SUPPORT TO THE COMPETITIVENESS OF THE RICE SECTOR IN THE CARIBBEAN, PROJECT 9ACP RPR 006

START-UP PHASE

REHABILITATION AND COMPLETION OF THE IRRIGATION AND DRAINAGE INFRASTRUCTURE IN NICKERIE

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INTRODUCTION

Rice cultivation in Suriname mainly takes place in the northwestern part of Suriname, within the districts Saramacca, Coronie and Nickerie. The rice culture is most developed in the Nickerie district. More than 80% of Nickerie's population is in some way involved in or dependent on the rice sector. An important group is that of the small farmers who have rice fields less than 4ha. These farmers are concentrated in various polders, which are being divided into eastern and western polders. These polders receive their irrigation water from the Nanni Swamp and the Corantijnkanaal. A second group of farmers, named as the "middenstands" (middle class) farmers have rice fields larger than 4 ha but less than 24 ha. A part of them have their fields located southerly of the eastern and western polders, close to the Nanni swamp and the Corantijnkanaal. However, the largest part of the middle class farmers can be found on the right bank of the Nickerie river close to the rice polders of Wageningen. The third group of farmers, cultivating rice fields larger than 24 ha and indicated as the big farmers, are mainly found on the right bank of the Nickerie river. A small number of big farmers are found at the left bank side of the Nickerie river, close to the Nanni swamp and the Maratakka river.

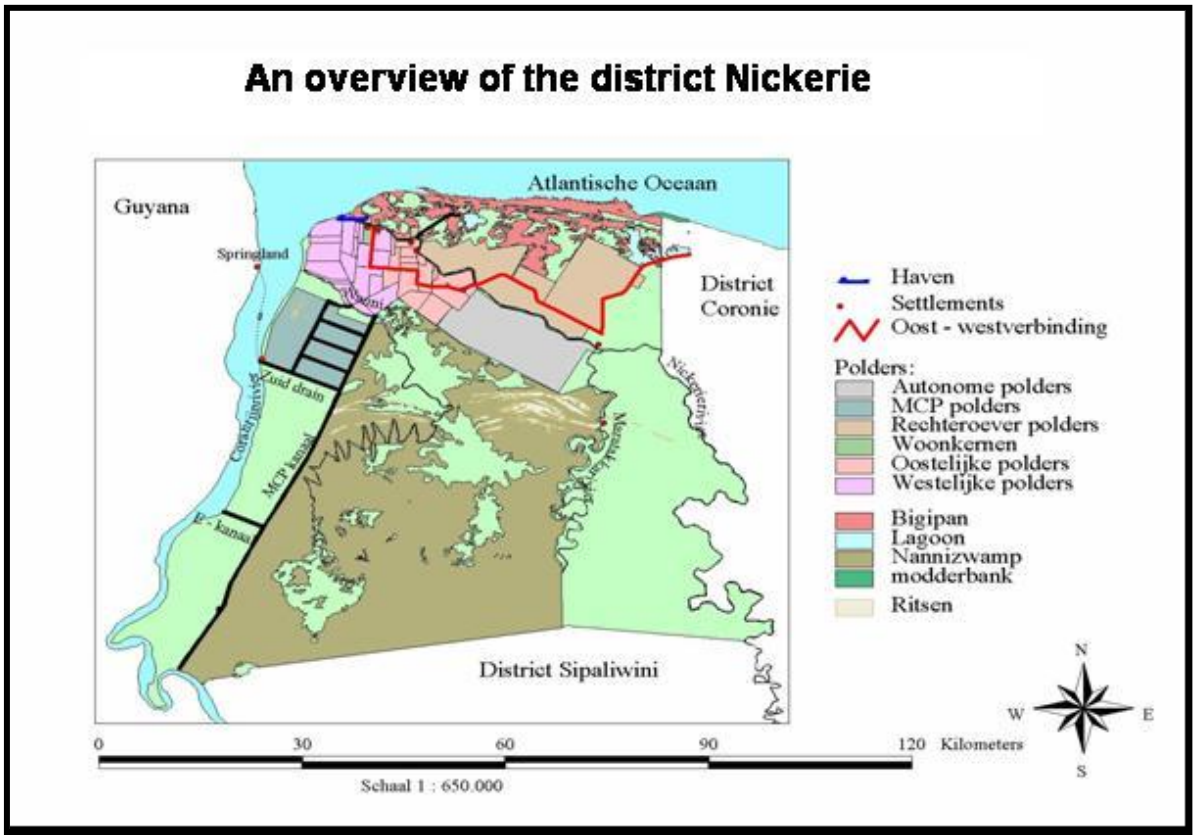


Figure 1: Map of the district Nickerie (Source: NARENA, 2003).

The rice farmers on the left bank are dependent on irrigation water coming from two sources, namely the Nanni swamp and the Corantijnkanaal, whilst the farmers on the right bank can only get their irrigation water from the Nickerie river. Other farmers extract their irrigation water from the nearby swamp. In the Coronie district the main water source is the Coronie swamp, and in the Saramacca district the Coesewijne swamp and the swamp on the right bank of the Saramacca river provide the rice farmers with irrigation water for their fields.

Annually about 48.000 ha is being used for paddy production. Changes in the climate, including the frequent occurrence of the El Niño phenomenon, affect the water resources negatively. Moreover, improper functioning of the irrigation and drainage infrastructure, resulting from overdue maintenance of canals and engineering works, damaged and uncompleted infrastructural works enhance further the inefficiency of the available freshwater use.

In addition, the inadequate functioning of the water management units contributes substantially to this inefficiency. All this leads to an increasing pressure on the existing water resources.

These circumstances have also contributed to the decline in the paddy production in Suriname over the last decade. Since about 80% of the district's population is dependent on rice production, deterioration in this sector means a further increase of poverty. The number of farmers involved in the rice cultivation in district Nickerie is presented in table 1. This table also illustrates the net agriculture area of each polder in the district.

