LOWLANDS DEVELOPMENT IN INDONESIA, IN THE PAST, PRESENT AND FUTURE

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ABSTRACT

Since the beginning of the last century, Buginese, Bajarese and Malays have reclaimed coastal strips of Indonesia. They have many years of experience in the practice how to reclaim lowland areas and to cope with the related soil and water management problems. The reclamation is mainly for agricultural purposes and with their simple technique about 2 million ha have been reclaimed along the astern coast of Sumatra (Riau, Jambi, South Sumatra and Lampung provinces) and along the western and southern coast of Kalimantan.

Lowlands become more and more important for Indonesia and will be the future for agricultural development potential because mainly in Java, there is a continuous loss of agricultural lands for urbanization, industry and roads infrastructure. Rice production on Java will continue to decrease in future as the urban requirements or land and water are in strong competition with the requirements for rice cultivation and it is estimated that the rate of the loss of agricultural land is about 30,000 to 40,000 ha/year.

Lowland development in Indonesia is already for more than 25 years and the Central Government, especially the Ministry of Public Works, DG Water Resources Development and the Ministry of Agriculture have been involved for a long time, both in research, planning and implementation.

Lowland development is a dynamic long term process of land and water development and most of the lowland development schemes in Indonesia are in the second stage and for further development where their potentials might be considered as an important means to increase food production, realization of crop diversification and the development oaf the are itself. The question for the future development, and by considering the field experiences in lowland development in general and the economic conditions of Indonesia now, it is thought that may be a better utilization of the lowland resources would be possible, for example with a more sophisticated water management system directly, instead of a simple open drainage systems or to skip some preliminary steps of the development. A careful evaluation has to be done included the environmental impacts of the development which should cover technical as well as non-technical aspects.

A kind of nation wide study for lowland development in Indonesia where the characters are different from place to place and unit to unit should be carried out soon in order to inventories the field and environmental conditions, development stage, potentials and also constraints for the future use

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(agriculture, conservation, urban, etc.) and the previous nation wide result can be used as the bases. Next to that, a monitoring programme for climate change, especially sea level rise should be done soon in order to analyse and to evaluate the possible impact of sea level rise to lowland development in Indonesia and based on that sound measures can be proposed as early as possible.

Keywords: *lowland development, food crops, sustainable development, climate change, soil and water management, nation wide activities*

INTRODUCTION

Lowland area is either water logged, or temporarily or permanently covered with a water layer. In this paper, the domain will be limited to the lowland areas where the incoming water originates from rainfall and/or tides.

Since the beginning of the last century, Bulginess, Banjarese and Malays have reclaimed coastal strips of Indonesia. The main motivation is to find new living spaces because of the limitation of further expansion possibilities in their village of origin (after Collier et al., 1981). Most of the Bulginess has many years of experience in the practice how to reclaim lowland areas and to cope with the related soil and water management problems. They are pioneers in this field. They reclaim those lands mainly for agricultural purposes. With their simple technique about 2 million ha have been reclaimed along the eastern coast of Sumatra (Riau, Jambi, South Sumatra and Lampung provinces and along the western and southern coast of Kalimantan (Manuwoto et al., 1986).

Worldwide, the Lowlands appear to be the most successful environment for rice production. Lowlands are highly suited for mechanization and often found with relatively large farm-holdings, good for an efficient rice production with competitive world market prices. There are usually also ample potentials for water supply from large rivers (LWMTL, 2005a, 2005b and 2005c). Some characteristics data on population growth as shown in Table 1.

Rice production on Java will continue to decrease in future as the urban requirements or land and water are in strong competition with the requirements for rice cultivation and it is estimated that the rate of the loss of agricultural land is about 30,000 to 40,000 ha/year (Soenarno, 1993).

Table I. Some characteristic data on population and population growth (BAPPENAS et al., 2002; Schultz et al., 2005; International Commission on Irrigation and Drainage, 2006; Schultz, 2006)

	Area in million ha	Paddy rice area in million ha	Population in million			Population density in persons per km^2 with respect to:	
			2005	2025	2050	Total area	Paddy rice area
Java	13	3.3	120	142*)	153*)	923	3,636
Other islands	178	5.2	103	122*)	132*)	58	1,980
Indonesia	191	8.5	223	264	285	117	2,623
Asia	3,177	133	3,927	4,752	5,240	124	2,950
World	13,271	148	6,487	7,930	9,100	49	4,383

*) Computed, based on the same ratio as Indonesia as whole

LOWLAND DEVELOPMENT STRATEGY

Since 1060, the Indonesian Government is reclaiming the lowland with the following objectives (Swamp Directorate, 1980):

- To increase the national food production, mainly rice, in order to obtain self sufficiency;
- To provide agricultural land for trasnmigrants in order to support the Government Transmigration Programme;
- To support regional development;
- To increase the income per capita;
- To increase the security on coasts along the border lines.

