COLLABORATIVE RESEARCH TO IMPROVE THE WATER MANAGEMENT IN THE NICKERIE DISTRICT, SURINAM[1]

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Abstract

In Surinam, the contribution of the exploitation of the natural resources (minerals and forest products) is gradually decreasing. Subsequently, the agricultural sector (mainly the rice sector) becomes more important for the national income and food security. The rice sector, however, has become less competitive as the knowledge on recent developments in cultivation practices and land & water management is poor; the organization of the operation and maintenance is fragmentized; the infrastructure has been neglected, and; vocational education facilities in the Nickerie district, the main rice cultivation district, are lacking. For sustainable development appropriate land and water development strategies have to be developed. A collaborative research project was initiated to develop recommendations how to improve the water management systems, both a field and system level.

At field level, the effect of land levelling was studied in farmers' fields in four representative polders. The results show that variation in micro-relief in the paddy fields is quite pronounced resulting in a variation in the depth of the standing water up to 0.35m. Subsequently more than 25% of an average field is either too wet or too dry resulting in yield reduction. In a levelled field, water savings were negligible but, due to a more uniform layer of standing water, a yield increase from 1.8 to 2.6 t/ha was observed.

At system level, a participatory modelling approach was initiated to get a better understanding of the functioning of the water management system and to investigate whether simulation models can be used as a tool to facility the discussion between the various organizations involved in the water management in order to assist them to make informed operational and strategic decisions. The traditional validation process was replaced by joint plausibility discussions and shared vision building in order to improve the understanding of cause-effect relationships and proposals for water management measures. The aim was to match the tacit knowledge of the local stakeholders with explicit scientific knowledge in order to create a mutual basis for an integrated approach for the operation of the water management system. As a first step the main supply canal, the Corantijn Canal, was modelled. The participatory modelling approach proved to be a useful tool to increase the knowledge of the functioning of the canal. The results of both studies were used to prepare a train-the-trainers module on water management in rice fields. In November 2012, the project was concluded with a one-week train-the-trainers course for 18 professional working in the rice sector in Surinam.

Key words: tidal areas; sustainable development; integrated land and water management, participatory modelling, capacity building.

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Introduction

The Nickerie district, in the north-west counter of Surinam on the border of Guyana (5° 56' N, 57° 01'W), is the rice bowl of Surinam. With a population of about 35,000, rice is cultivated in 22 polders (about 15,000 ha). The majority of the farmers are smallholders with an average plot size of 3.1 ha (Annex 1). The soils are mainly marine clays (clay percentage around 80%) with low hydraulic conductivity (< 5 mm/d) (Wildschut, 1999). The climate is humid with an average annual rainfall of around 1800 mm and two rainy seasons: the "long" rainy season lasting from April to August and a shorter one from November to February (Figure 1). During both seasons rice is grown. In the long rainy season, rainfall is abundant; the water management system is mainly used to discharge excess rainfall. Irrigation is preliminary used at the beginning of the season for land preparation and sowing (Table 1). Peak irrigation requirements in the short rainy seasons are much higher, especially in the period October to January when rainfall is not sufficient and irrigation is needed for land preparation and sowing. The design of the irrigation system is based on a peak water requirement of 1.75 l/s/ha, needed for land preparation and sowing in November (Table 2.)

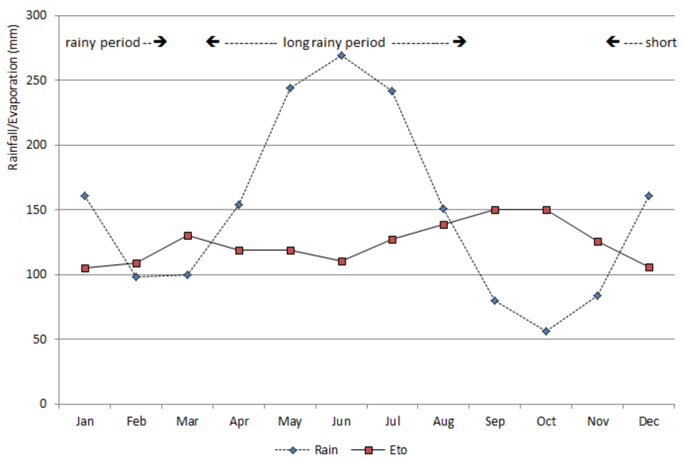


Figure 1 Average rainfall and evaporation in the Nickerie district (source: CLIMWAT, FAO, 2010).