Table 1: Number of farmers (rice fields) in the respective polders

	Farmers in district Nickerie			
Polders	**Total area(ha)**	**Average area(ha)**	**Fields [Farmers]**	**Number of series**
Western polders				
Nanni	1,062	5.5	194	21
Nanni Bruto	358	5.3	68	
Clarapolder	1,245	3.4	365	4
Corantijnpolder	747	1.3	573	3
Van Drimmelenpolder	850	1.5	568	9
Waldeck	84	0.7	120	
Sidoredjo	164	1.0	169	2
Margarethenburg	104	1.1	92	
Euro Zuid	1,140	5.3	214	6
Euro Noord	1,035	6.5	160	11
Total West	**6,789**	**2.7**	**2,523**	
Eastern I				
Boonackerpolder	171	4.3	40	
Paradise A & B	313	1.4	222	
Uitbr. Par. 1 t/m 4	395	1.9	206	
Longmay en Uitbreiding	375	1.2	314	
Hamptoncourt A t/m G	1,226	2.3	540	7
Krappahoek G(a), H(b)	130	1.8	71	
Sawmillkreekpolder	236	2.4	97	
Total Eastern I	**2,846**	**1.9**	**1,490**	
Eastern II				
Groot Henarpolder	2,100	4.0	520	
Klein Henarpolder	141	1.8	78	
Middenstandspolder	1,431	21.0	68	
Total Eastern II	**3,672**	**5.5**	**666**	
Uitbreiding Groot Henarpolders				
Uitbr. Groot Henarpolder I	1200	11.1	108	
Uitbr. Groot Henarpolder II	750	11.7	64	
Total Uitbr. Gr. Henarpolder	**1,950**	**11.3**	**172**	
Total	**15,257**		**4,851**	

(Source: Ministry of Agriculture)

The majority of farmers are cultivating two crops annually. For this reason, a large quantity of fresh water is required. This water is being derived from the Nanni swamp or pumped by the Wakay pumping station out of the Corantijn river into the Corantijnkanaal. The latter transports the pumped water to the main irrigation canals through which the various polders in the district are being supplied the necessary volume of irrigation water. Notwithstanding the abundance of freshwater in the region, scarcity is being experienced annually, especially during the second crop, which coincide with the small rainy season. During this period, supplement irrigation is needed for the paddy production, which, as mentioned earlier, is being withdrawn from the Corantijn river.

Until now, interventions, such as the digging of the Corantijnkanaal, have not led to the desired results. Water scarcity still occurs and farmers are forced to pump water in their fields. On the other hand, water is being wasted due to improper functioning of the civil engineering works, including sluices, inappropriate infrastructure, lack of pumps, water regulators, diverters, and poor water management.

To make use of the existing water resources more efficiently rehabilitation of the existing infrastructure is very important. In this regard, an inventory is needed. This inventory regards in the first place the 13,000 ha agricultural area, consisting of the east and west polders in the district Nickerie and secondly the agriculture land on the right bank of the Nickerie river, the Coronie and the Saramacca rice polders.

For this purpose, the EU is willing to support the rehabilitation of the Drainage and Irrigation system as part of the EU/Cariforum Rice Programme: Support to the competitiveness of the rice sector in the Caribbean.

Different agencies and government departments are responsible for maintenance of the existing infrastructure. The Ministry of Public Works is responsible for most of the primary canals. However, the Ministry of Agriculture is also involved with the maintenance of the primary canals.

In this report, the emphasis is on the primary infrastructure, which includes primary irrigation canals and primary drainage canals, including the sluices, and other civil engineering works. Liquidation of these shortcomings or deficiencies will lead ultimately to higher yields and a quarantined livelihood.

Approach in assessing the shortcomings and deficiencies of the infrastructure

To facilitate the listing of the shortcomings and deficiencies of the existing infrastructure a division has been made into the following groups:

1. The Corantijnkanaal with all its elements, including the diversion, locations for establishment of weirs and culverts, and other civil engineering works.
2. The Van Wouwkanaal, including the Nanni inlet
3. The Nanni creek
4. The Surinamkanaal
5. The HA sluice and the corresponding irrigation canal
6. The IKUGH sluice and the Stondansiekanaal
7. The Maratakkakanaal
8. The right bank of the Nickerie river, including the Stondansie lake
9. The Coronie rice area
10. The Saramacca rice area
11. The Drainage systems

Finally, all the shortcomings and deficiencies are listed in an integrated table.

