General Discussion

Chairman (Kung): Ladies and Gentlemen:

Now, this is our last session of this Seminar. This session will be the free discussion. I am sure in the past three days due to the limit of time many gentlemen still have something in your mind. So, this last session will be for the general discussion. But this discussion will be a bit different from the previous discussions. There is no speaker. I hope everybody will be the speaker. That means you are free to raise questions and make comments. Because of limited time available, we would like to limit all discussions to three main subjects. Irrigation, and secondly drainage. Because good irrigation and good drainage make good water management. Of course if we want to reach our goal we need the good facilities. So the last item will be the facilities needed to achieve those purposes. Now the floor is open for everybody.

Fukuda: The data of evapotranspiration treated by Dr. Sugimoto in his paper were explained to be directly useful for calculating irrigation requirements with some consideration on percolation. It sounds very reasonable in principle. But I suppose that there might be some variations in evapotranspiration values depending on environmental conditions or background in which such figures were born, so that, if this is acceptable, it would be very beneficial for our engineering side to get a summarized chart or table in which the data of evapotranspiration are contained. If Dr. Sugimoto or someone else will be kind enough to compile such various charts, we will be very glad.

Chairman (Kung): Dr. Sugimoto, can you make some reply on this very kind request? I think this may be a matter of time just to compile and make this more simple.

Sugimoto: My report contains a summarized table on the evapotranspiration data in Southeast Asian countries such Malaysia, as Thailand, Cambodia, Laos, Bangladesh, Sri Lanka, and one data from India, as well as data in the temperate and subtropical zones; Taiwan, Korea and Japan. There is a high correlation between the growth duration and evapotranspiration in the tropics but not so in the subtropical and temperate zones. The reason may be that in the subtropical and temperate zone, rice is grown from the time when the temperature increases and after the heading time or the middle of the growing period, the temperature decreases gradually. On the contrary, in the tropics the air temperature is almost constant during the whole growing period. Summarized many data indicate that the daily evapotranspiration is almost 5.5 to 6.5 mm/day in the tropics. There is no big difference among varieties and cropping seasons and latitudes in the tropics. So that, if we know the length of growth duration—how many days from sowing to harvest or how many days from the transplanting to maturity—we can estimate the actual figure of evapotranspiration. Another thing I would like to add is that there are high correlations between evapotranspiration and pan evaporation. The ratio of evapotranspiration to pan evaporation obtained in the tropics comes to 1.2 in an average in most cases. So, if we know the normal year value of pan evaporation, we can estimate the figure of evapotranspiration. And another point is we can also estimate the evapotranspiration value by data of solar radiation. As 65% to 70% of solar radiation is used for evapotranspiration according to three data, we can estimate the approximate evapotranspiration through solar radiation. But as mentioned by Dr. Fukuda, percolation is location-specific.

Fukuda: Thank you, Dr. Sugimoto, fro your kind explanation about the factors affecting evapotranspiration. But as you mentioned there might be some variations which would appear in the value of evapotranspiration depending on the environmental conditions. Will you be kind enough to give us a simplified and summarized chart which we the engineering side can easily use in computing irrigation requirements? And

if possible will you put it in our final report of this symposium?

Pande: I quite appreciate the work of Dr. Sugimoto on the evapotranspiration and the suggestion that the data will be used by the engineering people to work out the water requirements. But there is one point that, when we go for the water requirements, the percolation loss in many places plays the major role. In some areas more than 60% of the water is lost by percolation. Until percolation for every, at least, type of soil to get the rough idea is coupled with, only the evapotranspiration data may not be of much value to computing the irrigation requirements. So that, I would suggest that for the major type of soil the percolation data is also included in the information, at least as the guide line.

Lewis: Dr. Sugimoto, I would like to know under what condition the evapotranspiration was measured. They might have been in flooded conditions or with unlimited water without any soil moisture stress. But you would agree that if there is a soil moisture stress—and in some countries, probably in Sri Lanka, quite a large extent of rice may be grown in the future with probably 25% depletion of moisture or in some cases 50% depletion of the moisture. And do you feel there would be significant differences in evapotranspiration rates if rice is grown with a certain depletion of moisture?

Sugimoto: My summary of the results comes from the standing water condition. If there is a shortage of water and the soil is in saturated condition. Evaporation will be reduced to say 2/3 as that of the flooded condition although transpiration is not so much different. And when the severe drought damage comes to the plant, transpiration will also be affected.