Table 1 Water needs for paddy production in the Nickerie district, Surinam

Month	Activity	Water needs (l/s/ha)	Water needs (% of peak water requirements)
January	Crop water requirements	0.70	40
February	Crop water requirements	0.46	26
March	Harvest	0.66	38
April	Land preparation	1.09	62
May	Land preparation/ sowing	0.58	33
June	Sowing	0.28	16
July	Crop water requirements	0.08	5
August	Crop water requirements	0.04	2
September	Harvest	0	0
October	Land preparation	1.15	66
November	Land preparation/ sowing	1.75	100
December	Sowing	0.95	54

To facilitate mechanical land preparation and harvest, the rice fields in Nickerie are quite large: in the older polders the fields are 50 to 100 m wide and 500 to 700 m long. In the more recently reclaimed newer polders the width can be as much as 300 m. The fields are poorly levelled increasing pests and diseases, for example the risk for “red” rice in the higher parts and poor germination in the lower, wetter, parts (ADRON, 2008). Average yield is around 4.8 t/ha, but especially in the large-scale commercial polders yields are lower (Graanoogst, 2007). The source of the irrigation water is the Nanni Swamp, a Nature Reserve of about 54,000 ha and famous for its populations of spectacled caiman (*Caiman crocodilus*) and manatees (*Trichechus manatus*) (Baal, 2005). In dry period, when the Nanni swamp cannot provide sufficient water, additional irrigation water is pumped from the Corantijn River and transported through the 67 km long Corantijn Canal (Naipal, 2005). The cost of pumping is high and often no diesel is available to run he pumps. In the rainy season the main function of the canal system is to evacuate excess rainwater to the Corantijn and Nickerie rivers. Disposal is complicated because of the low elevation and because both rivers are under the influence of the daily tide.

The polders were reclaimed over a period of more than hundred years and consequently the irrigation and drainage systems were enlarged over time. It has resulted in a complex system without much options to control both the irrigation and drainage flows (Mertens, 2008). Not only the physical infrastructure is complex and outdated, but also the institutional set-up is complex. In 2007, the Water board OW-MCP, was established with the aim to get the overarching responsibility over the water management in the Nickerie Polders. At present, however, there are still many with many (Government) organizations involved in the operation and maintenance (Grijpstra, 2008a).

The rice sector has become less competitive as the knowledge on recent developments in cultivation practices and land & water management is poor; the infrastructure has been neglected, and vocational education facilities in the Nickerie district, the main rice cultivation district, are lacking. In 2010, the project “VERRIJST! – Strengthening the rice sector in Suriname” was initiated. The main objectives of the project were to contribute to the improvement of the Surinam rice sector by supporting the Surinam institutions ADRON (Rice Research Institute), OW-MCP (Water Board) and AdeKUS (University) to enhance of the current level of knowledge; to develop recommendations how to improve the institutional settings; to strengthen the research activities and to introduce new methods for mid-career education. In the framework of this project several research activities were initiated, among others a field study to assess the effect of land levelling on the water management in rice fields and a modelling study to get a better understanding of the functioning of the main irrigation and drainage system. In this paper some preliminary results are presented.

Methodology

For the study on the effect of land levelling, rice fields in four representative polders were selected, i.e. in (Table 2):

- Hamptoncourt polder, with an average plot size of 2.3 ha, is representative for the small-holder polders in the eastern part of the district. These low-lying polders are irrigated directly by gravity irrigation from the Nanni inlet.
- Clara polder, with an average plot size of 3.4 ha, is representative for a small-holder polder in the western part of the district. These polders are relatively high, thus irrigation water is supplied by the Clara pumping station.

- Euro-noord polder, also in the western part of the district, but cultivated by medium-size farmers (average plot size 6.5 ha) is also irrigation by gravity.
- Nanni-oost polder (formerly Cooperation West Surinam), representative for the large commercial polders mostly cultivated by entrepreneurs (average plot size 11 ha). In this polder a field (no. A6+A7) was levelled with a laser-controlled scraper on 16 November 2010.

Table 2 Characteristics of the fields selected for the water balance study.