1. MAIN IRRIGATION CANALS

1.1 The Corantijnkanaal

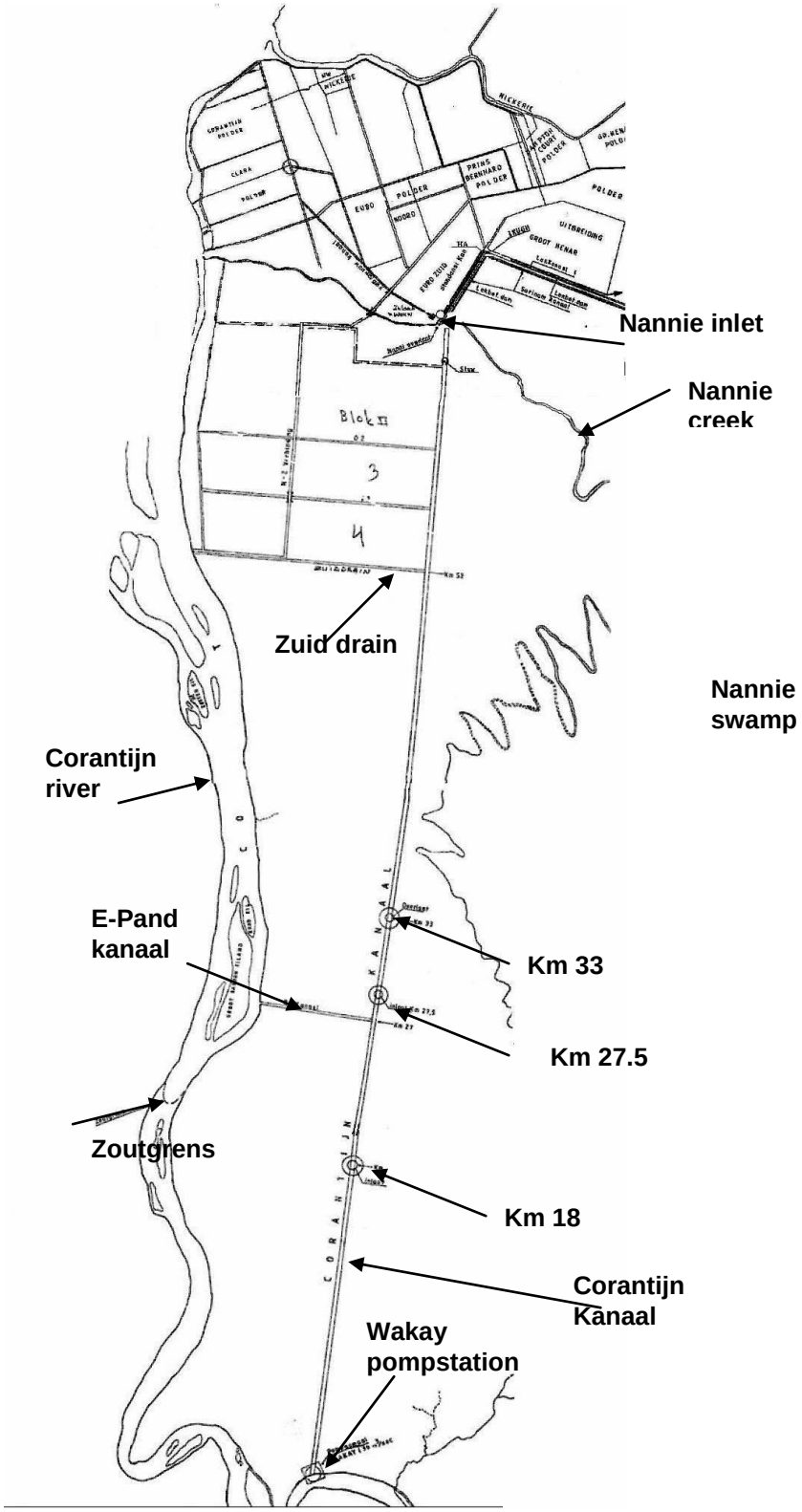


Figure 2. The Corantijn kanaal

1.1.1 Dimensions of the Corantijnkanaal

Length is about 66.7 km.
Width at the bottom is about 22.5m.
Width at the top is about 60 m.
The depth is about 3.5 m.
The maximum design discharge is about 50 m^3/s.

On both sides of the canal, dams have been constructed. The dam on the left side (at the side of the Corantijn river) has a top width of about 15 m whilst at the bottom the width is about 21 m. This dam is interrupted by 4 canals (see fig. 2). Starting from upstream towards the downstream:

- The E-pand,
- The South drain
- The second polder in the MCP polders (blocks 1 and 2)
- The first canal in the MCP polders (blocks 3 and 4)

1.1.2 The E-Pand

Objective of the canal: to divert excess water from the Nanni swamp into the Corantijn River via the E-Pand.
Dimensions of the canal: see original document, project MCP kanaal.
Design discharge of E-Pand: see original document, project MCP kanaal.
Present situation: overgrown, not in use; hydraulically connected with the Corantijnkanaal.
Civil engineering work, such as a sluice gate, a diversion pipe, weir, etc. is not needed at present. Since water sacristy increases and no large-scale flood has been observed the inlet of the E-Pand canal has been closed with earth fill materials.

The dam on the left side bank is made with the intention to construct a road via Wakay to Apoera. The road is designed to have a width of 9 m and a roadside of 3m at least. The design width is about 32,75 m at the bottom and 22,5 m at the top.

The water retention dam on the right side of the Corantijnkanaal has a bottom width of 20,75 m and a top width of 10,5 m.

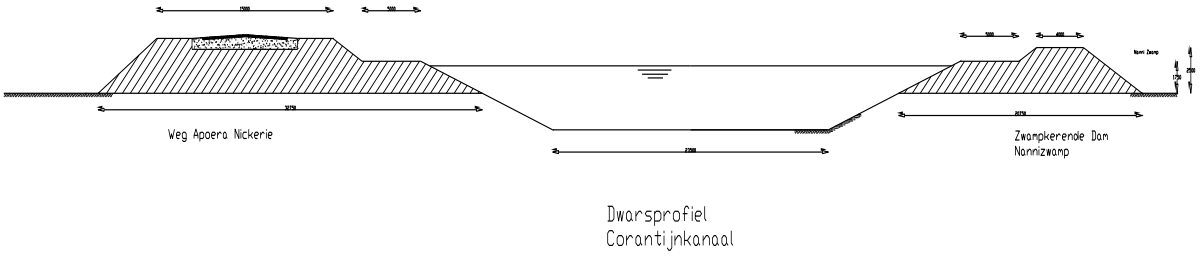


Figure 3. Cross section of the Corantijnkanaal

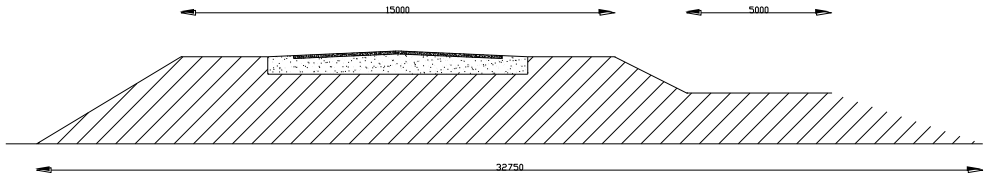
THE CORANTIJNKANAAL

Objective: To convey pumped water from Wakay to the eastern and western rice polders for irrigation purposes for optimal production of paddy. It facilitates also the flow from the Nanni swamp into the Van Wouwkanaal via the inlets made in the right side dam. The latter takes mostly place during the wet seasons of the year. During the dry seasons, pumped water has been conveyed to the respectively polders.