Cheong: This is indeed a very interesting, and from our country's point of view, a very exciting topic to discuss.

Yesterday, I showed a formula pertaining to the assessment of the field water requirements for presaturation. A number of factors are affecting the water losses in the field: (1) Evapotranspiration, (2) percolation loss, and (3) the water that is required to bring the unsaturated soil to a saturated condition.

So, it seems to me from the engineering point of view, for the purpose of designing the system capacity and for the purpose of operating the irrigation system, it would be necessary not only to know the evapotranspiration, but also to know the percolation losses and also, for the various types of soil, the amount of water required for soil saturation. Quite apart from this, there is another point which constantly worries engineers and this is the kind of the farm or field losses that can occur in the different situations. For a sophisticated system, you probably can bring the losses down to a minimum. But for a situation where the on-farm facility is rather poor, the order of loss may be very high. In our experience, the farm loss or the field loss is at least 50% of the field water requirements. So, I think when we talk about these various numbers we have to take this in consideration. A lot of work has been done on evapotranspiration, but rather little is done, I am afraid, in assessing other factors. Perhaps a concerted effort needs to be done by all countries to establish percolation losses, to establish the order of water required for soil saturation, and also the order of farm losses for different systems of the on-farm facilities.

Chairman (Kung): This is really the center or the focus of the discussions of the last three days. This is so important. This is so useful and this is also the work the engineering needs the agronomists, and the integrated work. Personally, I am thinking we need this kind of formula or figures badly because water is the problem in tropical Asia—either certain areas need more water or have too much water. I think most of the countries are willing to invest a large sum for irrigation. There are a lot of international cooperation in this respect but unfortunately the basic study on water requirements is still not very much. So we hope this kind of a research will be carried out

in more places and also hope the Japanese experts try the best to help those countries produce and create those kinds of figures.

Saito: I agree with Mr. Cheong's opinion. I worked about three years in the dry zone of Sri Lanka and there we got the data regarding the duty of water. We observed over 10 feet of duty of water during the irrigation period. Accoridng to Dr. Sugimoto the total sum of evapotranspiration comes to—in the irrigation period of, say, about 100 days—about 600 mm or 700 mm. But our observed duty of water was more than 3,000 mm. In that case the evapotranspiration is less than 20% of the duty of water actually observed. Conditions are different betwen Malaysia, Thailand and the dry zone of Sri Lanka. But from the engineering point of view, we must investigate very accurately the percolation. The Sri Lanka Government developed some devices to measure percolation and we used such a local one and other devices developed by Dr. Yamazaki. But we still need more accurate devices. Because some devices can be used only in the experimental area—not in the actual paddy fields.. When we use them in the project area, some devices are not so useful. We need some portable percolation devices. The device developed by Dr. Yamazaki is a portable one, but it can not measure accurately the percolation less than 15 mm per day. The portable, accurate percolation meter is needed.

Lewis: I fully agree with Dr. Saito on this question of percolation losses from the field to the field. Since he mentioned about Sri Lanka, I would like to touch upon what is known as the useful irrigation. The seepage loss—what is lost as farm losses in the well drained high slopes of areas—automatically goes down and irrigates as useful irrigation. One Japanese scientists from the Dewhuwa project in Sri Lanka has estimated that in one of the colonization schemes in Sri Lanka about 20,000 acres are irrigation, but the water lost from those fields is enough to irrigate additional 4,000 acres when the losses were irrigated to an additional acreage. So, if the engineers are thinking of devices, not only the percolation losses but also the devices to find out the useful irrigation will be needed.

Chairman (Kung): There are big variations in percolation due to different soil types. So that if we in one country study the water requirement or consumption in one region, this is not enough. We should divide it into several soil zones and we should study in each zone. Then, the results will be more practical and can be more useful than when we use only one figure. Of course, in the small country you use maybe one or two sets of the figures but I think large countries should have several regions and each region should have its own figure.

