

CHAPTER 4
BASIC CONCEPT

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The study is considered as Phase 4 of the Arenal-Tempisque Irrigation Project. The Phases 1 and 2 of the project has already been completed, and is now in operation. Phase 3 of the project has been leadoff in Dec.2000 in order to expand the west canal and supply 15 m³/s of irrigation water mainly to the left bank of the Tempisque (Cabuyo and Tempisque sub-districts) and the southern part of the right bank (Zapandi-Sur sub-district), and is planned to start service in May, 2003. As the irrigation water from the west main canal will be supplied to 2,500ha of land in the Study Area, readjustments of water rights are expected.

The Arenal-Tempisque Irrigation Project had been planned for mainly the purpose of increasing of the agricultural production with installation of the irrigation facilities in 1978, however, the idea of project plan has been greatly changed with the changing of the back ground for during these more than 20 years. The aspects that have large influenced to the project are as follows:

- As it is necessary to enforce the international competitiveness of the agriculture under the conditions of globalization of market economy, the supporting to small and medium-scale farmers incapable in self-development is required urgently.
- As there are so many uncertain factors in the international market in the future, it is necessary to guide the diversification of agriculture, which is mainly producing rice, sugar cane and livestock at present.
- The Guanacasute Province is one of the poorest provinces in Costa Rica, and, it is necessary to correct the regional differences with the other regions through the bottom-up of the low-income inhabitants.
- Though the water source of the project has been expected from the flow out discharge of ARCOSAN hydroelectric power station, it is clear now that the irrigation water will not be supplied as the expectation at first.

In the Phase 4 project (the right bank of the Tempisque River), using the water being able to develop, improving the irrigation/drainage and flood protection with a consideration of environmental impact, the integrated agricultural development with the purpose of the achievement of sustainable agricultural development for the small and medium scale farmers is expected. Therefore, for the improvement of the agricultural management of the small and medium-scale farmers, and, for the improvement of the socio-economic conditions surrounding said farmers, the irrigation will be partially installed for mainly for the small and medium-scale farmers. For the achievement of this purpose, it will be the basic condition that the policy of the water rite of the Tempisque river shall be decide AyA of MINAE.

From the considering mentioned above, the beneficiaries of Phase 4 (the proposed plan of this study) are targeted mainly on the small and medium-scale farmers that have strong limitations, both technically and financially, for agricultural self-development, and the benefited area is the area where irrigation facilities are not installed in the middle basin of Tempisque River. Furthermore, considering regional features of the middle basin, the development plan also aims on flood protection and environmental consideration, finally, combining with the activities such as Irrigation/drainage improvement, establishment of farmer's organizations and improvement of cultivation and farming techniques, the development objective is set as "achievement of the sustainable agricultural development of the small and medium-scale farmers". By this project, the regional socio-economic development is expected with the increasing of the agricultural production through the improvement of agricultural management of small and medium-scale farmers.

Therefore, it is important to shows the methodology for small and medium-scale farmers, who has insufficient power on both financially and technically, that to improve the present agriculture by self-effort based on the existing technique and crops known already, but, it is not the purpose of this study to show the high progressive agriculture witch small and medium-scale farmers cannot adopt at present.

4.1 SUBJECT AND DEVELOPMENT DIRECTION IN THE STUDY AREA

The agriculture of Guanacaste Province has been developed with mainly the large-scale farmers. Costa Rica has developed its large-scale agriculture mainly based on cattle raising, sugarcane and rice, in the middle basin of Tempisque River where low flat lands spread. However, in the Study Area, regional development and improvement of living and has been suppressed by the factors such as low productivity of small and medium-scale farmers mainly due to the lack of irrigation facilities, and damages brought by inundation in the rainy season.

Improvement of agricultural productivity, especially for the small and medium-scale farmers, is required for the low flat lands of Costa Rica.

Development with minimizing impact on natural environment is required for the area located surrounding conservation areas.

Enlightenment for the inhabitants concerning conservation and rational use of natural resources

- there are many mountainous and hilly areas in Costa Rica and the main agricultural crops are coffee, bananas, sugar cane etc. In contrast, Guanacaste Province embraces a significant sum of low flat lands and forms a major production area of rice, sugar cane and cattle raising. The share of production areas is more than 45% and 50% for rice and sugar cane, respectively. It may be said that the Phases 1 and 2 Irrigation Projects and the water intake from Tempisque River have largely contributed to the agricultural productions. Still yet, there are further demands in improving the productivity of crops such as rice and sugar cane, especially for the small and medium-scale farmers of the Study Area, due to the recent changes of economic environment represented by states such as the liberalization of the Central American Market
- Costa Rica has national conservation systems consisting (SINAC) of 11 conservation areas. The area of these exceeds one fourth of the nation area. The Study Area is located in the Conservation Areas of Guanacaste and Tempisque, with the National Parks of Santa Rosa and Palo Verde in the upper and down parts of the Study Area, respectively. The Guanacaste Conservation Area consists of Santa Rosa National Park, Rincón de la Vieja National Park and other conservation areas. A part of the Santa Rosa National Park is registered by UNESCO as a World Heritage, granting its long-term eager activities on conservation and restoration of forests such as the tropical dry forests endangered by isolation due to deforestation. The Costa Rican government carries out policies aiming on development of regional economy, by utilizing these Conservation Areas in sustainable manners. Though the Study Area has been used as an area of industrial activities (agricultural production), development with minimum impact to the surrounding natural environment shall be considered, for its location near the areas with valuable natural features and subject to conservation.
- The protection and rational use of the natural resources is significant for Achievement of sustainable agricultural development and it is necessary to Enlighten for the inhabitants concerning those.

It is necessary for Small and medium scale farmers to develop their ability in sustainable manners and to improve farming techniques by their own efforts.

Improvement of farming practice in order to improve the productivities of small and medium-scale farmers.

Development capable of accepting various approaches of agriculture, such as the coexistence of full-time and part-time farmers is required.

It is necessary to enlarge and improve the farming scale by grouping small and medium-scale farmers.

Suitable support is required for women in rural area in order to contribute the improvement of home environment.

- There are approximately 870 small-scale farmers and 130 medium-scale farmers in the Study Area, and they will be the beneficiaries of the proposed project. The small and medium-scale farmers in

the study area has the following features:

- ⇒ Most farmers are not in poor conditions.
 - ⇒ Literacy rate is 99.5% and almost all of the farmers educated at least of primary school
 - ⇒ Most of the farmers are part-time farmers with off-farm income exceeding on-farm income.
 - ⇒ However, many of the farmers are forced to rely on off –farm income due to low productivity of existing agriculture and they intend to continue the agriculture if the productivity improved. Therefore, their willingness for agriculture is no low.
 - ⇒ Many of the farmers do not reside near their fields.
 - ⇒ The agricultural land owned by small-scale farmers is only 7-8 ha averagely and it is not enough for extensive agriculture.
- In order for small and medium-scale farmers to prosper in sustainable manners, it is necessary for them to develop their basic abilities to think and act with their own efforts, as well as improving cultivation and management techniques. However, with most of these farmers highly depending on off-farm income, it is not practical for all of them to leap to the stage of highly intensive farming. Therefore, it is necessary for the development to be capable of accepting various approaches of agriculture.
 - In order to improve the agricultural productivity for rice, sugar cane and cattle raising, it is necessary to improve farming by expanding the farm size in a moderate scale. The grouping of small and medium-scale farmers will be necessary for this achievement.
 - In the Study Area, there are many mothers who are not married. In many cases, the households of these mothers lack of stable income, and favorable environments for raising children are not ensured. Therefore, proper support to the women of rural areas including these single mothers are required, in order to improve the home environment for the children, as the future of regional development depend on them

Installation irrigation/drainage facilities and the enlargement of farm size through grouping of small and medium-scale farmers are required.

The increase of employment opportunity for agricultural laborers is necessary.

Recovering of river maintenance flow with effective use of river water is required.