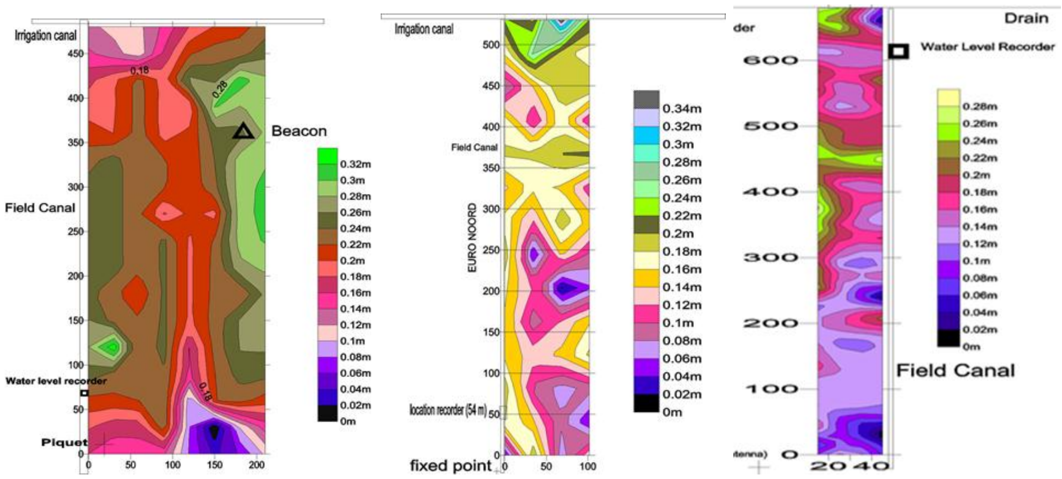
Polder	Clara	Euro-noord	Hamptoncourt	Nanni polder
Owner	Dwarka	Kisoensingh	Chatta	Batali
Area (ha)	3.8	5.4	3.8	10.4 ha
Length (m)	650	530	950	450
Width (m)	60	102	40	230
Levelled	no	no	no	yes
Compartments	no	no	1	no
Field drains	One site	Both sites	One site	Both sites & centre
Variation in elevation (m)	0.60 – 0.70	0.30 – 0.40	0.30 – 0.50 (dome shaped)	Levelled
Irrigation inlet	Gravity pipe & pumped	1 x Ø 0.25 m	1 x Ø 0.25 m	2 x Ø 0.25 m
Drainage outlet	Gravity pipe	1 x Ø 0.25 m	1 x Ø 0.20 m, length 6 m	2 x Ø 0.25 m

Before the start of the growing season, the selected fields were surveyed and automatic water level recorders (WLR) and staff gauges were installed. Furthermore the farmers were asked to record their operation land & water management practices. The fields were visited twice once per week to interview the farmers and to check the WLRs. At the end of the season, the farmers filled in the so-called ADRON questionnaire. Since 2002, ADRON uses this questionnaire to collect information on rice production by smallholders by means of random sample of about 5% of the rice fields (Grijpstra and Soerdjan, 2008).

A participatory modelling programme was initiated to get a better understanding of the functioning of the water management system and to investigate whether simulation models can be used as a tool to facility the discussion between the various organizations involved in the water management in order to assist them to make informed operational and strategic decisions. DUFLOW, a one-dimensional, non-steady state, model for water movement and water quality was used (Duflow Modelling Studio, 2010). Models like DUFLOW require long-time data sets, which were not available, thus new ways have to be found to validate the model. The traditional validation process was replaced by joint plausibility discussions and shared vision building in order to improve the understanding of cause-effect relationships and proposals for water management measures. The aim was to match the tacit knowledge of the local stakeholders with explicit scientific knowledge in order to obtain a consensus of opinions among the stakeholders. The participatory research approach adopted for the study is based on a combination of the principles of Integrated Water Resource Management (IWRM), Participatory Learning and Action (PLA) and experiences with participatory modelling from India and Vietnam (Ritzema, *et al.*, 2010; Ritzema, *et al.*, 2011). The main system was modelled and calibrated using measured water levels (available since 2010) and in-situ discharge measurements. In addition, interviews with operation and maintenance staff of the various organizations involved in the O&M were conducted and their tacit knowledge of past extreme events was used for validation. Results of the simulations were discussed with these stakeholders and used to formulate improvement options for the existing measuring and monitoring programme.