Nakagawa: I would like to make a supplementary explanation of the optimum percolation in Japan described on the day before yesterday. The optimum percolation has been clarified by agronomic research and the observation of water consumption in paddy fields. However, the value of the optimum percolation of 15 mm to 25 mm per day is not the strict value but only a rough standard. It means that the percolation of this range is favorable to obtain high yields. According to the past research up to the present, the following have been clarified:

(1) The optimum percolation is between 15 and 25 mm per day, that means optimum duty of water is between 20 and 30 mm per day. If the percolation is less than 10 mm per day or more than 50 mm per day, much application of fertilizers does not result in high yields, ie, more than 5 or 6 tons per ha. However, the amount of percolation is not important for the rice cultivation at low yield levels.

(2) After the maximum tillering stage the influence of percolation becomes more apparent than in the period before that. In Japan the drainage system such as the underdraining and subsoil improvement is planned so as to give necessary percolation when required in areas of low percolation. On the other hand, in areas of too much

percolation, soil dressing and subsoil compaction are planned in order to reduce too much percolation.

Changing the viewpoint, the low percolation is desirable for intensive water utilization, but the high percolation is favorable for drainage aiming at the farm mechanization. The agreeable percolation between these two contradictory requirement comes to the range from 15 to 25 mm per day.

Charin: I would like to convey a few words. I appreciate very much Dr. Fukuda's view on the consumptive use of water. That is a fundamental information for our engineers; for our planning the consumptive use of water is quite important. I appreciate Dr. Sugimoto for his paper. In fact, Dr. Peter Kung and I have done experiments during last 15 years and up to now. And I am not satisfied with the consumptive use of water in our country. I fully agree that percolation is the important factor in our figure of water requirement or consumptive use. And I would like to say that so far as the better water management, is concerned, I have already seen the need to apply the research. The second is the concern of eduaction. That is why I said that learning by doing is quite important, but it takes some time, too. And the third one the training of our economists to understand our engineering work on irrigation and agronomy, too. The last one concerns my job. That is, I take responsibility and look after operation and maintenance. Those four items are very important for better water management.

I wrote something for conclusion about two years ago. And I still use that for consumptive use of water requirement. I wrote like this: that the planning for optimum utilization of available water supply involves the consumptive use of water as its basic component for future development of any area, whether it be for irriagtion, flood control, harbor or municipal use of multiple purposes. Water requirements of crops grown under different conditions of climate, soil, cropping patterns and water supply have been the subjects of many research studies since 1900. One of the first of such studies of the use of water by irrigated crops was made in Southern California in 1903 by the Irrigation Investigation Setcion, Office of the Experimental Stations, in the U.S. Department of Agriculture. Various methods have been used to measure or determine the amount of water consumed by crops and natural vegetation. The procedure included the direct measurement of evaporation and evapotranspiration, pan and large evapometer determination, field pump experiments, soil moisture, depletion study, and inflow and outflow methods for large areas. The results from such studies have been correlated with evaporation as measured by pan and other evapo-meter and with climatic data. Direct measurement of consumptive use in any large area is expensive and time consuming. And it is also very difficult because of the difficulty of the direct measurement. And a large number of empirical formula have been proposed for estimating the consumptive ues for irrigation area using readily available climatic data such as the temperature, humidity, wind velocity and solar radiation their length. And the most common of those was the Lowry and Johnson's in 1942, Penman in 1948, Thornthwaite 1948, and Blaney and Criddle in 1950. And as to the data in our country, in fact Peter Kung has done already a lot on our consumptive use. But I will have to decide on our new project, I will have to mix or correlate with the formula. At present, I use Bradley and Cliddon's formula to check our experiments. It will still need continued study and more experiments on this type of things.

Chairman (Kung): Some other comments?

Julian: This is in connection with the very nice technical report persented by Dr. Nakagawa, which deals with the water requirements and their determination. I know not only the irrigation engineers but planning engineers, designing engineers or operating engineers in the Philippines will be very hghly benefited from this technical report.

I will get very much information from this, being an operation engineer, also.

And also the suggestion of Dr. Fukuda—if the author of the technical report could prepare a table wherein those data will be re-presented very briefly, it will be very useful for the developing countries.

And in connection with the report of Dr. Nakagawa, particularly on the determination of the irrigation requirement which is the field water requirement plus farm waste minus effective rainfall, I will be very happy also if some data already obtained in Japan's condition about the farm waste will be included in the paper. Because actually in the estimation of water requirement we have, information about the evaporation, transpiration, percolation and conveyance losses, but honestly speaking we still do not know the magnitude of farm waste. So, this is the inforamtion that will be very useful for the engineers, operation engineers, and if Dr. Nakagawa could include some information about this, we can start with that in our estimation of water requirements, and perhaps later on we will be able to arrive at the data that are really obtained in the Philippine conditions specially.

