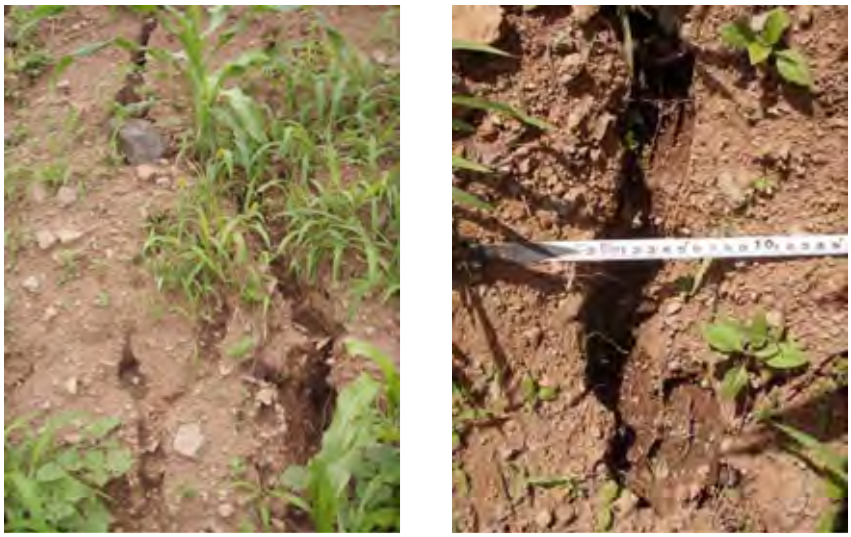
The shearing stress of the surface soil was also measured by vane shear test[1]. The shear stress measured was evaluated as mechanical stress of the soil against the flow of rainwater and surface water.

The results of the observation showed that clear rill erosion (clear gully with 5 cm in width and 5 cm in depth) was observed in the area where crescent filling works had not been installed. In some places, networks of some 12 cm of rill erosion were observed. On the other hand, although small-scale erosion was observed sporadically in the area where crescent filling works had been set up, there were no spots where rill erosion advanced in larger area. This was reflected to the value of vane sheer test. In the slopes where the rill erosion was advanced, surface soil lost its strength and showed lower values (6.79 kPa) than those (8.88 kPa) of the protected area around the crescent filling works. The following is the result of the project.

Table 6.4.3 Vane Sheer Test

No.	Profile	Sheer Strength (kPa)
1	Around the crescent filling works. (cultivating of corns)	8.88
2	No conservation works/vicinity to the area where rill erosion occurs. (cultivating the corns)	6.79
3	No conservation works/gradual slopes for corn cropping	10.1
4	Surface of the soil with cropping of pigeon peas (plowing traces frequently remains)	1.59



Damage Caused by Erosion in Furrows
(Upside of the pictures correspond to upstream)

・Growth of Planted Trees

This sturdy selects five samples out of the planted fruit trees, calculating the height and the shape of trunk of trees. Three months later in December 2009, and four months later in

[1] The erosion resistance was measured from 3 cm of the surface soil by 1.5 cm of reel in diameter.

January 2010, it carried out measurement again and observed growth conditions. There was almost no difference in the figures in December and in January, same as in Rui Vaz. This apparently indicates that lack of water brings about the delay in growth of plants at the advent of the dry season. Variation of growth speed can be observed according to the kinds of fruit. This is because of the difference in adaptability to the environment (altitude, climate, hours of daylight, precipitation). Regarding the growth conditions of the trees, it was observed that papayas had grown in good condition, and so did the azaleas. On the other hand, no major changes were observed in the growth of lemons and mangoes. Baseline figures and that of four months later are shown in the following table:

Table 6.4.4 Growth Conditions of Planted Trees in Lagoa

Project sites: Lagoa

Plants	Height. (cm)		Diameter of Trunk (mm)	
	Baseline	4 months	Baseline	4months
Avocado（Persea americana）	67.2	82.2	0.98	1.38
Azalea (Phyllanthus acidus ozelea）	77.4	106.0	1.70	2.72
Guava	56.8	79.0	1.34	1.80
Lemon（Citrus limonia）	21.4	24.2	0.78	0.92
Mangoes（Mangifera indica）	20.8	26.4	0.54	0.76
Papayas（Carica papaya）	79.0	143.0	2.34	7.80
Coconut	94.0	127.8	-	10.0

Researchers in INIDA indicate the altitude of ZAE III and IV (500 m - 800 m) affect the growth of especially Mangoes and Papayas. On the other hand, since the gap of altitude extends as high as a few hundred meters, further investigation might be required to analyze the impact of condition of the altitude on the growth of plants. Also, Azalea, which is a kind of evergreen scrub trees, can be expected to grow abundantly, especially in Lagoa. Research institutes, such as INIDA, shall attempt to evaluate the adaptability of Azalea in the region, including the effectiveness of fruits in the neighboring area.

・Simple pluviometer

Since there was now whether observatory near the district of Lagoa, simple pluviometers (maximum measuring up to 140 mm) were placed in the yard of farmers adjourning the project site. The rainfall data were recorded in cooperation with the local residents.

・Questionnaires

The study team conducted brief hearing in Rui Vaz and Lagoa in order to analyze the recognition/understanding of rural residents on the project.

The result of hearing on the soil and water conservation project revealed the lack of notification to the association members by leaders of ACBs and the coordinators, and of

information sharing regarding the employment in the construction both in Rui Vaz and in Lagoa. Fair opportunities for farmers' participation in the construction might have ensured their interest in the soil conservation project (e.g. farmers' own perspectives on the cost-performance of conservation works), even though it was the temporary regional public project. Some respondents answered that they developed newly arable land and planted fruit trees, with regards to the interesting points of this project. As for the land conditions, some respondents said they were suffering from the effluence of surface soil, especially on the steep slopes.

6.4.3 Evaluation

(1) Verification of Achievement

- ACBs constructed soil and water conservation works, such as stone masonry works, crescent filling works and fruit tree planting etc.
- In terms of 'output', construction of soil and water works has been completed, although it had been delayed by planned delivery time. Planted trees are required to be irrigated, since severe droughts hit planted fruits during the dry season.
- Rain-fed beans are cultivated in the land created by conservation works, so that farmers could gain more yields than average year, only with the rainfall of this dry season.

(2) Verification of Implementation Process

- In implementation of construction in Rui Vaz and Lagoa, the study observed the lack of notification to the association members by leaders of ACBs and the coordinators: information sharing regarding the employment of constructors. Fair opportunities for participation of farmers to the soil conservation project might have ensured the interest of it, even though it was the temporal regional public project.
- The construction was delayed due to the decreased participation of farmers during the busiest agricultural cropping season. It is required to plan a more time-framed process from the study to the order of works.

(3) Evaluation Result by Five Evaluation Criteria

The evaluation result of this component by five evaluation criteria is as follows:

Relevance

- Project Component of the Preservation of Soil and Water has the effect of controlling soil erosion, which causes the decrease in the fertile land. This component is called upon in the supreme plan of "Strategic Plan for Agricultural Development, Horizon 2015 and the Action Plan 2005-2008 (PEDA)".
- Rural residents are highly interested in natural resources. By implementing this component, they might learn the importance of natural resources management and voluntary implementation. Hence, this component can be valid from this perspective.

Effectiveness

- Further devastation of the arable land was prevented by soil and water conservation.
- Through participation in the implementation of conservation works, farmers could raise their consciousness on the need for integrated management of natural resources
- Since fruit trees are planted in the soil conservation works, farmers can make profits out of these trees in the future, which ensure the effectiveness of this project.
- Through observations made on the fields, the evolution of apparent erosion in furrows was observed at the points where no conservation works were installed. The results of tests also indicated the decline in resistance of the surface soil on the slopes where erosion is advanced into grooves: and low value (6.79 kPa) was marked compared to the area where crescent filling works are implemented (8.88 kPa). Therefore, the effect was recognized as soil and water conservation works.

Efficiency

- In terms of timing of the project, planting of fruit trees have been completed before the rainy season, although construction of facilities were behind the schedule.
- However, some of the fruit trees die out in the dry season because of the comparatively low humidity to the average years. It is expected that the fruit trees be flourished, if ACB continue to water the trees until the next rainy season.
- Although the accurate amount of potential profit is still uncertain, more profit can be accrued from the cultivation of fruit in addition to the yields of beans, if the fruit trees take roots. Moreover, it is generally accepted that, with respect to the efficiency of input, devastation of the national land can be prevented by setting up the conservation works.

Impact

- ACB autonomously volunteered to weed, put the weed around the fruit trees in order to restrict the weeds and water loss derived from the evaporation.
- As mentioned above, ACB voluntarily watered fruit trees which are apt to die out. This represents the farmers' responsibility toward the fruit trees.

Sustainability

- Soil and water conservation facilities are strong enough for long-term use.
- As indicated above, ACB are watering fruit plants which are dying.
- Planting fruit trees ensures diversity of sustainable income source for decades.

6.4.4 Conclusion

Confirmation of Hypothesis

Hypothesis: By implementing the soil and water conservation works, ACB become aware of the importance of integrated management of natural resources, and take initiatives in implementing the soil and water conservation works autonomously.

Members of ACBs constructed the water and soil conservation works. They fully understood the structure of the works, articulating that they had confidence in fixation of the facilities in case of the accidents. Regarding the awareness of the importance of integrated management of natural resources, the research proved that ACB members did not implement the conservation works on voluntary base, since the impact of the works is still invisible to motivate members. It is uncertain that ACBs continue implementing the conservation works, despite that they seem to reconsider the importance of conservation of soil and water. Hence, it is difficult to confirm the hypothesis; however, rural residents start to be aware of the importance of integrated management of natural resources through this project.

Conclusion

The result of observation reveals that accurate rill erosion was observed in the area where soil and water conservation works did not exist. Value of shear test also indicates the decline in stress in the surface soil on the slopes where erosion grooves are advanced, showing the low value (6.79 kPa) compared to the area around the crescent filling works (8.88 kPa). Therefore, the functions of the soil and water conservation works are recognized in this study. However, it is required for ACBs to water fruit trees in the first dry season until the fruit plants take roots, which is one of the concerns for ACBs for sustainable use of conservation works.

ACB members are actively engaged in the construction of works in this project, in which they are becoming aware of the importance of integrated management of natural resources, including watering the fruit trees. This component of the project enables income generation of farmers through the fruit cultivation and is environmentally friendly, although the result can only be obtained in the next rainy season. Growth of fruit can strengthen the function of soil and water conservation works as rechargers of ground water. However, this study cannot prove the function of recharge.

