantan; the people of Halmahera, of interior Ceram, of the interior of most of the Lesser Sunda Islands; and the Gayo, Redjang, and Lampong of Sumatra. Most of these mountain societies remained at least until the present century in virtual isolation from the outside world, each developing its own distinctive patterns of life. Many were, well into the last century, regularly engaged in war and head-hunting. Generally left untouched by either Hinduism or Islam, many of the tribal peoples have been the successful object of recent Christian missionary activity. Most are shifting cultivators of dry rice or gardeners of sage, maize, or root crops. When the opportunity presents itself, they adopt wet-rice or commercial cultivation if they are genuinely profitable; however, many of these peoples inhabit marginal lands which are not capable of conversion to irrigated farming. Kinship ties are stressed by most of these groups instead of territorial or "feudal" political bonds, and they often have large corporate groups of kinsmen which own land, ritual objects, or status titles as a unit. Today, however, the process of administrative rationalization, which has brought the creation of regular territorial districts headed by civil servants, has gone quite far to alter the traditional community farms.

These three categories do not merely represent different kinds of economy, nor are they culture areas. They are better termed "socio-cultural types," as they have been constructed on the basis of similarities in ecological adaptation, political structure, and stratification, and both social structure and cultural pattern are taken into account. The three types are by no means exclusive; the categories are to be viewed

not as sharply bounded pigeonholes, but rather as indistinct conceptual divisions into which many of Indonesia's three hundred ethnic groups can be crudely fitted. Aside from a number of small and peculiar groups which do not mesh, with the scheme, there are several important ones which do not fit it at all. These latter, notably the Batak, Minangkabau, Minahassans, and Ambonese have undergone very rapid and extensive changes in the past century. A fully developed typology of Indonesian groups would have to include a dimension of change and the distinction made here within the category of inland rice growers between traditional and posttraditional is a step in this direction.

### III. Indonesian History

Fragmentary stone and metal inscriptions dating back to the beginning of the Fifth Century A. D. provide our most ancient evidence of Indonesia's history. It is apparent from them that Indonesian civilization had already undergone influence from India, and therefore have no real knowledge of the archipelago prior to its absorption of elements from abroad. It would seem, however, that the earliest Indonesian political institutions above the village level were formed by local leaders who attempted to combine village and clan groups into large, more stable communities under their rule. As commercial contacts with India developed, the western Indonesian islands lay on the trade route from southern to eastern Asia and were sources of spices, gold, sandalwood and other desired goods - local chieftains become acquainted with Indian social and political concepts. These embodying a centralized, hierarchical state organization under a sacred king, aroused the interest of Indonesian leaders seeking a cultural vehicle for the legitimization and extension of their authority. Consequently, they may use of Brahmans from India to advise on the organization of government ritual. The early Indonesian states thus assumed an Indianized form, through there is little evidence that the common people were affected by the adopted state culture.

Chinese chronicles, our second source of information on this early period, indicate that a number of Indianized states on Java, Kalimantan, and Sumatra during the Sixth and Seventh Centuries and appear to have engaged in trade with India and China. It also makes clear that Hinduism was not the only Indian religion introduced into the archipelago for Buddhism was reported as being practised in one of Javanese kingdoms in the seventh century. It appears to have been of the Theravada school, which was widely popular in the Southeast Asia; soon, however, temporarily dominant on Java and more permanently in Sumatra.

Early in the eighth century, Sandjaja, King of Mataram, achieved suzerainty over Central Java and may have extended his authority to Sunda (West Java), part of Sumatra and Bali. The first of the great Central Javanese monuments, the Shaivite temple remains of the Dieng Plateau, dates from about the time of Sandjaja's reign.

In the latter half of the eighth century both the Sumatran and Javanese kingdom appear to have come under the control of a single dynasty, that of the Sailandras (Lords of the Mountain). Under their rule, great Mahayana Buddhist monuments were built on Java. The most famous of these, the Barobudur, was built around 772 A. D. near the present city of Jogjakarta; it is an immense stupa, the terraces of which are decorated with sculptures, illustrating Mahayana texts.

About the year 930, King Sindok moved the capital eastward from its original site in the Solo river area to the Brantas river valley, apparently in response to the extension of wet-rice agriculture, and its accompanying irrigation systems into the latter region. The rulers of this east Javanese kingdom, which was maintained until 1,222, continued to use the title "King of Matarum." Concerned by expanding Mongol power in mainland East Asia, Kertanegara (1,268-1,292) set out to strengthen his influence over neighbouring areas. Kertanegara felt strong enough to insult the envoys of Kublai Khan when they came to demand his submission. However, his forces did not succeed in preventing the ensuing Chinese expeditionary force from reaching Java.

During the time of Madjapahit, three exogenous elements which were to dominate Indonesian history from about 1,400 to modern times the Moslems, the Europeans, and the Chinese made their appearance in the archipelago. European contacts at the time of Madjapahit were limited to the occasional traveller, one notable example being Marco Polo, whose account of his stay late in the thirteenth century was widely read in Europe. The Chinese had been in contact with Indonesia since the earliest time, but the first large Chinese settlement seems to date from the period of Madjapahit.

Matarum's greatest ruler was sultan Agung, who reigned from 1,613 to 1,645 and who viewed his stage as a continuation of Madjapahit. Since commercial and power relationships in the archipelago did not permit a revival of Madjapahit's imperial rule, Agung was forced to base his authority in the interior and to concentrate on control of land and of rice production as the source of Matarum's strength. Although Agung utilized the older Hinduized state concepts in legitimizing his rule, he was careful for part of his reign at least to maintain the outward appearance of a Moslem prince, for by now Islam was a factor which no ruler could refuse to acknowledge. He sought direct contacts with the heart of the Moslem world, and in 1,641 he received the title of Sultan from Mecca.

The Dutch had come to Indonesia, as traders, their principal aim being to obtain a monopoly over the spices of Moluccas. In order to strengthen its hand in securing the spice monopoly, the Netherlands Government secured the combination of Dutch merchant interests into the United East India Company which was chartered in 1,602 and existed for almost two centuries.

When the Dutch first arrived in Indonesia in 1,596, they put into the port of Bantam. At that time Bantam was, together with Atjeh, the most powerful state in the western part of the archipelago. Atjeh controlled the Sumatra pepper production, but Bantam was the commercial centre through which much of this pepper entered world trade, moreover, with the decline of the Pasisir principalities, Bantam became the focal point for the Moluccan spice trade.

The confusion of Dutch policies regarding the positions, European and Javanese led, in 1,825, to the outbreak of the Java War, which was the last major outburst against Dutch rule on that island prior to the Indonesian revolution. The spark that touched off the conflict was the colonial government's abrogation of land rental contracts which had been closed between European entrepreneurs and princes of the Vorstenlanden, the Central Javanese principalities of Surakarta and Jogjakarta which, after 1,755, were all that remained of the kingdom of Mataram. They turned for leadership to Diponegoro, a prince of European influence at the court and who had a great reputation as a mystical leader, Diponegoro raised the banner of revolt and proclaimed an Islamic "holy war" against Dutch. The ensuing conflict was a guerrilla war which lasted until 1,830 and was brought under control only with great difficulty.

The Government dealt with the village as a unit, both for the levying of taxes and for the recruitment of labour. Though individual landownership in the Western sense was not generally known in central and eastern Java, there had been a system of individual and family dispositional rights over certain plots of ground. In many areas, the application of the Cultivation System rode roughshod over those rights and forced the population to accept a communalized system with periodic revision of the land. In this process, the role of the village headman was enhanced, he became the agent through which the colonial authorities dealt with village and was given control over the village's most precious possession, its land. At the same time, the headman became more dependent upon the Dutch, for the authorities could reward him or punish him according to his performances in crop production. As a result, the position of the village headman began to change in parts of the Java, in the eyes of villagers he often became a source of governmental oppression rather than, as previously, the keystone of village solidarity and protection.

During the Dutch colonial period, which lasted from 1,870 to about 1,900, was a time of great economic expansion. Until 1,885 this took place on small private initiatives, and after that under the guidance of large capitalist combinations. The production figures and the variety of new crops introduced in this era dwarfed the achievements of the Cultivation System, the plantation economy which was henceforth to characterize Indonesia now became firmly established.

Considerable attention was also given to the extension of Western style education, which before 1,900 had been available only to a very few Indonesians. Although the number of Indonesians attending public schools expanded considerably during the remainder of the colonial period, the proportion remained small in comparison to the total population. This limitation was particularly noticeable above the primary school level. For most Indonesians, Western style education represented a means to entering government service, and during the first decades of the century the administration expanded rapidly enough to absorb virtually all those who qualified.

The cooperative efforts of the Indonesian political movement achieved little more success than their non cooperative ones, for the government displayed the utmost reluctance to make political concessions to even the moderate nationalists. In the face of this intransigence, the Indonesian groups consolidated their forces further in 1,939 forming the Indonesian Political Concentration (GAPI), in which conservative and radical nationalists united to press for an Indonesian parliament, and in 1,941 creating the Council of the Indonesian People, which combined both secular and religious groups and called for a parliament and the adoption of the Indonesian national language, anthem, and flag.

These later developments took place under the growing shadow of Japanese expansion toward the Southeast Asia. Since the fall of the Netherlands to Germany in 1,940, Japan had put great pressure on the Indonesian Government to supply materials, especially oil, for the Japanese war machine. The Dutch adamantly refused, but they were in no position to defend the archipelago when, in March 1,942, the Japanese pursued their objectives by invasion.

Since the Japanese occupation was a military operation, the administration of the country was carried out, in so far as possible, by the military authorities and according to Japanese concepts. Promising self-government to Indonesia in the near future, the Japanese sponsored the creation in March 1,943 of the PUTERA (Centre of People's Power), which was to include all former nationalist associations. Later the same year, they sought to rally Islamic support by stimulating the organization of the MASJUMI (Council of Indonesian Moslem Associations) which was to combine all Islamic religious groups.

The largest and most important thing was the Peta (Volunteer Army), which was trained by the Japanese but manned and officered by Indonesians; by mid-1945 the Peta numbered about 120,000 men, and it became the nucleus of the future Indonesian republican army.

Sukarno and Hatta made, on August 17, 1945, an unequivocal declaration of Indonesia's independence which demanding a declaration of independence completely free from Japanese sponsorship.