So far, the development of lowlands in Indonesia has been carried out as a gradually long term process, known as the step wise development strategy. This strategy was based on the following considerations (Soesanto Soedibyo, 1977):

- Limited availability of construction budget, and the need to reclaim large areas;
- Lack of knowledge, experience and design criteria;
- The social cultural problem of the transmigration people where most of them are coming from 'dry' land and were not familiar with wet lowland conditions.

At present, most of the lowland schemes are in the second development stage. On one hand large areas of lowland schemes are not yet well developed, where on the other hand their potentials might be considered as an important means to increase food production, to realize crop diversification and the development of the are itself. Now, the question for the future development, and by considering the field experiences in lowland development in general and the economic conditions of Indonesia in general, it is thought that may be a better utilization of the lowland resources would be possible, for example with a more sophisticated water management system directly, instead of a simple open drainage systems or to skip some preliminary steps of the development. Of course prior to that, a careful evaluation has to be done included the environmental impacts of the development which should cover technical as well as non-technical aspects.

POTENTIALS AND CONSTRAINTS

Out of 162.4 million ha land resources in Indonesia, about 39.4 million ha are lowlands. See Figure 1.
The lowlands have their characteristics in accordance with their geographical and hydro-topographical conditions. Based on those conditions they can be divided into two sub-groups, i.e. coastal swamps and inland swamps (lebak). The coastal swamps are influenced by tidal fluctuations of the sea and inland swamps are mainly influenced by river flood plain characteristics.
Lowlands are also important areas in Indonesia for biodiversity with its mangroves, peat swamp forest, fresh and brackish swamp forest. Indonesia has about 60% of the world's tropical peat lands across an area of around 22.5 million ha (Fadilan, 2009).

Within the context of the agricultural development in Indonesian lowlands, there are potentials and constraints which have to be considered (Suryadi, 2006, Hartoyo et al., 2006):

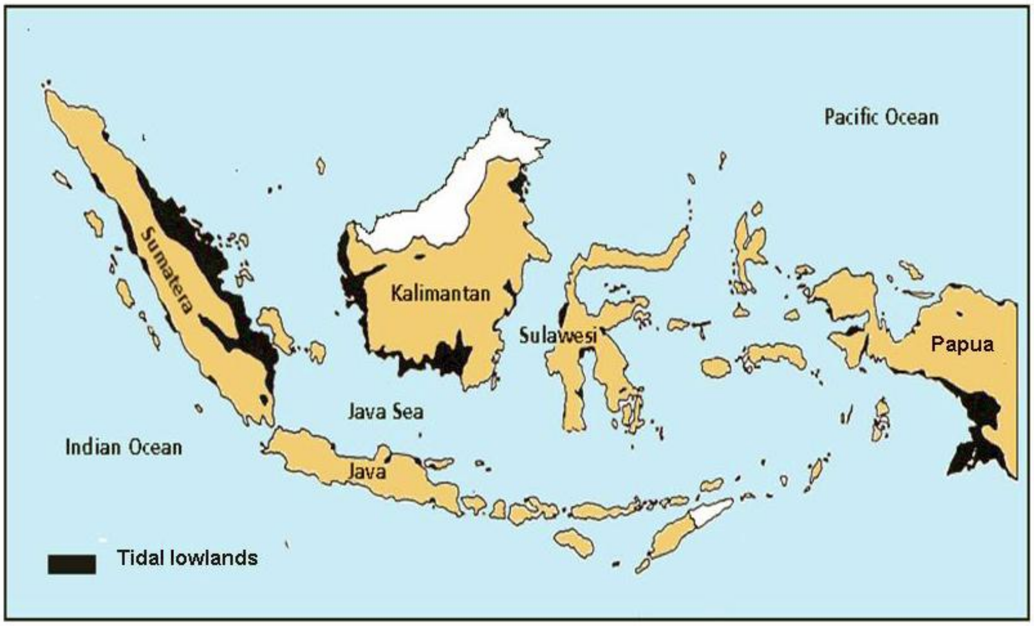

Figure 1. Lowlands in Indonesia

Potentials:

- Soils are mainly clays, which make them productive after reclamation, unless they are covered by peat;
- Rainfall amount and distribution in the wet season are adequate for one rainfed crop;
- If additional irrigation is introduced (low lift pumping), wetland rice will provide a high yield under proper water management. This alternative may in future prove to be a feasible development option;
- If drainage measures are taken, upland crop cultivation, such as cassava, maize and soybeans, will be possible. Perennial crops like coconut and oil palm may grow well.