Capacity of the canal: 50 m^3/s at its maximum
Dimensions of the canal: The canal having a composed profile with a trapezium form has a bottom depth of about 22.5 m and a top width of about 60 m. The average depth is about 3.5 m
Management and responsibility: This is being done by the MCP, which, for his part, is depended on the Ministry of LVV.
Present status: The left half side of the canal is now being cleared from vegetation and is therefore partly overgrown. The water flow is very low, less than 0.2 m/s.
Comment: The canal should function optimal as designed, not only for period of pumping, but also during the rest of the year. However, for most time of the year the canal is not functioning optimal, since the Canal is overgrown. Excess water in the Nanni swamp is therefore obstructed and can result in dam breaks or dam overflow. For this purpose, the canals E-pand and South drain are constructed.

THE CANAL BANKS

A draft view of the left bank of the Corantijnkanaal is given here below. This bank has two functions: 1) to prevent water from flowing (leaking) into the western direction, thus the flow into the Corantijn river and 2) to use the dam as a connection road Nieuw Nickerie - Apoera. However, serious subsidence has been observed in the dam, which, if not rehabilitated in time, might cause serious problems. These subsidences have to be detected and rehabilitated.

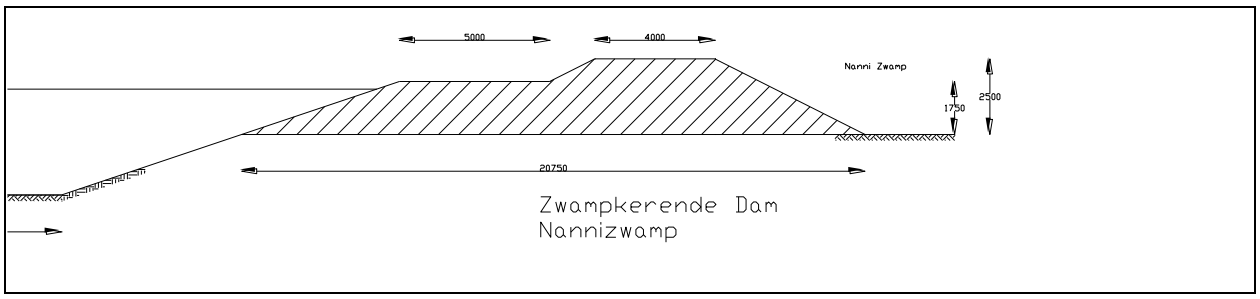


Within the dam possibilities have been created to spill waters when needed, especially during serious wet years. Neglecting this may result in dam break.

There a two possible site created for such a spillways; one at the E-Pand and the second, at the South Drain. The latter is equipped with double culverts, each with a diameter of 1.0 m. However, the inlet of the construction needs to be improved to guarantee a more efficient management.

The E-pand location is now dammed up with earth material, indicating that the need to construct a spillway here is of a low priority.
The MCP polders are located further downstream on the left side bank of the Corantijnkanaal. The irrigation canals of these polders, if in production, will also be connected to the Corantijnkanaal. At present the inlet of the canals, which are directly connected to the Corantijnkanaal, are filled up with earth material. This too indicates the low priority of constructing a civil engineering work as planned in the original design planning.

The right bank of the canal, profile of which is given here below in the figure, has in general one function: to prevent water flow from the canal to the swamp. However, water flow from the swamp into the canal is allowed at three locations of the bank where civil works as weirs, culverts or sluices are intended to be constructed and which until now have not been realized, except the construction of some trenches. The objective of these constructions is to regulate the water level of both sides. First, to allow water to flow from the Nanni swamp into the Canal (which can be used for irrigation purposes), in a way to prevent the water-retaining dam from being breached or over flooded. Second, to prevent water flow from the Canal towards the Nanni swamp in order to reduce losses. These aspects should be considered when constructing the civil engineering works.



The civil engineering works should meet with the following conditions:
- Maintenance free as much as possible, due to the poor accessibility of the locations
- Not expensive and long lasting
- Self regulating
- Not laborious

Hydraulic and hydrological data for constructing these civil works have been gathered already and are to be found at the Hydraulic Research Division (W.L.A). Technical drawings are also available. The initial civil works to be constructed here were weirs, however other constructions, fulfilling the conditions as given here above, are also possible.

Finally, the right bank, which is the water-retaining dam of the Nanni swamp, needs be inspected for subsidence.

Under the current conditions huge water losses are being experienced during the pumping period, especially during the first 2-3 days of the pumping period when due to the high water level in the canal significant losses are observed. Regrettably, these losses have never been registered. There is a general consensus that the losses are very substantial and need to be minimized as soon as possible. It therefore of very high priority to put the civil engineering works in place.

2. THE VAN WOUWKANAAL

This canal finds its source at the Nanni inlet and stops at the Gemaal distribution network providing five polders with irrigation water. In general, this canal is relatively clean. It is maintenance by using herbicides in combination with mechanical methods.

The two-door Nanni sluice is the inlet of this canal. When the sluices at the Gemaal distribution network are closed, bank overflow can occur if the Nanni inlet is not close on time. The banks on both side of the Van Wouwkanaal, in particular the left side bank, needs to be raised.

The retention dams at the Nanni weir also needs to be raised at least with one (1) meter. At high water levels, the left side bank is being over flooded. Under these circumstances, it is difficult to open the weir, as the stop logs are difficult to pull. A new mechanism has to be found to facilitate the operation of the weir properly during high waters in the swamp.