Conservation function was observed, which meets with the requirements of national policy on the conservation of soil. Moreover, the conservation facilities not only can contribute to income generation of farmers through the cultivation of fruit and beans, but also fulfill the environmental requirements. Therefore, this project is considered as high priority project. In implementing this program, however, ACBs should be responsible for the cost to execute irrigation during the first dry season. In this regard, implementers should bear in mind that ACBs are inclined to be passive in executing activities in CV. Future group leaders should be trained in the project for group leaders training including the points o concerns in implementing the project.

6.4.5 Lessons Learned and Reflection to Action Plan

Table 6.4.5 Lessons Learned and Reflection to Action Plan: Soil and Water Conservation

Lessons Learned from Pilot Project Implementation	Reflection to Action Plan
• Original action plan did not consider watering after the fruit planting. Watering during the first dry season might be required, since nursery plants are not likely to take roots at a time. In this regard, it is with noting the importance of watering during the initial dry season.	→ Include the watering during the first dry season.
• Initial project planned mixing cultivation of beans and fruit trees. However, as beans grow, the stem of it began to entangle with the fruit trees. When beans are planted next to the fruit trees, it is important to manage the stems so that they do not twine around the trunk of fruit trees.	→ Manage the stems of beans so that the fruit trees do not get tangled with them. → Consider the better management of fruit trees in the training of group leaders and distributors.

6.5 Process and Evaluation of Project Component: Water-harvesting

6.5.1 Profile and Objectives

Little precipitation in Santiago Island inhibits cultivation of crops and vegetables. Water from the rivers directly flows into the ocean at a time during the strong rainfall. In order to solve the problem, the small-scale water resources development project in the Action Plan proposes the introduction of water-harvesting for arid area. However, this technique is not proved to suit the natural conditions in the target watershed. Hence, this project attempted to analyze the applicability of water-harvesting to natural conditions of target area by means of implementing the water-harvesting by ACB, as well as to conserve water and soil, and secure/ increase the numbers of cultivation.

6.5.2 Activities

This project was implemented in Água de Gato and Portal, situated in ZAE III and ZAE II respectively. The following is the achievement of activities.

Table 6.5.1 Activities: Water-harvesting

Activities	Expected Results	Schedule	Responsibility Officers	Input
		2008: o n D / 2009: j f m a m j j a s o n d / 2010: j f m a		
1-1 Elaboration of the implementation plan in coordination with the extension officers and rural residents under the instruction of experts on irrigation	Implementation Plan	■	Counterparts External advisors	CV: Functionaries and ACB JICA: Members of the study team and external experts
1-2 Selection of implementation methods	Selected methods for implementation	■	Counterparts External advisors	CV: Functionaries and ACB JICA: Members of the study team, external advisors and the cost for measurement
1-3 Designing of facilities, Planning of the Process, and Estimation of the cost	Design book, Construction schedule report, and Cost estimation report	■	Counterparts External advisors	CV: Functionaries and ACB JICA: Members of the study team, external advisors, and the cost for the architectural drawing
1-4 Participation of ACB in the construction of infrastructure	Infrastructure	■	Counter parts External Advisors	CV: Functionaries and ACB JICA: Members of the study team, external advisors, construction materials, irrigation facilities, etc.
1-5 Implementation of cultivation by ACB using water-harvesting facilities	Cultivation of Crops	■ ■ ■ ■	Counter parts External advisors	CV: Functionaries and ACB JICA: Members of the study team, agricultural materials
1-6 Monitoring by extension officers and ACB	Monitoring	■	Counter parts	CV: Functionaries and ACB JICA: Members of the study team
1-7 Organization of the seminars for the purpose of disseminating the outcomes to the rural residents	Rural residents who have acquired knowledge on water harvesting	■	Counter parts	CV: Functionaries and ACB JICA: Members of the study team

The study team conducted detailed meeting with the counterparts regarding the contents of the project. As for Água de Gato, where annual precipitation is 400 mm, which is more than that of Portal (250 mm), rainfall flowing over the stone paved roads will be used for supplementary irrigation, collecting it before it enters into the rivers and storing it in the water tanks. This prevents the flowing water on the roads from directly flowing into the river, and ensures the effective use of rain water.

In Portal, the project aims at the maximum utilization of limited rainfall in order to cultivate the forage crops by establishing pasture on the slopes with small depressions, where surface rainwater floats in rainy days. Since the volume of rainfall is small, small scale catchment dikes shall be constructed to secure the supplementary water.

Discussions on the contents of the project was made with the counterparts and both ACBs as for the components of this project, and designing of the facilities was commissioned to local consultants. As a result of selection of contractors, each of the ACBs was contracted as builders, and implemented construction works.

<u>Água de Gato (ZAE III)</u>

Contract was concluded with ACB of Água de Gato, and the construction started in the middle of

June. ACB, as a contractor, had experience in similar works; however, its implementation capacity was less than expected, causing delay in the progress of work. The study team considered that it was difficult to complete the construction of 2 reservoirs before the rainy seasons; therefore, the reservoir in the upstream was prioritized to be constructed in the middle of August. As a result, water intakes with the roads and pipe line construction were completed, and these facilities functioned as one of the systems in the upstream. In consequence, construction of the whole work was delayed until the end of September.

With regard to the facilities, the following changes were made in implementing the project.

- The water is mixed together with earth and sand, due to the fact that the water flows on the surface of the road together with earth and sand. For this reason, sand box was installed in the upstream of reservoir, making the clean water flows into the reservoir, instead of catching water from the pipe lines directly.

The Profile of the facilities is shown below:

Cleaning of Catchment Roads: L = 186 m
Installation of Pipe Lines: L = 200 m
Reservoirs (Block wet masonry, V = 80 m3): 2
Catchment Under Drain: 2

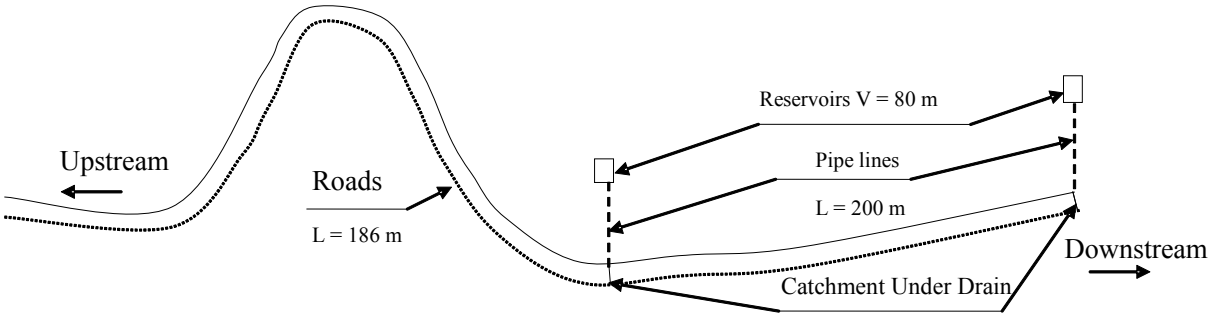


Figure 6.5.1 Profile Água de Gato

《Monitoring》

Objective of this pilot project is to promote supplementary irrigation in seasons with little precipitation, by implementing catchment roads and reservoirs to retain the runoff rainfall. As a monitoring, functions of the facilities and storing water volume of reservoirs shall be confirmed. It will also assesses how the farmers use water collected by water-harvesting (e.g. irrigation and other purposes) in the two 80 m^3 reservoirs installed at the downstream of catchment roads.

Progress:

・Study on the Functions of Facilities and Reservoir Conditions

This study confirmed the functions of system in the upstream during the rainfall. Facilities were functioning in catching surface water, in making sand submerged and in conveying water to culverts. However, precipitation of sand was advanced in sand box at the end of September. The level of preserved water was 50.2 m^3 at that moment.

Left: Conditions of the catchment on the surface roads

Right: Influent of water in the reservoirs (specifically into the sand box outside the reservoir)

・Situation in the Use of Reserved Water

The facilities were completed, and the rainwater on the surface of the roads was collected and stored in the reservoirs as planned. However, there was little demand for supplementary irrigation, since farmers enjoyed abundant rainfall in this season; therefore, they did not use the stored water at the final evaluation.

ACB would attempt dry-season cropping after the cultivation of beans by utilizing water stored in the reservoirs. They plan to continue irrigation by well water also storing it in the reservoir, although little precipitation is expected during the dry season.

Also, brief questionnaires were conducted, in order to collect information on how ACB/ individual rural residents use newly developed water resources in this project. The followings are the responses from the residents:

- Newly acquired water resources are basically used within the communities for agricultural production; however, surplus water can be sold to other areas where water supply is limited.
- Stored water can be used as resources for drip irrigation. Stored water can be sold in order to finance the activities of ACB.
- In addition to the use of irrigated agriculture, is it possible to use the water for livestock breeding and for public industrial water?
- Reservoirs should be used for agricultural activities within the communities.
- Stored water should be used for irrigation water during the dry season.

Portal（ZAE II）

Contract was concluded with ACB of Portal, and construction started in the middle of June. The capacity of ACB, as a contractor, which had experienced similar works, is less than expected, causing delays in the progress of the work.

The followings are the profile of the project in Portal.