Effect of Land Levelling on the Water Balance in Rice Fields

To study the effect of land levelling on the water balance, topographic surveys were used to make detailed maps of the micro-relief of the rice fields that were not levelled (Figure 2). Differences in elevation up to 0.35 m were observed. To quantify the variation of the depth of this water layer a cumulative distribution of the depth related to the lowest point in the fields was made (Figure 3). If we assumed an optimum depth of the water layer of 0.15 m, we can concluded that in the Nanni-oost polder (Batali) almost 87% of the field is within this limit. In other words, only 13% is too wet or too dry. In the other two fields the variation is much larger: more than 25% of the fields are either too wet or too dry. These sub-optimum water layers result in poor yields: in the parts that are too high yield reduction is caused by the occurrence of “red rice” and in the parts that are too low poor germination occurs.



Figuur 2 Micro-relief of the un-levelled rice fields in the Nanni-oost ploder (left), Euro-noord polder (centre) and Clara polder (right) (Witmer, 2012).

The depth of the actual water layer varies because of the combination of rainfall, irrigation, crop evaporation and drainage (Figure 4). Rainfall data from ADRON meteorological station was used: the rainfall during the observed period (November-March 2010/2011) was average, but the distribution over the growing season was not: December and January were well below average and February and March well above average (Figure 5). Crop evapotanspiration was calculated with CROPWAT (FAO, 2010). Analysis the data indicates that large amounts of irrigation water were applied in the first three months and much excess rainfall had to be drained off in the second part of the growing season (Witmer, 2012). Consequently, water efficiencies were low. Based on the variation of the depth of the standing water the water balance in the rice fields was estimated. Preliminary results indicate that levelling fields (Batali) did not result in water savings but, because of the more uniform layer of standing water, higher yields were observed: and increase from 1.8 to 2.6 t/ha (Witmer, 2012). These yields are still well below average, a reason can be that the large commercial enterprises, like

Batali, do not tailor-made their water management and agronomic practices to a specific field but they treat all their fields in the same way to reduce operational costs.

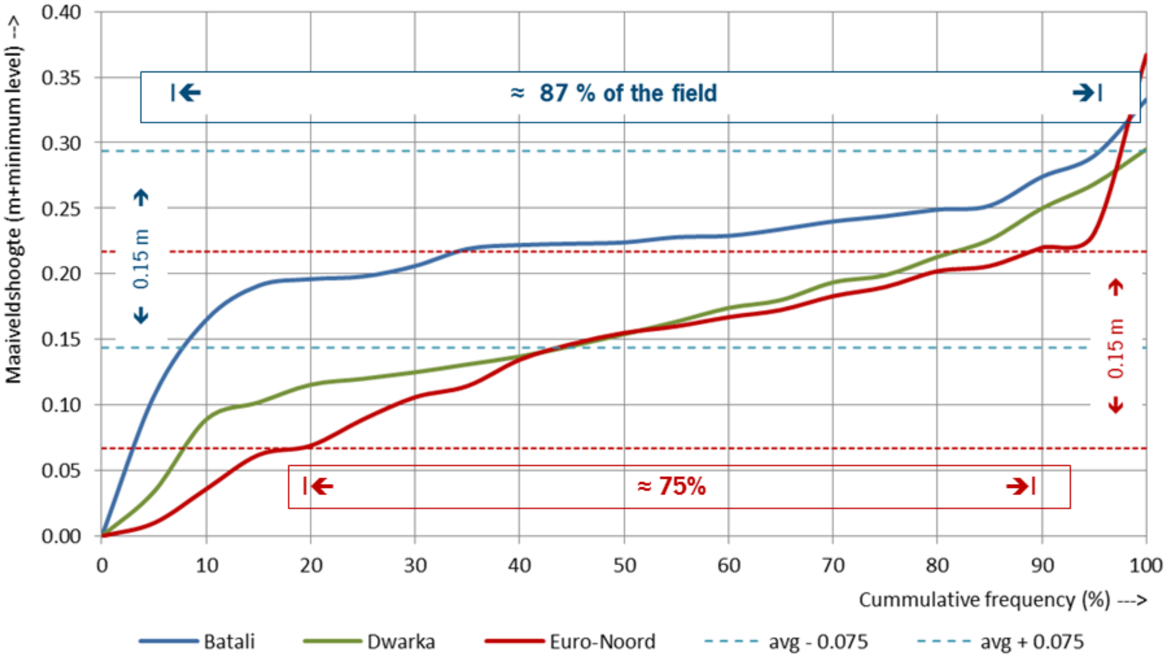


Figure 3 Cumulative distribution of the depth of the standing water layer in the three selected fields.