#### IV. General in Bali

##### 1. History, culture and communities

###### (1) Historical setting

In the third and fourth centuries A.D., Indian sailors bound for China, with the help of the monsoon winds, used the port facilities of the lower end of Sumatra, the east coast of the inland of Kalimantan, and the western tip of Java. By means still being guessed at, an elaborate Hinduized culture developed in the coastal communities along main trade routes and pre-eminently in the populous inland agricultural communities of Java. Finding no evidence to suggest either large-scale settlement or control or invasion by Indians, scholars attribute the heavy influence of Indian civilization in parts of Indonesia to the readiness of the more developed indigenous societies to absorb selected features of Indian civilization.

The Hindu and the Buddhist religions of India provided the Indonesian ruler with an ideology upon which to build a more elaborately pyramidal political structure. The kingdom was seen as the cosmos in miniature and the king as an avatar of Siva or Vishnu in the Hindu pantheon or as a Bodhisattva (Buddha-in-the-Making) in the Buddhist system. Although architectural evidence shows that some dynasties preferred Buddhism to Hinduism or vice versa, much mutual tolerance and interchange existed between devotees of the two systems.

Of equal importance to the ruling elite was the introduction of Indian learning in all fields. The Sanskrit alphabet brought literacy to the courts and with it an extensive literature on scientific, artistic, political, and religious subjects.

By the Seventh Century A.D. "Indianized" kingdoms were the dominant powers in South Sumatra and West and Central Java. One of these, Srivijaya centered in the Palembang area of Sumatra, had established suzerainty over large areas of Sumatra, Western Java and much of the Malay Peninsula.

Slightly to the east, in the Prambanan Plain near Solo, are the very substantial remains of the great Hindu Kingdom of Matarum, which came into being in the late ninth century and disappeared within one hundred years. The name "Matarum" was used later in East Java in the Brantas river valley. As the dynasties moved eastward, the long process of fusion and Javanization of Hindu and Buddhist elements became increasingly evident.

From the Tenth to Fifteenth Centuries, East Java was the centre of Hindu-Javanese culture and of kingdoms rivaling Srivijaya. Under the greatest king of the first East Java dynasty, Dharmavamsa (A.D. 985-1006), Javanese laws were codified, and many Sanskrit texts including a



part of the Mahabharata, were translated - the first known literature in the Javanese language. In an attempt to make his kingdom a commercial power, Dharmavamsa brought Bali and West Kalimantan under his suzerainty, but his unsuccessful attack on Srivijaya brought his empire to disaster. The empire revived under king Airlangga, a Balinese who established an alliance through marriage, with Srivijaya which, after Dharmavamsa's time, had been weakened by Indian (Chola dynasty) attacks.

Islam first gained a foothold in the northern tip of Sumatra at the end of Thirteenth Century, but the major impetus to conversion came with the establishment of the new kingdom of Malacca on the Malayan coast which was found about A. D. 1,400 by a Sumatra-born refugees from Madjapahit Java. The coastal ports of Java were brought under the influences of Islamic leadership by the second half of the Fifteenth Century, but interior areas held to their Hindu-Javanese tradition for at least 50 more years. Finally, in the Sixteenth Century the new Mataram Empire arose in Central Java, this time at least nominally Muslim. This Islamized Mataram Empire gradually re-established the inland power over the coastal ports which Madjapahit had maintained for so long.

The Hindu religion remains dominant only on Bali and Lombok and even there it shows a mixture with and tolerance towards Buddhism; moreover, it has been further modified by previously existing patterns of community life.

## (2) Culture and Communities

Bali, which possessed in 1971 a population of about 2,314,000, is located immediately at the east of Java, with only a narrow strait of water between them. The kingdoms of medieval Bali were closely allied with those of Java, and many elements of their respective cultures are very similar. As it has described, however, their systems of social organization are strikingly different. Bali is a much smaller island; its heartland, a limited region of fertile soils and heavy population, is located on its southern side, cut off by high mountains from the commerce of Java sea. As a result of this isolation, Islam and interisland trade completely by-passed Bali, while colonial government was not introduced until 1908. The Dutch at that time began a process of rationalizing the village and supravillage governmental structures, but this development has never gone so far as it has in Java. Commercial agriculture, too, has not yet reached Bali, with the minor exceptions of small coffee plantations in the mountains and a fairly lively cattle export trade.

Isolation has not meant cultural inertia; on the contrary, Bali is noted for the vigor, sophistication, and completely of its arts especially its music, dance and drama, but also painting and sculpture.

In contrast to Java, where the practice of the arts, while more subtle and profound, is today largely confined to court circles and to a few professional dramatic and orchestral troupes; aesthetic expression in Bali is an activity pursued by large member of persons from all segments of the society. In Java, aside from rather than crude popularized productions, new artistic creation has slowed down, and most effort is towards the preservation in detail of reversed traditional masterpieces; in Bali, where earlier forms are still very much alive, there is also considerable improvisation and development. Art for both culture has perhaps greater significance than elsewhere in the archipelago, possessing a central and dynamic religious meaningfulness. In Java, this significance is philosophical and moral inner stasis, while in Bali external ritual display and more direct aesthetic pleasure are involved.

(a) Aesthetic - religious activities

In Bali two sets of institutions provide frequent opportunities for aesthetic activity; the temples and the series of personal life cycle ceremonies. There are thousands of temples in Bali - each village has at least three or four - and they reflect many different functions and histories. Each one has a fairly fixed congregational group which maintains it physically and performs the rituals required at it. These congregations overlap in membership; every Balinese belongs to a number of them, usually by reasons of descent but sometimes by residence or magical command. He may belong to one representing his local patrimonial descent group, to one for a larger non-local descent group, to three village temples, to one or two temples for his rice fields, and to several others of no specific function. These are not sect temples, for the religious system is identical for all. Most of the Balinese temples are similar in form; two walled-in courtyards, connected by a narrow gate, the first a forecourt for the orchestra and for making preparations, the second the actual temple itself with altars and raised pavillions for offerings. The altars, walls, and gates are often elaborately and fairly carved, and during a ceremony they are decorated with many additional ornamentations of palm leaves, bamboo, coloured cloth banners and streamers, and so on. Every important temple ceremony takes the form of a gala party to which the distant gods are invited and requires an orchestra, processions and dances, and hundreds of deftly made offerings of food in intricate palited baskets. There may also be a cockfight and a dramatic performance in the evening outside the temple. The ceremony at many village death temples includes a special performance of the eerie dance-drama of the fight between Rangda the witch and Barong the bearlike dragon, during which some of the performers may spectacularly fall into trance and attempt to stab themselves with their own krisses.

The series of personal life cycle ceremonies are additional occasions for artistic performances and displays. The most important are teeth-filing, which ceremonially marks the entrance to adulthood (although in fact it may be postponed for economic reasons until middle age), and

cremation. Other points in the life cycle, such as marriage or the achieving of the third month of life, may also be celebrated with more than simple ritual. Cremation is such a costly and elaborate festival that it is generally postponed for years after death, the body being buried at death in the village graveyard and disinterred at the time of cremation.

Gentry, priests, and commoners comprise only very general status categories in Bali; they are not distinctly separate groups, for they all share precisely the same culture, and their members are mutually and intricately related to one another. The main status distinction is that between gentry and commoner or, as the Balinese say, between the *djero* and the *djaba*, the "insiders" and the "outsiders," signifying those who live inside a "palace" and those who live outside. The latter represent at least 90 percent of the population. With the exception of the supravillage political organization to be discussed below, aristocratic blood is not associated with superior position in, for example, economic power or artistic training. Aristocrats always command high deference in speech and posture from their inferiors, but little else. A "palace" is nearly indistinguishable in elegance and comfort from a commoner's home, and nearly everyone has about the same standard of living.

The traditional stratification system in Bali is neither a feudal system of landlords and serfs nor a Hindu caste system, although it has often been depicted as one or the other. While there were, prior to 1,908, some service relationships between certain gentry and specific commoners which have been termed "feudal," these did not involve land or agricultural labour; aristocrats either did their own farming or employed sharecroppers. There are marriage restrictions between groups of differing rank, but these do not prohibit any marriage across status group lines, but rather prohibit women from marrying below their rank and men from marrying upwards.

The Balinese system of ranking, it is closely connected to the kinship system, which is also unusual in form and peculiar to Bali, being one of patrilineal descent groups which are largely endogamous, optional and mainly localized. These kinship groups (*dadia*) are corporate-- that is, they are permanent organizations which endure even though their actual membership changes through birth, death, change of residence, etc. Each *dadia* owns a special temple and has several chosen leaders and a treasury. Gentry *dadia* are distinguished from commoner ones in that commoner *dadia* are confined in membership to kinsmen living within a single hamlet, while gentry *dadia* are nonlocalized and have members scattered over a wide region. The members of a *dadia* all have the same personal title. These titles are ranked, but their relation prestige is not entirely agreed upon by everyone, and as a result there is a constant undercover struggle for recognition of the superiority of one's own title. Even the border between gentry and commoner is sometimes indistinct and contested. Aristocratic titles are always explicitly employed in

address, but commoner ones are merely understood, thereby creating even further grounds for competition. Such rivalry for prestige is an exceedingly important element in the Balinese social climate.

Before 1,908, political life was based essentially on this system of competing titled descent groups, for the ruling kings were the heads of successful gentry kingroups who were able to achieve and maintain, however briefly, status ascendancy over an entire region. At the time the Dutch administration was instituted, there were six major kings and countless minor independent princes. The six kingdoms were mapped, given territorial boundaries (which they had never had before) and transformed into the present-day governmental districts (swapradja). The smaller princedoms were incorporated into one of another district. Today the top government officials for all but two of these districts are the direct descendants of former kings, and much of the bureaucracy is manned by nobles.

As in the past, the real significance of the highest gentry lies not in its political position but in its function as organizing centre for many aesthetico-religious activities. The ceremonies for the kingroup temples of the highest gentry families, for their personal life cycle festivities, and for certain regional temples for the general welfare, all involve the participation of thousands of commoners, both skilled and unskilled, as contributors and as spectators. Formerly the kings maintained communities of fine craftsmen-gold and silver workers, stone carvers, weavers, and the like; many of these crafts have declined, and some are now supported by the local government.

One small segment of the aristocracy is the Brahmana priestly class, made up of a group of unlocalized dadia which are at the very top of the prestige ladder. Some Brahmana dadia were in the past closely associated with dominant princes by marriage and ritual ties, and today some top officials come from this rank; but more are, and were, merely farmers. Each Brahmana dadia usually has a prest (pedanda) who serves a varying number of clients, both aristocratic and commoner. A Brahmana priest is not connected to any temple nor to any particular region, but is spiritual minister to individual families in various villages scattered over large distances. Every Balinese has such a tie to a specific pedanda; he goes to him, however, only on special occasions for the holy water which is needed for all ceremonies, most of his religious needs being met by the temples and their priests, and by folk curers and mediums. While in the legal sense - and Balinese make usually precise legal distinctions - most institutions associated with the village are wholly independent of the supravillage political and religious systems, nevertheless these upper ranks form an integral part of Balinese society and give it much of its vitality.