Target Surface Area: A = 3 ha

Sediment Control Dam (Wet Masonry, L = 4.0 m, H = 1.5 m, W = 1.42 m): 1

Catchment Dam (Wet Masonry, L = 5.0 m, H = 1.2 m, W = 1.5 m): 1

Installation of Pipe Lines: L = 600 m

Fence (Bar-bed Wire): L = 900 m

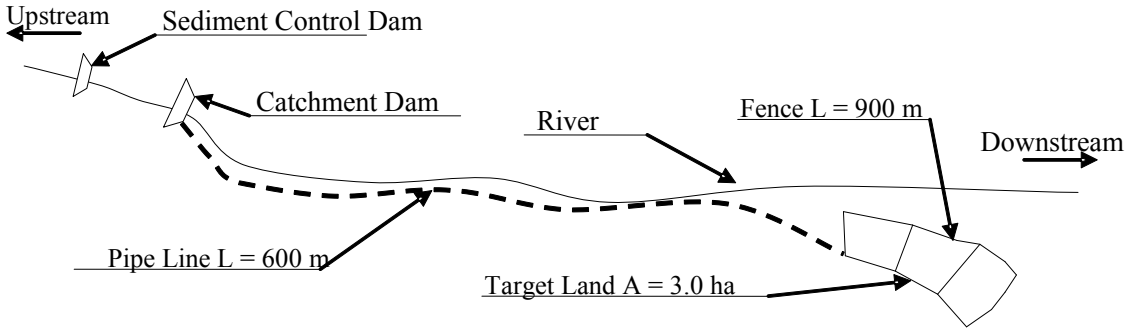


Figure 6.5.2 Profile: Portal

《Monitoring》

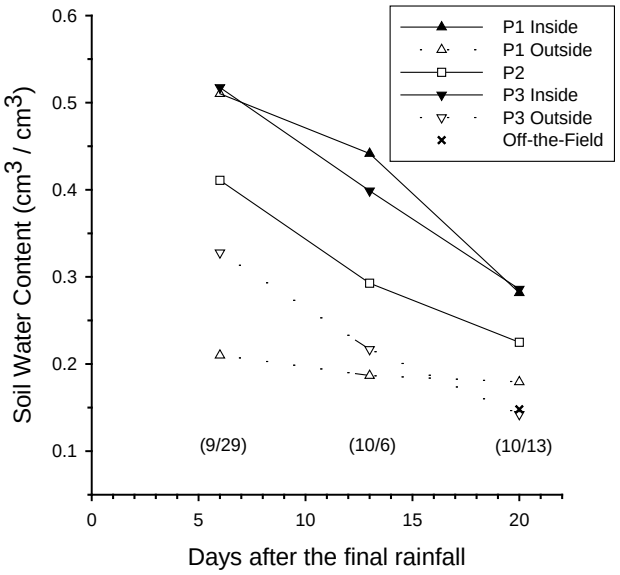
Objective of this component of the Pilot Project is the efficient use of rainfall in the forage cropping land with banquet (singular pocket with 0.2 m in depth and 1.5 m in width). Growth condition and condition of water cultivation were evaluated in the target forage cropping land. The study team also compares two different farm fields where banquets will be installed (Parcel 1: 5 m interval, Parcel 2: 10 m interval), and an area without banquet (Parcel 2).

Progress:

・Variation in Residual Soil Moisture before and after the Irrigation

Analysis was conducted by observing the variation in residual moisture retained in the soil (in percentages of moisture content), using natural soil samples. Soil samples were collected from 10-15 cm in depth, using a metal cylinder, with a 100 cm^3 volumetric capacity. Soil moisture content was assessed using the drying stove.

Variations in the soil moisture (in percentage of moisture content) in the areas with and without banquet (P1-P3) (See details of the P 1 and P 3 in the figure below) after the last rainfall are laid down below.



▲ represents the interior part of banquet of Parcel 1 (interval = 5 m)

△ represents the exterior part of the same banquet.

▼ represents the interior part of banquet of Parcel 3 (interval = 10 m)

▽ represents the exterior part of the same banquet.

□ represents the volume of moisture containing in the soil of Parcel 2 (the surface is shaped in ridges in depth.)

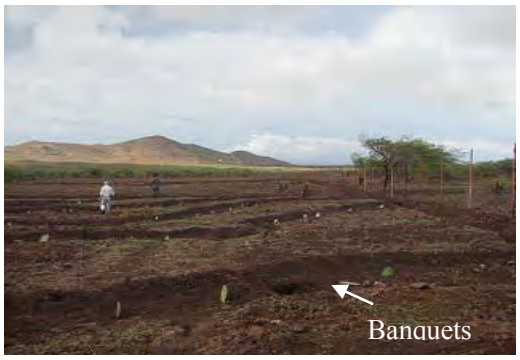
Figure 6.5.3 Volume of Residual Soil Moisture in Each Experimental Field

From the beginning of the evaluation, relatively high humidity in the interior of the banquettes was observed. By contrast, lower values of moisture than in the interior of banquettes were observed in Parcel 2 during the whole period of evaluation.

Functions of catchment and cultivation of water were observed in the banquets, although the study was conducted within a limited period of three weeks.

However, the simple pluviometer in Portal showed that some 190 mm of precipitation in total at three times within a week. Compared to the average precipitation in this district (200 ~ 400 mm) in ZAE II, unusual volume of rainfall was expected. However, there was little precipitation in November, which brought such unfavorable growth conditions to the forage crops, as some cracks penetrated into the soil surface in the banquets due to the dry weather, and evaporation was accelerated.

・Growth Conditions of Planted Fruit Trees



Two forage crops (cactus and parkinsonia) were planted in the two fields with the banquets. Cacti, whose depth of planting was not enough, showed difficulty in consolidating; therefore some of the cacti fell down, and others had partial dieback. Hence, some cacti were replanted. In consequence, some sprouts were observed from planted cacti, and its roots started to grow in the soil. Growth condition seemed to be good, regarding the pakinsonias as well. However, as for cacti, which appeared to grow in good condition at the end of November 2009, died out due to the diseases caused by germs and dry damage in the beginning of

January 2010. Dry damage prevented pakinsonias from proper growing as well. The profile of Portal Site and the summary of growth conditions of forage crops in Parcel 1 and 3 are shown as follows.

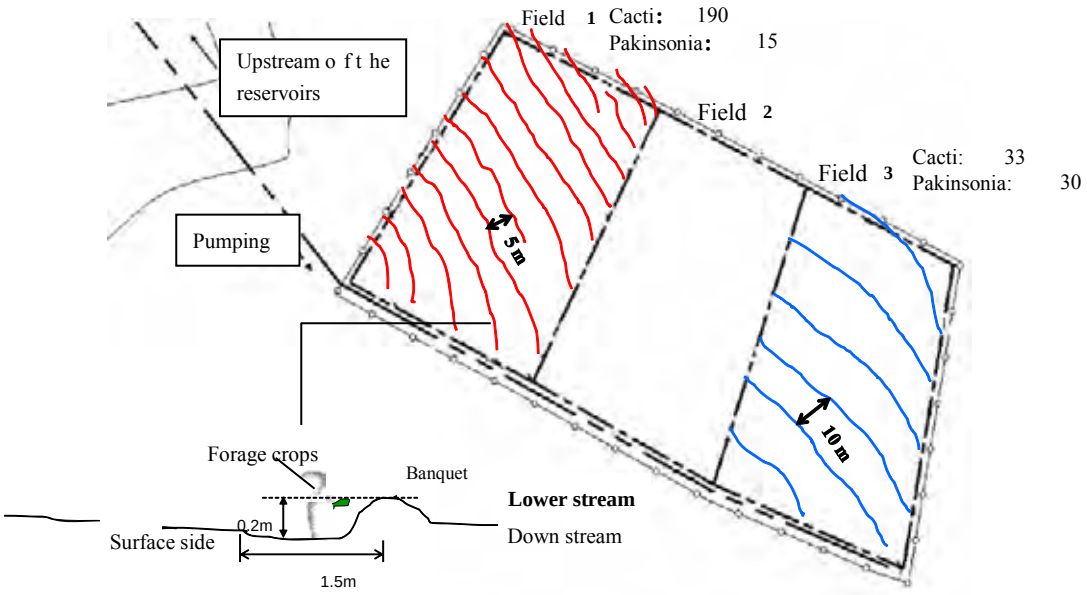


Figure 6.5.4 Profile of Portal Site

Table 6.5.2 Summary of Growth Conditions of Forage Crops

Species	Field	Height (cm)		Diameter (cm)	
		Nov. 2009	Jan. 2010	Nov. 2009	Jan. 2010
Cactus (Cactaceae Opuntia sp)	Field 1	27.6	(Die Out.)	-	-
	Field 2	34.2	34.2	-	-
Parkinsonia (Parkinsonia aculeata L.)	Field 1	48.2	48.2	0.60	0.60
	Field 2	40.4	49.0	0.50	0.60

・Simple pluviometer

The study team installed the simple pluviometer, since the weather observation data (breakdown of the physical instruments since 2004) were not available in this district. We asked the president of ACB to keep and note the data on the rainfall.

6.5.3 Evaluation

(1) Verification of Achievement

- In Água de Gato, it was confirmed that rainfall in the wet season was stored in the installed reservoirs which caught the surface water on the roads.
- Demand for the supplementary irrigation was low, due to the big precipitation in the wet season. Stored water was not used at the final evaluation.

- In Portal, banquets (banquet: a small depression with 0.2 m in depth and 1.5 m in width) were installed in the target area to plant pastoral trees and to saw seeds of pastoral grass.
- As for planting of pastoral trees and seeding the grass, input was properly conducted and completed before the rainy season.
- Most of the pastoral trees died out in 2010 because of the extreme decrease in the soil moisture, despite that growth condition was maintained by the ground water stored in the banquets right after the wet season.
- Farmers are waiting for cultivating pastoral grass which have grown by the ground water retained during the wet season.

(2) Verification of Implementation Process

- ACB of Água de Gato, which were commissioned, have experienced similar implementation processes. However, the construction capacity was lower than expected, which caused the delay in the construction.
- In Portal, ABC plans to cultivate the pastoral grass after weeds around will have diminished, and feed them to the livestock animals, since there was plenty of rainfall in the wet season this year which produced abundant weeds for animals.

(3) Evaluation Result by Five Evaluation Criteria

The evaluation result of this component by five evaluation criteria is as follows:

Relevance

- Rain water which used to directly flow in the river, became possible to use through the implementation of water-harvesting that can secure water resources. It also corresponds to the national policy.
- The project is relevant, since PEDA stressed importance of securement of water resources, and farmers can expand the cultivation of crops and vegetables.

Effectiveness

- The project can benefit farmers, since implementation of water-harvesting enables the expansion of cultivation.
- In Água de Gato, rainfall in the wet season was stored in the installed reservoirs which caught the surface water on the roads.
- In Portal, the pastoral grass was grown as scheduled, however, the pastoral trees was not grown as scheduled.

Efficiency

- In terms of the timing of implementation, in Água de Gato, the facilities could successfully store the rainwater, since the construction of facilities in the upper stream was completed before the rainy seasons, despite some delay.
- In Portal, planting of the pastoral trees have been completed before the wet season, with some delay in the construction of the facilities.

- The efficiency with regards to the input of water-harvesting is still uncertain in Água de Gato, since stored water has not been used nor is there agricultural production. It should be noted that the facilities did not fully function, considering the die out of pastoral plants in Portal. However, on the contrary, with regard to the pastoral grass, the level of efficiency is good, considering only the input of the fence.