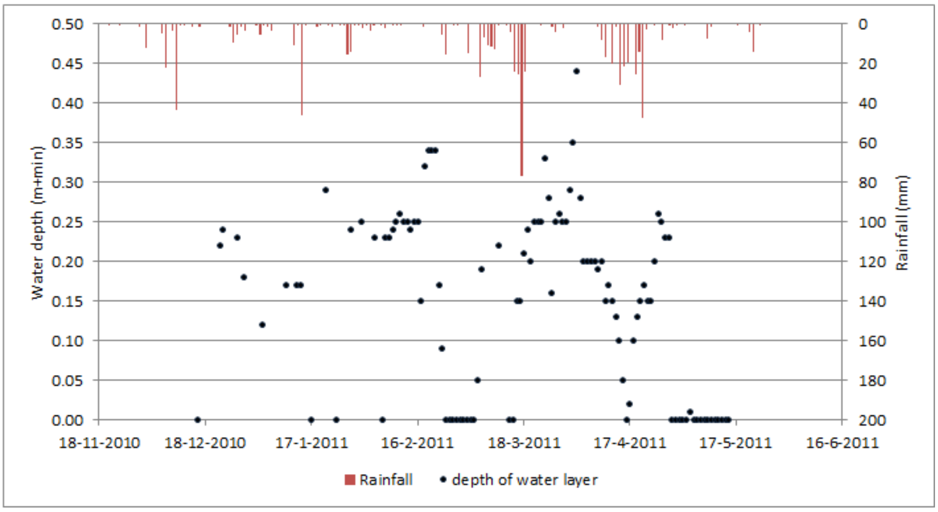


Figure 4 The depth of the water layer fluctuates under the influence of irrigation, rainfall, crop evaporation and drainage: example from a rice field in the Nanni-oost polder.

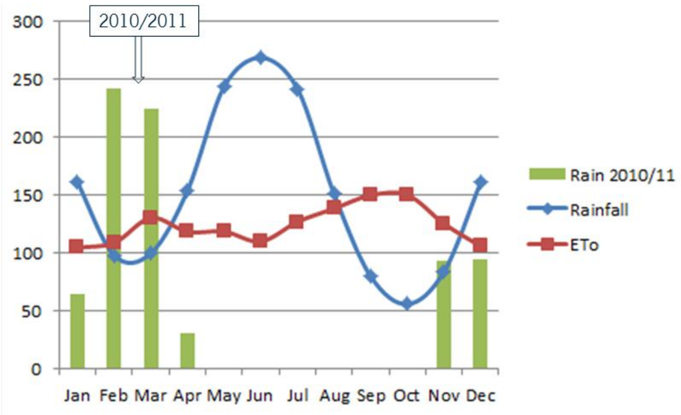


Figure 5 Rainfall during the short rainy period in 2010/2011 (November-March) was well above average.

To reduce the variation of the depth of the standing water two methods are used: (i) compartmenting and levelling. Compartments are used in fields were the elevation changes gradually from one side to the other. An example is the field in the Clara polder (Figure 6). Compartmenting makes water management more complicated because the compartments do not have direct access to the irrigation canal (at the top end of the field) or the drain (at the bottom end of the field) and consequently the water has to let in/out from compartment to compartment.

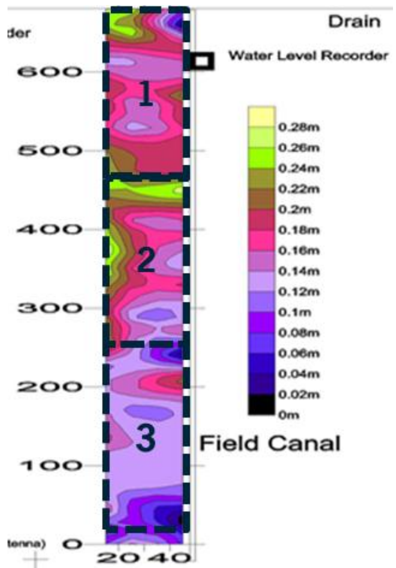


Figure 6 Compartments are used to separate the higher and lower parts of a field: example of a field in the Clara polder.