Constraints:

- Tidal lowlands are located in remote areas, hindering supply of inputs and marketing of products;
- Close to river mouth, salinity may create problems for agriculture and drinking water, especially during the dry season;
- A substantial part of the tidal lowlands are covered by (potential) acid sulphate soils and/or peat soils. Soil development takes time before a stable situation is reached. The water management infrastructure has to be adjusted to the changing conditions;
- Inadequate soil and water management systems in most places;
- In many tidal lowlands, lack of supporting data, mainly related to the soil conditions, hydro-topographical conditions and land suitability conditions.
- Labour shortages that favour farming technology systems without land preparation based on low yielding traditional rice varieties;
- Lack of operation and maintenance of the water management systems at tertiary and secondary level and almost non on-farm water management;
- Inadequate infrastructure and post harvesting management facilities;
- Lack of good credit facilities and availability of agricultural inputs and limited market facilities;
- In some schemes the soils are still not well matured and due to inadequate land and water management possibilities and practises, locally acidity problems are still rampant;
- Pest and diseases.

These potentials and constraints factors show that an increase in food production in lowland areas needs an environmentally sound, integrated and stake holder involvement approach that requires a continuous attention from government to tackle the problems.

Total area of lowlands in Indonesia is about 33.4 million ha, out of this 20 million is tidal lowlands and 12 million ha is non-tidal lowlands and about 1.4 million inland swamps (lebak). So far the reclamation of tidal lowlands covers the following: 2.5 million ha by spontaneous settlers, 1.3 million ha through the Government schemesand the remaining potential area for agricultural development is about 4 to 5 million ha. For detail information, see Table 2.

Table 2. Distribution of lowland in Indonesia (source: Ministry of Public Works, 1996)

Location	Total lowland areas (*1000 ha)			Developed by Indonesian Government (*1000 ha)		
	tidal	Non-tidal	total	tidal	Non-tidal	total
Sumatra	6,604	2,766	9,370	615	279	895
Kalimantan	8,127	3,580	11,707	220	192	412
Sulawesi	1,149	645	1,793	-	2	2
Papua	4,217	6,306	10,522	-	6	6
Total	20,097	13,296	33,393	835	480	1,315

LAND SUITABILITY AND WATER MANAGEMENT SYSTEMS

The hydro-topographical conditions in the tidal lowlands as the starting point for the land suitability analysis are defined as the field elevation in comparison to river, or canal water levels in the nearest open water system (Suryadi, 1996). Four hydro-topographic classes are generally distinguished:

- *category A (tidal irrigated areas).* The fields can be flooded by the tides at least 4 or 5 times during a 14-day neap-spring tidal cycle in both the wet and the dry season. These areas are situated mostly in depressions, or close to river mouths;
- *category B (periodically tidal irrigated areas).* The fields can be flooded by the tides at least 4 or 5 times during a 14-day neap-spring tidal cycle in the wet season only;
- *category C (areas just above tidal high water).* The fields cannot be regularly flooded during high tide. The groundwater table may still be influenced by the tides. Cropping is mainly dependent on rainfall, although some additional water supply by infiltration might be possible with an intensive field ditch system. Many category C areas in the wet season are generally planted with a rice crop. For the dry season a dry food crop is the most likely alternative. With a sufficiently large tidal range the cultivation of tree crops is an option for these areas;
- *category D (upland areas).* The fields are entirely above tidal influence. Dry food crops and tree crops are best suited to these areas when they do not receive extra water from adjoining higher areas.

In the relatively low tidal lowland areas (category A and B) the main purpose of the water management system is to control drainage by operating the water control structures based on the water requirement in each cropping stage. If required water can be supplied during dry periods. From time to time flushing may be required in areas where acidity still can develop. In the relatively high tidal lowland areas the rice is completely depending on rainfall, but subsurface flow of groundwater to the adjoining secondary canals may cause relatively high water losses. Therefore the main purpose of the water management system may be to control relative high water levels in the secondary canals to prevent too low groundwater tables (Land and Water Management Tidal Lowlands. 2005b).