Impact

- In Água de Gato, located in the lower stream of the river, the rainwater has not stored due to the delay in the construction. However, there remained the surplus well water, owing to the abundant rainfall and to the low needs for the well water. The surplus water was used efficiently, pumping it and storing it in the reservoir at the downstream.

Sustainability

- Facilities, such as reservoirs and small dams, are constructed strong enough for a long term use. Appropriate maintenance should be required as for the exposed part of the pipelines.
- In Água de Gato, ACB voluntarily plans to restore well and spring water in the dry season, with efficiently using reservoirs, which originally aimed to collect the surface water from roads, which indicates the seeds of sustainability.
- In Portal, rural residents seem to continue seeding and cultivating pastoral grass before the rainy season. Effectiveness of this component can continue from this point of view.
- Large scale irrigation shall be planned for the pastoral trees to take roots.

6.5.4 Conclusion

Confirmation of Hypothesis

Hypothesis 1: By practicing water-harvesting, farmers can maintain production by the supplementary irrigation in the wet season with water which they store the rain water.

It was confirmed that rainfall in the wet season was stored in the installed reservoirs which caught the surface water on the roads. However, farmers did not practice supplementary irrigation, due to the abundant rainfall in the wet season. Hence, stored water was not used at the final phase of this study. Therefore, this hypothesis cannot be confirmed. However, the farmers are expressing their will to use stored water for irrigation in the dry season.

Hypothesis 2: By implementing the water-harvesting, chiefly excavation of the depressions, farmers can cultivate the pastoral plants and grass**.**

Banquets are installed in the target area, and planting of pastoral trees and seeding of the pastoral grass were conducted. Pastoral trees have steadily grown, using the ground water retained in the soil after the wet season. However, they suddenly died out in the beginning of 2010, due to the heavy dry damage. Pastoral grass grew with the ground water in the rainy season as expected, being prepared for cultivation. Farmers will feed surplus weeds to the livestock animals after they will have finished using weed around, thanks for the plenty of rainfall this year.

In order for the pastoral trees to take roots, irrigation shall be required in the first dry season after

planting them. The study team figured out that some yields of pastoral grass had been secured by the rain water in the wet season, and it was confirmed to cultivate pastoral grass preventing livestock animals from entering by means of fence. Therefore, this study verified the hypothesis on the pasture grass; on the contrary, it could not verify the hypothesis with respect to the planting of trees.

Conclusion

In Á gua de Gato, facilities was completed to collect the surface rain water as planned. Consequently, the surface water was successfully restored in the reservoirs. However, the stored water was not used at the final evaluation, since abundant rainwater in this rainy season did not require supplementary irrigation.

ACB plans to use the stored water in the reservoirs. They start the dry-season cropping after the cultivation of beans as the wet-season cropping as well. Moreover, they also attempt to continue irrigation by means of well water even in the dry season.

Therefore, this project shall consist of a component of the Action Plan for the small-scale water resources development, not only because the function of the facilities are confirmed, but also because the project can contribute to the income generation of farmers by irrigative cultivation.

In Portal, the facilities were readily constructed, and planting of fodder shrubs and seeding of forage grass were conducted as the original plan. However, most of the pastoral trees suddenly died out due to the heavy dry damage. To resolve the problem, rather large scale irrigation shall be required in the first dry season. It should be noted that irrigation of pastoral trees requires the scale of the project, which cannot expect the voluntary participation from the farmers.

Pastoral grass successfully has grown with the rainfall in the dry season. The grass was not destroyed by the livestock animals, owing that the fence were installed in the area. Therefore, it is possible to include this project as one of the Action Program which aims at the proper management of pastoral activities for the cultivation of pastoral grass by enclosure. As has been discussed above, this project is viable, and the study team confirmed that some of the facilities were functioning. However, the study team did not sufficiently verified technical effectiveness, yet most of the hypothesis was not verified. Hence, in elaborating the final Action Plan, the study team has decided to drop this pilot project out of the prioritized project. It is worthwhile noting that the project shall be employed in the future, when the government of CV continuously provide assistance to ACB to confirm that the project is effective.

However, since the study team has recognized the effectiveness of cultivating pastoral grass preventing livestock animals from intruding the pasturage, this component is put as the priority program of the Action Plan as “Management of Livestock Farming”.

6.5.5 Lessons Learned and Reflection of Action Plan

Table 6.5.3 Lessons Learned and Reflection to Action Plan: Water-harvesting

Lessons Learned from Pilot Project Implementation	Reflection to Action Plan
• Large-scale irrigation project is required in order to plant pastoral trees. • The study team will consider the possibility to integrate the project for cultivation of pastoral grass into one of the components of 'Project for Proper Management of Pastoral Activities' in the Action Program.	→ Review of the project shall be required, regarding the planting of the pastoral trees. → The project for pastoral grass shall be replaced into the project for Management of Adequate Pasturage from small-scale water resources management project.

6.6 Process and Evaluation of Project Component: Leaching of Salt Damaged Farm

6.6.1 Profile and Objectives

In the farms located at the outfall of rivers of ZAE I, salt damaged soil blocks vegetable cropping, because ground water contaminated by high level of salt has been used for irrigation. On the other hand, in the rainy season, substantial amount of rainfall in the upstream of the river is there, whereas there is little precipitation around the outlet of the river. Rainwater in the upstream flows into the river and directly ran off to the sea without moistening the land downstream.

This study proposes the desalinization of salt damaged soil by leaching, employing the "Water-spreading" in the programs of 'Salt Damaged Farm Recovery' and ' Small-scale Water Resources Development'. However, CV has not employed the "Water-spreading" and desalination of the salt damaged soil utilizing it, which uncertain the potential and effects of them.

Therefore, this study will implement this project in Baía (ZAE I) in order to analyze the possibility and effectiveness of leaching by Water-spreading. This component attempts to prevent/minimize the salt damage, to maintain productive irrigated agriculture and to efficiently utilize the effluent water.

6.6.2 Activities

This project was implemented in Baía, located in ZAE I. The achievement of activities is shown below.

Table 6.6.1 Activities: Leaching of Salt Damaged Farms

Activities	Expected Results	Schedule	Responsible Officers	Input
		2008 (o n D) 2009 (j F m a M j j a s o n d) 2010 (j f m a)		
1-1 Selection of the sites in coordination with the distributors and rural residents under the instruction of experts on irrigation	Cooperation of estate owners		Counterparts	CV: Functionaries and ACB JICA: Members of the study team and external advisers
1-2 Realization of topographical survey	Topographic chart		Counterparts	CV: Functionaries and ACB JICA: Members of the study team, external experts and the cost for measurement
1-3 Designing of facilities, Planning of the Process, and Estimation of the cost	Design book, Construction schedule report, and Cost estimation report		Counterparts	CV: Functionaries and ACB JICA: Members of the study team, external experts, and the cost for the architectural drawing
1-4 Construction of the Infrastructure	Infrastructure		Counterparts	CV: Functionaries and ACB JICA: Members of the study team, external experts, constructors, etc.
1-5 Selection of the salinized sites for this component of the project and estimation of the volume of the salt in the lands	Targeted leaching farms and salt density in the soil		Counterparts External Advisers	CV: Functionaries and ACB JICA: Members of the study team
1-6 Implementation of leaching using water-harvesting by functionaries of DGASP and ACB	Targeted leaching farms and salt density in the soil		Counterparts External Advisers	CV: Functionaries and ACB JICA: Members of the study team
1-7 Monitoring by functionaries of DGASP and ACB	Monitoring		Counterparts	CV: Functionaries and ACB JICA: Members of the study team and external advisers

The study team discussed the components of the project with the counterparts. There were several feedbacks and inquires from the counterparts with regard to the forms of catchment facilities. As a result, they agreed to construct dams, and designing of the facilities was assigned to the local consultants. After the selection of contractor, the project contract with INERF was concluded and the construction started in the middle of June. As for constructing facilities, local farmers were employed by INERF, in accordance with the Terms of Reference. The study team observed the delay in the progress of the work, since the depth of excavation was raised, in order to ensure the settlement of the foundation on the rock, and also because of machine malfunction and the delay in procurement. In the end, the completion of all the works was retarded until the end of September.

The following changes were made in the construction of infrastructure.

- The bedrock was located in the deeper soil than expected. Depth of excavation has become profound (1.0 m - 2.2 m) for securement of the base of bedrock.
- Considering the existing revetment works, the height of the dam has lowered from 2.2 m to 1.8 m.
- Expecting that the water will run under the levees, since the top layer of the soil consists of gravel soil in which water is permeable, and cut-off wall was constructed under the levee to 10 m upstream of the dam.

The profile of the facilities is shown below:

Catchment Dam (Wet Masonry, L = 10.26 m, H = 1.10 m, W = 1.30 m): 1
Open Canal: L = 330 m
Target Surface Area: A = 1.05 ha
Appurtenant Facilities (inlet and outlet of the water)

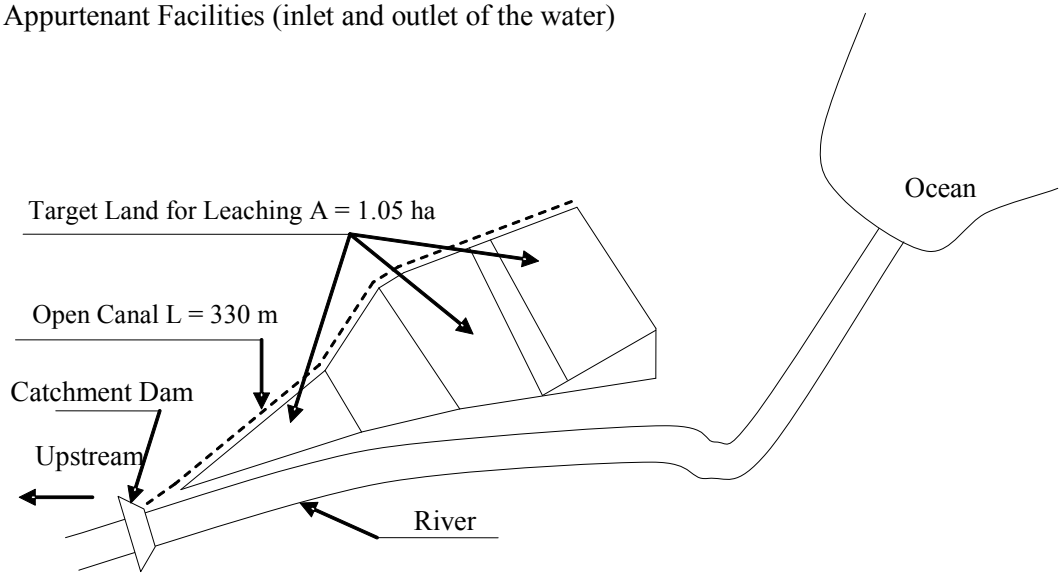


Figure 6.6.1 Profile Baía

《Monitoring》

Objective of this project is the restoration of salt damaged arable land using water-spreading facilities and desalinating the land. This study assessed the conditions of salinity before and after the implementation of leaching.