Levelling is either done by scrapers or hydraulic excavators; afterwards the field is puddled with a beam (Figure 7). Land preparation by puddling requires a large volume of water (Table 1). The cost of levelling in Nickerie is estimated to be in the range US$ 600-750 per hectare, depending on the method (personal communication Bert Vermeulen, 2012).

Figure 7 Levelling by scraper (left), hydraulic excavator (centre) both followed by puddling (right).

Water Management at System Level

As mentioned before, the water management system in the Nickerie district has been gradually enlarged over the last century. In the beginning the Nanni swamp was the only source of irrigation water, but because of the reclamation of new polders water shortage became more frequent. In 1985, the Corantijn Canal was constructed (Naipal, 2005). The 67 km long canal is used to pump water from the Corantijn River to supplement the irrigation from the Nanni swamps in the periods of water shortage, mainly in the months November and December. The canal is so long, because the intake had to be located upstream the maximum limit of salt wedge in the river (about 20 km upstream of the Wakay pumping station). The canal has embankments on both sides. At the right hand (eastern) side to separate the canal from the Nanni swamp and the left hand (western) side to avoid that the water is flowing back to the Corantijn River (Figure 8, left). The main function of the canal is to transport water from the Wakay pumping station to the Nickerie polders, operation, however, is complicated because of the complicated infrastructure (Figure 8, right) and associated organization set-up.

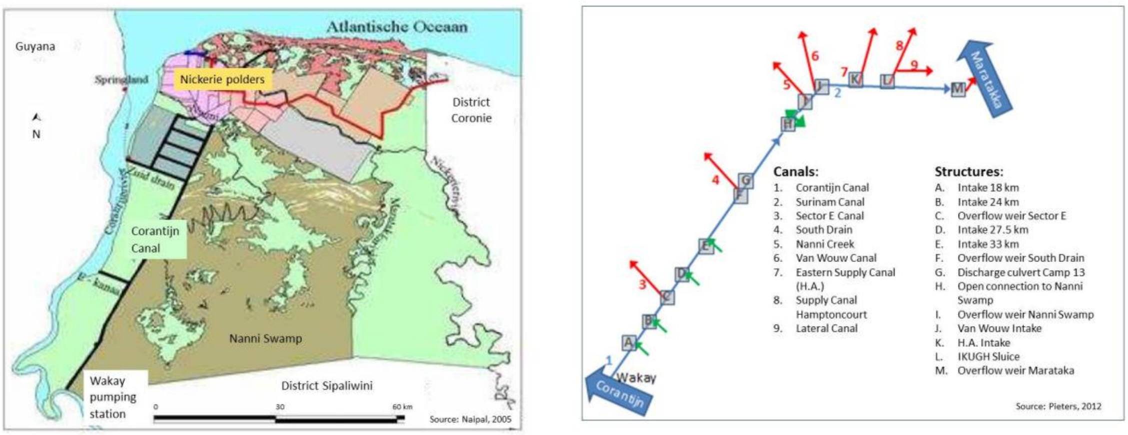


Figure 8 Map of the Nickerie district (left) and the schematization of the Corantijn canal (right).

To set up a model of the main supply canal all existing data, scattered over a number of organizations both in files and in the minds of people, had to be collected. The first step was to make an inventory of the organizations involved in the water management in the Nickerie polders, i.e. (Graanoogst, 2007):

- Water Board “Overliggend Waterschap Multipurpose Corantijn project” (OW-MCP)
- Ministry of Public Works (OW)
- Ministry of Agriculture and Fisheries (LVV)
- Ministry of Rural Development (RO)
- Districts Commissioner (DC)
- Internal Water Boards of the individual polders (IW’s), 6 out of 12 still have to be established.

In 2007, OW-MCP was appointed to coordinate the overall water management in all polders in the Nickerie district. OW-MCP is under the restriction of the Ministry of RO. Most tasks and responsibilities, however, have not yet handed over to OW-MCP (Table 3). To allocate the tasks between OW-MCP and the IWs the Steering Committee Water Boards was established, under the Chairmanship of the District Commissioner. For only one IW a charter has drafted in which the rules for operation and maintenance have been formulated. This charter, however, has not yet got legal status (Grijpstra, 2008b). For all other polders, rehabilitation projects are in progress or planned before the responsibilities are handed over. The activities of these project include the following:

- Preparation of action plans to (re-)activates the IW's.
- Rehabilitation and upgrading of the canals and structures.
- Organisation of operation and maintenance.