Chairman (Kung): I quite appreciate your points. We realize that the consumptive use is only a small fraction of total water duty and we lose a lot of water due to conveyance losses. So that the irrigation efficiency is the kind of the study we need. And this kind of a study should be a joint venture between the engineers and agronomists. I think we need very much such a joint venture in all countries. I think in Japan you may have accumulated a lot of figures already. But for the Southeast Asian region we need it very much.

We already spent about 45 minutes on this important subject. If there is no further comments or questions, can we turn over to the drainage side, if some gentlement want to discuss about the drainage? I know that Department of Irrigation and Drainage in Malaysia was started as the Drainage Department, and then extended the work to cover both drainage and irrigation. I don't know whatever our friend, Mr. Cheong, can tell us something about the drainage in Malaysia, how they dealt with this problem in the early days.

Cheong: I feel quite honored to start the ball rolling. If the distinguished delegates and participants would recall the slides I showed yesterday with regard to the location of the major rice growing areas, they occur on the coastal plains. Now, this coastal plain normally consists of saline fertile marine clay. But under the natural condition, there was one very great disadvantage. This is the effect of the tidal intrusion and the saline contamination. So, even from the early days, in terms of the drainage, in terms of avoiding the flooding from the sea, flooding from the river near the estuary, it is important the area is protected from the intrusion of the sea water and saline contamination. It is in this context that we have undertaken so called drainage work. Having created that kind of a condition, then we started applying irrigation. Of course in this way we improved the productivity of the reclaimed land. Taking this into further stage of development, that is in the actual manipulation of soil moisture, it is not only to regenerate the soil in order to remove the harmful material developed under the prolonged flooded condition but from the point of view of mechanized operations. It has now brought to light that it is necessary to effect certain drainage during the off season or even before the harvesting starts in order to regain soil bearing capacities so that the mechanized harvesting can be undertaken without much difficulty. As I said yesterday, we have still to find out what is the practical way of effecting this kind of drainage.

Pande: Now, as far as the drainage is concerned, we must identify first at what position or at what location it is desirable. We had a problem in India. We have Chambal-irrigation Project where irrigation was introduced and within about three year's

time the subsoil water rose and the soil salt moved upward. While in the first year there was a good crop, the second year was normal and the third year started to fail. Now, in such a situation where the irrigation system has been introduced, it will be imperative to introduce or find out the drainage. Within last three years the work has been taken up and soils are coming normal and the water table has been reduced. One of the ways that we took in the Project is that the water has been pond-out, ie, we have a certain number of wells to pond the sub-water and reduce the water table. Now in other situation, ie, the drainage for the normal cultivation of the rice crop—for example draining of the water will result in a good effect on crop root. The third problem is that in some situation, ie, the inherently saline soil, if you drain out the water, it is going to harm the crop than doing any good. So, I think, our deliberations should go and should be location-specific.

Chairman (Kung): I quite understand the water logging problem serious in India. How you deal with this problem, how do you solve this water logging in the existing irrigation period? Can you tell us a little bit in detail?

Pande: In some area, a canal irrigated area, we have the deep open surface drain. Of course, it is anticipated that the water has somewhere to be drained out. So, mostly the canalled areas have the open drains for draining of the surface water but where the subsurface water has risen up and has come very close to the surface and salt has accumulated, and this situation has come at least in one areas in this Chambal-irrigation Project. It is in the central state, comprising the States of Madhya Pradesh and Rajasthan. There, Tube wells, what we call shallow tube wells, have been installed to pump out the water and lower down the water table, which was the main source of bringing the salt to the surface. So, this is the very good method and we have found it has lead to the success. It means where the water table was rising up with every year irrigation, pumping out the subsoil water, installing the tube wells, and then the water table has been reduced. In other area particularly in the eastern part of the country, comprising the States of West Bengal and Rissa, where we get the flood, we don't have the answer as yet. Because the vast area gets flooded and during the rainy season it is difficult to drain out and for that probably an enormous effort that is needed may not be met with. And we have to think of adopting other means, what Mr. Peter Kung said, may be going further for deep water piling. There is the area, probably it is drained, and a good crop of high yield varieties may be cultivated, but since it cannot be drained particularly during the rainy season, we have been thinking in some area being put under the deep water piling.