Progress:

- Electrical Conductivity (EC) of surface soil before and after the leaching;
  The study defined eight sampling points of soil for analysis, from upstream to downstream in the field where leaching plans to be implemented. The depth of the sampling soil was defined as: 0 - 5 cm, 5 - 10 cm and 10 - 20 cm respectively. The following is the profile of the target site.

Profile of the Target Area of Soil Sampling

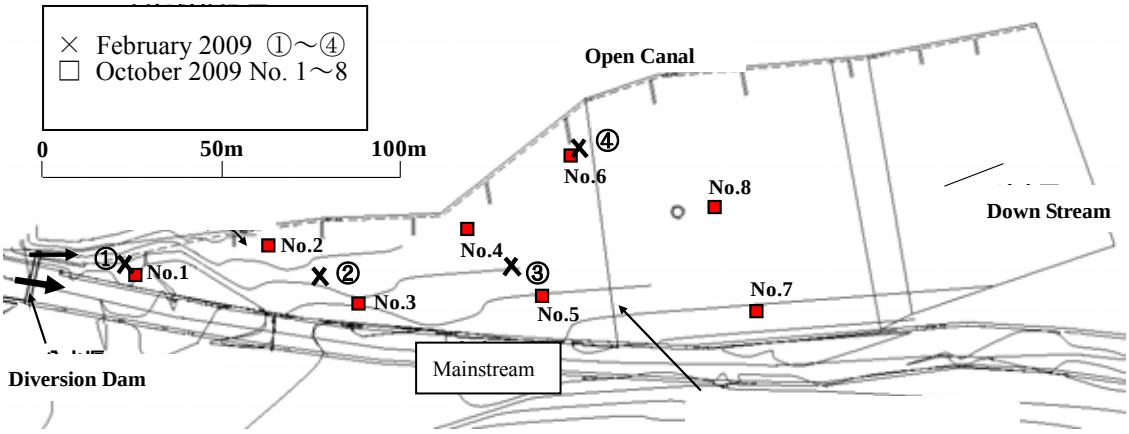


Figure 6.6.2 Profile of Leaching Experimental Fields

The chart below shows the result of EC on the soil sampling extracted from the field of leaching project. The level of layer for sampling is indicated on the axis line (0 ~ 5 cm, 5 ~ 10 cm, 10 ~ 20 cm). In terms of the legend, the values of "Feb. 2009" are obtained in the baseline study before this project in the experimental field (× in the profile of leaching experimental field indicates the collection sights). Similarly, the sample values of "Sep 2009. 14" are collected after the floods, and the sample values of "2009 Oct. 5" indicates the value in response to the floods on the 24th of September.

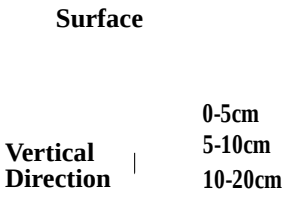
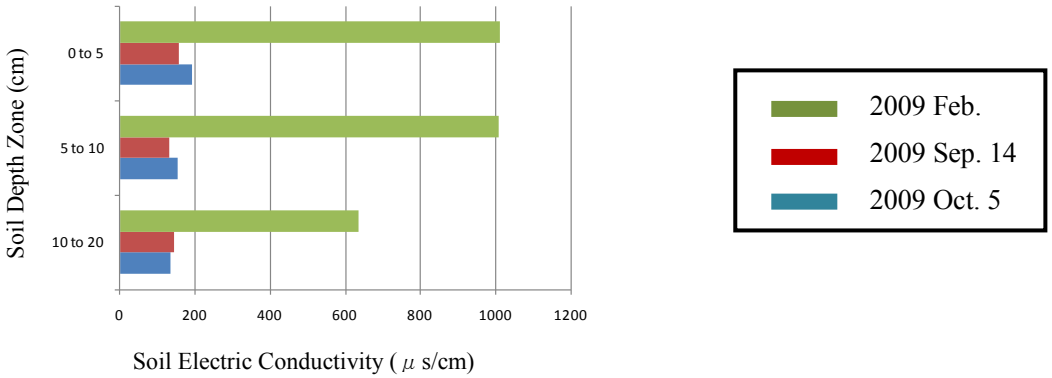


Figure 6.6.3 Material Collection Sight

No.1



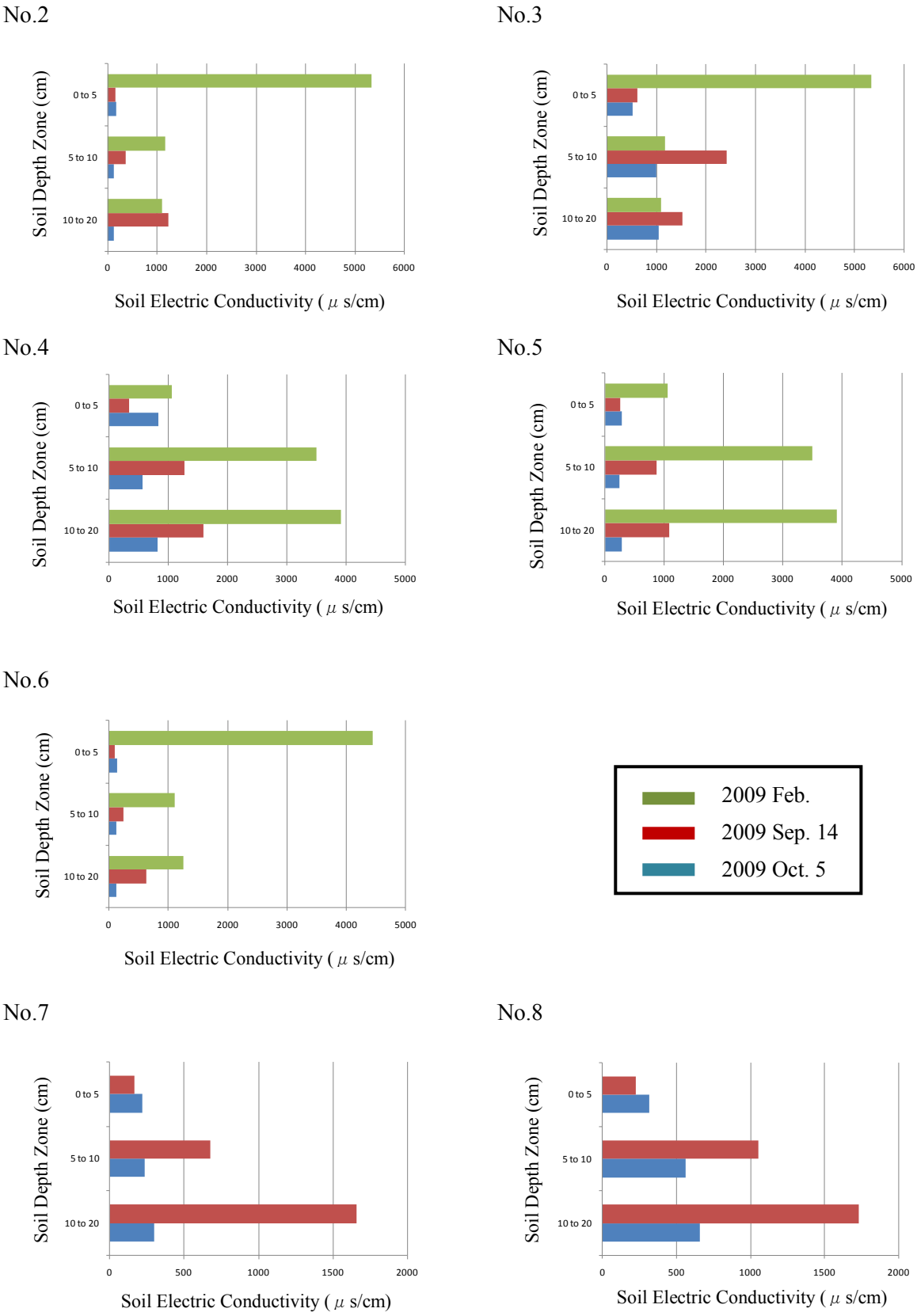


Figure 6.6.4 Values of Electrical Conductivity

The result shows that the values of EC decreased in almost all points (No. 1 ~ No. 8) in the field. The tendency of the decrease in the EC can be observed in all level of the layers in the soils. This infers that soil water including the sodium, such as NaCl, has moved and melted into the deeper layer (lower part than 20 cm layer) by several times of percolation within the field. As for the field where leaching was conducted, compared to the value of EC before the wet season, it was found that the value lowered to 1,000 μs/m, which was 4,000 μs/m on average originally. This confirms the effectiveness of the leaching facilities. (Less than1,000 μs/m is ideal for the vegetable cultivation, and more than 2,000 μs/m can harm the growth of the crops.)

Condition of inundation in the field of leaching project is shown below (observed on the 9th of September).

・Cultivation in the desalinated fields

After the leaching, farmers started to cultivate bananas in the target area. This indicates that desalination enabled banana cropping in the field where banana cropping was originally impossible. According to farmers, the followings are the reasons why they started to cultivate the bananas: 1) resolution of soil damage by desalination: 2) the land became fertile by the inflow of river water: 3) cultivation of moisture friendly crops represented by bananas became possible, since farmers can use the water from leaching facilities in the area where irrigation is the sole solution for the drought even in the rainy season. This indicates that the facilities not only benefit the target farmers, but also restore the land/improve the yields of bananas in other banana farms in watershed whose production was declined due to the soil damage.

6.6.3 Evaluation

(1) Verification of Achievement

- Leaching facilities for the purpose of diverting water in flood was constructed, and the facilities diverted the water flowing into the target area.
- Regarding the land where leaching was conducted using flood water, the result of volume of salt measured in the EC shows that the value of EC has lowered to 1,000 μs/m, which originally was 4,000 μs/m, compared to the value in the rainy season.