The land suitability and water management zoning is one of the thematic information in relation to the agricultural potential in land water development (Kucera et al., 1993). They are base don a lot of information with spatial distribution characteristics which have to be taken into account i.e., topography, soil, hydraulic, hydrology, cropping systems and local practices. By using this information, the risk of misuse in land water utilization can be minimized and sustainable development of the area can be proposed. An example of the present field conditions is shown in Figure 2.

Figure 2. Present field condition in Telang 1, South Sumatra

PAST, PRESENT AND FUTURE LOWLAND DEVELOPMENT

Four basic types of water management systems layout for lowlands are known in Indonesia. See Figure 3.

Type 1: Traditional system

This is the oldest system, applied by Banjarese, Buginese and Malays. They reclaimed the backswamps by connecting them with a tidal river. During low tides, the connecting canal drains the (toxic) water to the river, while during high tides fresh water enters the canal system and can be conveyed to the fields. Each canal serves about 40 ha agricultural land, so only a fringe of few km along the river can be developed by this system. The distance between two canals is about 400 m. This scheme has been widely implemented in Sumatra and Kalimantan.

Type 2: Anjir system

In South and Central Kalimantan, main canals were constructed in the period 1950 to 1970. These canals were constructed between two tidal rivers, to allow for inland navigation. Their length varies between 15.00 to 30,000 m. In a later stage, these navigation canals were incorporated in Government lowland reclamation projects. They also serve for irrigation and drainage of the related swampy areas. Sedimentation problems occur in these canals, where tides at both ends have more or less the same phase. Due to the fact there is a dead point somewhere in the middle of these canals and most of the sediments are coming from the canal bank erosion due to navigation activities.

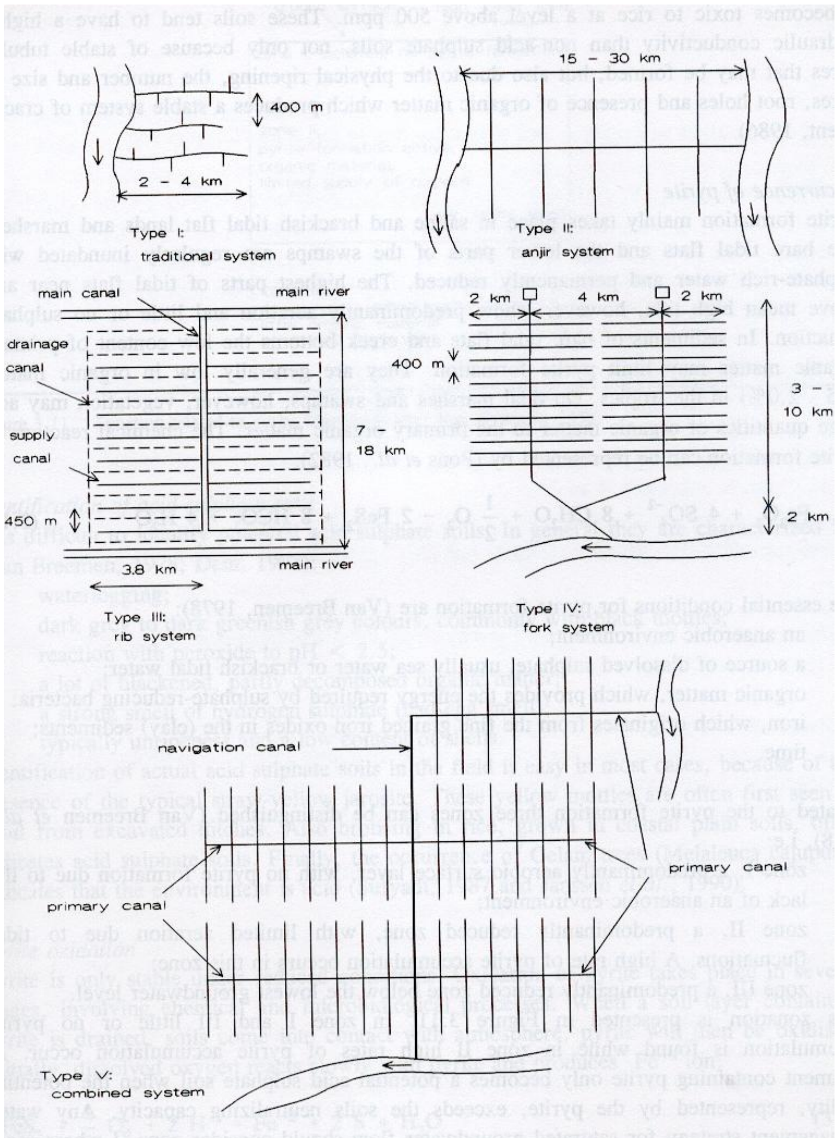

Figure 3 Types of lay out at primary and secondary level of water management systems in tidal lowlands in Indonesia