Sakai: How to decide the desirable water management, such as the percolation control and drainage treatment, is a very difficult problem. There are many factors affecting the desirable measure but I think there are three or four major factors.

One is the soil fertility, especially nitrogenous and the amount of fertilizers.

The second may be the temperature. In the warmer region in Japan, root rot is very popular so that irrigation control is very important in contrast with the northern part of Japan, the cool regions, where even continuous irrigation is very helpful to get the high yields. However some data obtained in India presented in my report indicates that even with no percolation, a very high yield is obtained. It seems to me that this alkaline deep black soil is quite different from the other unfertile soil.

Now, the third problem may be the soil hazard caused by special soil. Some saline soils, and degraded soils, or nutrient deficient soils, and sulfate acid soils should be discussed separately.

And so far as the percolation control is concerned, no percolation may be desirable to save water. The excessive percolation may cause some troubles especially soil degradation. Continuous percolation may induce such degraded soil because all nutrients,

even irons and manganese, will be leached out. Such soils are very popular in Japan. We call it the degraded soil. So I would like to remind you of this problem of percolation.

Chairman (Kung): Can I request Dr. Yamada to tell us something about this?

Yamada: I consider that the drainage should be done in order to prevent the water logging, and flooding or in order to facilitate the use of heavy tractors or to facilitate the harvesting operation at the time of maturity. The purpose of the drainage of the paddy field is like this.

But percolation can also be regarded as a kind of drainage. If you consided the percolation is one kind of drainage, then the problem of percolation will be included in the problems related to drainage in this discussion. As to the problem of the percolation, Dr. Nakagawa presented one picture, in which the optimum rate of percolation is indicated very clearly in relation to the grain yields. But I am not sure whether that data actually indicate us that, when there is less percolation, we have to do something to increase the rate of percolation to the optimum rate of percolation, that is about 15 to 25 mm. It is actually necessary or not?

If the percolation exceeds the optimum rate, of course we have to reduce the rate of percolation, because the higher rate of percolation indicates directly the loss of water. So, in order to save water, we have to reduce the rate of percolation. But, actually, do we need to increase the rate of percolation in the area where the rate of percolation is small under the natural condition? I have the doubt about this because the percolation has several advantages and disadvantages. Advantages are to supply oxygen to the root's sphere, to the soils around the root. Dissolved oxygen in the water goes down with the percolating water, so it supplies oxygen to the deeper soil layer and at the same time the toxic substances such as the sulfide or organic acids, which have been discussed in the past three days comprehensively, be washed away to the lower part of the soil and keep the rice roots very healthy. But at the same time the percolation or the higher percolation may cause a loss of soil nutrients, especially nitrogen. It is known that the roots of the *indica* rice are very resistant to the reductive state of soil, as compared to the usual *japonica* rice. So that if the higher rate of percolation is necessary for the *japonica* rice, it may not be true with the *indica* rice except in some areas with so-called problem soils.

That is my personal question regarding the existence of the optimum rate of percolation, whether it exists or not in the tropical paddy fields.

Fukuda: This morning our chairman so smartly divided our general discussions into two parts, first irrigation and then drainage. But in principle this should be discussed at the same time in comprehensive meanings. That meaning—I hope one point which might be interesting to you. Irrigation and drainage must be functioned at the same time with intimate cooperation. So, this concept of cooperation is applicable not only in humid regions but also in arid regions. In Japan, drainage works started to remove surplus waters from paddy field, after the harvesting of the paddy field or paddy rice in summer. But I told that at the present we have some areas of subdrainage in irrigated paddy fields. That has very important meaning to supply fresh oxygen to roots and to keep good environmental condition for healthy growth of roots, really to keep high levels of yields of paddy rice. This is one example of how important cooperation within irrigation and drainage is. So this is an example in the humid region.

But in arid regions, as Prof. Pande pointed out, there are some problems. It is the optimum balance between the irrigation requirement and the salinity improvement. In arid regions, generally, we are suffering from shortage of water and by such shortage water we must improve salinity, saline soils. So there, we must find the optimum point between the irrigation requirement and salinity improvement, which is to be improved by such short water resources. So, like this, intimate cooperation between irrigation

and drainage must be intensively implemented in arid regions and also in humid regions.