- As for the first step of development, keeping the balance of the present agricultural form based on main crops; rice, sugar cane and cattle raising, the development of intensive farming is targeted in a ten-years period through the crop diversification, and, with installation of irrigation facilities and enlargement of farm management scale by grouping of the small and medium-scale farmers, the farm management for them will be improved. In this process the usage of the technical and financial backups by the combination of large enterprises and government agencies will be effective and the crop market is secured already. The capacity of the sugar and rice processing plants in the Study Area exceeds the present its' production, and therefore the enterprises are willing to purchase more of these materials. On the other hand, numerous farmer's organizations exist in the Study Area, where some are in good practice and others are nearly collapse and it is indispensable for the success of the Project to strengthen and support for farmers' organizations (existing/new). Though the farmers know very well how it is difficult to keep the organization from their experience, at same time, they recognize the necessity of these organizations.
- Though the agricultural laborers, who do not have their own fields, will not be the direct beneficiaries of the Project, it is necessary to consider the increase of employment opportunities for them. These laborers are assumed to compose the low-income class in the region, and the

increase of their employment opportunity will be significant for the balanced development of the entire region.

- Presently, the water resource of the Tempisque River in the dry season is completely utilized and environmental impact is worried due to the drying up the river water in the dry season at the down stream. This problem is deeply related with the water usage of the area it is necessary to recover the river maintenance flow, not only with controlling the water use by regulation, but also with getting the consensus of the inhabitants and realizing of effective water use. In addition to the present on-going productive activities, for the realization of sustainable development of activities newly started with implementation of the proposed project, the crush and build of the water right of the Tempisque river is required and the participation of MINAE is indispensable.

The mitigation of inundation damage is required in order to enable stable farming of the small and medium-scale farmers.

Ensuring security for the life of local residents is required.

- Most of the Study Area is categorized in potential flood damage zone according to the Guanacaste inundation potential hazard map, prepared by CNE. The area is constantly damaged by inundation and Oct. 1999, inundation brought by Hurricane Floyd has damaged 16,000ha of farmland and 400 houses. Also, some communities were isolated in flooding time and problems may occur in cases of emergency such as urgent transportation of patients. However, local residents take refuge voluntarily with the increasing of water level of the river. With these procedures, human damage by inundation has been found scarcely in the Study Area. Therefore, it is necessary to mitigate inundation damages on farmlands and to ensure the safety of the local residents.

4.2 BASIC COMPONENTS OF DEVELOPMENT

The four basic components as indicated below were established in order to achieve the development objective; “achievement of sustainable agricultural development for the small and medium-scale farmers”.

| Present Subjects | Basic Component |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| <ul style="list-style-type: none"> • Improvement of the productivity of small and medium-scale farmers • Enlargement of farming scale and crop diversification • Increase of employment opportunity for agricultural laborers based on the productive activities through the year | Irrigation/Drainage Plan |
| <ul style="list-style-type: none"> • Mitigation of inundation damages on farmlands • Ensuring security for living | Flood Protection Plan |
| <ul style="list-style-type: none"> • Minimization of impact against the natural environment • Securing of river maintenance flow • Enlightenment for the inhabitants concerning conservation and rational use of natural resources | Environmental Conservation Plan |
| <ul style="list-style-type: none"> • Improvement of cultivation and farming techniques of the small and medium-scale farmers • Various approaches of agriculture by the small and medium-scale farmers • Enlargement of farming scale by grouping • Supporting to women in the rural areas | Strengthen of Agricultural Supporting Plan |

4.3 BASIC CONCEPT OF DEVELOPMENT

4.3.1 Target Year

The plan in this study aims the achievement to sustainable agricultural development for the small and medium-scale farmers improving the four Basic Components (Irrigation/Drainage, Flood Protection, Natural Conservation and strengthen of agricultural Supporting) through doing of farmers' effort and governmental supporting activities. The target year of this plan is set 10 years after the completion of the construction of the main irrigation facilities. This comes from the ideas; if it is too long period the plan will not be practical, if it is too short the objectives become to be too low or impossible to achieve, it is better to set for the objectives as concrete and realizable ones within 10 to 15 years, and, the construction of main irrigation facilities is expected to be completed for around 3 years including detailed design. Therefore, the target year of this plan will be 13 years after commencement of the project. Additionally, it is necessary 1 year more before project implementation as a preparation period for the adoption of the project, and, in this period, the preparatory works such as the necessary procedures, consensus building of beneficiaries and related persons concerned, etc.

| Before implementation (before adoption) | After commencement of the implementation | | remark |
|--------------------------------------------|------------------------------------------|----------------------------------|-----------------------------------------------------------------------|
| Preparation period | Main construction period | After completion of construction | Target yeas is 13 years after commencement of project implementation* |
| 1 years | 3 years | 10 years | |

Note*: it is 14 years including preparation period.

4.3.2 Irrigation and Drainage Plan

According to the results of the study as shown below for water source facilities of the irrigation for non-irrigated lands, mainly of the small and medium-scale farmers in the Study Area, as for the water source facilities in this plan, the pumping station plan intaking the water from the Tempisque river directory (maximum 3 m³/s with transferring the water right) and groundwater irrigation system (around 1 m³/s in peak time) are adopted and the other plans such as dam construction plan are not recommendable for this plan. (the construction plan of La Cueva dam was studied as Pre-F/S and it is infeasible to include in the plan for this study. The Pre-F/S including cost estimation of other plans are indicated in appendix)

(1) Alternative Study

8 alternative plans were studied for expected water source for the project. As result, the “2 pumping stations at Tempisque river” and “groundwater irrigation system” were adopted for the water source of the proposed project.

Alternatives of water source

| Alternatives | | Environmental Impact | Economic efficiency | Adopted /not adopted |
|-------------------------------------------------|----------------------------------|----------------------|---------------------|----------------------|
| Newly development of river water | A. La Cueva Dam | Large | Low | not adopted |
| | B. Piedras Dam | Large | Low | not adopted |
| | C. Brasilito Dam | Large | Low | not adopted |
| Transfer of water rights of the Tempisque river | D. Head works/ at upper stream | Large | Low | not adopted |
| | E. Head works/ at lower stream | Moderate | Medium | not adopted |
| | F. 1 Pumping station | Slight | High | not adopted |
| | G. 2 Pumping stations | Slight | High | Adopted |
| | H. Groundwater irrigation system | Slight* | High | Adopted |

*: Groundwater will be developed considering the potential and influential area of respective wells.

The contents of the alternatives are shown as follows.

1) Newly development of river water

In and around the Study Area, there are no rivers having surplus water sources for newly development

except the Tempisque river. Therefore, the following 3 dam plans using the river water stored in rainy season are studied. the water of these dams can be used for also supplementary irrigation in the rainy season.

A. La Cueva Dam

Outline of plan: constructing a dam with 40 meters height with the storage capacity of 80 million tons at La Cueva, Irrigating around 7,000 ha with 6 m³/s of new irrigation water in dry season. The beneficiaries are approximately 1,000 small and medium-size farmers.

Problems: A part of the Horizontal Reserve registered as a World Heritages is included in the submerged area.

A part of the Pan-American Highway is in the submerged area and it will be necessary to re construct the new route for 4 km.

Approximately 30 residences will be submerged.

There is around 1,000 ha of pasture land with irrigation facilities in the submerged area.

As this dam will cut the Tempisque river, the natural environmental impact is expected such as obstruction of movement of wiled life.

The construction cost is too high and economically infeasible.

Estimated project cost: Approximately US\$ 81,224 thousand, and approximately US\$ 614 thousand for O/M per annum.

Economical efficiency: FIRR=6.06%, B/C=0.53 (with 12% as discount rate)

Evaluation: Due to its high impact against the natural environment and low economical efficiency, this plan is not recommended in this Study. (The standard of the mentioned economical efficiency is; more than 12% in FIRR, which is the loaning condition of IDB and other international financial institutions. See appendix)

B. Piedras Dam

Outline of plan: at the upper stream of Piedras River, constructing a dam 35 meters height with the storage capacity of 83 million tons, Irrigating 6,500 ha with 6.5 m³/s of new irrigation water. It is useful for the right bank of the Tempisque river and the number of benefited small and medium-size farmers are approximately 100.