Type 3: Rib system

This system is mainly applied in Sumatra and it can be characterized by its right-angled layout (Sugandar, 1976). The principle of this system is that areas are made suitable for agriculture at low costs by making maximum use of the tidal fluctuations in the canals. Next to drainage, the system allows for (tidal) irrigation for areas in the category A and B hydro-topography. The system composes main canals which are used for navigation, secondary canals and tertiary canals. These water management systems are more flexible for adaptation when required.

Type 4: Fork system

This system is introduced by the Gajah Mada University in Yogyakarta.It was designed to overcome acidity problems, which developed in reclamation schemes in Kalimantan upon reclamation of potential acid sulphate soils (Soenarjo, 1977 and Harjosopangarso, 1986). The system consists of a primary canal of approximately 2000 m in length and it braches into two or three secondary canals with length on the range of 3,000 to 10,000 m. Tertiary canals are constructed perpendicular to the secondary canals and have lengths of 2,000 m. The primary and secondary canals have also a navigation function. Most of the systems have a large pond (a so called kolam) at the end of each secondary canal with the dimension of 200x200 m^2. In fact the dimension of the kolam is too small in order to have the jet flow effect for flushing the systems.

Type 5: combined system
In addition to the above four systems, a combination of the rib and fork system has been applied as well. The navigation canal is connected to a tidal river, whereas each secondary block has a layout according to the rib system. This combined system can be found in the Karang Agung I reclamation project in South Sumatra which covers an area of 9,000 ha (Euroconsult, 1991).

The development of lowlands is very much a matter of land and water management. The projection shows that the total population of Indonesia will increase in the next 25 years, from 205 million in 2000 to 273 million in 2025. This growth decrease is caused by the decrease of mortality rate in Indonesia in the last decade. It means that the main objectives of lowland development and management in the present day policy of the Indonesian Government is to contribute to the required increase in food production (Suriadikarta et al., 2001; Suprapto, 2002; Schultz, 2006).

Lowland development has been neglected since 1998, since the abandonment of the Mega Rice Project (MRP) (Proyek Lahan Gambut) in Central Kalimantan. Next to the effect of this project, due to the lack of investment in lowlands and decentralization played also a role in this situation. The construction of the canal system of the Mega-Rice Project that has left many of the existing communities with reduced livelihood opportunities and a land that is prone to uncontrolled fires (Euroconsult Mott MacDonald et al, 2008).

In formulating future developments and directions in the tidal lowlands a distinction will have to be made in the improvements in reclaimed areas, new reclamations and the conservation of areas not to be reclaimed (Schultz, 2006):

- *improvements in reclaimed areas.* Related to the improvement options in reclaimed areas quite some experiences are available now (Hartoyo Suprianto et al., 2006). Based on these experiences the first priority would have to be to make better use of the developed infrastructure by a better operation and maintenance, both at on-farm and main system level. The experiences as outlined above may serve as a guidance;
- *new tidal lowland reclamation projects.* In general terms the areas that have a potential for reclamation have been identified in the Nation wide study of 1984 (Ministry of Public Works, 1984). It may be expected that sooner, or later the remaining potential tidal lowland areas (about 4 million ha) will be reclaimed. This is still a very substantial area compared to the present total cultivated area with paddy rice in the country of about 8.5 million ha;
- *environmental considerations and sustainability.* Until some twenty years ago, ecological data were not often used in reaching a decision on lowland development projects. This has led to various unforeseen consequences. Increasingly ecological data are used in all decisions on future lowland development projects. In the tidal lowland areas especially the deep peat areas are basically unsuitable for development on a sustainable basis in many locations and would have to be preserved;
- *first generation problems.* In newly reclaimed areas, several problems can be regarded as first generation problems, like:
    * in the initial stage there is a strong commitment of the involved organizations. However, if the development has to be continued without further external resources, stagnation may occur;
    * farm sizes and layout pattern, that initially have been implemented, may become inadequate to cope with developments in society. Due to this, farming may become uneconomic;

* insufficient institutional arrangements and organisation to properly operate and maintain the flood protection, water management and infrastructure facilities;
* insufficient skill of farmers to cultivate crops under the conditions as prevailing in the newly reclaimed land;
* development of (potential) acid sulphate soils.