I have been using subdrainage as an index of expressing intensification of agriculture. If we can find a large area which has been provided with subdrainage, especially in paddy field, I would like to judge that the area is now under intensive operation of agriculture. There might be some opponent opinions about this point. But I would like to hear about opinions about this importance of subdrainage from someone from you.

Okabe: I would like to make one comment in using the terminology of "optimum". In these reports presented in last three days' sessions and also in this morning, we sometimes use the "optimum" irrigation, or "optimum" amount of drainage and so on. But, we have to consider many aspects as Dr. Nakagawa mentioned a little earlier. We have many factors to be considered, not only from the technical point of view but from the social or economic, or financial point of view. Anyhow, we have a lot of things to be considered to use "optimum". There are two extremes for irrigation/drainage systems. One is well developed facilities and the other one is low or moderately developed facilities. From the technical point of view we can estimate some amount of irrigation water as optimum or drainage water as optimum. But it is not always true with the real "optimum" from farmer's point of vief. So, we have to be careful to use this terminology "optimum".

Chairman (Kung): Some other comments? If not, then we will turn over to the facilities needed and also the implementation of what we discussed about water management. For instance, intermittent irrigation and depth of water, or the facilities what we need, something about the land consolidation and land levelling, all those things.

Deguchi: In this symposium we heard very often a technical term "land consolidation" and we saw many "land consolidations" in the papers. This English word is a comparatively new one, I mean I didn't hear before 1950 in my memory. So, my question is: "How we define land consolidation as an international terminology?" I would like to hear something about this definition from Mr. Kung or FAO.

Chairman (Kung): This chairman is not the speaker. Our friend, Mr. Taniyama made a very good report on the land consolidation yesterday. Can you answer something about Dr. Deguchi's point?

Taniyama: I defined the land consolidation as the consolidation of irrigation canals and drainage canals and readjustment of farm blocks and consolidation of farm roads, and also the soil improvement of the paddy field. So, there are five kinds of works included in the land consolidation in Japan". But in other countries may be there is another definition.

Chairman (Kung): Dr. Fukuda, can you give some points?

Fukuda: I would not adhere to the opinion of the Japanese government. In my understanding the "land consolidation" is a part of the land preparation in general. The land preparation is divided as follows: It starts with the land clearing. The second the land smoothing. Uplands must be adjusted to let sprinkler irrigation possible. The third one, the supply of irrigation which is made by the socalled surface method fallow method or border method. The next step is the land shaping. A simple adjustment of land. And in my understanding most, not all, of Southeast Asian countries are calling this stage as the land consolidation. But in real meaning, the land consolidation must be the consolidation of lands. Some part of lands must be put together including the exchange of the property of land. Otherwise, the land consolidation has no real meaning. Of course, some countries in Southeast Asia have now advanced in such a real meaning of land consolidation. But farmers have so strict resistance to exchange land properties.

So, even in Muda area of Malaysia which is a representative of the good designed irrigation system, there are some difficulties of such kind. Even in India, I experienced such difficulties in Kopoli area in the Japanese Cooperation Centre. But in the

new reclaimed land such as settlement areas in Landacalania in India, it is easy to do it. But in jungle areas, there appears a big imbalance between such highly developed techniques and jungle forests. Such an imbalance will cause another difficulty in developing agriculture. That is another point.

Any way, in my understanding, the land consolidation must include the exchange of the land property.

Deguchi: I agree with Prof. Fukuda's opinion but I would add something. We never used the "land consolidation" formally. But, yesterday, Professor Yukawa showed us the slides on the old land consolidation. At that time, when the old land consolidation was executed, we called such a work the "land improvement" or "land adjustment". So, I wonder if such works as the "land improvement" or "land adjustment" were changed to "land consolidation".

But I think such a simple work must not be included or must not be called the "land consolidation". In European countries after the War, many kinds of the land consolidation work have been carried out under the name of Flurberreinigung in Deutschland and Ruielverkaveling in the Netherlands, and so in France and so on. In such cases, land consolidation works included many kinds of works not only improvement of soil conditions or irrigation conditions but also other kinds of works, for example, improving the infrastructure of the comunity area, including house moving or new telephone line setting, a new work yard commonly used by the group of farmers in the area and so on. So, when we use the "land consolidation" it must mean the wider or newer sense or newer contents. That is, I want to confirm.