- After the leaching, the farmers started to cultivate bananas. This indicates that desalinization by the leaching enables cultivation of bananas in area where cultivation of bananas was considered to be difficult before.

(2) Verification of Implementation Process

- When floods occurred before the completion of whole facilities, diverted water flowed into the planned leaching area, as the main facilities were functioning. Also, the strength of the facilities was confirmed as designed, since no major damage was observed.
- Monitoring on the volume of salt after the leaching was carried out with no retard.

(3) Evaluation Result by Five Evaluation Criteria

The evaluation result of this component by five evaluation criteria is as follows:

Relevance

- Efficient use of a part of the river water, which flowed into the ocean, was possible by water-harvesting, which ensures the securement of water resources at national level.
- PEDA, which is the superior plan, points out the responses for the soil damage; however, its concrete solution measures has not been carried out. This plan expects the desalination of salt damaged field and increase in the yields of cultivated produce per unit by utilization of the river water.
- This project can meet the needs of farmers who will gain profit out of the increased yields of cultivated crops.

Effectiveness

- This component of the Pilot Project is beneficial to the farmers, since it restores the salinized field.
- Farmers started to cultivate bananas in the target area. This infers that desalinization by the leaching enables cultivation of bananas in area where cultivation of bananas was once considered to be difficult. This indicates the facilities not only benefit the target farmers, but also restore the land/improve the yields of bananas in other banana farms in watershed whose production was declined due to the soil damage.

Efficiency

- In terms of the timing of the implementation, facilities for diverting water had not been completely launched when the flood occurred: however, there were no major problems in diverting leaching water, since the principle structure of the facilities had been constructed before the flood.
- Considering the cost effectiveness of this component of the project for the restoration of cultivated land by desalinating salt damaged land by means of leaching, the cost of this project does not correspond to the scale of this pilot project in itself. However, it is worth while noting that fertilization of soil and the supply of agricultural water can be the byproducts of this pilot project, other than the desalination, as indicated in the column of the impact.

In CV, in the beginning of 1980s, revetment works were being constructed with funds from USAID for the purpose of prevention of the flood at the inlet of river. However, salt damages occurred in the areas where water inflow had sopped due to the revetment works, causing the degradation of soil. Therefore, installation of the revetment works discontinued in Santiago Island after 6 works had been constructed. In some watersheds, farmers destroyed the revetment works. Countermeasure shall be required to utilize the existing revetment works, not to destroy them.

In this project, new facilities (diversion dams) were constructed for the purpose of diverting river water. This component of the project poses some possibilities of restoration of salt damaged field, fertilization of soil and supply for the agricultural water, although appropriate management might be required. In order to save the cost, existing sediment controlling dams with new water channels, to which the diversion function was added, shall be renovated in the upper stream of the river, instead of constructing new diversion dams. This might expand benefitted field, depending on the volume of flood water, to some extent. The efficiency can be secured, if the experience of this project contributes to improvement of other watersheds with the revetment works.

Impact

- As discussed before, the farmers started to cultivate bananas in the desalinized area. According to them, the followings are the reasons why they started to cultivate the bananas: 1) resolution of soil damage by desalination: 2) the land became fertile by the inflow of river water: 3) cultivation of moisture friendly crops represented by bananas became possible, since farmers can use the water from leaching facilities in the area where irrigation is the sole solution for the drought even in the rainy season.

  Therefore, this component of the pilot projects yield unexpected positive impact other than desalinization of the fields (e.g. the soil was fertilized and the facility diverse the water without depending on irrigation).
- Increased level of water was confirmed after the rainfall of the construction of dam in the shallow wells at the upstream of the diversion dam. Assumingly, this is the effect of the dam by which part of the river water was stored in the upstream, raising the volume of infiltration into the groundwater, and pushing the water level of the well. Construction of dam promotes cultivation of the ground water.

Sustainability

- Facilities are strong enough for long-term use.
- Counterpart organization is actively engaged in the promotion of this project as a solution for the revetment works, and considers to involve the project in the name of DGASP, taking advantage of this opportunity.

6.6.4 Conclusion

Confirmation of Hypothesis

Hypothesis: Facilities utilizing water-harvesting enable the securement of water for the purpose of leaching the field.

Although the flood occurred on the 1st of September, before the completion of facilities, they successfully led the water to the target leaching field by diverted water, since the most of the principle structure of the construction had been completed. Considerable amount of leaching water was obtained from the floods on the 9th of September. Leaching water was fully secured by the rainfall in this year.

The result of the volume of salt calculated by EC in the soil where leaching was carried out showed that the value of EC had lowered to 1,000 μs/m, which was originally 4,000 μs/m on average, which assured the effectiveness of the project.

Therefore, this hypothesis was fully confirmed.

Conclusion

The leaching for the purpose of desalinizing the salt damaged field was carried out by the facilities which diverted a portion of the water from the river in flood. This confirms the efficiency of the project. Also, the project can be extended to other watersheds, by lowering the cost using the existing dams, since it can also realize the fertilization of soil and the supply of agricultural water. Therefore, this project shall be recognized as a high-priority project.

This project shall be implemented as a part of the project for desalination of salt damaged lands in the draft action program. As a result, the study team verified the efficiency on the desalination of the salt damaged land by leaching utilized by water-spreading techniques. Also, introduction of water-spreading technique has been proposed in small-scale water resources development which enables to catch part of the flow water in flood. It also enables to moisten lands adjoining to the rivers and to fertilize the soil by floods. Therefore, this pilot project shall be renamed as project for water-spreading. In this project, water-spreading technique is applied to the leaching for desalinization in ZAE I for fertile soil to cultivate arable land. Also, in ZAE II, this project shall attempt both to moisten agricultural lands and to fertilize soil excepting introducing leaching for desalination, since the salt damage does not exist.

6.6.5 Lessons Learned and Reflection of Action Plan

Table 6.6.2 Lessons Learned and Reflection to Action Plan: Leaching of Salt Damaged Farm

Lessons Learned from Pilot Project Implementation	Reflection to Action Plan
• The operating cost ended up rather high, due to the fact that new revetment dam had been constructed in this pilot project. It might be required to reduce the cost by alternating the existing dams to ones with the diversion function.	→ Include the alternative plan for using the existing dams.
• This project solely targeted desalination of the salt damaged field: however, this component can be alternated into a more integrated development, including the project for fertilizing the soil and for securing the agricultural water.	→ Alternate the project to the integrated plan.

6.7 Process and Evaluation of Project Component: Small-scale Water Resources Development

6.7.1 Profile and Objectives

Irrigated agriculture is still under development in Santiago Island and farmers carry out it with the limited water. On the other hand, the facilities to collect water before flowing into rivers are not sufficient.

Small-scale Water Resources Development Project planned in the Draft Action Plan proposes introduction of Water-harvesting as the facilities for capturing water before it enters into rivers.

This project aims at efficient use of spring water which currently flows down without any efficient use due to insufficient facilities, capturing it before it enters into rivers for the irrigation water in the downstream area.

The small-scale facilities shall be constructed and its effectiveness shall be verified. The suitability of the facilities scale shall be verified as well.

The facilities will be constructed in the form of cooperation with the Government of CV sharing the construction costs. It will hopefully realize the increase in the selection of how to secure the budget for the project costs.

6.7.2 Activities

This component of the pilot project was implemented in Milho Branco, located in ZAE II. The achievement of activities is shown below.

Table 6.7.1 Activities: Small-scale Water Resources Development

Activities	Expected Results	Schedule	Responsible officers	Input
		2008: o N d / 2009: j f m a M j j a s o n d / 2010: j f m a		
1-1Elaboration of the implementation plan in coordination with the functionaries of DGASP and rural residents under the instruction of experts on irrigation	Planning of Implementation	▪	Counterparts External advisers	CV: Functionaries and ACB JICA: Members of the study team and external advisers
1-8 Selection of implementation Methods	Selected methods for implementation	▪	Counterparts External advisers	CV: Functionaries/ ACB JICA: Members of the study team, external advisers and the cost for topography
1-3Designing of facilities, Planning of the Processes, and Estimation of the cost	Design book, Construction schedule report, and Cost estimation report	▪	Counterparts External advisers	CV: Functionaries and ACB JICA: Members of the study team, external advisers, and the cost for the architectural drawing
1-4Designing of facilities, Planning of the Processes, and Estimation of the cost	Infrastructure	▬	Counterparts External advisers_	CV: Functionaries and ACB JICA: Members of the study team, external advisers, construction materials, irrigation facilities, etc
1-5 Participation of ACB in the construction of infrastructure	Cultivation of crops		Counterparts External advisers	CV: Functionaries and ACB JICA: Members of the study team, agricultural facilities
1-6Monitoring by distributors and ACB	Monitoring	▬	Counterparts	CV: Functionaries and ACB JICA: Members of the study team, external advisers

In ZAE II, though the precipitation is less than that in the upper reaches of the Watershed, there is a spring in the upper stream of Milho Branco there which does not dry up during the dry season. The small-scale water resources development was planned using this spring water. In the rainy season, a certain amount of effluent derived from rain is also anticipated there, and this development plan can make it possible to store this effluent and use it for supplementary irrigation resources. It should be noted, however, that securement of a certain amount of budget will be required to cover the construction costs of small-scale catchment dams and reservoirs. Therefore, this project will be co-financed both by the study team and CV: DGASP will cover a part of the project costs within their budget, and the pilot project will supplement the cost which DGASP can not cover.

The study team discussed the component of the plan with the counterparts, while designing of the facilities was assigned to the local consultant. After the selection of local contractor for construction of the facilities, the contract was concluded with ACB of Milho Branco, and implemented construction works. Stone materials for the catchment dams are collected from the construction area. With regard to other materials (cement, sands and crusher-run), mostly women transported them from material yards located in the lower reaches of the project area with some 0.6 km far and 100 m in height. This

inhibited the smooth progress of the construction of a small scale-dam. In addition to this, ACB had experience in similar works; however, its implementation capacity was less than expected, also causing delay in the progress of work. As a result, the project had to wait for completion of all the construction until the middle of September.

Some changes have been made in the implementation of facilities.

- Since it was difficult to construct openings in arch within the dam due to insufficient matereials, the design was changed to a flat type structure, reinforced with steel bars D13 @ 150.
- Access road to the reservoir was constructed, which was also used as the construction road.
- The exterior wall of the reservoir was not designed to paint in the original plan; however the wall was painted in blue by the decision of ACB by his own expenses.