Table 3 Organizations involved in the water management in the Nickerie district and their responsibilities

Organization	Duties & responsibilities
Water Board OW-MCP	O&M Wakay pumping station, Corantijn Canal and MCP polder
Ministry of Public Works	O&M main irrigation – and drainage canals, including the inlet works at Nanni and HA, Clara pumping station and all drainage sluices
Ministry of Agriculture and Fisheries	Operational management of the Wakay and Clara pumping stations, the distribution of water between the polders and O&M of IKUGH inlet and some main drains
Ministry of Rural Development	O&M of all other works
Districts Commissioner	Water management inside the polders
Internal Water Boards	Chairman of the Steering Committee Water Boards

Interviews with staff members of these organizations were conducted to collect data of the existing system, including an assessment of the existing problems and proposed improvement options. Based on these interviews and the existing literature a first model schematization of the system was developed (Figure 8, right). During a presentation to representatives of the above mentioned organizations this first schematization was discussed and an inventory was made of the perceptions of the involved stakeholders of the benefits and limitations of the proposed modelling approach. The first schematization was favourably received and it was decided to collect additional information on water levels and discharges with the aim to further develop the existing monitoring programme. This existing monitoring programme has been set up by OW-MCP, in cooperation with the Anton de Kom University; automatic water level recorders have been installed at strategic locations in the irrigation canal network to monitor water levels, e.g. at the van Wouw intake structure (Figure 9). The ultimate aim of this monitoring system is to regulate the required water flows to the separate polders. At present, however, the number of regulation structures is too limited or their operational status is too poor, to manage the system properly.

Field trips were made to update the inventory of dimensions and operational status of the existing canals and structures (Nienhuis, 2011) and to do some additional flow measurements. The data was used to improve the schematization of the Corantijn Canal and to formulate recommendations for further modelling studies and monitoring programmes. Again these recommendations were discussed with the stakeholders (Nienhuis and Pieters, 2011) and are currently implemented.

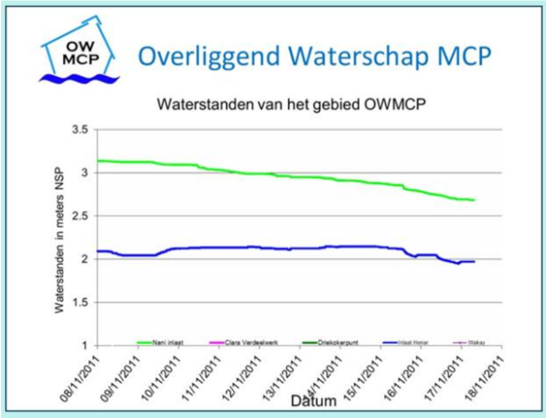


Figure 20 An automatic monitoring network has been established to continuously monitor water levels at strategic points in the irrigation system (www.owmcp.org/waterstanden).

Train-the-trainers course

The results of these studies were used to develop a curriculum for a train-the-trainers course, i.e. lecture notes and PowerPoints. The target group is mid-career professionals working in the rice sector, i.e. trainers, extension workers, foremen of the large commercial enterprises, etc. The objective of the course is to give these professionals the tools and capabilities to disseminate their knowledge to other (small-holder) rice producers and production workers. The subjects cover the complete rice production cycle, i.e. seed production, land preparation, crop and water management, mechanization, organization and marketing. The course is based on the following didactic principles (Verrijst, 2011):

- Constructive learning: starting point is the knowledge and experiences of the participants.
- Social learning: leaning from each other, i.e. participants from each other as well teachers and participants and vice versa.
- Practical oriented learning: the starting point is the actual situation in the rice sector in Nickerie.
- Participatory learning: learning by doing, both in the classroom and in the field.
- Competence-oriented learning: an integrated approach focussing on all aspects of rice production and the capability to disseminate the obtained knowledge.

In November 2012, a one-week training was conducted for 18 professional working in the rice sector in Surinam.