The competition with more profitable crops is not the only found on Java where horticultural crops replace rice at many places. In lowland also there is now a major challenge coming from the oil palm industry that looks for extension of suitable areas, including the lowlands. When analysing the profitability of the food crops in comparison with oil palm it appears that it is essential that production levels per ha be increased, but also that at least two crops per year are harvested. In this case, a National Lowland Development Strategy (Mott MacDonald, 2008) may be expected to provide the framework for integrated lowland management, addressing policy, legal and institutional aspects and closely linked strategies for conservation, existing agriculture and new development as well. Based on this, a Master Plan for the future development should be prepared with the following aspects in its perspective (Euroconsult Mott MacDonals et al., 2008):

- National strategy and policies;
- Integrated water resources management;
- Environmental considerations;
- Food production area needs
- Regional development;
- Planning, actuating, organizing and controlling.

It means that an action plan for the medium and long term lowland development should be derived where the following components should be considered:

- Data base development, including inventory activities and seminar of lowland development in Indonesia in order to know the actual stage of development which cover physical and human resources;
- Integration of lowland development with the regional spatial planning;
- Effect of climate changes in lowland development in Indonesia;
- Capacity building and human resources development related to lowland development in Indonesia.

CLIMATE CHANGE AND IMPACT ON LOWLAND DEVELOPMENT

Climate change and particularly the sea level rise which is predicted as 0.65m per century (BAPPENAS, 2004) will have an impact to the lowland conditions especially related to it hydro-topographical conditions. The impact will be more areas will change from B hydro-topographical category to A and from C to B (Rahmadi, 2009). It means that more possible for tidal irrigation in one hand but more problems with drainage, salinity intrusion and flood protection due to the sea level rise and changes in rainfall pattern in another hand. It means that water management systems would have to be adapted to these conditions. In order to evaluate the sea level rise, a monitoring system should be considered as early as possible.

The issue of climate change on water management zoning is very crucial to be analysed, since it may have important influence on the success of the agricultural sector in tidal lowland (Rahmadi, 2009). However, there would be negative effects of sea level rise or climate change in general, where the salt concentration becomes higher and salinity wedge becomes longer in the river.

Related to CO_2 emission, it is reported that it was caused by decomposition of drained peat lands and this will increase in coming decades unless land and water management systems and its operation are changed properly (WL|Delft Hydraulics et al., 2006). It means that, in order to reduce CO_2 emission and to stabilize greenhouse gas emission and to reduce it significantly to 20% in 20020, proper measures have to be taken accordingly and a balance have to be considered between lowland development and land conservation.

CONCLUDING REMARKS

Lowland development is a long term and dynamic process of land and water development. Most of the lowland development schemes in Indonesia are in the second stage and for further development, a careful and environmental sound scenario should be followed.

Lowland development in Indonesia is already for more than 25 years and the Central Government, especially the Ministry of Public Works, DG Water Resources Development and the Ministry of Agriculture have been involved for a long time, both in research, planning and implementation.

It takes time before an area really becomes prosperous and be flexible to enable accommodation of future changes in society, land use and decide carefully on the development concept by considering technical, non-technical as well as environmental aspects. See Figure 4 for comparing the conditions when the people just arrived and after 25 years settling in the area.

Figure 4. The conditions when they arrived and after 25 years

Lowlands in Indonesia are potential to become the rice belt of Indonesia. For that purpose, the first priority is to make better use of the developed infrastructure by doing a better O&M at on-farm and system level. Next to that farmers have to be supported in improving agricultural practices, crop diversification and post harvest activities. Of course in this case, also to protect the ecological valuable areas as well and do not reclaim areas where land subsidence may create problems in the near future.

A kind of nation wide study for lowland development in Indonesia should be carried out soon in order to inventory the field and environmental conditions, development stage, human resources development, potentials and also constraints for the future use (agriculture, conservation, urban, effect of climate changes, etc.) and the previous nation wide result (Euroconsult, 1982) can be used as the bases.

Based on these activities, an action plan for lowland development in Indonesia for medium and long term can be derived.

A monitoring programme for climate change, especially sea level rise should be done soon in order to analyse and to evaluate the possible impact of sea level rise to lowland development in Indonesia and based on that sound measures can be proposed as early as possible.

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