Problems: As 40% of the current river flow water will be converted from Piedras River basin to the Tempisque River basin, it is expected the big environmental impact to surrounding are including the Palo Verde National Park at the down stream. Furthermore, as topographic and geological conditions for dam foundation is not suitable and it is necessary to construct approximant 40 km of driving canal including expansion of existing canal, the construction costs will be high. For the distribution of the irrigation water to the right bank of the Tempisque river, more cost will be required.

Estimated project cost: Approximately US\$ 71,160 thousand, and approximately US\$ 573 thousand for O/M per annum.

Economical efficiency: FIRR=6.26%, B/C=0.52 (with 12% as discount rate)

Evaluation: Due to its high impact against the natural environment and low economical efficiency, this plan is not recommended in this Study.

C. Sardinal-Brasilito Dam

Outline of plan: Constructing a dam 20 meters height with the storage capacity of 56 million tons at the west part of Sardinal, Irrigating 4,000 ha with $4\text{m}^3/\text{s}$. The beneficiaries are approximately 300 small and medium-size farmers.

problems: The catchment basin of the dam (72km^2) is smaller than the abovementioned dams and the dam may not be filled in drought year. In addition to the low economic impact, there are 2 communes with approximately 80 residences in the submerged area and a huge social impact is expected.

Evaluation: As the big economic impact cannot be expected and a huge natural and social impact is expected, this plan is not recommended in this Study.

2) Transfer of water rights

In the Tempisque river, with the completion of Phase 3 of the Arenal Tempisque project, newly supplying $10.5\text{ m}^3/\text{s}$ of water to the large-scale farmers in the area and turning back a part of water rights ($6.0\text{ m}^3/\text{s}$ in April in average year) to the MINAE which is in charge of water rights control, the transfer of water right is scheduled. Out of the returned water rights, $3.0\text{ m}^3/\text{s}$ of water will be used as a water source for irrigation in this plan ($1.5\text{ m}^3/\text{s}$ will be released for river maintenance flow).

However, it is necessary to consider that the full use of the $3.0\text{ m}^3/\text{s}$ will not be possible during the dry season in drought years when the discharge of Tempisque river is insufficient. Therefore, the crush and build the water right system by MINAE is required and the reduction of the volume of intake water for all water users in the drought year with low water level is indispensable. This kind of saving water action in the drought year will be done by not only some of users but also by the all users.

The construction of head works or pumping stations can be considered for intake facilities.

D. Head works/at upper stream

Outline of plan: Constructing head works 2 meters height (72 meters length) near Irigaray in the upper stream of Tempisque River, Irrigating 3,000 ha with $3.0\text{ m}^3/\text{sec}$ of irrigation water. The beneficiaries are approximately 900 small and medium-size farmers.

Problems: Natural forests must be cut down for 24km of the 26km of driving canal. As the construction of a tunnel is necessary for the reason of topographical features, unit cost for supplied water will be high.

Estimated project cost: Approximately US\$ 55,168 thousand, and approximately US\$ 435 thousand for O/M per annum.

Economical efficiency: FIRR=6.02%, B/C=0.53 (with 12% as discount rate)

Evaluation: Not adopted due to its low economical efficiency and high construction costs.

E. Head works/at downstream

Outline of plan: Constructing head works 2 meters height (75 meters length), Irrigating 3,000ha with $3.0\text{ m}^3/\text{sof}$ irrigation water. In order to shorten the driving canal compared with that of upper stream plan, the head works will be constructed near La Cueva of Tempisque River. The beneficiaries are approximately 700 small and medium-size farmers.

Problems: Natural forests must be cut down for 12 km of the 14 km of driving canal. Though the construction costs are lower than that of the upper stream, distribution of the water will be limited to the down stream of Guardia.

Estimated project cost: Approximately US\$ 27,451 thousand, and approximately US\$ 252 thousand for O/M per annum.

Economical efficiency: FIRR=12.01%, B/C=1.01 (with 12% as discount rate)

Evaluation: Though the economic efficiency is improved compared with that of upper stream plan, irrigation area will be limited to the down part of the area. In addition, the cost to irrigate the same area is US\$ 10 million higher than that of pumping station plan (which is described below), and therefore this plan is not adopted.

F. 1 Pumping station

Outline of plan: installation of pumping stations facility (with three pumps of 800mm gauge, Total head 30m) near Monte Galán, which is the upper stream edge of Tempisque River in the Study Area, Irrigating 3,000 ha with 3.0 m³/s of irrigation water. The beneficiaries are approximately 900 small and medium-size farmers.

Problems: Though the construction cost will be lower than that of Head works, the beneficiaries may have financial disadvantage due to the high running cost. The life period relatively shorter than other facilities will require finance for replacement. By the construction of reservoirs necessary for the operation, 40 ha of land will be submerged. As the canals will be crossing the large-scale farmers lands where are not benefited area, the maintenance of the canals will be difficult.

Estimated project cost: Approximately US\$ 17,568 thousand, and approximately US\$ 329 to 341 thousand for O/M per annum.

Economical efficiency: FIRR=12.16%, B/C=1.01 (with 12% as discount rate)

Evaluation: Though there are merits such as the FIRR exceeding 12%, low impact against natural environment and SENARA having experience of similar projects, the plan is not adopted due to the estimated difficulties of maintenance and installation of canals.

G. 2 Pumping stations

Outline of plan: Installation of pumping stations near Monte Galán (three pumps of 500 mm gauge, total head: 20m, capacity: 1 m³/s) and Filadelfia (three pumps of 700 mm gauge, total head: 30 m, capacity: 2m³/s), Irrigating 3,000ha. The beneficiaries are approximately 500 small and medium-size farmers.

Problems: The running cost/facility increases and is financially disadvantageous comparing with that of 1 pumping station plan. The construction cost will be lower than that of 1 pumping station plan.

Estimated project cost: Approximately US\$ 16,027 thousand, and approximately US\$ 408 to 421 thousand for O/M per annum.

Economical efficiency: FIRR=15.77%, B/C=1.38 (with 12% as discount rate)

Evaluation: There are merits such as the FIRR exceeding 12%, low impact against natural environment and SENARA having experience of similar projects. Furthermore, the canal length is shorter than that of 1 pumping station plan, and canals will not cross the large-scale farmers lands. Thus, 2 pumping stations plan will be adopted as for the water sources of this plan.

3) groundwater irrigation system

Outline of plan: The topological features along the Las Palmas River being depression, the area is conventionally active of groundwater usage. However, the development of

groundwater requires careful attention, for it contains numerous uncertain elements. The annual recharge of groundwater is estimated as 62 to 116 MCM/year. Referring to the annual usage of ground water being 21 MCM/year, at least 41 MCM/year of ground water is estimated to be able to be developed. Considering estimated groundwater recharge and present groundwater rights, approximately 1.5 m³/s of new groundwater can be expected for sustainable development. However, the excess pumping up of groundwater may result in numerous negative impacts against the social and natural environment, and groundwater development must be done with sufficient allowance. In this area, considering safety factor for the sustainable development, the utilizable amount of groundwater for proposed project is expected to be 14 MCM/year (average: 0.4m³/s, maximum: 1.0 m³/s). The beneficiaries are approximately 500 small and medium-size farmers.

Problems: Though the facility constructing cost is low, high running cost and replacement cost may be financially disadvantageous. Furthermore, running cost and construction cost per unit area will further increase due to the necessity of plural small facilities.

Estimated project cast: Approximately US\$ 3,370 thousand, and approximately US\$ 67 thousand for O/M per annum.

Economical efficiency: FIRR=12.04%, B/C=1.00 (with 12% as discount rate)

Evaluation: The usage of groundwater increases the O/M cost/unit area. Therefore irrigation with ground water should be done only for crops high liquidation rates such as vegetables and melons that bear fast profits.

From the alternatives abovementioned, in the proposed plan will adopt the water from the Tempisque river (maximum: 3.0 m³/s) and from groundwater (maximum: 1.0 m³/s) for the irrigation water source.

(2) Sustainable agricultural Development of Small and Medium-Scale Farmers (study of irrigation areas)

In order to achieve sustainable development of the small and medium farmers, the improvement of farm management of is attempted through the enlargement of farming scale based on the grouping of these farmers.