Conclusions

At field level, the daily fluctuation of the level of the standing water was monitored in both levelled and unlevelled fields to study the effect of levelling on water use. In addition, the agricultural management practices were monitored to assess the effect of levelling on crop yield. Fields in four representative polders were selected: (i) Hamptoncourt polder (1 226 ha) in the eastern part of the district representing small farmers (average plot size 2.3 ha) with a gravity irrigation system; (ii) Clara polder (1 245 ha) in the western part of the district also small farmers (average plot size 3.4 ha) but in a pumped irrigation system; (iii) Euro Noord (1 035 ha), also in the western part but cultivated by bigger commercial farmers (average plot size 6.5 ha), and; (iv) the Tewarie polder, an extension of the Nanni-east polder in the western part of the district and cultivated by a commercial estate (average plot size 12 ha). In the unlevelled fields the variation of the ground surface is as high as 0.35 m; on average more than 25% of the fields have an elevation that is more than 75 mm above or below the average. In the levelled fields this percentage was reduced to around 10%. The main benefits of the levelling were not so much water savings, as no significant differences were discovered between the water consumption in the levelled and unlevelled fields, but in the levelled plot the average depth of the water layer was more in line with the recommended depth of 0.10-0.15 m. As a result the yield in the levelled plot increased from 1.8 to 2.6 t/ha. These yields are still well below the potential yield (5-6 t/ha), mainly because the larger fields size makes it virtually impossible to maintained the recommended depth of the water layer. Furthermore, the agricultural management practices are aiming at reducing operational costs and not at maximizing yield.

A participatory modelling programme was initiated to get a better understanding of the functioning of the water management system and to investigate whether simulation models can be used as a tool to facility the discussion between the various organizations involved in the water management in order to assist them to make informed operational and strategic decisions. DUFLOW, a one-dimensional, non-steady state, model for water movement and water quality was used. Models like DUFLOW require long-time data sets, which were not available, thus new ways have to be found to validate the model. The traditional validation process was replaced by joint plausibility discussions and shared vision building in order to improve the understanding of cause-effect relationships and proposals for water management measures. The aim was to match the tacit knowledge of the local stakeholders with explicit scientific knowledge in order to obtain a consensus of opinions among the stakeholders. The main system was modelled and calibrated using measured water levels (available since 2010) and in-situ discharge measurements. In addition, many interviews with operation and maintenance staff of the various organizations involved in the O&M were conducted and their tacit knowledge of past extreme events was used for validation. Results of the simulations were discussed with these stakeholders and proved to be a useful tool to get a better understanding of the complex water management system. The results were used to formulate a follow-up research programme and the associated measuring network. In November 2012, the project was concluded with a one-week train-the trainers course for 18 professional working in the rice sector in Surinam. Although, the VERRIJST-project has formally ended, research and monitoring activities are continued on an ad hoc basis.

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Annex 1 Polders on the left bank of the Nickerie River supplied by irrigation water from the Nanni Swamp and Corantijn River (Naipal, 2005).

	Area [ha]	Average plot size [ha]	No. of fields
Western part:			
• Nanni	1,062	5.5	194
• Nanni Bruto	358	5.3	68
• Clara	1,245	3.4	365
• Corantijn	747	1.3	573
• Van Drimmelen	850	1.5	568
• Waldeck	84	0.7	120
• Sidoredjo	164	1.0	169
• Margarethenburg	104	1.1	92
• Euro Zuid	1,140	5.3	214
• Euro Noord	1,035	6.5	160
Total Western part	6,789	2.7	2,523
Eastern part I:			
• Boonackerpolder	171	4.3	40
• Paradise A & B	313	1.4	222
• Uitbr. Par. 1 t/m 4	395	1.9	206
• Longmay and Extension	375	1.2	314
• Hamptoncourt A t/m G	1,226	2.3	540
• Krappahoek G(a), H(b)	130	1.8	71
• Sawmillkreekpolder	236	2.4	97
Total Earstern part I	2,846	1.9	1,490
Eastern part II:			
• Groot Henar polder	2,100	4.0	520
• Klein	141	1.8	78
• Middenstandspolder	1,431	21.0	68
Total Eastern part II	3,672	5.5	666
Extension Groot Henar polders:			
• Extension Groot I	1,200	11.1	108
• Extension Groot II	750	11.7	64
Total Extension polders	1,950	11.3	172
Grand total 'old' polders	**15,257**	**3.1**	**4851**
MCP polder (under development)	**12,500**		