Balinese religious organization is very intricately distributed among a number of different structures. Worship is never personal or familial as it tends to be in Java, but always take place in an organized group.

Each ritual association centered on a specific temple, is usually also some sort of functional group. The *dadia* is one such group; another is the agricultural society.

(b) Agricultural societies (Subak)

There are thousands of agricultural societies (subaks) in Bali, each corresponding to a small section of irrigated paddies. Each society represents not only a temple congregation but also an independent local irrigation system, for its members have constructed and maintain its dams and channels, with all members having equal responsibilities and equal rights. This fragmented organizational pattern is encouraged by the rough topography of Bali, where deep ravines, cut by rivers running rapidly and steeply from the central volcanic mountains to the sea, corrugate the land, leaving few extensive flat areas. Between the ravines rise long parallel ridges, with settlements strung along the top and paddies terraced down the ravine slopes on either side. Since the river lies below the fields, each society ingeniously taps it at a point some kilometres upstream, and leads the water down by canals and tunnels. Down the course of a river there may be as many as fifty societies using its water, but each one is fully autonomous. Disputes between societies over water can only be arbitrated, for there is no superior authority. Formerly the princes used the agricultural societies as a means for taxing the peasants, and the royal tax official had some arbitration powers; today a government department performs the same functions. Actually there are few disputes, for, so far, there is plenty of water for everyone in monsoon season but rational use in dry period. At the outlets from the river and in the midst of each society's paddies are temples where the society holds its rituals and festivals. There are also certain religious rituals seasonally performed at the head of each river, which temple were formerly the duty of the local prince and today are performed by the staff of the Subak.

The agricultural societies (Subaks) are independent of any village organizations; unlike Java, where a village government has jurisdiction over both its house land and its surrounding paddy fields, in Bali the two spheres are kept apart. Within any settlement cluster live members of many different agricultural societies, and a well-to-do farmer with several plots of land may belong to several different ones. All land is privately owned; it may be sold, pawned, or given to someone else at the will of the owner, but the ritual and irrigation work responsibilities are transferred with the title to the land.

(c) Social Institutions

Settlements - clusters of walled-in courtyards, with coconut and fruit trees, temples and other public buildings - range in size from small hamlets of twenty households to large communities of several hundred households. Large settlements are usually subdivided into smaller units,

but in a variety of different ways. There are three types of social unit when correspond in a general sense to the usual notion of a "village". All three of these are present in every settlement, but they hardly ever have the same membership or territory. They are the Kahyangan-Tiga groups, the bandjar, and the governmental village administration, the desa.

The Kahyangan-Tiga is a set of three temples to which nearly every Balinese belongs; there are over a thousand of these sets on the island. One of the three components is the pura puseh, or "origin temple," which represents the ancestral spirits of the present inhabitants of the area, going back to the first group who settled there. The second is the pura balai agung, the "great council temple," representing the host of deities and spirits which can bestow or withdraw the general well-being of the people and surrounding rice fields. The third is the pura dalem, the death temple, usually placed near the graveyard and at which the local dead and the gods of death are placated. In some cases, and perhaps ideally, all three temples have the same congregation, but this is not always the case. Often part of the membership for one of the three comes from another settlement; sometimes the congregation is divided into three segments, each sharing the heaviest ritual obligations for one temple and making occasional token offerings to the others.

It sometimes happens that the membership of the Kahyangan-Tiga and the bandjar or "hamlet association" coincide; most often a bandjar community as a unit has ritual responsibility for only one of the three. The fundamental function of the bandjar is, however, not religious but governmental. The bandjar is a council of heads of households, each with a required female co-member - usually his wife - to take care of ritual duties. It is witness to marriage, divorce, and inheritance transactions; it serves as prosecutor and judge of criminal offenses, and acts as local police. The bandjar sees to the building and maintenance of the public roads, bathing places, meeting house, market sheds, cockfighting pit, and the like. It generally is also a burial society, with every member required on penalty of fine to attend the funeral and participate in the cremation of every other member. It often owns a gamelan orchestra, and perhaps dancing costumes, which it can lend or rent out to private musical societies. It has powers of taxation, usually levied by means of bandjar-wide parties which goes into the bandjar treasury. The council can also punish backsliders or criminals by means of fines, and in extreme cases by eviction from the village, for the bandjar usually owns all the house land and can decide who shall or shall not live there. Such evictions still occur from time to time, the ostracized one moving to another region or into the household of a wealthy prince as a dependent servant. Most decisions are made by the bandjar association unanimously in its monthly meetings, and there are elected chairman who administers these decisions. In large settlements there are usually a number of bandjar, and often these are not territorial in jurisdiction but have their membership interspersed through each other. Immediately proximate neighbours can and often do



belong to different bandjar, different Kahyangan-Tiga temples, and different agricultural societies; can have different Brahmana priests; and, in the past, owned allegiance to different princes. Moreover, each neighbour may choose to join a variety of different special interest societies; orchestra clubs, dance clubs, or work associations for carpentry, brick making, roof building, mat weaving, and so on. In recent times there have been some attempts, mainly futile, to simplify the Balinese social organization; they were especially promoted by the Dutch, who found it unwieldy and confusing. One consequence has been the establishment of the government-defined village, the desa.

The Balinese desa is an affiliation of several nearby bandjar, under a single desa head, who is called a perbekel or bendesa. This man is generally a government appointee, a literate villager whose main functions are transmitting information from the government and keeping certain records of births, deaths, and the like. The bandjar which are joined together into a single desa often have little in common with one another, aside from proximity. Sometimes a desa represents a single Kahyangan-Tiga set, or the bailiwick of a former lesser lord, but these are the exceptions. The desa head is usually a man of considerable influence in his own bandjar, but he is only a peripheral outsider to the others in his desa.

The intricacy of Balinese social structure, with the remains of its "feudal" states, its many temple associations, ranked title groups, corporate kingroups, agricultural societies, hamlet associations, government villages and districts, and musical and dramatic groups, contrasts strongly with the simplicity of the Javanese. Plainly, social change due to contact with the Western world does not necessarily lead to increased complexity. However, the nub of the distinction between "traditional" and "posttraditional" societies is not the degree of complexity, but rather the firmness and distinctness of social institutions, the proportion of social statuses which are ascribed and permanent, and the predominance of primary, face-to-face social groupings. Even though Balinese society is densely populated, highly stratified, and complexly differentiated into diverse interpenetrating groupings, it is at the same time sharply localized. Nearly every relationship is both a personal one, in the sense that the actors have long been fully acquainted and know a good deal about one another, and also a clearly defined one, in the sense that the rights and responsibilities each has to the other are distinctly specified and enforced.

To be "traditional" does not mean to be inflexible in the face of new challenges; the innovations of the new Indonesia are being vigorously adopted, but within traditional channels. The upper levels of the government administration are, by and large, in the hands of the former aristocracy. Political parties, economic co-operatives and co-operations, new art forms such as easel painting, all are channelled through one or more of the existing groupings - the bandjar, the titled kingroups, the petty kingdom, the agricultural society, etc. The existence of these older social forms seems in many cases to facilitate rather than impede the acceptance of the new and the reinterpretation of the old. This may also be true for many of those other peoples of Indonesia who were until this century still traditional in social structure.



## 2. Location

Bali island is located latitudes 8°03' and 8°15'S and between 114°26' and 115°43' E. It is a part of the Nusa Tenggara (formerly Lesser Sunda Islands comprising Bali, Lombok, Timor, Flores, Savu, etc.) and it is bounded on the west by Java with Bali strait, on east by Lombok and on the north and south surround Indo-China Sea and Indian Ocean. Bali extends over an area of 5,426 square kilometres (2,095 square miles).

## 3. Physiography

Bali is living volcanic mountainous island. The famous peaks, as a chain spanning its length from west to east, are Gunung Agung (3,142 m); Mt. Abang (2,151m); Mt. Batur (1,716m); Mt. Panulisan (1,743 m); Mt. Catur (2,138m); Mt. Baturiti (2,073m); Mt. Batukau (2,352 m); Mt. Patas (1,417m); Mt. Merbuk (1,387m); and Mt. Sangiang (1,006m).

It is characterized by a maze of rivers, streams and ravines which flow mostly to the south from the central mountains. About 41 main rivers flow to south and 20 rivers flow to northern sea from the central mountain (it shows in Table 1). The most serious problems of the river systems in Bali are that of siltation of river bed in rather big rivers and eroding stream bed in narrow ravines. Soil and water conservation, and stabilized stream flow measures should be concentrated by the Public Works Department in Bali Province for environmental improvement.

Bali occupies about 20 percent of area forestry, and central part of southern slope is well developed as terraced paddy cultivation. The land slopes deeply from north to south in the Southern area and more steeply from south to north in the northern area. Main cropped areas including rice, maize, cassava, sweet potato, soybean, and peanut was about 267,333 hectares in Bali in 1971 (Table 2). Of which, about 191,000 hectares covered by paddy field.

Bali is the most highly volcanic region in the country over a ten peaks are either actual volcanoes or were active until recently. In 1963 Gunung Agung (the Great Mountain) erupted, killing thousands and rendering others homeless. In addition to volcanic disasters, Bali has suffered from earthquakes. These are mostly of tectonic origin, the greater part of the foci being located within the crust of the earth or within less than 60 kilometres below the surface. But the volcanic ash enriches the soil and the greatest population density is to be found in these areas.

The tidal effects can only be observed at southern coastal areas in Tuban and in Bena.

#### 4. Climate and rainfall

The tropical monsoon climate of Bali island by her situation between two continental land-masses and by wide differences in elevation. The climate of the lowlands is marked by heavy rainfall, low winds, high temperature, and very high humidity with cloudiness. The monsoon season, October-March, is period of the highest rainfall and an average seventy to eighty percent of the annual rainfall is normally received during this period. The premonsoon season, August-September, has the highest temperatures and evaporation rates. The post-monsoon season, March-April, is hot and humid, but sunny with heavy dew fall at night. The summer, July-September, is hot, dry and sunny. There are a few summer rains in the most parts of Bali, but in the south-eastern part of the island a quite heavy July rain, in other words, there are two dry periods in May and September (show in Figure 1).