The profile of the facilities is shown below:

Sediment Control Dam (Wet masonry, L = 5.0 m, H = 1.5 m, W = 1.39 m): 1 (DGASP)
Catchment Dam (Wet masonry, L = 3.0 m, H = 2.5 m, W = 1.35 m): 1 (DGASP)
Catchment Dam (Wet Masonry, L = 7.0 m, H = 1.7 m, W = 2.38 m): 1
Pipelines: L = 1,900 m
Reservoir (Block masonry, V = 80 m^3): 1

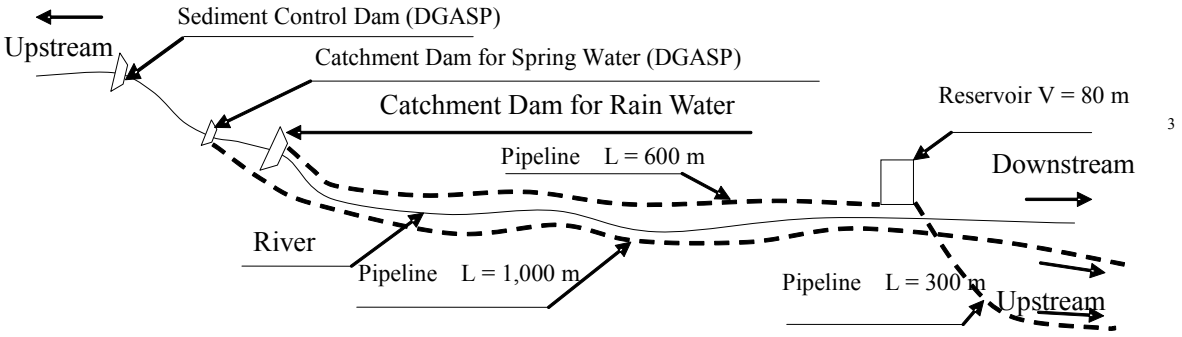


Figure 6.7.1 Profile: Milho Branco

《Monitoring》

The objective of this project is promotion of the small-scale irrigation in the dry season and supplementary irrigation in the rainy season in the lower reaches of river, with catchment dams and reservoir (80 m^3) to be constructed to collect both spring water and rain water. Monitoring shall be conducted to assess the functions of the facilities and the stored water in the reservoir during the monitoring period. This study also analyzes the possibility of the use of stored water in the future.

Progress:

・Conditions of Functions of the Facilities and Stored Water

The study analyzed the working conditions of catchment dam and reservoir after rain. It also observed them of pipelines and conduct field study on the environmental changes around the small rivers. The working conditions of catchment and storage of water (stored inside the dam or the upper reaches of the dam) were observed in the dam. From the observation, it was found

that the members of ACB did not make proper operation of the valve attached to the dam. Hence, the surplus water was discharged when rainfall exceeded the maximum volume of storage, with the valve remaining open. The study team instructed ACB to store the water within the dam by closing the valve, for efficient use of water resources. Currently, 80 m^3 of water is always stored in the reservoir, as well as management of catchment and storage is undergone by ACB members.

・Organization of Workshop and Questionnaires for Participants

In order to grasp the opinions towards the catchment facilities on the use of water and agricultural activities by the farmers and rural residents, the workshop was organized. Brief questionnaires were distributed to the participants in the workshop. The questionnaires attempted to analyze how they would like to use the new water resources in the future. Before the opening of the workshop, participants visited the target project area.

The followings are the responses of the questionnaires.

- Surplus water can be utilized for small-scale irrigated agriculture by which cultivation of carrots, tomatoes and lettuce can be possible in each horticultural farm.
- They expect the surplus water, not only for cultivation and pastoral activities, but also for their daily lives by transmitting water from the reservoir.
- They want to utilize these new water resources for various activities of ACB.
- It might be necessary to have personnel who are responsible for the management and maintenance of reservoir and distribution of water.
- Local ACB, as the management body of newly developed facilities, consider the benefit of all members in utilizing the water resources. Planning of water resources should be carried out by the participants in the community. Water resources created by this project should be used for irrigation activities (drip irrigation) for free, not for sales.


Workshop in Milo Bronco
(Left: Field study by all the Participants; Right: Discussion)

・Use of Stored Water

Reservoir was filled with rainwater, when the rainy season came. However, demand for the supplementary irrigation in the rainy season was balanced out by the plenty of rainfall in this rainy season, and stored water was not used at the moment of the monitoring survey. One

ACB member fetched water in drum for the drip irrigation for bananas. According to ACB, the stored water is now sold at 100 ECV/m^3.

Mr. Barros, who was the agricultural engineering department director, showed his intension to exhibit drip irrigation using stored water. He promised to purchase drip irrigation equipment by the budget of DGASP and provide ACB members. Since, ACB is counting on the director, waiting for the arrival of the equipment and do not have any other options of the water use in the reservoir. Supply of the equipment at an early timing is expected for the purpose of promotion as experimental farms.

6.7.3 Evaluation

(1) Verification of Achievement

- Construction of the facilities (catchment dam to collect water in the rainy season, reservoir and pipelines to connect those facilities) were completed.
- The reservoir was filled with the river water in the rainy season.
- The demand for the supplementary irrigation in the wet season was balanced out by the plenty of rainfall in the rainy season, and stored water was not used at the moment of the monitoring survey.
- Sediment control dam, which DGASP was planned to construct at the initial stage, had not been constructed yet. The director said the contract would be concluded, since the annual budget was confirmed.
- Exhibition of drip irrigation equipment using water from the reservoir, which DGASP planned, was behind the schedule. They will supply the equipment immediately, since the annual budget was confirmed, as same as the sediment control dam.
- One ACB member fetched water in drum for the drip irrigation of bananas. According to ACB, the stored water is sold at 100 ECV/m^3.

(2) Verification of Implementation Process

- Stone materials are collected around the targeted project area of dam. With regard to other materials (cement, sands and stone crusher-run), mostly women transported them from material yards located in the lower reaches to the project area with some 0.6 km far and 100 m in height. In addition to this, construction was delayed, since ACB, which had experienced the similar construction, had lower implementation capacity than expected.
- ACB decided to paint the exterior wall of the reservoir in blue, which was not included in the initial plan.
- The demand for the supplementary irrigation in the rainy season was balanced out by the plenty of rainfall in the rainy season, and stored water was not used at the moment of the monitoring survey.
- The system of this project, which convey the spring water directly to the reservoir with the pipeline, deprived livestock animals of drinking water. Water in the reservoir was decided to be supplied for the livestock animals for free in order to solve this problem.

- ACB does not consider the methods to utilize the stored water at this moment, since they wait for the drip irrigation equipment from DGASP.

(3) Evaluation Result by Five Evaluation Criteria

The evaluation result of this component by five evaluation criteria is as follows:

Relevance

- Utilization of rain water which used to flow into the rivers directly becomes possible by means of small-scale water resources development, which ensures the securement of water resources at national level.
- PEDA, the superior plan, stresses the securement of water resources and the farmers are able to extend the arable fields with this project. Therefore, this project is relevant.

Effectiveness

- Small-scale water resources development is beneficial to farmers, since it can expand the cropping.
- Reservoir was filled with rain water when the rainy season came. However, demand for the supplementary irrigation in the rainy season was balanced out by the plenty of rainfall in the rainy season, and stored water was not used at the moment of the monitoring survey. One ACB member fetched water in drum for the drip irrigation of bananas. According to ACB, the stored water is sold at 100 ECV/m^3.
- Mr. Barros, who is the agricultural engineering department director, announced his will in the implementation of the exhibition of drip irrigation using the stored water in the workshop organized on the 9th of October. He planned to purchase drip irrigation equipmen within the budget of DGASP, supplying for ACB members. ACB are counting on the director, waiting for the arrival of the equipment, and do not intend to have other options for the water in the reservoirs. Supply for the equipment at an early timing is expected for the purpose of promotion as an exhibition field.

Efficiency

- In terms of the implementation, construction had been completed before the rainy season, although the completion was behind the schedule. Surplus water was dripping off from the pipelines in September.
- The capacity of the reservoir, which had been designed for the project, seemed to be too small, since the reservoir was filled with rain water immediately after the advent of rainy season.
- The efficiency for the impact of the outcome is still unknown, since the stored water has not been used for agricultural cultivation.

Impact

- As mentioned above, little stored water is used at the moment of the study. Farmers do not consider other methods for the utilization of the surplus water of reservoir, waiting for the irrigation equipment from DGASP, causing the negative impact.

- On the other hand, exterior of the reservoir, which was expected to be covered only with mortar in the original contract, was painted in blue by ACB initiative within their budget, considering the landscape of reservoir.
- The system of this project, which convey the spring water directly to the reservoir with the pipeline, deprived livestock animals of drinking water. Water in the reservoir was decided to be supplied for the livestock animals for free in order to solve this problem.

Sustainability

- Facilities, such as dam and reservoir, are strong enough for long-term use. Proper maintenance of the exposure of the pipelines shall be required.
- As described above, ACB painted the exterior wall of the reservoir voluntarily. This indicates the ownership for their own facilities, which suggests that they will efficiently use the reservoir for the years to come.

6.7.4 Conclusion

Confirmation of Hypothesis

Hypothesis: The project can diversify the acquisition of cost for project by sharing the construction costs with CV.

This project cost was allocated to CV and the Pilot Project: CV would finance the cost which it could cover within the annual budget of DGASP, whereas this project would cover the rest of the cost. This was confirmed by the meeting of Steering Committees and the CV agreed to implement the cooperated project. However, the dams to be constructed by CV have not been under construction yet, due to the budgetary constraints. Director announced that the annual budget for this year had been concluded, and contract for construction would be undergoing. Therefore, this hypothesis has not been proved yet.

Conclusion

Water resources facilities to collect and store the rainwater have been constructed. However, the demand for the supplementary irrigation in the rainy season was balanced out by the plenty of rainfall in this rainy season, and the stored water has not been used at the moment of the monitoring survey. Also, since the farmers are waiting for the equipment for drip irrigation by DGASP, the stored water has scarcely been utilized. Therefore, this study cannot confirm the concrete outcome of the project.