3. THE NANNI CREEK

The Nanni creek is a natural watercourse to drain the water from the Nanni swamp into the Corantijn river. The creek has been closed in the late 40's at km 37 by using a weir for irrigation purposes. To increase the water level further at a higher level than before, water retention dams and sluices (the Nanni, HA and IKUGH sluices) have been constructed. These developments affected the flow of the Nanni creek tremendously. One of the main adverse developments is the abundant vegetation growth in the Nanni creek leading to sudden decrease of the flow towards the Nanni sluice. This problem has been was solved when a pontoon with a dragline was used to clean the creek and so to increase the flow from the swamp into the Van Wouwkanaal. The contribution of the creek during the dry period was significant. It has been noticed that large part of the western polders were

irrigated in the past by the water of the Nanni swamp. However, the water supply from this source has been decreased since the construction of the Corantijnkanaal. The Nanni creek has been abandoned, and the water source is currently not used optimally.

To increase the utilization of the water source of the Nanni swamp, the Nanni creek needs to be rehabilitated, which include mainly the cleaning-up of the creek. In this regard a study is required ensuring the contribution of the Nanni swamp, e.g. Nanni lake, to be essential and advantageous. Furthermore, to make use of the water of the Nanni swamp, e.g. from the lake, a weir or culvert, is needed, again in compliance with the conditions as given above. The location and the dimensions of the creek need to be determined.

4. THE SURINAMKANAAL

The canal found its origin in the construction of the water retention dam and the withdrawal of swamp water through the sluices HA and IKUGH. The Surinamkanaal starts at the Nanni sluice, where the Corantijnkanaal ends and conveys therefore large portion of the pumped water from Wakay to the western polders. The Nanni creek also supplies the Surinamkanaal with. Because the civil engineering works are absent in the outfall of the the Nanni creek, an unknown portion of the pumped water flows via the Nanni creek into the Nanni swamp. To reduce this loss a weir or a culvert with an automatic gate needs to be constructed.

The Suriname kanaal is a very important canal for the western polders and therefore needs to be maintained optimally. The following measures are proposed, given in the order of priority:

1. Clean up the canal, at least, up to the sluices HA and IKUGH
2. Rehabilitate the dam on the swamp side, enhancing thereby the capacity of the present water reservoir, which can be utilized during the dry seasons.
3. Construct a weir or a culvert with a pressure gate.
4. Clean the Surinamkanaal from the HA up to the Maratakka river
5. Construct a sluice at the end of the Surinamkanaal, which falls into the Maratakka river.

5. THE STONDANSIEKANAAL (EURO ZUID)

The Stondansiekanaal is the main canal for the rice fields in polder Euro South. This canal has two inlets, both of which are in good condition, except for the mechanism to open and to close the sluice gate. This mechanism is out of order due to damage and vandalism. The canal is in relatively good condition but requires regular cleaning. The cleaning could be done either mechanically, by using a dragline, or chemically, using the appropriate herbicide. The following actions are proposed to take in the following order of priority:

1. Clean-up the canal mechanically, for example, by using a dragline, at the same time repairing the inlets for the polders.
2. Maintain the canal by using appropriate chemicals
3. Maintain the canal by cleaning manually. This last option is environmentally friendly and will create additional jobs for the farmers, but could be expensive.

6. OOSTELIJKE AFTAKKING (HA TO ALIBUX)

This primary canal supplies water for the several series of the Henar polder and has therefore many inlets, of which almost all have a bad functioning door mechanism. A significant part of this canal is relatively clean, whereas the remaining part is abandoned and therefore needs to be cleaned. The cleaning-up of the canal is recommended to be done mechanically for this time. Hereafter the maintenance should be hand over to the respectively Water boards (Waterschappen) of the concerned area. The following actions are required (in the order of priority):

1. Clean and profile (if needed) this main irrigation canal, inclusive the dam. It should be noticed, that part of the dam along the canal is functioning as a transportation route, which due to the heavy transport is getting damaged and therefore needs rehabilitation.

2. The sluices need to be rehabilitated in such a way as to make it functional for the purpose of better water management
3. Advise the farmers towards the application and use of appropriate inlets. This branch will decrease water losses.
4. Training should be given to the members of the Water board, including the various methods of operation and maintenance of the main irrigation canal and the civil engineering works. The training should also include observation of the water levels, flow and canal condition as vegetation cover in the canal, etc.

7. THE IKUGH TO SERIE 17 (GROOT HENARPOLDER)

This primary canal shows the same shortcomings as the one described above. The only difference is in the length and number of the intakes and the sluices. The same actions are suggested for this main canal.

8. THE IKUGH TO SERIE 23 (UGH T/M ALIBUX)

This main canal is relatively clean, however a part is overgrown with aquatic weeds. It should be cleaned in the same way as given above. Two intakes are found in this canal, which supply water to the Alibux's rice fields and the polders of the Klein Henar. The intakes here are overgrown with grasses and almost inaccessible. It seems that the intake, which is a sluice, is not functioning, or has not been used for a long time.
In order to have a good functioning of the canal the same actions as abovementioned are required.

9. BORDER HAMPTONCOURT / HENAR POLDER

This canal has a length of about 1 km and is heavily overgrown with swamp vegetation. Due to the high waters in the swamp and the other main canals to which the Hamptoncourt polder is connected, over flooding of the dam occurs. Separate from loss of water, harm is being done to the rice crop in these areas, as the rice fields can remain inundated for days. Both sluices, except their fundament, are missing. The intake is vast overgrown and the water flow is very slow.

The following actions have to be taken (in the order of priority):
1. Clean and profile this main irrigation canal, especially the dam, which should be prevented from over flooding.
2. The intake sluice needs to be rehabilitated in a way to make it functional for the purpose of better water management.
3. Advise the farmers towards the application and use of appropriate inlets, this will decrease water losses.
4. Training should be given to the members of the Water board, including the various methods of operation and maintenance of the main irrigation canals and the civil engineering works. The training should also include the observation of the water levels, flow and recording of the canal condition.