Mean annual rainfall is the lowest in the north-east (1,064 mm) and the highest in the south-east, and northern hill (more than 2,800 mm). Denpasar gets about 1,960 mm. The highest rainfall occurs in the Duda area where the foothill of the Mt. Agung gets more than 3,000 mm. Maximum mean monthly rainfall was 465 mm in December in Besakih and minimum was 1 mm in Bondslem in north-eastern castal area. The annual rainfalls vary appreciably from year to year mainly because of the irregular incidence of heavy rainfall periods within the monsoon season. (show in Table 3). There is no cyclonic either typhoon storms in the island.

Because its position outside the equator, Bali has not seasons as understood in the temperate zones; the day and nights are each 12 hours long; there is less than 2 degrees variation between the warmest and the coolest months, and humidity average over 70 percent on the year round. Although temperature never reach excessive levels, the daily maximum and minimum range between 31°C, and 25°C., occasionally reaching a low of 24°C. (Table 4).

Evaporation rates range from about 50-77 mm per month in April-May to 100-180 mm per month in August-September with generally about 100-130 mm per month during monsoon season. Mean excess evaporation over rainfall in the dry season ranges from 200-500 mm in the southern centre and west and about 380-460 mm in the north and northeast. During monsoon period rainfall greatly exceeds evaporation rate.

#### 5. The Flood problem

Due to landscape, there is no severe flood problems in Bali. As previously described, the siltation and upland erosion are serious matters for water resources development and management, and for natural environment.

In addition to this, volcanic disaster, lava flow to rivers and lowland areas where fertile arable land. Eruption of Mt. Agung has accelerated the siltation and erosion of hillsides.

#### 6. Land Use

The gross area of Bali is equal to 542,605 hectares. Of this, 161,914 hectares are occupied by arable land while the total area cropped in 1971 amounts of 267,333 hectares which is equivalent to a cropping intensity of 166 percent.

Land use, paddy area and production, and Irrigated area in Bali is shown in Table 5. From this table it can also be seen that rice crop area has increased 22 percent during the 10-year period 1962/1971.

#### 7. District Setting

The Bali Province is divided into 8 districts namely, Buleleng, Jemberana, Tabanan, Badung, Gianyar, Bangli Kelungkung and Karangasem. Much of the land in Central Southern districts, Tabanah, Badung and Gianyar, was developed as terraced paddy fields which is over 60 percent of total irrigated paddy area of the Bali province. The Buleleng, Northern districts are followed in paddy areas and the Jembarana district, Southwest, is less developed district for paddy cultivation.

Transportation in Bali is well developed not only economic development but also tourism, the paved roads reach the various volcanic mountains, temples, and local towns.

#### 8. Soils

On the basis of their geological origin and properties, the soils of Bali have been broadly classified into 8 tracts. The characteristics of each tract together with the nutrient status of the soil are given below:

(1) Latosols Comprises central southern slope and northern slope, it is covered little over 30 percent of Bali island. This tract is mainly composed of Dark Red and Dark Reddish-Brown Latosols. Latosols are sharply weathered and deep, but do not show clear horizon differentiation. They are high in clay which is mainly composed of kaolinite and iron oxides; silt content is low. They are friable and show a high degree of aggregate similarity. Soil colours are red and reddish-brown. They have a low content of primary minerals and a relatively low content of organic matters. There is little or no evidence of clay migration. Their sorptive capacity is low, but they have excellent physical properties. Under reducing conditions of prolonged irrigation, the iron and manganese of the upper layer are mobilized and migrated downwards with percolating water. These compounds are re-oxidized by the oxygen present in the sub-soil and precipitate at a depth of about 20-30 cms. Iron manganese concretions are formed, which may cement

to a hard pan. The surface layer becomes pale-coloured and shows signs of wetness. This phenomenon has been described as "Paddy Soil" formation. It occurs on terraced irrigated land and has been observed mainly on Latosols, Regosols from ash and Andosols.

Latosols offer a wide range of agricultural possibilities. They lend themselves well to terracing and are extensively used to grow irrigated rice. They also produce various food crops (peanuts, sweet potatoes, beans), a great variety of fruits (papaya, citrus, jackfruit, bananas, pineapples), cassava and industrial crops such as rubber, sisal and kapok. Owing to good physical conditions erosion hazards are small. They respond well to nitrogen and phosphorus application and for specific crops also to applications of minor elements.

Population density in the Latosols region varies between 300 to 600; 67 percent of land is under cultivation, of which 40 percent is irrigated.

(2) Soil Complexes Comprises west part, southern edge and northeastern part of island, it is covered nearly 30 percent of area. The composition of this association is complex and varies considerably from one area to another. It also comprises Latosols, Red-Yellow Podzolic soils, soils with concretionary horizons (lateritic), Lithosols and to a minor extent Red Mediterranean soils. These soils are developed from breccias, conglomerates, limestone, shales and sandstones. The landscape is deeply dissected mountainous to rough broken land. It is largely covered with secondary forest. Cultivation is limited to scattered subsistence agriculture and some rubber plantations are established in the lower ranges of the landscape.

(3) Regosols (Volcanic ashes) Comprises northeast and southeastern parts of island, and covers less than 15 percent of the area. This association is mainly composed of Regosols from volcanic ashes and also includes minor extension of Andosols and Latosols. On the lower part of the volcanic slopes, the watersorted ash material grades progressively into the plains and does not show a clear boundary with alluvial soils, of which a certain extent may be included in this unit.

These soils show no profile differentiation except for the development of a weak accumulation of organic matter at the surface. They are composed of volcanic ash of varying texture and composition, and are often layered as a result of successive showers. The coarser material are found closest to the creators while texture becomes finer with increasing distance from the eruption centre. Concurrently, the silica content increases while calcium and iron contents decrease. These soils may be very stony and big boulders are often scattered over the land surface. Regosols from ash frequently have hardpans (Padas) at various depths probably formed at the time of the deposition of the ash. Under irrigated conditions the hardpan formation may be pedogenetic.

Large extents of Regosols on volcanic ash occur on the slopes of young volcanoes of which several are still active.

(4) Andosols and Regosols Extends mainly in the higher ranges of most of the volcanic complexes of Bali and covers less than 10 percent of territory. This association is mainly composed of Andosols with local inclusion of Regosols on fresh ashes. Inclusions of Latosols on older deposits occur. Organic soils and Hydromorphic soils occur in depressions. At high elevations rainfall passes its maximum and decreases towards the summit so that soils of dry development occur. However, they have not been studied and have not yet been adequately classified.

(5) Andosols and Regosols Comprises higher mountainous area of island and covers less than 5 percent of area. The Brown Latosols have a general morphology similar to the Dark Reddish-Brown Latosols. These soils partly used for irrigated rice and food crops. They are well-known for the high production of bananas. The lower ranges of the association grow rubber while the higher ranges grow tea and coffee.

(6) Red Mediterranean soils and Lithosols Comprises parts of southern edge of Bali and it covers only about 5 percent of area. Dominant soils in this association are Red Mediterranean soils. Inclusions of Lithosols occur on eroded slopes and on rock outcrops.

Red Mediterranean soils show a surface horizon of medium organic matter content overlying a red heavy-textured horizon of clay accumulation with sub-angular blocky structure. They are weakly acid, pH 6 to 7, and have a medium and high base saturation. They may contain calcareous and ferruginous concretions in the lower horizons. Depth of these soils is very irregular ranging from 20 to 100 cms.

(7) Alluvial soils Comprises parts of northern, northwestern and southwestern coastal areas and also southern edge of island. It covers less than 5 percent of Bali. These soils formed from recent or sub-recent marine, river or lacustrine deposits. In areas where the transition between volcanic ashes on the lower volcano slopes and the alluvial plains is not clear. Regosols from volcanic ashes may also be included.

Since Alluvial soils are built up by progressive deposits, a succession of different layers often occurs. Large extents of these soils show greyish colours and other signs of wetness due to high groundwater tables and/or surface irrigation. It is clear that differences in groundwater table, texture and mineral composition are of the highest importance in assessing the agricultural value of these soils.

Most of the Alluvial soils are used for irrigated rice, where enough water is available, two or even three crops of rice are grown. Where only one irrigated crop is harvested, rice is followed by dry land crops

such as peanuts, cassava, and sweet potatoes. In low rainfall areas where irrigation water is not available and physical soil conditions are unfavourable, only one rice crop a year is grown, during the rainy season, and the land is then left as pasture for cattle.

Use of fertilizers on most of this land has given very good responses. Alluvial soils are known to produce substantially increased yields after application of super-phosphates.

#### 9. Water Resources

Water resources development in Bali has been initiated since 1966 namely, "Basic Principle of Bali Water Resources Development" which including rehabilitation of Mt. Agung eruption for Eastern region, developed irrigated areas in Central and underdeveloped area in Western region. Reconnaissance Report on the Master Plan of Bali Water Resources Development was prepared by Mr. Virama Karya in 1971.

In the first 5-year Plan (1,969/70-1,973/74), the following rivers have been planned to study and to develop for agriculture and domestic water supply:

- (1) Tamblang project on Daya river (Beleleng) with dam and reservoir at Tamblang;
- (2) Burga project on Banyuraras-Saba river (Buleleng) with surga dam and reservoir;
- (3) Les-Tejakula project on Anyar-Les river (Buleleng) with dam and regulating reservoir;
- (4) Pengumbaban project on Pengumbaban river with dam and small reservoir;
- (5) Parasari project on Sangianggede river with Palassari dam and reservoir for 1,812 hectares of irrigation improvement;
- (6) Gelar project on Daya river (Jembarana) with Gelar dam and reservoir;
- (7) Pulukan project on Pulukan river with Pulukan weir; and
- (8) Balian project on Balian river with Balian weir.

In addition to these surface water development, the groundwater exploration and exploitation are carried out by Bali Provincial Public Works Department for agricultural use and domestic water supply in rural areas, especially southeastern and northern region of island. Take for instance, the area between Pingaraja and Temukus of north Bali is high groundwater table and some springs and it will easily extend irrigation area by tube-well irrigation systems. In the southeastern coastal areas also possible to exploitate on groundwater development for both domestic and agricultural use.

Inland lakes namely, Batur and Beratan should also be studied and developed for agriculture and fisheries in future through lift irrigation projects.

#### 10. Crops

Area, production and unit productivity under principal crops are shown in the following table in 1962 and 1971. It is seen that more than 60 percent of the crop area is devoted to rice and maize for about 18 percent:

As a result of hydrological and climatic conditions (in particular rainfall and irrigation), two distinct rice cropping seasons in irrigated paddy are under BIMAS, INMAS and non-BIMAS/INMAS. Paddy Gogo (non-irrigated rice) is only for rainy season.