The lands of the small and medium-scale farmers are distributed in the Study Area as shown in Fig. 4.1.

The farmland tenure in the Study Area (ha)

| Presence of irrigation | Right margin of Tempisque River | | | Left margin | Total |
|------------------------|---------------------------------|------------------------|----------|-------------|--------|
| | Large-scale | Small and medium-scale | Subtotal | Large-scale | |
| Irrigated | 2,720 | 105 | 2,825 | 7,100 | 9,925 |
| Non irrigated | 4,500 | 12,675 | 17,175 | 3,300 | 20,475 |
| Total | 7,220 | 12,780 | 20,000 | 10,400 | 30,400 |

The current state of the crop cultivated by small and medium-scale farmers, along with land classification of each block is as follows;

Land classification for each small and medium-size farmers blocks

| Block No. | Area (ha) | current state of crops | Land classification | Soil |
|-----------|-----------|------------------------|---------------------|----------|
| 1 | 300 | Rice, Sugar cane | & | Vertisol |
| 2 | 450 | Rice, Sugar cane | | Mollisol |
| 3 | 460 | Sugar cane, Cattle | | Vertisol |
| 4 | 1,550 | Cattle | | Alfisol |
| 5 | 960 | Cattle | | Mollisol |
| 6 | 840 | Cattle | | Alfisol |
| 7 | 900 | Sugar cane | | Mollisol |

Land classification for each small and medium-size farmers blocks

| Block No. | Area (ha) | current state of crops | Land classification | Soil |
|-----------|-----------|------------------------|---------------------|------------|
| 8 | 1,800 | Cattle | | Inceptisol |
| 9 | 900 | Sugar cane, Rice | | Vertisol |
| 10 | 1,450 | Cattle | | Alfisol |
| 11 | 1,190 | Sugar cane | | Mollisol |
| 12 | 1,480 | Sugar cane, Rice | | Mollisol |

Land classification: II = Suitable for agriculture, III = Limited agricultural production, IV = High limitation to agricultural production

Soil: Mollisol = fertile and suitable for crop growth, Vertisol = utilized for the production of rice and pasture, Inceptisol = utilized for the production of pasture, Alfisol = soil amendment and sub soiling is necessary for agricultural use

The Study Area is limited of water recourses and considering such regional land characteristics, several directions for future agriculture in the Study Area are proposed as follows.

1) The conversion from pasture; mainly to mango (Zone A)

The soils of Blocks No. 4, 6, 8, 10 and 13 are of the Inceptisol or Alfisol orders, which have low agricultural productivity and classified as type IV. Due to these characteristics, unless topographic features enables conversion of crops to ones such as sugar cane, it is difficult to obtain good benefits against production costs in these blocks, even with irrigation farming (refer to Fig.4.2 land classification map and Fig. 4.3 soil map). Furthermore, for these blocks are located far from the Tempisque River and has only low potential of groundwater, it is difficult to obtain the sustainability even if irrigation facilities are installed. Therefore, in these blocks, the aim shall be focusing on to diversify the farming of small and medium-scale farmers to such forms as cattle raising and other crops through the converting partially from pasture to mango and organizing of the small and medium-scale farmers as much as possible. However, since fields cultivating sugar cane are expected to increase production by irrigation, or may be converted to vegetable cropping depending on soil characteristics, ground water small-scale irrigation system shall be installed in these fields, when the groundwater potential exceeds the minimum rates (10 l/s/well).

2) Intensive diversified farming with groundwater irrigation system (Zone B)

Though Blocks No. 1, 2 and 3 embrace good fields with fertile soil characteristics, the location of the Blocks requires long canals from the pumping station at the Tempisque river regarding the scale of the blocks (300 to 450 ha). With these canals, crossing the large-scale farmers lands where are not benefited area, problems for land acquisition and O/M of system may occur. In adverse, the area has the good ground water potential and more than 100 ha/Block of agricultural land can be irrigated. Therefore, in this Zone, the achievement of intensive diversified farming by irrigation with groundwater will be aimed. In the procedure, agricultural organizations will be strengthened centering groundwater irrigation system, and sugar cane and pasture will be converted to crops such as vegetables (water melon, chili etc.).

3) Development of diversified and the large-scale farming with river pump irrigation system (Zone C)

The Blocks No. 5, 7, 9, 11 and 12 embraces fertile soil and are located in areas where topographical features without limitation of the facileness of irrigation by the water pumped up from the Tempisque River. In this Zone, based on the irrigation agriculture using the river pumping system, through the strengthen of the framers' organizations and enlargement of farming scale for small and medium scale farmers, keeping irrigation to the sugar cane, the establishment of intensive farming on high profit crops such as vegetables and melons will be achieved.

4.3.3 Flood Protection Plan

Many of the damages caused by seasonal floods are coursed by the inundation in the surrounding area of Corralillo, Ortega and Bolsón communities. The inundation in this area occurs by those the overflow to the right bank of the Tempisque River caused by the insufficient flowing capacity around

Guinea, the overflow is flowing towards Palmas-Bolsón River and inundated with the insufficient flow capacities of the Palmas-Bolsón River. The areas frequently damaged by these floods are the 28,000 ha (including the 3,000 ha under tidal influence, and 600 ha of the Palo Verde National Park) lower than 10 m above sea level. The Palmas - Bolsón river with 300 km² river basin and narrow river width has not a enough flow capacity for the outflow from the Tempisque river. In case of big flood, overflow from the Tempisque main river course also occurs in the upper stream of Filadelfia, and the rivers of Tempisque and Palmas flows down as a single current. Therefore, the proposed plan is focusing on the mitigation of flood damage at the frequent inundated area based on the controlling the flood discharge (the design discharge may be the flood for the 10 year return period) at the each river considering the suitable flood scale (the big flood for more than 10 year return period will not be protected). Furthermore, the plan will also aim on securing the safety of the local residents at the times of floods exceeding the estimated flood discharge. The recommendations on urbanization control (land use control considering safety) and ideas on alert systems will also be described

1) Alternatives for the flood protection plan

As alternatives of the plan for flood protection, river improvement works, the construction of flood control dams, construction of communal dikes, instillation of retarding basin and construction of diversion channels were studied and the results based on the present conditions area summarized below.

i) River improvement works

The plan of river improvement stands on the basis that floods will be treated within each channel. However, current state of areas under tidal influence will kept as it is and will be conserved as flooded periphery. The 40 km section from Guardia, near the beginning of the alluvial plain, to the SENARA canal was examined for river improvement for the main course of Tempisque. The area downstream of SENARA canal, in relation with the Palo Verde National Park is not under consideration of river improvement. The river section between Guardia and Palmira is approximately 1,700m³/s at the current state, which is equivalent to the flow rate of 1/20year probability. On the other hand, the confluence point of the rivers of Guinea and Liberia, which has the smallest river section requires a capacity of several times more than the current state in order to accept its flow rate of 1/20year probability of 1,800-2,300 m³/s. Therefore, the designed flow rate will be set at the flow rate of 1/10year probability. The river improvement will be done basically by building a high-water channel through embankment. The current riverbed will not be reconstructed and will be the positioned as the low-water channel. Embankment will be done for the right bank, which is lower than the left. Excluding the 14km section where embankment is already done, a 13km section of the bank will be planned for embankment. In the down stream of Guinea, the channel will be expanded towards the left bank to secure the river section. For the Palmas-Bolsón River, the river section between the confluence point with the Belen River and Tempisque River is smaller than the section upstream. Therefore, in order to reduce the outflow and flooding of the midstream basin, expansion of channel will be planned for the 16.5km section between the confluence point with Belen River and Puerto Ballena (uppermost area affected by tidal influence). Embankment for securing the channel will not be done, for most of the land use of the surrounding area is of extensive agriculture. Also, from the viewpoint of preservation of the forests on the riverbanks, there will be no shortcut works of the river, and the flow rate of 1/5year probability will be adopted for the designed flow rate.