10. RICE FARMS AT THE RIGHT BANK OF THE NICKERIE RIVER

The farmers at the Right Bank of the Nickerie river, except the Middenstands farmers, withdraw their irrigation water from the Nickerie river during the dry season. However, as the ocean water (salt water) penetrates into the river during severe dry seasons, river water may become brackish and even saline and, therefore unusable as irrigation water for the rice cultivation. It should be noted that the majority rice cultivation here (at the right bank) takes place on large-scale. Contribution of these farmers to the total rice production is therefore significant and should be taken into the rehabilitation plan, since Suriname is to commit a rice production of about 85000 ton rice annually. From this background, it is of great interest to facilitate these farmers in getting irrigation water when needed. In this regard the following actions could be implemented (in the order of priority)
1. Install at least 4 automatic hydrological stations to monitor the water quality of the river at any time of the year. This will allow the farmers to have real information about quality of the water to be used for irrigation purposes.

2. Rehabilitate the Surinamkanaal and to construct the sluice as designed at the end of this canal.
3. Construct the Stondansie dam, according to the design as made before. The dam may have at least two functions: (1) to regulate water flow during the different seasons, and (2) to generate hydropower, which can be used for the Amerindian villages at the lower course of the Nickerie and the Wayambo river.

11. THE MIDDENSTANDSPOLDER

The farmers of the Middenstandpolder also suffer from the chronically shortage of irrigation water. Their irrigation depends on the irrigation of the Wageningen polder. Since the Wageningen polder has financial problems and due to this, not able to function properly for years, the middenstandspolder experiences great difficulty in having access to enough irrigation water, as they are also hold liable for not paying the pumping costs. The pump at the Kaaimanpolder in Wageningen is in operation, but requires rehabilitation, since this pumping station has not been maintained for years. If necessary funding is available fundamental steps could be taken to rehabilitate the pump. This investment includes the rehabilitation of the pump, including the machine and the pumping house.
The following has to be done in the order:
1. Rehabilitate the pump, including the powerhouse
2. Construct a trash rack
3. Clean all the main irrigation canals from weed and profile the canal.
4. Train the farmers in the paddy production

12. THE MARATAKAKANAAL

This canal is the continuation of the Surinamkanaal. The Maratakakanaal has not been cleaned for years. There is an urgent need to clean the Maratakkakanaal, however, if not managed properly the canal will be overgrown within a short time. Therefore, these actions should be taken in close cooperation with the farmers of this area, which is called the Autonomous area. Big farmers are mostly found here.
The actions to be taken include the construction of the Marataka sluice. This sluice is needed to control the outflow of water from the Nanni swamp into the Marataka river. By constructing the sluice, freshwater outflow could be saved during the dry period.

13. THE CORONIE RICE AREA

The Coronie rice area consists of about 4000 ha and is depended on the water from the Coronie swamp. During the dry seasons, periods of high demand swamp near to the rice polder dies up and water sacristy is frequently experienced. On the other side during the rainy season, when there is abundant rainfall, flooding is experienced. Both conditions are not avourable for rice production in the area. Drainage of this area includes a proper functioning of the drainage canals, which have not been maintained for years. Profiling of the canal anew is required, with proper functioning sluices and good trained operators.

For water supply during the dry season the following actions are proposed:
1. Dig a canal up to the middle of the swamp where the umbrageous vegetation is found. This action requires a detail investigation in the topography and hydrology of the area.

2. Establish or construct a lake or conservancy which can be maintained easily. This last mentioned option is easier in construction than the canal and is easier in maintenance. However, it requires a detailed study of the topography and the hydrology. The water balance of the lake should be worked out properly. In this regard, all aspects of the swamp hydrology should be taking into consideration and should be worked out in the construction of the lake.

3. The creation of a reservoir in the Coronie swamp by damming-up of the Koffiemaka creek. For this purpose a 30 km water retention dam needs to be built along the Nickerie river to prevent water loss from the swamp towards the river. Water in the reservoir will then flow gravitationally to the rice fields from south to north.

4. Training for proper maintenance and operation is highly required.

Al this requires a detailed study on the irrigation capacity of the Coronie swamp, at least of the area from where water will be withdrawn for the irrigational purposes. In addition, an environmental report is needed in this regard.

14. THE SARAMACCA RICE AREA

The main rice fields in district Saramacca can be divided in two groups: first, rice areas located between the Coesewijne river and east-west road connection, and, second, on the right bank of the Saramacca river. The rice fields in the first group are north south located. Irrigation water is withdrawn from the Coesewijne river and is being drained into the Saramacca and the Coesewijne rivers. To assure these rice fields of irrigation water at any time, a new structure of water supply is required, comprising a new main irrigation canal equipped with a pump of Stork type with a pumping capacity of 7,5 m^3/s. Water will be withdrawn from the Coesewijne river, from a point where the salt-water intrusion will be kept within limits. In addition, expansion of rice fields should be monitored, as the Coesewijne river is a protected area. In addition, the pumping capacity should not be increased, as this will cause intrusion of the salt wedge deeper into the river. It is therefore of utmost importance to study the irrigation capacity of the Coesewijne river. An environmental report is also required in this regard.

The excess water needs to be drained in a way where less environmental damage is to be observed. Against this background and conditions, it is recommended to consider studies done in the past and to suggest new studies. One of these studies might include establishing of a new drainage system towards the Saramacca river.

Rice fields on the right bank of the Saramacca river should take advantage from the freshwater swamp there. This area, which is a breeding, feeding and over wintering place for the many species found here, is ecologically very important. Rice cultivation may harm the existence of the ecology of the area. It is of utmost important to study the hydrology of the area very careful, prior to withdraw freshwater from the swamp for irrigation purposes. Small changes in the water budget might harm the ecosystem irreversible. In this regard, the following actions should be undertaken:
First, to study the area carefully and determine the irrigation capacity, including the impacts of climate changes, salt intrusion, becoming brackish of the area, etc.
Second, to study the alternative sources of income for the local population, as for instance, promotion of eco-tourism, rather than rice cultivation.
Third, construction of reservoirs/lakes for recycling purposes needs to be studied as one of the options to continue with rice cultivation. Use of airplane in the rice cultivation here should be forbidden.