##### Harvested area in Ha.

<u>Year</u>	<u>Rice</u>	<u>%</u>	<u>Maize</u>	<u>%</u>	<u>Cassava</u>	<u>%</u>	<u>S.Potato</u>	<u>%</u>	<u>Soybean</u>	<u>%</u>	<u>Peanut</u>	<u>%</u>	<u>Total</u>
1962	132,562	51.5	60,311	23.7	13,721	5.3	32,425	12.5	11,808	4.6	5,781	2.4	256,598
1971	161,914	60.0	48,078	18.1	15,609	5.7	24,029	9.6	10,645	4.0	7,060	2.6	267,333

#### 11. Irrigation

The need for irrigation is clearly established by the presence of a marked long dry period. Irrigation in the dry period would enable the "cropping intensity" to increase to about 400 percent (irrigated rice 4.401 tons/ha and paddy Gogo 1.174 T/ha in 1972) not only by creating a third growing season but also by permitting different cropping patterns during the other season.

In addition, the rainfall during the monsoon season varies considerably from year to year and often cannot satisfy the water demands at the beginning of wet season in October/November. The problem in the monsoon season is to provide dependable water supplies to the rice crops.

Small scale non-technical irrigation has been employed for many hundred years. Water is diverted from rivers and streams by primitive methods to irrigate rice. More recently well designed diversion dams have been employed to irrigate large areas in supplemental irrigation during wet season and dry season irrigation. To boost agricultural production quickly, a programme of irrigation development under pure technical project has been started and also same time has been initiated improving distribution system and proper water management and control at farmer's level.



## V. Subak System in Bali

### 1. Irrigation History

As described previously in Indonesian history and agricultural societies, paddy irrigation has been practising for thousand years in Bali. Based on R. Gori earliest writing for irrigation was found in 600 A.D. and there was regular agricultural civilization with its system of sawah (wet rice) and irrigation. The King Sindok, about the year 930, had extended sawah agriculture and its accompanying irrigation system. Because of the topographic features of Bali, its irrigation system needs generally Tunnel (Aungan) between intake structure and benefited areas. Considering the sawah, water is divided from stream and distributed through tunnels and open canals which systems are quite logical for expansion of wet-rice agriculture. Many Kings during the Hindu Kingdom, had been concentrated in expanding sawah in Bali. Before 1,908 under the Dutch Administration, the six kingdoms were mapped, given territorial boundaries and transformed into present-day government districts. These six kingdoms and small principedoms were also expanded irrigation systems and maintained subak system within their own territory.

### 2. The Subak

As previously described, the Subak is agricultural societies in Bali, each corresponding to a small section of irrigated paddies for expansion, operation and maintenance of irrigation systems. The first word of Subak was found in the Prasasti Raja Purana in 1,072 AD in which a society of farmers arranges irrigation system as much as possible for the farmers and it is kept Banjar Sengguan Pemejan Temple in Kelungking District.

Each Subak represents not only a temple congregation but also an independent own irrigation system, for its members have constructed and maintained its dams and canals, with all members having equal responsibilities and equal rights. The regulation of Subak (Awig-Awig) is flexible and democratic which guarantees the arrangement of everything dealing with farmers' needs at their sawahs to be equal and just. Everyone that violates the regulation is punished or fined in accordance with the kind of violation he makes.

### 3. The Organization of Subak

In general, average area of a subak is about 100 hectares. There are over one thousand of subaks in Bali and area of subak varies from subak to subak. The smallest subak is Subak Belimbing only 3.545 hectares and the largest is subak Aseman 799.175 hectares.

If a subak is too large in Balinese sense, it is usually divided into subdivision which is called Tempekan in Bangli, Gianyar and Kelungking District, Munduk in Buleleng District, and Arahan in Jembrana District.

The borders of each subak are quite clear in the forms of natural topographical boundaries and so does the borders of the subdivision of subak. Table 6 shows the number of Pasedahan (subak supervising local government office), subak and area of sawah in Bali:

The members of subak which are in Balinese term is called "Kerama Subak" elect democratically their organizing members. The chief of subak is called "Kelihan Subak" or "Pekaseh" who is assisted by the "Kesinom" to observe weirs, tunnels, canals and the Subak buildings together with some "Juru Arah" or "Saya" (Messenger) who delivers calls, announcement and instruction from the chief to subak members. If a certain subak subdivides into some subdivisions that of chief calls "Kelihan Tempek" who is assisting the chief of subak.

At each district level, there is a chief officer who calls "Sadahan Agung" and there are also sub-district chief officer calls "Sedahan Tukad" or "Sedahan Yeh". They are government officials and financing by the provincial government together with their staff and who are responsible not only in supervising subaks but also responsible for collection of land taxes from the subak members. Table 8 shows the organization Chart of a subak:

#### 4. Water Distribution System in Subak

Water distribution to each paddy plot is based on the proportional amount of paddy seed needed. One tenah of paddy seed (25-30 kg) gets water from each tektek at a areal base. At head of each grade of canal there is measuring devices and at the quaternaly canal device, the measuring unit, calls Tektek in Balinese, is installed for individual paddy plot. In other words, the width of a "Tembuku" (normally a piece of log) devices water for each plot of paddy field.

During dry season the water is not enough for entire subak area, rotational irrigation system and/or proportional water distribution will be arranged for plantation of one area to another. There are three paddy crops a year according to the plantation period in Bali such as Ngulu, Maongin and Ngesep:

- (1) Ngulu (ulu means head) is the first turn of rice plantation about November/December.
- (2) Maongin (maong means neck) is the second turn of rice plantation around January/February.
- (3) Mgesep (sep means late) is the last turn of rice plantation around March/April.

Usually, lower part of subak takes the Ngulu system and higher and upper area take either Maongin or Ngesep may be, in order to keep even and rational distribution of water. Water distribution system shows on Figure 3.

In rotational irrigation water distribution programme, water supplies 24 hours a day and subak members are irrigating water day and night to their paddy plots, particularly during the water supply for land preparation and rice transplantation which calls Metilik and Megebagan in Balinese. Twentyfour hours system of water supply is a very advanced one by which water is efficiently distributed and canals can be provided economically.

#### 5. Meetings

Each Subak has held monthly regular meeting (35 days) to discuss for operation of irrigation system and subak temple and with whole subak members are invited which is called Sangkep or Pesangkepan in Balinese. The Chief has decided the date for meetings such as Anggar Kasih (Tuesday Kliwon), Buda Kliwon (Wednesday Kliwon) and Saniscara Kliwon or Tumpek (Saturday Kliwon).

The main topics, to discuss at the meeting, are monthly activities in the past and future month, new members, contribution of the inactive members (pengampel), development plan for irrigation system, temple ceremony, fine money, expenditure and budget plan, etc. Apart from the routine meetings, the special meetings are called by subak chief for urgent problems such as rehabilitation and improvement of irrigation facilities, election of new organizing members, the existing germs and emergency relief.

#### 6. Financial Sources for Budget of Subak

In general, the budgetary sources are: membership fee based on irrigated area which is in cash/or in kind of their agricultural products of main and second crop, penalty from the members, fine money, labour contribution for operation and maintenance of irrigation systems and temples, etc.

Those cash and kind of grains are kept by subak chief (Kelihan subak or Pekaseh) and/or sub-division chief.

These cash and kinds are spent for expansion, rehabilitation, maintenance, and new construction for subak temples, meeting halls and irrigation system, and for subak temple ceremonies, anniversary, etc. which are decided by the members of the meetings.

#### 7. Subak Regulation

Each subak has its own regulation which is called Awig-Awig or Sjme/Pesuaru in Balinese. The regulation is in written or unwritten form which is ruling everything for the life and the development of subak.

The regulation consists of the following things in general which are: duties and rights for the members in irrigating water for rice plantation and second crops; the voluntary works on temple buildings, meeting halls and irrigation systems including dams, weirs, tunnels, canals and structures; solution for conflicts which may occur among the subak members; security, violations and punishments for subak operations; and offerings for temple ceremony, etc.

## VI. Conclusion and Recommendations

### 1. Conclusion

The Subak system has long history and development experiences in the agriculture and rural societies for about nine centuries in Bali with a strong relationship with the Hindu religion. These facts made the society so strong and a firm organization which they are offering willingly their duties, products and labours as the member of subak with a full responsibilities.

Moreover, the Government policies in agricultural development are successfully disseminated to the individual farmers through this agricultural society. However, as described previously, the production under BIMAS Baru (new paddy variety under BIMAS programme) has reached 8.382 tons per hectare in 1971. It means the one of the highest paddy productions in unit area in irrigated rice production in the Region. Furthermore, in collecting water charge and offering voluntary works for operation and maintenance of irrigation system are well developed for many centuries which are completely neglected in Java, Sumatra, Kalimantan and Sulawesi. In this connection, further studies on subak system will be excellent to introduce the other provinces of Indonesia.

Rice is the staple food of Bali. The production of this crop is largely dependent on irrigation. The deterioration of irrigation systems, which is widespread in the island, is to a large extent responsible for the shortage of this product. The crop (rice) intensity is 153 percent in 1971, it shows in Table 7, which is mainly due to lack of new technology on water management and control, and also modern agricultural practices especially at farmer's level. The deterioration of existing irrigation systems causes also a loss in rice production. Among the many adverse factors causing this deterioration the most important are:

- (1) Shortage of trained personnel and funds for repairs, renewals, maintenance and supervision of the systems;
- (2) Deterioration of basin headwaters;
- (3) Shortcomings in original designs and ageing of the systems;
- (4) Mismanagement of operations for the supply of irrigation water;
- (5) Inefficient water management and control at the farmer's level.

Together with the adverse effect of these conditions on the irrigation systems, the following factors also aggravate both the problems mentioned above:

- (1) The need to grow rice, which has reduced the land available for other crops, thus creating certain shortage in the rural population diet (animal proteins, fats, mineral, etc.)
- (2) Fragmentation of land ownership, due to increase of population;
- (3) Deterioration of soils, mainly in the sloped terraced areas, on account of inefficient agricultural practices (lack of crop rotation, poor tillage, etc.);
- (4) Gradual increase in the elevation of the fields through siltation.

The country is short of trained personnel, equipment and funds to carry out the operations required to solve the problems indicated above.