Chairman (Kung): I think this is a foreign term and we just picked the foreign terms which has been used for other countries for years. So, don't think it ours, just picked it up and used as the land projects. For example, in Taiwan, we also have this project. But in the Chinese meaning, we called it the "land readjustment" or "improvement", or something like this.

Kitamura: I would like to tell you about applying the land consolidation works in Indonesia.

The Japanese International Cooperation Agency, to which I belong, has three agricultural development projects in Indonesia. In each case, we have some troubles to extend the land consolidation demonstration farm to other surrounding areas, due to the very high cost and other reasons. At that time, although I suggested the necessity of the land consolidation in Indonesia, I was inversely asked by the officials in Indonesia: "Why you suggest like that? As you see, the farmers are now quite satisfied with the plot to plot irrigation system and fortunately the tributary of the rivers is situated near the area, so that land is very well drained. People can enter into the fields very easily on foot and buffalo can do, too. To harvest, they can carry the products on their shoulders or on their heads". The idea of land consolidation was theoretically agreed. But the time to apply it is not yet matured. The country wanted to raise the land productivity at first but not labor productivity, they said. For this purpose they will choose rather more effective or economical way, not by land consolidation but by the rehabilitation or intensification. That is to construct water source facilities for double cropping. So, even if the cheaper way is applied than that in Japan, people in Indonesia would not be able to stand that burden of high cost.

Sunaryo: It is true. We know about land consolidation but as our first step, we choose rehabilitation. And we know about the consolidations in the technical approach first and our opiinon is like that.

(1) How to convey water through the water system up to the rice field.
(2) The system how to drain water from each field.
(3) About the communication, for instance, in this case, like good farm roads, so on.

(4) Water control.

You know our country, specially Java Island, is very densely populated. Also, Mr. Soekarso has informed you yesterday of land owners. In Java Island, about 0.35 ha per family. That is why in Java Island we still study about, for instance, communication, and farm roads. It is very difficult for us to introduce to our farmers because their own land is only 0.35 ha. We have just the pilot project, but not land consolidation like Mr. Taniyama informed us.

Yamada: I would like to take advantage of this convocation. Dr. Deguchi pointed out some confusion in the terminology relating to the land consolidation. I have in my mind some other terminology problems, for example,—"water requirements". Words "water requirements" indicate the amount of dry matter which is produced per unit amount of water in the physiological terminoilogy. Plant physiology uses "water requirements" as indicating the physiological efficiency of water utilization by different kinds or different varieties of crops. How much amount of dry matters can be produced per unit amount of water absorbed. This is related only to the absorption and transpiration of water, but not including the evaporation, not including the percolation. But, according to the terminology of agricultural engineering the word "water requirements" indicates the total sum of the evaporation, transpiration and percolation. We have to be careful about that. Another confusion in terminology is "intermittent irrigation". We use "intermittent irrigation" very often but it seems to me that there may be two kinds of intermittent irrigations. One is a rotational irrigation i.e., rotational irrigation with submergence on each paddy field. Each paddy field is kept submerged, but the supply of water is just intermittently, starting from this paddy field, next day another paddy field and coming back again after several days. This indicates the continuous submerged irrigation but the method of water supply is just intermittent. Another meaning of the intermittent irrigation is the alternation of dry land condition and submerged condition. I think we have to distinguish each other exactly. The third example is the "mid-summer drainage". This word is originated from the Japanese word "nakaboshi". But the Japanese word "nakaboshi" doesn't mean the midsummer. This is just the mid-growing-season. So, if we use the "mid-summer drainage" in Indonesia, it should be the mid-winter drainage. The word "mid-season drainage" is preferable and more appropriate.

Chairman (Yukawa): At the end of the session, I would like to request Dr. Fukuda. For any suggestion or advance.

Fukuda: My keen interest is in the intimate corporation on the water management from both the agronomy side and the engineering side to make water managements a success. There may be many factors contributing to that target. If I may suggest some items which may be contributing to such cooperation, one is so-called canal density at present in most Southeast Asian countries in the irrigated area is about 16 m to 20 m per ha in an average. We are recommending this value up to at least 80 or 90 meters per ha, which means the intensification of water management eventually.