15. DRAINAGE CANALS

The main drainage canals are:
1) The Nanni creek,
2) Onderleider to Nanni sluis,
3) Upstream between Nickerie 1 and 2 to Cyrusbrug Upstream,
4) Hampton court polder canal,
5) Attaoellahweg to sluice Groot Henar and
6) The Lareco kanaal.

From all these mentioned canals the Nanni creek is the most overgrown and needs to get cleaned up and re-profiled, followed by the “Onderleider to Nanni sluis” and “upstream between Nickerie 1 and 2 to Cyrusbrug upstream. The rest are relatively clean and discharges water in time.
Water logging is mostly found within the secondary canals. The canals here are filled up with sedimentation and are deformed. Re-profiling is needed.

16. MAINTENANCE OF THE CANALS

Since the canals are not used the whole year continuously as designed, vegetation growth covers the entire canal within a relatively short period, especially when irrigation water is not needed in the field. These periods coincide often with low water levels in the canals and low flow, promoting thereby intensive weed growth. Cleaning-up of the canals is therefore inevitable, in particular large and long canals as the Corantijnkanaal, the Van Wouwkanaal, the Stondansiekanaal and so on. As this one of the most important aspects of the operation and maintenance methods of cleaning the canals should be well known and well understood.

There are in general four options:

1. The Mechanical method, which may include all mechanical equipment and labor to be used for cleaning-up of a canal. This may comprise dragline with all necessary components, a wheel tractor and a weed cutter able to clean the slopes of the canals, a pontoon equipped with special cleaning bucket, used to clean-up the canal or other type of equipment cleaning the canals mechanically. Under the present condition, cleaning-up of the canals should be done mechanically. The methods for maintaining the canal clean hereafter needs then to be discussed.
2. The chemical method. This method requires knowledge of the chemicals and their impact on the environment. It is recommended not to use this method beyond the polder limits. For instance, the use of chemicals in primary canals as the Corantijnkanaal, is not allowed, whilst its use in the secondary canals can be considered. It should be further noticed that the chemical method is far cheaper than the mechanical method. This method, using Glyphosaat is recommended by the research center ADRON.
3. The biological method. This method is still unknown and not much applied in Suriname. It includes the use of Carps, grass eating fish type, manatees (also eating large amounts of water vegetation), planting of shadow trees along the canals, etc.
4. A combination of the above mentioned methods.

The last mentioned method required more studies and experiences. If well understood, this method could be, in combination with a group of well trained people, the most suitable, cheap and environmental friendly method. At this moment the most suitable method to maintain the primary canals is the mechanical method. The use of dragline, provided with special hoisting structure, is the most used option for cleaning –up of the primary canals. Since this method is expensive, cleaning up of the Canal takes place only in urgent cases. Water flow in the remaining period is therefore hampered by the existence of vegetation

17. SUMMARY

The above-mentioned shortcoming and their corresponding costs in Euro are given in table here below.

Table: To be taken actions prioritized in the descending order.

To be taken actions	Priority level			Maintenance level	EU Assis-tance needed	Estimate Costs in euro
	High	Middle	Low			
Corantijnkanaal				Mech+Biol		588,800
Cleaning-up and Maintenance						
Construction of culverts/ weirs						
Construction of culverts E-Pand						
Rehabilitation of the RB						
Rehabilitation of the LB						
Wakay pompstation						
Rehabilitation of the landing stage						583,500
Cleaning up and maintenance of the Wakay area						
New pump to be purchase						
Replacement of generator						
Replacement of pressure motor						
Rehabilitation of the pump					Needed	
Rehabilitation of the buildings						
Water transportation for the personnel						
Elaboration of a water calendar						
Training and organization						
Nanni creek				Mech		27,000
Cleaning-up creek						
Weir/ culvert construction						
Nanni sluice						
Nanni sluice rehabilitation						
Raising of the water retention dam						
Rehabilitation of the Nanni weir						
Van Wouwkanaal				Mech+Chem		3,500
Maintenance						
Surinam Kanaal				Mech+Biol		69,000
Cleaning-up of the canal						
Rehabilitation of the dam						
Rehabilitation of the IKUGH sluice						35,000
Rehabilitation of the HA sluice						3,890
Finalizing watchman house						
Stondansiekanaal				Mech+Chem		
Cleaning-up						29,300
Rehabilitation sluices (inlets)						
Border Hamptoncourt/Henar polder				Mech+Chem		22,600
Cleaning -up						
Rehabilitation sluices (inlets)						
Irrigation canal eastern branch (HA till Alibux)						

To be taken actions	Priority level			Maintenance level	EU Assis-tance needed	Estimate Costs in euro
	High	Middle	Low			
Cleaning-up				Mech+Chem		35,000
Rehabilitation sluices (inlets)						
IKUGH to serie 17-Groot Henar polder				Mech+Chem		30,500
Cleaning-up						
Rehabilitation sluices						
IKUGH to serie 23 (IKUGH to Alibux)				Mech+Chem		35,800
Cleaning-up						
Rehabilitation sluices						
Cleaning-up and profiling Nanni creek						
Nanni creek						26,500
Onderleider to Nanni sluis						23,500
Upstream between Nickerie 1 and 2 to Cyrusbrug						8,600
Upstream Hamptoncourt polder canal						5,830
Lareco kanaal						1,600
Attaoellahweg to sluice Groot Henar						7,400
Maratakkakanaal				Mech		38,900
Cleaning-up						
Construction Maratakka sluice						
Right Bank of Nickerie river						
Construction of the Stondansie dam					Needed	
Damming-up of Nickerie river					Needed	
Middenstandspolder						
Pump rehabilitation						272,000
Cleaning-up of irrigation canal						15,600
Coronie swamp						
Coronie swamp study					Needed	310,000
Construction of canals						
Construction of CT works						
Rehabilitation drainage canals						250,000
Rehabilitation sluices						125,000
Saramacca						
Construction new irr&dra systems					Needed	428,000
Coesewijne swamp study					Needed	77,800
Study of water household of RB					Needed	77,800
Construction of Wadoeks						195,000
Equipment needed						
Maintenance Mechanically						
Pontoon with lever / cut machine						51,000
Tractor with mower						74,000
Training						7,800
Maintenance chemically						
Purchase of chemicals						38,900
Purchase of sprayer equipment's						3,100