## 2. Recommendations

The major difficulty to be overcome will be the restricted supply of water which will not be sufficient for more intensive agriculture; this difficulty could be overcome as follows:

- (1) By reducing misuse and wastage of water by improving, upgrading and rehabilitating existing irrigation systems as well as by checking soil deterioration, especially in sloped terracing paddy area and alluvial coastal plains;
- (2) By making additional water available to agriculture through improved management and control at the farm level, distribution and conservation as well as by tapping new sources;
- (3) By trying to reverse soil deterioration processes through improved agricultural practices;
- (4) By reducing land spaces in distribution systems by improving land consolidation and irrigation and drainage systems in some areas.

The chief measures needed to rehabilitate the irrigation systems are as follows:

- (1) A general study of the climate and, more particularly, of the hydrological conditions prevailing in each basin of the irrigation systems;

- (2) The redesigning and demonstration of:
  - (i) intake structures, taking into account the present and future operating conditions of the systems, river flow, the required desilting and scouring arrangements, regulating gates, etc. ;
  - (ii) conveyance systems, with special regard to the gradient and velocity of the water in the canals, taking into account the nature and quantity of the silt transported in suspension and providing adequate measuring devices, regulating structures, etc. ;
  - (iii) land consolidation demonstration; with special attention to soil-water-crop relationship, irrigation methods, cropping patterns and modern agricultural practices.
- (3) Improvement of infrastructures such as access roads, applied research, inspection facilities, etc.
- (4) Groundwater exploration and exploitation for agriculture in northern and southeastern districts.
- (5) Irrigation expansion by lake water resources.

Although the items above are mainly related with water management techniques on farm level, it is natural that they should be implemented in good balance of other relevant factors, such as agronomical, social and economic.

In this meaning, it should be emphasized in the establishment of applied research, demonstration and training farms on water management and control for upgrading of irrigation systems, intensification and diversification of agriculture, and introducing modern agricultural practices to the farmers by surface and groundwater resources.

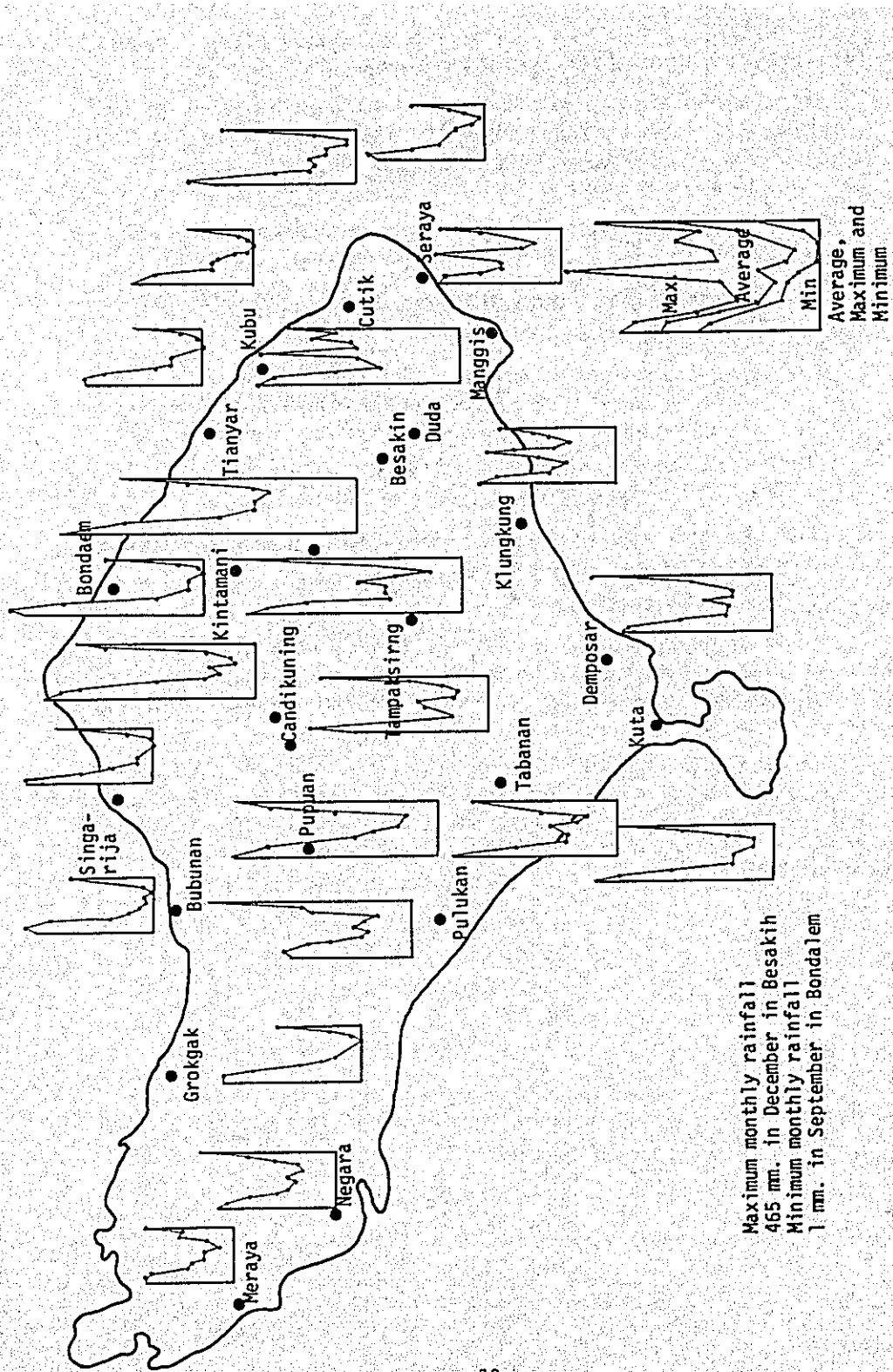


Fig.1 Monthly Rainfall in Different Station Bali, Average Rainfall 1948 - 1970, 23 Year