ii) Construction of flood control dams

The examination of the dam plan of the Tempisque has been done through the point of irrigating the area neighboring La Cueva, of the main course. Through the results of this examination, the effects of the flood protection dam may be indicated as follows (refer to appendix; pre-F/S of the La Cueva Dam):

- The maximum storage of the dam will be limited to 80MCM due to topographical features. The

limited amount disables the prevention by the dam alone of the overflows occurring at Guinea. (note: The capacity of peak control of the dam is only $100\text{m}^3/\text{s}$, whereas the flow rate exceeds $1,000\text{m}^3/\text{s}$ at the point near guinea, where the capacity is $300\text{m}^3/\text{s}$)

- A combination of river improvement (as abovementioned, with the river flow of 1/10 year probability as flow capacity) and a dam with the capacity of 70.5MCM will enable the area downstream of the dam to tolerate the river flow of 1/20 year probability. (note: the equipment of dykes/channel expansion corresponding to approximately $1,400\text{m}^3/\text{s}$, which is equivalent to the flow rate of 1/10 year probability, will enhance the capacity of peak control of the dam to $400\text{m}^3/\text{s}$. With the combination, floods up to $1,800\text{m}^3/\text{s}$ may be controlled.)
- The capacity of 129MCM will be necessary for the dam in order to control floods up to the flow rate of 1/50 year in the same manner.

Accordingly, flood control dams will not have large effects on the improvement of the current flood protection system, due to the limitation of its capacity. Therefore, dam plan is not recommended in this study.

iii) Construction of ring levees

The protection of assets, such as human safety and residences by dykes and levees are effective measures in areas frequently damaged by floods. In large areas with small communities scarcely distributed, such as the study area, surrounding the residential area by ring levees, is determined as a suitable measure. From the current states, the construction of ring levees will be done for the communities of Filadelfia, Guinea and Corralillo. In addition, the raising of the main existing roads will also be necessary in order to prevent the isolation of the communities during the flood. The height of the levees and raised roads shall correspond to the water level of 1/20 year probability of the main course of Tempisque River, and structures should be in scales capable of ensuring safety in cases of overflows from the channels.

iv) Construction of reservoirs

From the current state of land use, it is considered suitable to accept the overflow into the areas surrounding the channel during the floods. Accordingly, facilities such as dykes will neither be planned in the downstream area of Tempisque River affected by tidal influences nor in the downstream area of Bolsón-Charco river. Though examinations were done for reducing damages by small reservoirs, effective layouts could not be found, and therefore, construction of reservoirs will not be planned in the Study Area.

v) Construction of diversion channels

The construction of diversion channels reduces the necessary flow capacity of the main course by leading a portion of the flood to bypass areas highly damaged. Possible plans of diversion channels in the Study Area requires the rearrangement of watersheds along with the construction of structures such as tunnels, culverts and broad channels in relation to the height of the riverbed of the Tempisque, and enormous amounts of construction costs will be necessary. Regarding the economical efficiency as well as the urgency of the plan, the construction of diversion channels is considered to be unpractical.

2) Protection plan

As mentioned above, the basic aims of the flood protection of this plan is to reduce the damages in the areas frequently damaged by floods, along with ensuring the safety of residents and treating floods of certain sizes (under the estimated high-water discharge) in the respective channels. On the other hand, considering the urgency, effectiveness and benefits/cost upon the abovementioned measures for flood protection, the fitness-for-purpose, economical efficiency, actuality of river improvement works are considered to be highly dominant than the other alternatives. According to the resultant values of inundation in the Study Area, the area damaged by a flood of 1/10year probability can be largely reduced to 1/3 of the current state by the implementation of the proposed of river improvement works. Furthermore, areas near communities are mostly improved, and the areas to be damaged by these floods are limited to the lands below 6m from sea level. These damaged areas are mostly of pasture

and are low flatland-farm areas with conventional drainage problems.

Therefore, the flood protection of this plan will be based on river improvement, along with securing roads access through eliminating the road suspensions by the raising of main existing roads. The outlines of the respective plans along with their effects are as follows:

| Plan | | Contents | Effects |
|-------------------------|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| River improvement works | Bolsón – Palmas River | Expansion of channel for the 16.5km section between the confluence point with Belen River and Puerto Ballena (uppermost area affected by tidal influence). The flow rates of 1/5year probability will be adopted as the designed flow rate. | Reducing the current state of 21,000ha (6,600ha in the Study Area) of agricultural fields damaged by a flood of 1/5year probability to 7,000ha (1,300ha in the Study Area) |
| | Tempisque River | Embankment of the right bank and expansion of channel of the 13km section between Palmira and Guinea. The flow rates of 1/10year probability will be adopted as the designed flow rate. | Reducing 23,000ha (6,600ha in the Study Area) of agricultural fields damaged by a flood of 1/10year probability to 8,000ha (1,800ha in the Study Area) |
| Securing access roads | Raising of main roads | The raising of Filadelfia-Belen(6km), Filadelfia-Corralillo(10km), Palo Blanco -Guinea(5km), Corralillo-El Viejo(4km) and El Viejo -Bolsón(3.5km). The height of raising corresponds to the flow rate of 1/20year probability. | Securing road access by preventing the flooding of a total of 28.5km of the main roads at the time of a flood of 1/20year probability. |

Moreover, the plan proposes the measures of disaster prevention in farmlands through the point of integrated agricultural development, is aiming for the achievement of sustainable agricultural development for the small and medium scale farmers. Therefore, the comprehensive approaches combined with the soft side such as restriction of land use in consideration of floods through urbanization control and alert systems shall be taken by the other offices concerned and the only basic ideas will be shown in this report (refer to 5.4).

4.3.4 Environmental Conservation Plan

There are no reports on major problems concerning the natural environment in the Study Area. However, possibilities of future problems brought by aspects such as excessive use of agrochemicals due to agricultural development cannot be ignored. It is important that nature conservation is managed from the viewpoint of the whole watershed of the Tempisque River system, including the tributaries such as the Palmas River. Yet, the lack of information for establishing effective measures for predicted problems necessitates the installation of the ideas of watershed management and the implementation of systematic monitoring. For the issue concerning the elimination of river flow in the dry season at the downstream area of the Tempisque due to excessive intake of river water, a current of 1.5m³/sec will be kept for preserving the river flow and maintaining the eco-system. In addition, extension and enlightenment measures will be taken in order to encourage the local residents to cope with the issue.

Based on these ideas, improvement of consciousness of the locals mainly through environmental education will be achieved, and accumulation of information necessary for the enforcement of radical countermeasures will be done through the establishment of monitoring systems.

Development objectives

| | |
|----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Improvement of consciousness for watershed management | Establishment of systems for extension and enlightenment Establishment of systems for supporting nature conservation organizations |
| Extension of environmental conservation type agriculture | Research and extension of environmental conservation type agriculture |
| Recover and improvement of river maintenance flow | Replenishment the 1.5m ³ /s of maintenance flow for the Tempisque river |
| Conservation of groundwater | Implementation of systematic surveys, measures for the enlightenment of issues concerning groundwater, administrative control, monitoring of groundwater |
| Operation of monitoring | Establishment and operation of a simplified monitoring system for acquiring the overall status, accumulation of basic data |

4.3.5 Strengthen of Agricultural Supporting Plan

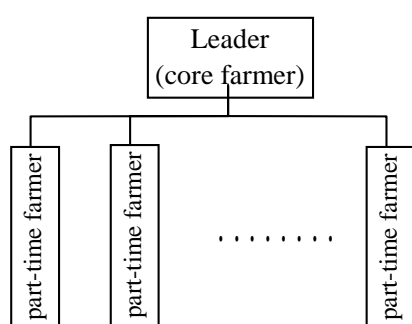
In addition to the abovementioned plans, extension of agricultural techniques (such as techniques for irrigated agriculture, cultivation and farming) along with support for farmer's organizations (support for enforcement, agricultural finance and others) are necessary to achieve sustainable agricultural development for the small and medium-scale farmers. Besides of its limitation on budgets, the act son supporting farmer's organization are not efficiently working mostly because of the lack of sufficient inter-agency coordination. Therefore, the support activities shall be strengthened with the aim of establishing a system that enables the agencies to coordinate organically with each other and to act jointly. Also, groups of women of the farm areas shall be supported in order to strengthen and spread its activities to the whole area.