To be taken actions	Priority level			Maintenance level	EU Assis-tance needed	Estimate Costs in euro
	High	Middle	Low			
Purchase of water transport						42,800
Training of personnel						7,800
Maintenance biologically						
Import of Carps					Needed	58,000
Import of water cows (Lamente)					Needed	58,000
Training in this field					Needed	7,800
Planting trees						19,500
Training people in this field						7,800
Total costs						**3,703,920**

RECOMMENDATIONS

It follows from the above given analyses and descriptions, that the rehabilitation and completion of the irrigation and drainage infrastructure in Nickerie comprise not only civil engineering aspects of the irrigation and drainage but also rehabilitation of the pumps (machines), buildings, the procurement of tools and spare parts for the machines and of maintenance equipment. Based on the complexity of rehabilitation and control (aquatic weed, as Water hyacinth, hydrilla, Water lily, coontail, hygrophila, duck weed, (lemna), cattails, Eurasian milfoil), it is recommended to work on the rehabilitation of the irrigation and drainage infrastructure separately, grouped as follows (in the random order):

1. Technical aspects of the rehabilitation, which includes the rehabilitation of the four (4) Stork 6 cylinders diesel engines, the rehabilitation of the generator and the air compressor and other related machines and equipment.
2. Rehabilitation of the buildings, including the Wakay pump house, which mainly include
    a. The renewing of the roof, and rehabilitation of the office, inclusive air-conditioning, the workshop and other small aspects related tot the building. Where possible to paint the Wakay pump building.
    b. Further, the rehabilitation of the guards' houses should also be included; two at the Wakay (two) and one at the HA and IKUGH emplacement.
3. Civil engineering works, including rehabilitation, or if needed replace, all sluices, in a way easy to operate but difficult to damage and therefore sustainable and long lasting. In this group of works, the rehabilitation of the dams, the weirs and culverts are included. Furthermore, the joins of the lateral canal connecting the MCP polders with the Corantijnkanaal need to be filled up. At the Wakay pumping station the scaffold, where the fuel boat is mooring, needs to be rehabilitated. Other civil engineering works include the construction of the weirs as in the indicated in the corresponding chapters, raising the water retention dams and where needed to rehabilitate the irrigation and drainage canals.
4. Procurement of machines and tools. This group is essential for the fast continuation and start of the rehabilitation. It includes the purchase of the 3 outboard motors of 40 horse power, 3 outboard motors of 15 Horsepower and 3 aluminum boats with a capacity of 6 persons per boot. Besides transportation, other equipment, regarding the cleaning-up of the canals is required. In this respect, equipment as tractors equipped with hydraulic mowers for the slopes as well as for plain areas are needed. Furthermore, for cleaning of waterways from aquatic weeds through the application of appropriate technology, which in this case could be the various weed harvesters and weed cutters, is recommended to purchase. Attention has to be paid for transportation means for additional transportation when moving this equipment to other locations.
5. Training of the MCP personnel and other personnel of the Ministries LVV and OW Nickerie regarding maintenance of the pumps, equipment, and irrigation and drainage canals. The training should also be open to farmers and interested persons from the area, and those who are now involved in the operation and maintenance of the irrigation and drainage systems in Nickerie, Saramacca, and Coronie. Other stakeholders are the water boards and the water units, including the individual big farmers.
6. Further studies regarding the determination of water resources for the Saramacca rice farmers should also be taken into consideration.

The same is valid for the Coronie farmers. The study / investigation in this district should concentrate on water supply during the dry seasons.

Photo essay of the irrigation and drainage infrastructure in district Nickerie.

The Nanni sluice approaching from the Van Wouwkanaal. The clean looking Van Wouwkanaal is due to the use of appropriate application of chemicals.

A view at the end of the Corantijnkanaal, nearby the Nanni sluice looking relatively good maintained.

Weir at the Nanni inlet. This weir allows excess water to flow through the Nanni creek to the Corantijn river. Operation of this weir is always a problem.

The Nanni sluice of the Nanni inlet. The fundaments looks good but the trash hark is missing and the doors are not functioning well.

Overgrown by aquatic weed Corantijnkanaal some 15 minutes boating from the Nanni sluice upstream the canal.

A more densely overgrown Corantijnkanaal

Cleaning up of the Corantijnkanaal by using dragline, equipped with local made tray. It should be noted that the tray can only reach up to the middle of the canal

Situation at km 27.5 of the right bank of the Corantijnkanaal, showing the location where an inlet (a possible weir / culvert ..) construction from the Nanni swamp into the canal was planned.

Approaching wakay pumping station. Note, aquatic weeds limited or washed away when pumps in operation.

The Storks pumps at the Wakay pumping station. The nearest pump (out of the 4 pumps in total) is not functioning at all.

Destroyed office room in the building of the Wakay pumping station.

Fuel bunker at Wakay with missing pumps to transfer fuel to fuel tanks of the pumps.

Mr. Padarath, technical assistant at the Wakay puming station, shows the Scaffold, arrear in maintenance. Tankers (fuel boats) can hardly moor here.

The Inlet sluice at IKUGH. The sluice doors are not functioning properly, however fundament of the construction in good condition.

Overgrown inlets at the “driekokerpunt” (Uitbreiding Hamptoncourtpolder).

An old pumping installation at the Kaaiman polder (Wageningen) providing irrigation water to the immediate rice fields and in the past also to the “Middenstandspolders” (middleclass farmers).

A clean drainage canal at the Henar polder.

The Stondansie irrigation canal, relatively clean but locally overgrown.

A look at the Maratakakanaal

Stondansiekanaal on the left and Maratakkakanaal on the right. The Maraka kanaal is hydraulically connected with the Nanni swamp