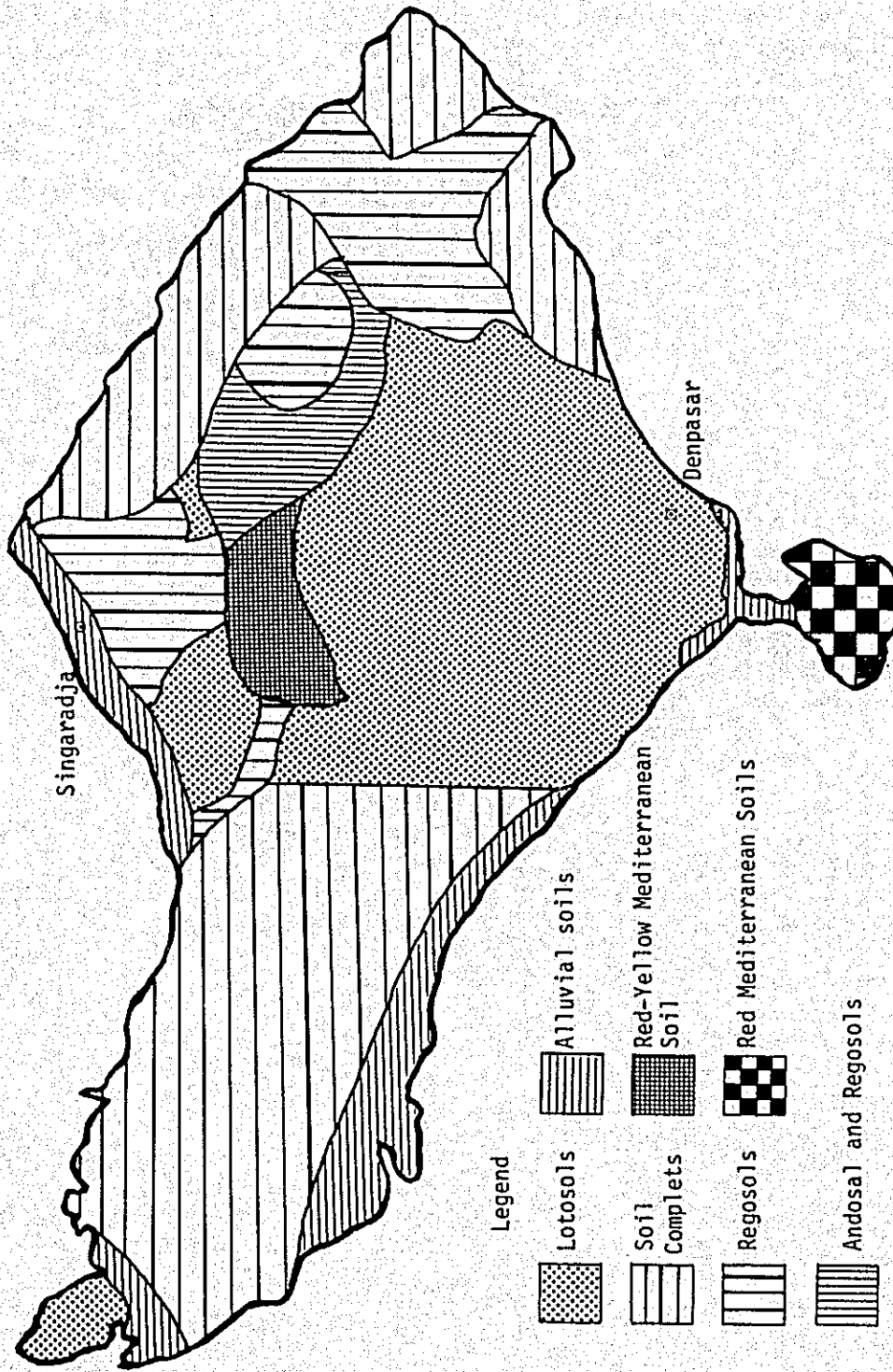


Fig.2 Soil Associations of Bali by Soil Research Institution Bogor, 1970

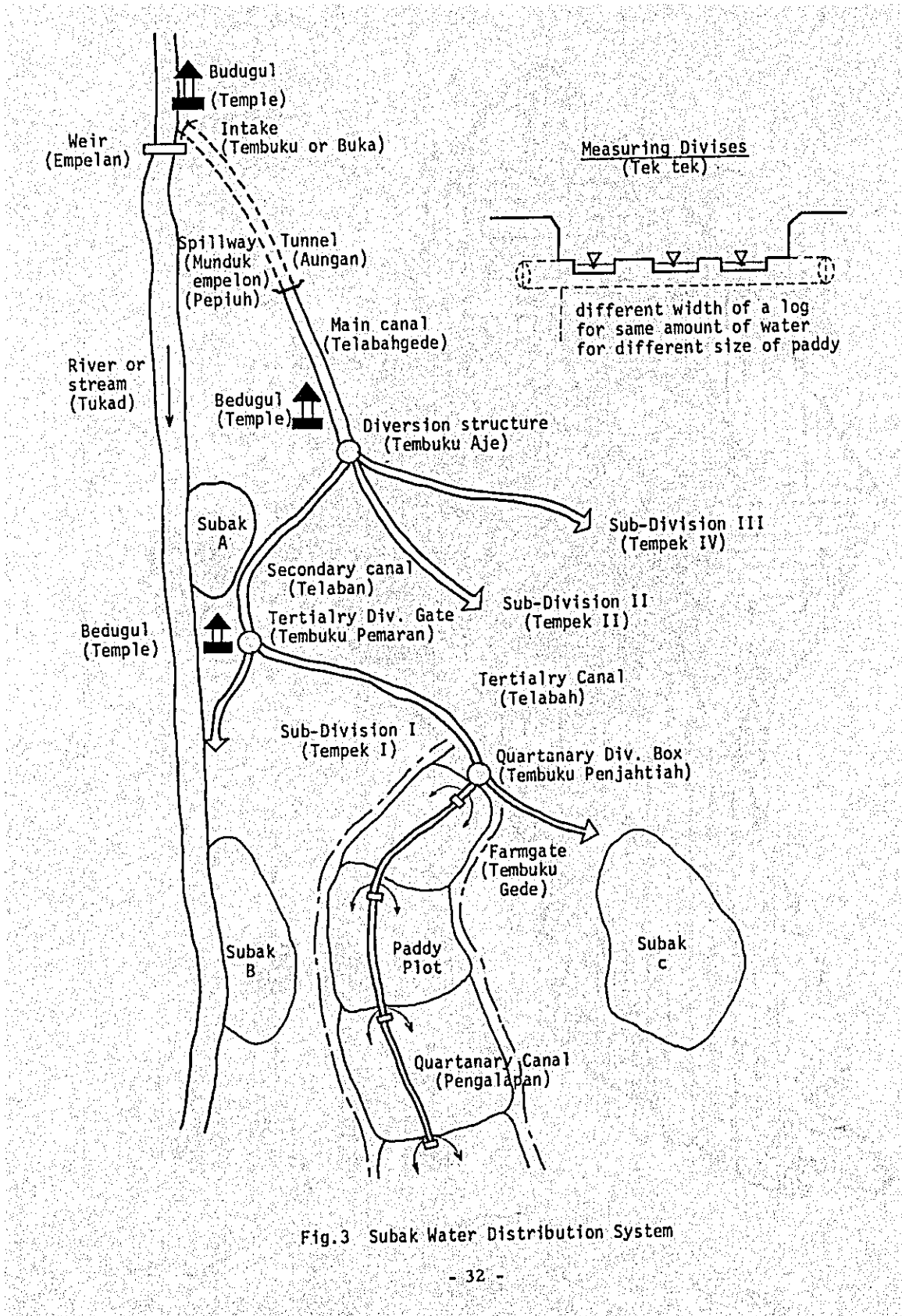


Fig.3 Subak Water Distribution System

TABLE 1

Rivers in Bali

<u>No.</u>	<u>River flows to</u>	<u>Name of River</u>
1	Badung Strait	Mguling
2		Bangka
3		Buhu
4		Betel
5		Unda
6		Telegawaja
7		Jina
8		Barong
9		Melangi
10		Sangsang
11		Pakrisan
12		Petamu
13		Oos
14		Angas
15		Ayung
16		Bangkong
17		Bratan
18	Indian Oceaam	Mati
19		Poh
20		Pangi
21		Sung
22		Panaham
23		Empus
24		He
25		Matan
26		Madah
27		Ha
28		Balian
29		Leh
30	Bali Strait	Pulikan
31		Medewe
32		Stang
33		Sambul
34		Embang
35		Bitukpoh
36		Lubang
37		Susut
38		Prancak
39		Daya
40		Sangiang

<u>No.</u>	<u>River flows to</u>	<u>Name of River</u>
41	Bali Strait	Melajo
42	Northwest of Southeast China Sea	Bayupoh
43		Grogak
44		Pancuran
45		Sabah
46		Mondaun
47		Tampekan
48		Banuluk
49		Gua
50		Bisuk
51		Pasangan
52		Daya
53	Northeast of Southeast China Sea	Bayad
54		Megyan
55		Deling
56		Lingah
57		Sakta
58		Buluh
59		Lamben
60		Manang
61		Klongtong

Source: Public works Department in Bali

TABLE 2  
Area and Production of Main Crops in Indonesia in 1962 and 1971

Province	Rice		Maize		Cassava	
	ha.	Tons	T/ha	ha.	Tons	T/ha
West Java	1,157,006	3,626,116	2,302	150,808	194,184	1,287
	1,771,259	6,228,187	3,516	107,986	113,649	1,052
	1,170,996	2,651,688	2,264	824,716	1,023,426	1,241
Central Java	1,276,259	4,928,138	3,861	549,468	670,254	1,220
	108,068	237,712	2,200	-	-	-
D. I. Jogjakarta	128,793	427,256	3,317	1,340,719	1,206,676	0,899
	1,214,116	3,339,730	2,751	1,156,290	1,048,644	0,907
East Java	1,218,900	4,717,501	3,870	36,254	28,196	0,778
	19,271	39,878	2,069	44,394	50,868	1,146
Others	14,059	29,377	2,090	2,352,597	2,450,482	1,042
	4,087,517	9,985,124	2,421	1,858,138	1,883,415	1,014
Java	4,409,306	16,330,459	3,704	1,858,138	1,883,415	1,014
	182,053	619,279	3,402	-	-	-
I. I. Aceh	217,575	649,056	2,983	-	-	-
	409,668	1,106,708	2,701	-	-	-
N. Sumatra	553,539	1,981,371	3,579	-	-	-
	206,162	610,981	2,964	-	-	-
W. Sumatra	263,421	845,455	3,210	-	-	-
	74,338	134,644	1,811	-	-	-
Riau	153,242	280,041	1,827	-	-	-
	64,792	156,386	2,414	-	-	-
Jambi	135,022	332,875	2,465	-	-	-
S. Sumatra	538,482	1,090,935	2,026	102,729	103,215	1,005
	660,539	1,483,519	2,403	76,386	111,350	1,449
Lampung	1,475,495	3,718,933	2,520	51,766	68,912	1,331
Others	1,983,335	5,582,317	2,815	102,729	103,215	1,005
Sumatra	284,645	344,828	1,211	128,612	180,262	1,402
	313,370	421,580	1,345	-	-	-
W. Kalimantan	197,556	403,034	2,040	-	-	-
S. Kalimantan	232,412	487,129	2,096	-	-	-
	176,263	258,328	1,466	-	-	-
Others	162,266	278,179	1,714	-	-	-
	658,464	1,006,190	1,528	23,073	15,407	0,663
Kalimantan	709,048	1,186,888	1,674	14,715	10,825	0,736
	18,962	135,101	71	-	-	-
	101,104	1,370,329	136	-	-	-
	36,068	388,141	108	-	-	-
	39,464	388,035	98	-	-	-
	101,104	1,370,329	136	-	-	-
	94,494	911,277	96	-	-	-
	15,885	137,622	87	-	-	-
	22,950	198,345	86	-	-	-
	16,070	216,913	135	-	-	-
	9,798	90,021	92	-	-	-
	33,995	354,535	111	-	-	-
	32,748	288,366	88	-	-	-

Sweet Potato			Soybean			Peanut			Total Area ha.
ha.	Tons	T/ha	ha.	Tons	T/ha	ha.	Tons	T/ha	
134,024	722,688	54	33,675	20,602	0,716	68,636	46,018	0,670	1,787,529
60,888	338,468	56	27,321	21,738	0,755	59,447	46,738	0,786	2,246,342
88,369	557,361	63	124,814	80,136	0,515	87,830	67,665	0,770	2,669,514
47,582	226,471	48	146,700	116,812	0,755	77,367	58,464	0,756	2,454,904
			25,153	11,335		11,300	4,354	0,385	196,079
114,452	664,987	56	25,365	13,068	0,515	23,322	18,055	0,774	242,723
63,855	370,004	58	330,560	225,061	0,801	121,085	83,770	0,681	3,583,096
12,607	74,342	59	382,110	306,144	0,801	135,824	100,145	0,737	3,412,547
2,515	11,597	46				2,185	1,241	0,568	77,057
349,452	2,019,378	57	514,202	337,154		551	387	0,704	64,771
174,840	946,540	54	581,496	415,732	0,777	293,036	203,048	0,693	8,733,014
						296,511	223,789	0,753	8,421,043
									182,053
28,183	336,927	120				5,766	3,701	0,641	217,575
311,670	193,552	61	6,435	4,708	0,732	5,196	5,623	1,082	443,627
						8,553	6,158	0,720	596,840
						4,511	5,572	1,233	214,715
									267,932
									74,338
									153,242
									64,792
									153,022
									18,962
									641,211
			15,610	10,111	0,648				788,603
27,586	232,673	84				11,265	6,562	0,583	38,851
17,623	120,999	69	3,407	2,642	0,775	8,487	6,395	0,754	120,747
55,769	569,600	102	22,723	18,060		25,594	16,421	0,642	1,783,414
49,293	314,551	64	25,452	17,462	0,686	18,194	17,590	0,967	2,299,380
									300,530
									336,320
									197,556
									232,412
									192,333
									172,064
5,502	33,109	64	1,361	889		1,709	1,416	0,829	724,104
4,515	25,013	55	1,784	1,145	0,618	2,014	1,552	0,771	764,824

Sweet Potato			Soybean			Peanut			Total Area ha.
ha.	Tons	T/ha	ha.	Tons	T/ha	ha.	Tons	T/ha	
			4,135	2,817	0,681	26,947	18,759	0,696	661,218
			1,283	799	0,623	7,918	6,064	0,766	753,561
41,156	245,316	60	7,763	4,445		26,947	18,759	0,696	9,201
28,109	158,283	56	5,418	3,616	0,667	28,902	20,300	0,702	1,189,320
2,872	21,110	75	-	-	-	7,337	982	0,734	<u>1,210,136</u>
34,828	292,531	84	295	235	0,797	4,357	3,306	0,759	27,617
32,425	293,024	121	11,808	10,212		5,781	3,874	0,670	<u>84,721</u>
24,029	230,072	96	10,645	7,481	0,703	7,060	6,526	0,924	256,598
32,285	241,439	75	35,410	25,569		14,178	13,940	0,983	267,333
12,156	70,804	58	54,041	33,738	0,624	10,653	6,682	0,629	383,019
25,272	176,904	70	820	510		4,252	2,248	0,529	363,986
28,996	173,566	60	494	236	0,478	8,061	4,028	0,500	329,034
89,982	811,367	90	48,038	36,291		24,211	20,062	0,829	351,131
65,281	474,442	73	65,180	41,455	0,636	25,774	17,236	0,669	963,651
544,433	3,679,880	68	594,087	396,839		372,834	260,688	0,699	<u>982,450</u>
356,866	2,211,360	62	679,625	515,644	0,759	357,752	283,773	0,755	13,421,120
									<u>14,762,554</u>