Even though this project can be said relevant due to possibility of securement of water resources at national level, its efficiency and hypotheses have not been verified yet, as the stored water was not used yet. Therefore, this project can not get the high priority to be proposed as one of the action programs in the Action Plan. However, there is a possibility to that this project will make good output in future with the continual support by the Government of CV. When the project will make the good output, this project may be proposed as one of action programs of the Action Plan.

6.7.5 Lessons learned and Reflection to Action Plan

Table 6.7.2 Lessons Learned and Reflection to Action Plan: Small-scale Water Resources Development

Lessons Learned from Pilot Project Implementation	Reflection to Action Plan
• The project intended to construct small scale irrigation facilities so that farmers could utilize and maintain the facilities by their own. However, this project should consider the middle-scale water resources facilities for more efficiency.	→ Lesson shall be included in the project.
• The project should include the painting of the exterior wall of the facilities, even though they are made of concrete, considering the landscape of the targeted areas.	→ The problem in question shall be included in the content.

6.8 Process and Evaluation of Project Component: Water Saving Irrigation/Water Management

6.8.1 Profile and Objectives

Since the drip irrigation method with good water saving efficiency is being promoted transferring from the traditional basin irrigation with low irrigation efficiency in Santiago Island, the water saving irrigation is proposed in the Action Program "Introduction of Water Saving Irrigation" of the Action Plan. The water saving irrigation is rather new in CV, and its method has not been fixed. Therefore, it is needed to set the water saving irrigation experimental farm for introducing its various techniques and researching the variation of the yields depending on the volume of the irrigation water. However, the basic data in implementing the water saving irrigation is not available in CV.

In implementing this project, this study attempts to collect basic data which is used as a baseline for the test on the water saving irrigation, and to pave the ways for CV to continue the experiment. Also, in order for the Government to take initiative, experts on the water management are necessarily trained. Therefore, through the training of functionaries on the management of water saving irrigation proposed in "Training on Water Saving Irrigation" of the Action Plan, the number of the trained functionaries shall be increased.

6.8.2 Activities

This project component was implemented in Achada Baleia, which is located in ZAEI. The achievement of activities is shown below.

Table 6.8.1 Activities: Water Saving Irrigation/Water Management

Activities	Expected Results	Schedule	Responsible Officers	Input
		2008 (o n d) 2009 (j f m a m J j a s o n d) 2010 (J f m a)		
1-1Participation of the functionaries in the training on the water saving irrigation and water resources management	Functionaries of DGASP who acquired knowledge on the water saving irrigation.		Counterparts External advisers	CV: Functionaries and ACB JICA: Members of the study team and external advisers
2-1 Selection of the ACB which could supply the experimental fields	ACB		Counterparts	CV: Functionaries and ACB JICA: Members of the study team and external advisers
2-2Implementation of topographic measurement	Topographic chart		Counterparts External advisers	CV: Functionaries and ACB JICA: Members of the study team, external advisers, and the cost for the architectural drawing
2-3 Designing of facilities, Planning of the Processes, and Estimation of the cost in the trial fields	Design book, Construction schedule report, and Cost estimation report		Counterparts External advisers o	CV: Functionaries and ACB JICA: Members of the study team, external advisers, construction materials, irrigation facilities, etc.
2-4 Participation of ACB in the construction of the farm facilities	Experimental farms		Counterparts External Advisers	CV: Functionaries and ACB JICA: Members of the study team, external advisers, irrigation equipments, etc.
2-5Implementation of agricultural assessment by DGASP	Result of the experiment for water saving irrigation		Counterparts External advisers	CV: Functionaries and ACB JICA: Members of the study team, external advisers, construction materials, irrigation facilities, etc.
2-6Monitoring by ACB	Monitoring		Counterparts	CV: Functionaries and ACB JICA: Members of the study team, external advisers, etc.
2-7Organization of seminars for the purpose of transmitting the outcome of the project	Rural residents who acquired the knowledge on the water saving irrigation		Counterparts	CV: Functionaries and ACB JICA: Members of the study team, external advisers, etc.
2-8Edition of the results for the formal manual l	Manual of experimental farms for water saving irrigation		Counterparts External advisers	CV: Functionaries and ACB JICA: Members of the study team, external advisers, etc.

"Project for Water Saving Irrigation" (Training on the Water Saving Irrigation)

During the five days (from 24th to 28th of November 2008), the training was conducted, aiming at acquisition of the proper water management of the water resources, for the functionaries of DGASP, the extension officers in the Agricultural Local Office in São Domingos (ALOSD), and the farmers who were practicing the irrigated agriculture here in the Watershed.

Twelve members of DGASP and ALOSD, and 26 farmers in Achada Baleia and in Baía near the coast. Among 5 days off training, initial 2 days were targeted only at the functionaries. The farmers participated in the training for the rest of 3 days, and the attempt that the trained functionaries instructed the farmers was made.

Contents of the Training Course

1st day : Training was conducted for members of DGASP and ALOSD. The trainees were asked to fill in the questionnaires in order to assess the knowledge on irrigation. The lecturers taught the basics for irrigation, principles of water saving irrigation, and its methods. Besides, not only water saving irrigation but also the salt damage for irrigation land caused by highly salt damaged irrigation water was explained.

2nd day: Lectures were organized for the official members in the same manner as the 1st day, regarding the catchment and storage methods, which are highly important in the irrigation facilities. The trainees also learned the water saving irrigation methods of farmers level, since they would extend the methods to the farmers.

3rd day: Target trainees were extended to the irrigation farmers. Functionaries and irrigation farmers learned about the water saving irrigation in Achada Baleia, using soil materials in the farm. Some functionaries who received the lecture attempted to give a small lecture to farmers.

4th day: The lecture was organized for the functionaries and the farmers. The lecturer gave some detailed explanation on the field study of the day before. Participants participated in the discussion on the issues around the irrigated agriculture.

5th day: The lecture was organized for both functionaries and farmers. The lecturer particularly focused on the salt damaged land, including the assessment of EC in the well water in Baía. Also, questionnaire survey was conducted for the assessment after the training.

<u>Evaluation before the Training</u>

On initiating the training for the functionaries and the farmers, questionnaire survey was conducted to evaluate the knowledge of trainees on the irrigation and validity of the planned training. 9 trainees responded to the questionnaires. The result of pre-training proved that most of the experienced engineers had never been given those kinds of trainings. Hence, it revealed that it might be essential to hold these kinds of trainings, considering the embodiment of the training system for the water saving irrigation. Also, the survey confirmed the importance of the components of the training to be conducted.

Evaluation after the Training

After the training, the questionnaire survey was conducted on the 12 participants.

Even though it was uncertain to what extent the capacities of participants have improved solely from the result of the final evaluation, it was assured that the awareness of the water saving irrigation had been improved. The training might have been of significance in the sense that the functionaries, who used to instruct farmers to shift from traditional to water saving irrigation without any understanding, have become learned the basics for irrigation and possible to instruct them. They wished to practice what they have learned during the training and to instruct the farmers about what they learned. Also, functionaries are eager for the training of fertilization of the soils and destructive insect control, as well as on the irrigation and salt damage.

"Project for Water saving Irrigation" (Water saving Irrigation Experimental Farm)

The study team discussed about the candidate site for the experimental water saving irrigation farm with the farmers in Achada Baleia, which was the target ACB, on the 10th of November 2008. The findings were as follows:

- Every farmer's farm was extremely small, and it was difficult to secure a large farm.
- Water for the experimental farm was supplied by the portion currently allocated to each of the farmers, since the water resources was exclusively from the well water and daily water for irrigation was limited.

Amidst all those constraints, one of the farmers offered currently uncultivated land. He also offered the allocated well water for irrigation use.

The site reconnaissance showed that the areas were nearly 0.2 ha with 24 m^3/week of irrigation water. The study team decided to employ this field, since searching other farms could have been an arduous task.

Discussion on the contents of the project with the counterparts were made, and the designing of the facilities was commissioned to the local consultant. After the selection of local contractor for construction of the facilities, the contract was concluded with ACB of Achada Baleia, and implemented construction works. Construction was almost completed within the period of contract, as the process was rather simple, such as the placement of gates, maintenance of the field, and installment of agricultural equipment. However, procurement of weather devices and production of the pots for pitcher irrigation[2] were delayed. For this reason, all the facilities and productions were all on hand for the launch as late as in October.

The profile of the facilities is shown below:

Achada Baleia (ZAE I)

Area for Experimental Farm: A = 1,500 m^2

(Nursery bed: 200 m^2, Drip Irrigation: 700 m^2, Pitcher Irrigation: 400 m^2,

Traditional Irrigation : 200 m^2)

[2] Pitcher irrigation is a pattern in which the water excluded from the buried pods is used for irrigative water.

Fence L = 200 m

Facilities (Drip irrigation, pitcher irrigation, etc.): 1 set

Measurement Devices: 1 set

《Monitoring》

This project shall be characterized as the baseline survey in relation to the irrigation experimental farm which shall be continued by the counterpart organizations. Therefore, functionaries of DGASP shall learn the usage of measurement appliances necessary for the assessment, and methodology of data collection as on-the-job training, for the purpose of acquiring the knowledge on the implementation of the experiment for water saving irrigation. Also, for the water requirements, it was attempted to grasp the current volume of irrigation water as a baseline survey. The cooperation from the farmers was required for the vegetable cultivation.

Implemented Irrigation Techniques:

- Drip Irrigation (without mulch)
- Drip Irrigation (with mulch)
- Pitcher Irrigation (without mulch)
- Pitcher Irrigation (with mulch)
- Traditional Irrigation
  (basin irrigation, furrow irrigation: for comparison)

Pitcher Irrigation

Measurement Parameters

- Volume of Irrigation Water (Flow meter)
- Degrees of Moisture in the Soil (pF meter)

Components:

- Detailed information on the experimental water saving irrigation farm shall be referenced in the chart of Profile of the Project Site at the end of this section.
- Volume of Irrigative Water
  Observation/measurement of the flow volume in irrigation measured by flow meter (integrated in meter) attached to the pipeline, hours of irrigation, conditions for the degrees of moisture in soil shall be conducted and estimated volume of irrigation water to each farm shall be recorded.
- Observation of the Volume of Moisture in the Soil during the Irrigation
  The study team installed the pF meter (20 cm in depth of the soil) in each of the experimental fields, and observed the value of pF.

Progress:

- Delivery of the pots for pitcher irrigation was behind the schedule, since they were produced in the rainy season influenced by humidity, and that electric kilns did not work due to power cut.
- After the planting of nursery plants, pF meters were installed.