Development targets

| | |
|---------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Strengthening farmers' organizations (Grouping farmers) | Reorganization and strengthening of the existing organizations of small and medium-scale farmers in the Study Area. The organizations shall be reorganized into about 60 new organizations and the average size of the respective organizations will be about 15farmers with the farming scale of about 200ha (more than 100ha at least) |
| Extension of management techniques | Improvement of management abilities necessary for the enhancement and diversification of farming of the small and medium-scale farmers through the extension of fundamental knowledge for management. |
| Extension of cultivation techniques | Extension of cultivation techniques for the improvement of farming that will correspond to the installation of irrigation and diversification of crops. |
| Agricultural finance | Enabling the use of agricultural credits by the small and medium-scale farmers for the improvement of farming. |
| Support for women activities in farm areas | Achievement of economic independence of the women in farm areas through encouraging their consciousness of and improving their skills. |

In order to achieve sustainable agricultural development for the small and medium-scale farmers, which is the development objective of this plan, the improvement of farming through the grouping of small and medium-scale farmers is indispensable as well as the reorganization and strengthening of the existing farmer's organization plays an extremely important roll. And for the formation of suitable farmer's organizations, as they are the foundation of the support activities for the farmers, holds the essentials of the success of the support plan, principles for the strengthening of the farmer's organizations will be as follows:

1) Formation of organizations with a mixture of full-time and part-time farmers



Basic organization of

Many of the farmers in the Study Area are part-time farmers where some of them practice agriculture as a side job. However, most of these small-scale farmers are constrained to rely on off-farm income due to the low productivity of agriculture. Therefore, it can be seen that the farmers do not lack willingness for agriculture, and with the introduction of irrigation increasing agricultural income, the farmers are willing to work actively on agricultural activities. Furthermore, some full-time farmers are in fact eager to improve their living through agricultural activities, and has the potential of being core farmers. The organizations of farmers are planned with these farmers performing as the

leaders and part-time farmers as the constituent members. From the results of public hearing conferences and of researches such as review meetings of working groups organized by the farmer representatives, there are more than 100 farmers estimated to have the ample ability and eagerness to act as a leader of the farmer's organizations. Moreover, there are some farmers that already act as leaders of existing organizations. And with the examples of some small and medium-scale farmers acting as organizations in the area, it may be said that, though it may not be easy, it is not merely impossible to reorganize and strengthen the farmer's the existing organizations. Though there were 43 agricultural production/farmer's organizations identified in the Study Area, 1/3 of them are ether

collapsed, are in the procedure of breaking up, in dormancy or scarcely working. The results of door-to-door surveys on 25 of the identified organizations (*Cooperativa*; 5, *Asociación*; 14, *Banco Comuna*; 4, others; 2) are shown in the appendix. Though all of these organizations hold problems considerably large, 8 of them are estimated to be stable enough to carry on, while 3 of them has already collapsed, and 14 of them may carry on with some sort of support.

As for the problems of the organizations that has already collapsed, are in the procedure of breaking up, in dormancy or scarcely working are summarized as follows:

The first point is that the merit incentive of being a member of the organization are not well-defined. Therefore, with members seceding from the organizations one by one, the activities gradually decelerates until it reaches a complete stop.

The second point is of monetary affairs. Cases such as misuse and peculation of the granted finance and money collected from the farmers discourage the farmers.

The third point is the shortage of current funds. Financial limitation of the organization, being unable to collect funds from farmers or to receive finance, decelerates activity as well as eagerness.

It is assumed that these problems can be overcome with the concrete side-support by government agencies and NGOs. Most of the organizations have been and are receiving some sort of support and are correspondingly trained. However, it seems that the knowledge and skills are not sufficiently effective at the actual stage.

The achievement of independence (organizing) of the farmers is possible in terms of devising relevant support programs such as increasing OJTs, and by conducting training based on actual situations.

2) The target of activities of the farmer's organizations

The objective of the farmer's organizations is to increase earnings through the improvement of farming by organizational measures. However, as indicated below, the targets of their activities shall differ according to the maturity of the respective organizations.

- Initial stage: Activities mainly aiming for the reduction of farming expenses, such as joint purchase of agricultural inputs and partnerships in arrangement of labor services.
- Intermediate stage: In addition to the abovementioned, activities aiming on the improvement of agricultural income, such as partnerships on shipment and sales will be practiced. In this stage, unerring marketing decisions of the leader will become important. Mutual trust upon the constituent members will also become important, for fair distribution of the earnings will be of concern.
- Final stage: Development of organized farming upon activities such as the selection of crops for diversification as well as developing strategies for diversified farming and financing will be done. The leader will be in charge of general management.

At first, the activities of the "Early stage" will be introduced as the target for the organizations. Upgrading of these targets are also possible, and decisions on such matters of necessities and defects will be made by the mutual agreements upon the constituent members.

3) Farming style

The style of farming of the organizations may also differ depending on the abilities and intentions of the constituent members.

Continuance of individual farming:

The farmers will continue their individual farming activities while participating in the organized activities of increasing their earnings. All organizations will begin their activities in this form at its initial stage. Improvement of farming may reveal with all the constituent members having the

corresponding ability, funds and eagerness for agricultural activities. In other cases, when the paces of the members are not uniform, high efficiencies are not likely to occur.

Joint or consigned management of the farms of the organizations:

The leader will take charge of the farming of the farmlands owned by the constituent members. Organized farming will be efficiently practiced as well as the farming based on management strategies on a larger point of view. In this case, the members may take such measures of consigning a contract with the leader or forming an enterprise through capital subscription. Matters such as the distribution of the earnings will need fairness to obtain the consent of the constituent members

4) Zonal requirements of organization functions

With the farming style of the organizations corresponding to the zones where they are located, the required functions of the organizations will also differ.

Zone A:

Diversification of crops will be practiced through the converting a portion of the pasture into orchards such as mango. Irrigation will not be introduced to this area due to its constraints. Loans will be necessary to small and medium-scale farmers that do not possess ample funds, for initial investments (purchasing nursery stocks, converting the fields, etc) will be necessary, and furthermore, there will be no returns from the converted fields during the first 1-2years after conversion. And though there are corresponding credit systems, it is difficult for individual farmers to receive these loans. Therefore, the major target of the farmer's organizations in Zone A, is to receive loans as a consortium. In addition, there are also other targets such as improving farming through reducing farming expenses through joint purchase of agricultural inputs and partnerships in arrangement of labor services. Moreover, the reduction of farming expense should not be only for mango, but also for the other products. The production area of mango will be 2-3ha/farmer. Organizational measures on shipping shall not be practiced at this stage, though it may be profitable, for it requires strong mutual trust between the constituent members concerning the distribution of their earnings.

Zone B

For Zone B, due to its high groundwater potential, the improvement of agriculture will be practiced through the introduction of irrigation utilizing groundwater. Accordingly, application to SENARA for the utilization of groundwater as an organization will be necessary, as it is for the existing small-scale groundwater irrigation projects (SENARA will screen the applications, equip the facilities and instruct the applicants). For this procedure, the organization must discuss about issues such as definition of responsibilities of O/M costs, kinds of crops to be raised by irrigation, adjustment of water rights, and has to clearly define the codes of the farmer's organization based on types of farming that they are to practice. For the existing areas irrigated with groundwater, cases of farmers sharing the O/M costs while irrigation water is distributed to the individual farmers are seen. However, cases of partnerships peculiar to irrigated areas, in which farmers consign the management of the irrigated fields to the leader and share the labor service and costs are also seen. The manner of introducing groundwater irrigation into their farming will be decided in the organization. However, technical support by SENARA will be necessary besides from the support for the strengthening of the organization. For the area to be irrigated by groundwater will be about 1-2ha/farmer, reduction of farming expenses through joint purchase of agricultural inputs and partnerships in arrangement of labor services will also be practiced for the rest of the area that are not irrigated.