TABLE 3

## Mean Monthly Rainfall in Bali

No.	Station No.	Name Station	Elevation	Year between 1948 - 70	Curah hujan rata-rata (mm)												Mean Annual (mm)
					January	February	March	April	May	June	July	August	September	October	November	December	
1.	437	Negara	+ 8	20	224	212	166	111	90	81	102	65	73	123	165	257	1668
2.	437b	Grogak	+ 45	23	271	271	207	124	75	48	42	20	1	19	61	158	1298
3.	437c	Pulukan	-	21	242	245	211	158	99	88	114	90	71	196	216	296	2030
4.	438	Singaraja	+ 40	16	238	245	174	77	43	36	28	11	2	3	50	197	1039
5.	438b	Pengotan	+1148	22	435	368	251	118	95	51	54	37	19	52	179	314	2073
6.	438d	Bondalem	+ 30	23	342	379	266	92	53	29	33	7	1	6	53	194	1423
7.	438f	Sukasada	+ 90	22	244	284	253	111	56	41	32	21	4	20	86	216	1415
8.	439	Munduk	+ 730	14	413	503	350	285	148	140	97	95	50	123	320	435	2959
9.	439a	Candikuning	+1247	23	412	382	338	190	99	69	86	42	46	97	291	372	2433
10.	439b	Baturiti	+ 888	23	283	346	319	205	188	97	116	89	60	156	268	395	2618
11.	439c	Bajra	+ 150	22	215	231	175	82	85	88	113	82	68	130	219	263	1705
12.	440	Tabanan	+ 130	23	315	248	201	98	95	112	132	83	70	149	204	284	2026
13.	440a	Blahkiuh	+ 200	23	361	308	221	122	127	108	200	104	81	175	241	334	2431
14.	440c	Tempaksiring	+ 500	13	256	351	171	74	87	120	135	68	60	92	170	334	2003
15.	481	Pupuan	+ 800	22	399	375	326	237	162	121	80	66	63	199	315	393	2756
16.	411b	Bangli	+ 500	20	348	310	185	115	126	165	200	136	100	187	202	440	2557
17.	441c	Kintamani	+1475	23	379	361	241	98	66	41	32	14	10	34	92	286	1652
18.	441d	Abang	+ 310	23	381	428	265	131	123	133	119	87	62	69	139	309	2243
19.	441e	Tianyay	+ 11	17	232	232	185	76	63	56	33	4	1	8	36	138	1111

Station No.	Name Station	Elevation (m)	Year between 1948 - 70	Mean Monthly												Mean Annual (mm)
				January	February	March	April	May	June	July	August	September	October	November	December	
20.	441f Kubu	+ 10	18	236	216	137	84	76	66	40	11	4	6	33	126	1061
21.	442 Karangasem	+105	23	295	260	183	92	97	84	113	41	37	74	103	212	1593
22.	442a Besakih	+900	17	420	375	298	143	148	151	200	134	65	149	278	465	2841
23.	442b Rendang (Pringalot)	+520	21	438	325	241	136	127	150	223	157	136	225	206	338	2661
24.	442c Culik	+149	15	274	331	163	90	81	88	56	64	22	23	83	257	1509
25.	442d Bebandam	+327	19	350	315	192	98	121	104	137	69	64	113	132	237	2023
26.	442e Manggis	+ 36	18	235	230	155	119	119	161	253	80	59	89	161	235	1811
27.	442f Scraya	+250	20	212	231	142	93	78	72	61	22	15	38	73	185	1209
28.	442g Pempatan	+700	23	456	486	287	158	116	102	151	94	58	152	239	404	2599
29.	443 Gianyar	+128	13	299	323	189	58	122	180	214	113	90	109	132	307	2115
30.	444 Klungkung	+ 85	22	264	234	128	121	104	148	247	123	85	131	162	222	1984
31.	444a Sampalan	+ 4	21	293	284	114	85	76	67	85	18	20	72	121	235	1482
32.	444c Telegan	+153	19	183	189	130	92	92	196	143	80	182	126	115	161	1534
33.	444d Duda	+522	16	389	361	241	163	180	204	394	201	210	292	239	343	3049
34.	445 Denpasar	+ 40	18	301	278	179	91	88	90	130	77	77	122	154	339	1960
35.	445b Kuta	+ 0	18	352	297	206	80	78	79	69	38	36	93	179	303	1833
36.	- Bubunan	+ 10	21	227	248	194	79	45	31	20	19	4	17	66	162	1097
37.	- Melaya	+ 7	16	165	169	158	90	75	61	61	34	45	113	104	172	1229
38.	- Sambirenteng Average	-	17	293	289	187	75	70	41	33	10	0	5	36	129	1164
				307	301	204	117	99	92	128	66	51	100	156	275	1888

TABLE 4

## Climatic Data      Denpasar 10 years (1956 - 1965)

Month	Atmospheric Pressure (millibars)	Temperature (°C)			Humidity (%)			Wind		Solar radiation (%)	Rainfall (mm)
		Max.	Mean	Min.	Max.	Mean	Min.	Direction	Velocity m/min.		
January	1007,6	30,8	28,4	25,5	88	79	66	SW.	8	62	345
February	1007,9	31,1	28,1	25,5	89	80	67	SW.	9	66	287
March	1008,3	31,0	28,0	25,5	88	80	67	E	8	57	211
April	1008,2	31,4	28,4	25,5	86	78	62	E	9	58	113
May	-	30,8	28,0	25,4	88	79	67	E	11	63	77
June	1010,6	30,3	27,3	24,5	85	76	61	E	8	62	95
July	1010,4	29,7	26,8	24,3	83	74	63	E	11	56	70
August	1010,6	29,9	26,7	24,6	84	73	60	E	11	75	32
September	1010,6	30,4	27,3	25,6	85	75	60	E	14	70	34
October	1011,0	31,3	27,8	25,1	85	76	62	E	11	76	88
November	1009,2	32,1	28,9	26,3	80	74	61	E	9	70	181
December	1008,7	30,9	28,0	25,7	85	78	67	SW.	11	62	299
Average	1009,4	30,8	27,8	25,2	85	71	65	E	10	65	1842

Source:      Meteorological Station in Bali

**TABLE 5**

**A. Land use in Bali in 1962 and 1971**

<u>Crops</u>	<u>ha. in 1962</u>	<u>ha. in 1971</u>
Rice	132,562	161,914
Maize	60,301	48,076
Cassava	13,721	15,609
Sweet Potato	32,425	24,029
Soybean	11,808	10,645
Peanut	5,781	7,060
<b>Total</b>	<b>256,598</b>	<b>267,333</b>

Source: Central Bureau of Statistics of Indonesia

**B. Paddy area and production in Bali**

<u>Crop and Season</u>	<u>Area in ha. 1971</u>			<u>Area in ha. 1972</u>		
	<u>Area ha.</u>	<u>Tons ha.</u>	<u>Total Production</u>	<u>Area ha.</u>	<u>Tons/ha.</u>	<u>Total Production</u>
1. Wet Paddy	150,842	4,147	625,811	155,823	4,415	688,026
Bimas biasa	22,689	5,106	115,854	37,780	4,935	186,439
Bimas baru	1,347	8,382	11,291	9,060	8,328	75,449
Inmas biasa	11,100	4,613	51,205	10,411	4,299	44,759
Inmas bara	811	7,976	6,468	2,401	7,308	17,546
Non Bimas/Inmas	114,895	3,838	440,993	96,171	3,783	363,833
2. Upland Paddy	11,072	0,973	14,551	12,391	1,174	14,551
<b>Total</b>	<b>161,914</b>	<b>3,932</b>	<b>702,578</b>	<b>168,214</b>	<b>4,177</b>	<b>702,578</b>

Source: Agricultural Department in Bali

**C. Irrigated areas in Bali in 1970 in ha.**

	<u>Total Wet-Paddy</u>	<u>Fully Technical</u>	<u>Semi-Tech.</u>	<u>Non-Tech.</u>	<u>Total</u>	<u>Ratio(%)</u>
Indonesia	5,909,002	1,550,932	1,256,388	1,295,248	4,102,568	69
Bali	97,609	-	32,848	64,762	97,609	100

Source: Directorate Water Resources Development

TABLE 6

## Pasedahan, Subak and Sawah in Bali (1971)

No.	District	Area ha(A)	No. of Pasedahan	No. of Subak	Sawah ha (B)	Ratio B/A %	Ratio B/C%
1	Buleleng	135,700	10	255	14,193	10.6	14.4
2	Jemberana	83,000	5	73	7,995	9.6	8.1
3	Tabanan	84,400	27	310	25,381	30.0	25.7
4	Badang	50,900	10	146	19,215	37.0	19.4
5	Gianyar	36,700	10	81	15,754	43.0	16.0
6	Bangli	31,200	3	46	3,226	10.2	3.3
7	Kelungkung	53,000	5	44	4,858	9.2	4.9
8	Karangasem	85,700	10	138(C)	8,068	9.5	8.2
	Total	560,600	80	1,193	98,690	17.5	100.0

Source: Subak System in Bali

TABLE 7

## Crop (Paddy) intensity and unit yield/ha. 1971

Sawah ha	Harvested Area ha	Crop intensity	Tons/ha
	Bimas biasa	22,689	5,106
	Bimas Baru	1,347	8,382
	Inmas biasa	11,100	4,613
	Inmas baru	811	7,976
	Non-Bimas/Inma	114,895	3,838
98,690		150,832	153
			4,160

Source: Department of Agriculture in Bali

TABLE 8

Subak Organization

Local Govern-  
ment Officers

District Chief Office  
(Sedahan Agung)

Sub-District Chief Office

---

(Sudahan Tukad)

Subak Chief

SC SC

SC SC

---

(Pekasch)

SDC SDC

Sub-Division Chief

SDC SDC

---

(Kelihan Tempek)

Subak

A&M A&M

Assistants Messengers

A&M A&M

---

(Kesinom) (Saya)

Subak Members  
(Kerama)



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