The second point is that the irrigated area to be covered by one unit volume of water, 1 cubic meter per second. In Japan in average we are assuming in the paddy field about 500 or 600 ha to be irrigated by one cubic meter per second. In most Southeast Asian countries in my experiments, I found that one litre per second per hectare. That means, 1,000 hectare to be irrigated by 1 cubic meter per second. Like this, this value should be increased which means the increase of the acreage to be irrigated by one unit of water.

The third one is irrigation efficiency. This term may be defined in many kinds and at present, ICID (International Committee on Irrigation/Drainage) with its headquarters located in New Delhi has been interested in this term. And this term has been

analyzed and summarized depending on the factors contributing or influencing this value. So, such elaborative works have been published already. This might be very helpful for our common research or experiment of water management in future. Any way, what I have mentioned just now is mostly limited to the engineering side.

Of course, in the field of agronomy, you will have many items which can indicate the intensification of water management, such as intensification of the labor productivity or land productivities or multiple cropping such as Dr. Bradfield of IRRI has worked out, or further diversification including fishery, forestry and agriculture. Such comprehensive developments may be a future aim of the world agriculture. According to the present situation of the development of agriculture and by keeping such targets, each country may have to do their best to increase their values in such items. Intimate cooperation betwen agronomy and engineering sides is required for that.

Julian: Because Dr. Fukuda is our consultant here and I think all his words are to be considered. Now in that case, I think it is up on the symposium committee to include these advices in the proceedings, so that the delegates coming from the various countries will benefit out of it.

Chairman (Kung): I think Dr. Fukuda's statement has been recorded and later on you will see the proceedings. Everybody I think accepted his good suggestions.

Chairman (Kung): I want to make a few words before we close our discussion.

In the past three days, we discussed about 20 papers and all of them have been well done by the author and the result has been presented to the meeting, followed with very good discussions. Of course, we cannot say we have collected all the reports for this subject matter. Many people are not available to participate in this meeting. So, we cannot see their paper. But any way these 20 papers represent the general idea of what we have done. From these papers, we also got some indications what should be done in the near future. I have an impression that much works have been done with the *japonica* rice and less on the *indica* rice. This is very natural, because the Japanese scientists started this kind of study many years ago and *japonica* is their own rice. But now, the *indica* rice is the only type in the tropical Asia or Southeast Asia. So, we think the study on the *indica* should be our future direction. Also, our future work will more or less concentrate on the transplanted rice. Very few work has been done on the water requirements of the broadcast rice. Of course, many of the broadcast rice is outside of the irrigation area. But still quite a few can be included in the irrigated area. But the scientific work on the water requirements of the broadcast rice seems to be none. Our work has been also more or less concentrated on the rice grown in the wet season and not too much on the off season rice, or dry season rice, or what we call the second rice. So, from now on may be we have to put a part of our efforts on the second rice. Also we have put our efforts mostly on the water management under the normal condition. But there are still many large areas of rice under the rain-fed and flood-fed conditions. There is always too much water or too little water. How we overcome such a condition? I know it is difficult to over-come but, whether can we solve a part of the problem? We don't have yet enough reliable information on the abnormal condition.

Also we concentrated on a study for rice alone. But in the Southeast Asian region in recent years we have double cropping, not only two rice crops but maybe one rice followed by one upland crop. What is the water management on this kind of double cropping? That means the water requirements or water management must be studied under the farming system, or, say, we have to consider the whole year as a unit. This kind of information I think we don't have. Also I think our studies mostly concentrated in the flat area. Definitely we have more flat areas than the slope area. But I think after a few years, if the flat area has been saturated, then we have to think about the slopes. Yesterday, we have already head from Sri Lanka that they have

already paid attention on the slopes. But in the past the study on this subject is not very much. Also, even this morning our focus of discussion is on the water requirements, the consumptive use. But the real study on the irrigation efficiency is very few. If you want to save water not by the consumptive use, because this is natural, but by increasing irrigation efficiency, you can save a lot of water for other use, to cover other areas. But where is the result? This is just my personal view. Maybe for future study can we just consider this or just think over whether this is worthwhile to put this in your future program?

We, Prof. Yukawa and myself, appreciate your active participation of this meeting very much. We thank you very much. Also the TARC made such a god arrangement for this gathering and enriched us very very much. Arigato-gazaimasu. Sainara.