Zone C

As pumping systems will be introduced to Zone C, it is necessary for the constituent members owning land in Zone C to discuss upon the distribution of irrigation water. At the initial stage of water supply, the areas to be irrigated will be instructed by SENARA. The amount of water corresponding to the area of irrigated fields will be distributed by SENARA, and farmers will pay

the water fee corresponding to the amount of supplied water. The distribution of water and decision of distributed amounts during water shortages will also be done by SENARA, as well as instructing adjustments of areas to be irrigated. The members of the organization should discuss the issues of this matter and reach common recognition.

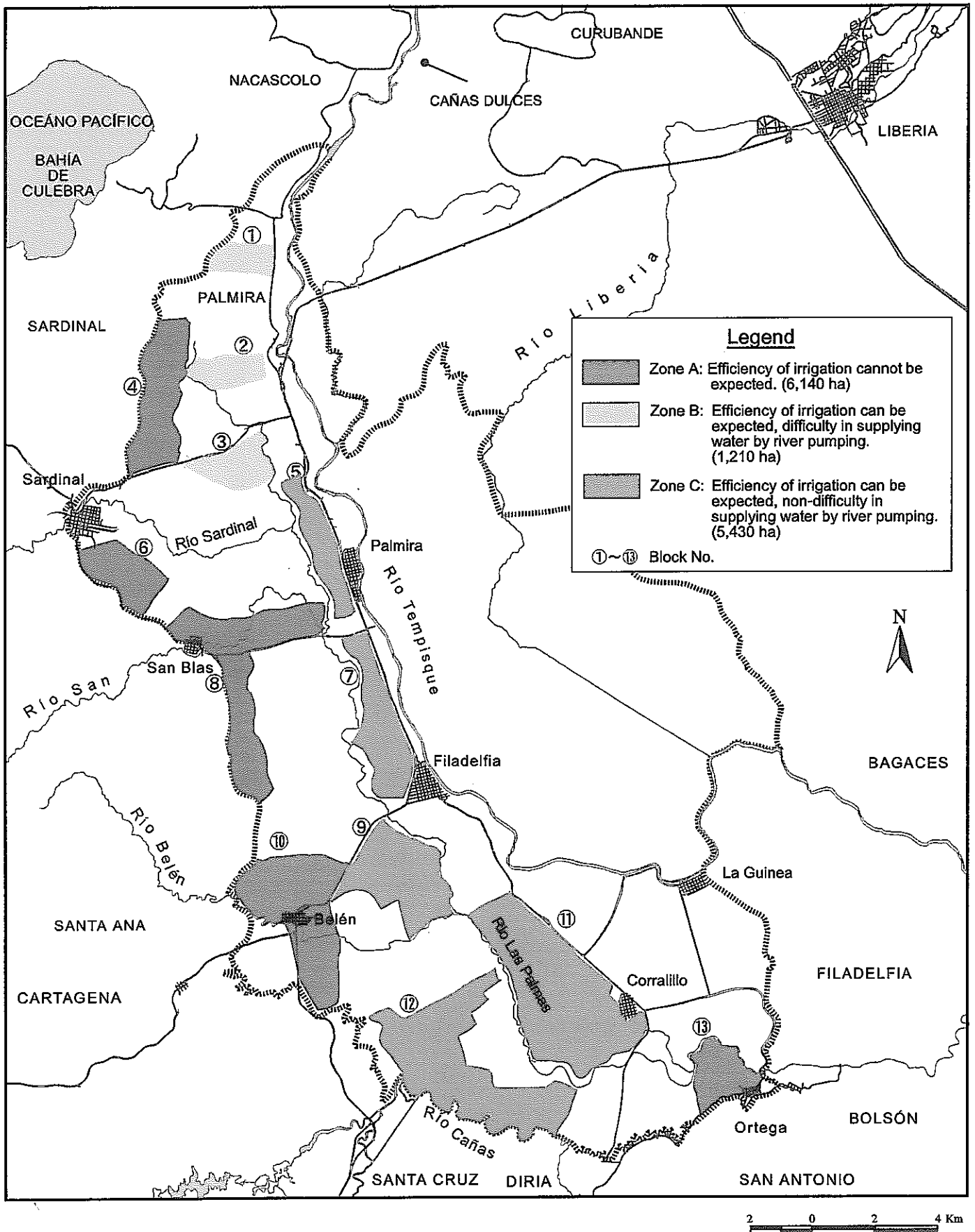


FIG.4-1 ZONING OF SMALL AND MEDIUM SCALE FARMERS

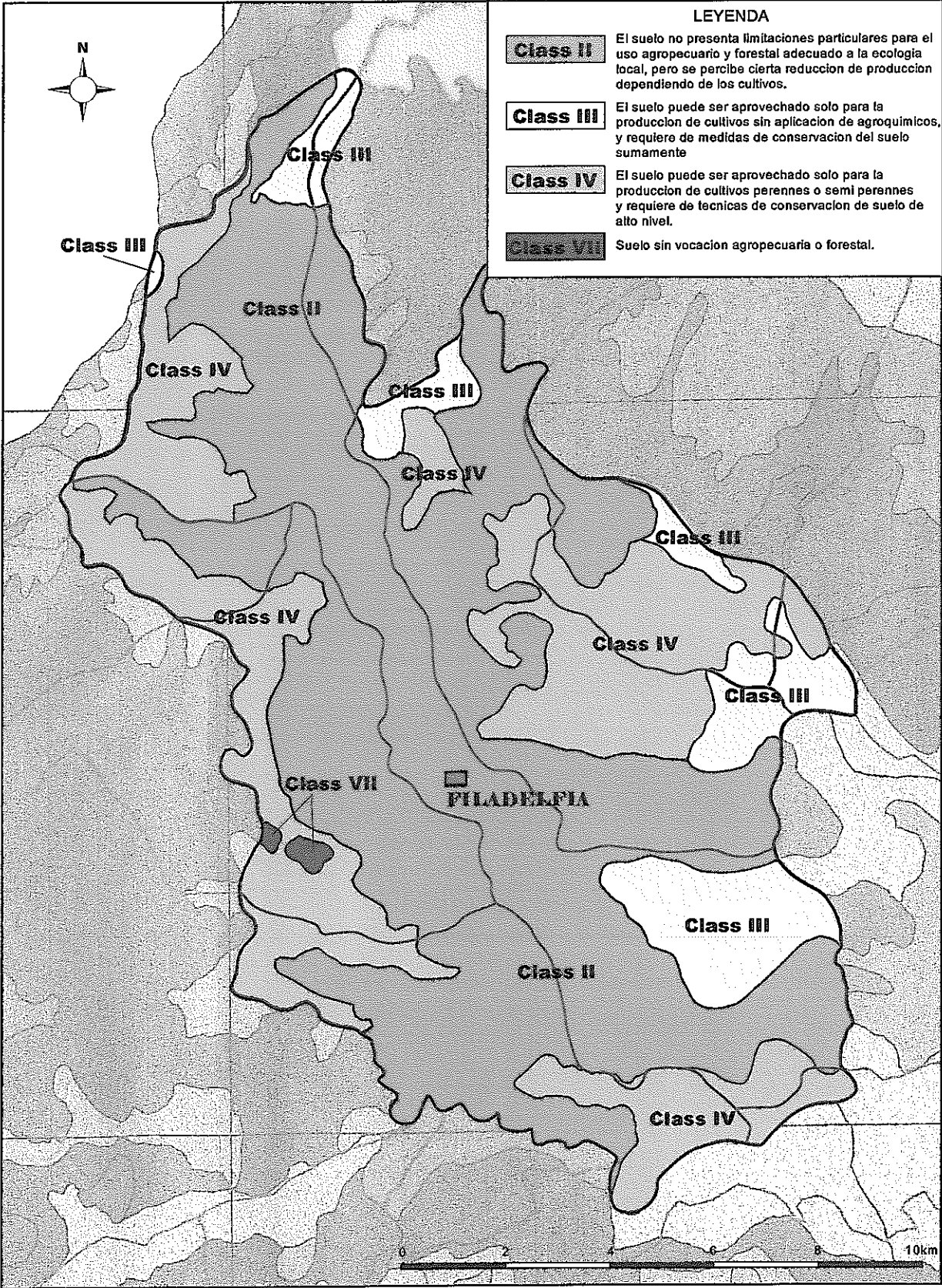


Figure 4.2 Land Classification

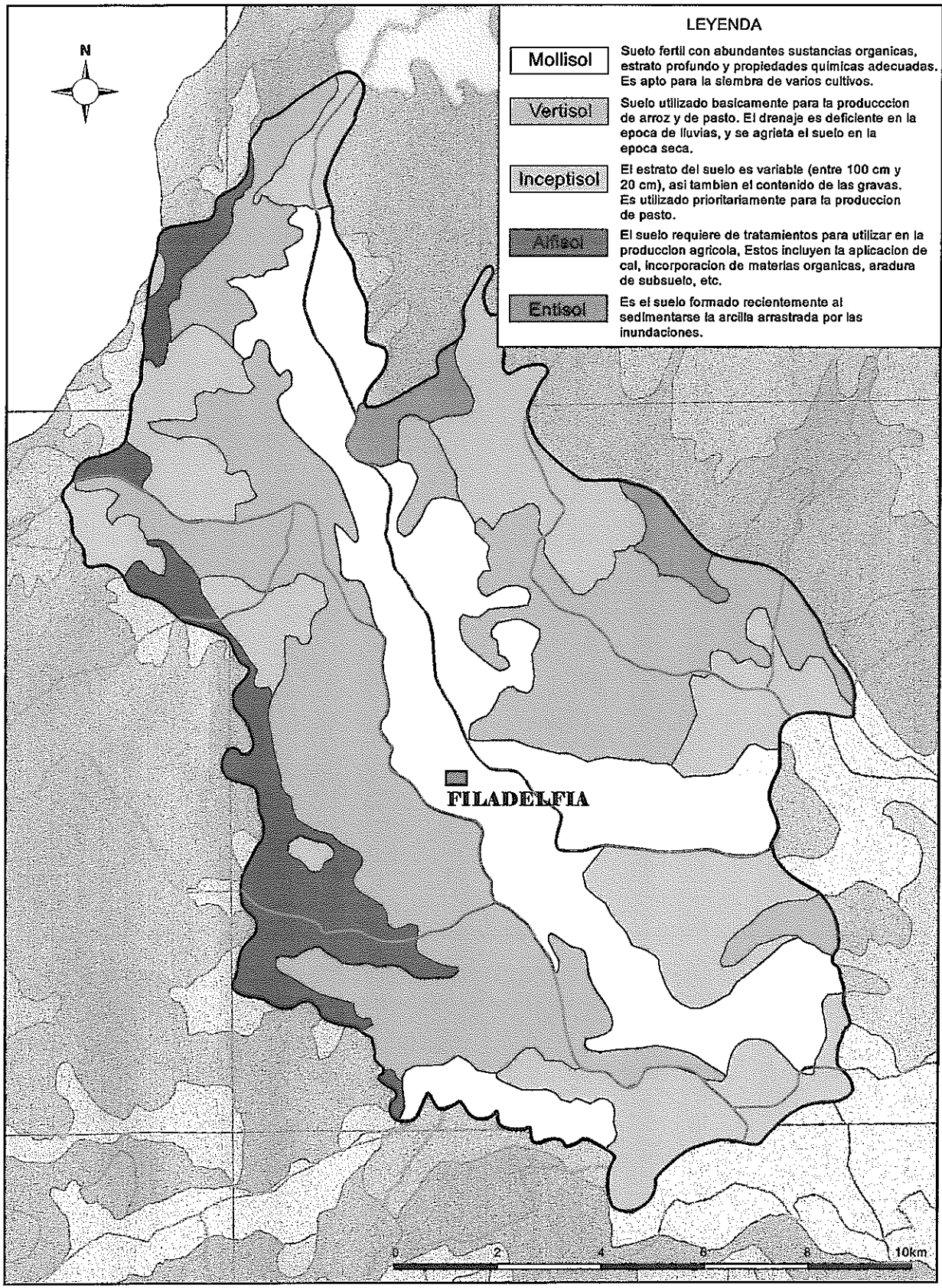


Figure 4.3 Soil Distribution

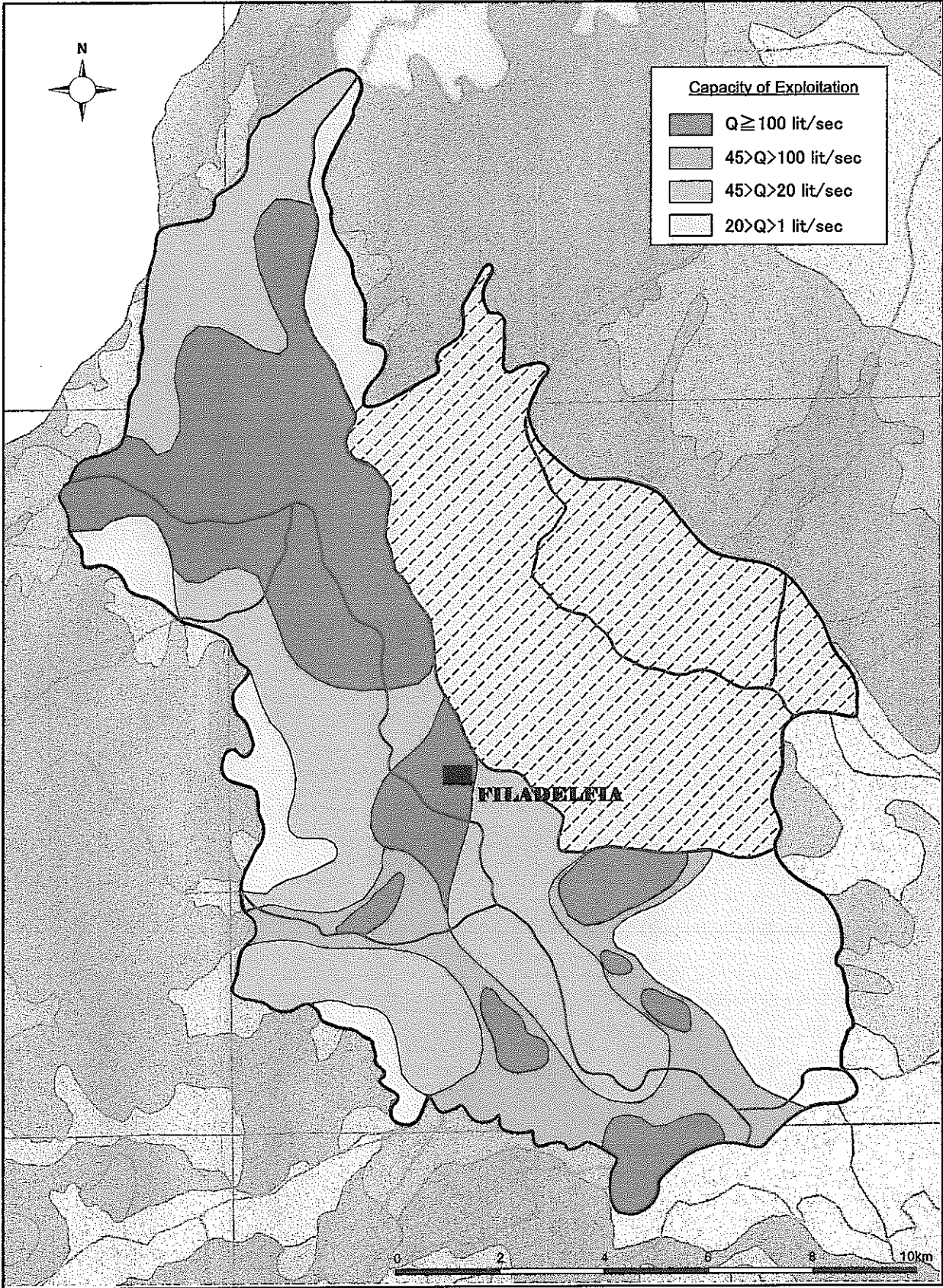


Figure 4.4 Groundwater Potential