Production of greenhouse vegetable crops; Principles for humid tropical areas

This study was prepared under Good Agricultural Practices (GAP) for Greenhouse Vegetables Crops. Principles for Tropical Climate Areas (Suriname), 2014 – SURAGRIC – 009, funded by the COMCEC.

Production of greenhouse vegetable crops; Principles for humid tropical areas

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with a
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Table of Contents

Figures

Tables

Boxes

Acronyms

ADEKUS	Anton de Kom University of Suriname
ADRON	Anne van Dijk Rice Research station Nickerie
AKF	Agrarian Loan Fund (*Agrarisch Kredietfonds*)
ALCOA	Aluminum Company of America
CAHFSA	Caribbean Agricultural Health & Food Safety Agency
CARICOM	Caribbean Community
CELOS	Centre for Agricultural Research in Suriname
COMCEC	Standing Committee for Economic and Commercial Cooperation of the OIC
EC	Electrical Conductivity
EDB	European Development Bank
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GOS	Government of Suriname
ICT	Information & Communication Technology
IDB	Inter-American Development Bank
IPM	Integrated Pest Management
ITCZ	Inter Tropical Convergence Zone
MAAHF	Ministry of Agriculture, Animal Husbandry and Fisheries
MRL	Maximal Residue Level
NAIB	National Agricultural Innovation Board
NATIN	Institute for professional agricultural / technical training
NFT	Nutrient Film Technology (type of hydroponic system)
OFA	Open Field Agriculture
PA	Protected Agriculture
PE	Polyethylene (type of plastic used for roof film and other materials)
PTC	Poly Technical College
PVC	Polyvinyl chloride (type of plastic used for roof film and other materials)
SRD	Suriname Dollar
T&T	Trinidad and Tobago
UNASUR	Union of South American Nations
USD	United States (of America) Dollar

Executive summary

In times of decreasing prices of its minerals Suriname is more aware of its great agricultural potential. Vegetables long have been a minor but steady export item to her Diaspora in the Netherlands. This trade is stagnant the last years and in the domestic market the share of import vegetables is increasing. Fruit exports have revived with the restart of the banana company for exports to the EU. Vegetables production also needs to become more professional by being less liable to adverse weather conditions. Greenhouse production gives vegetables growers more control on quality & quantity of their year-round produce.

In order to assess the on-going transfer of production areas of vegetables from open field to protected horticulture this study was done as part of the COMCEC project *Good Agricultural Practices (GAP) for Greenhouses vegetables crops; Principles for Tropical Climate areas (Suriname)* which aims at "*increasing the quality and effectiveness of the public services to support and train farmers in growing crops in a responsible manner taking the tropical climate into account".*

Production area of greenhouse crops in Suriname is still modest, just over 3 ha protected horticulture. Half with shadow roofs/houses and the other half with, most simple, greenhouses with soil as major growing medium. Crops like celery and tannia leaves dominated the shadow structures and in the greenhouses crops were more divers.

Most growers were satisfied with the results of their protected horticulture, both in terms of produce and financial results. Problems with marketing and pests & diseases were dominating, problems with input supply was more related to the technology level.

Data on costs and earnings of their activities were scarce, cost accounting is not a common activity. Most growers wanted (more) training and support from the extension service. Also within the extension service training in greenhouse production systems was requested.

Marketing was a major problem for most, despite their satisfaction with the financial results. Challenge for the commercial medium technology growers will become to market their produce on a limited domestic market of 0.5m consumers, successful export is depending on a still insecure bureaucratic system, without cold stores available at the airport and high transportation costs.

Government has to commit itself to solve/ease these problems for growers and exporters. The National Agricultural Innovation Board has to be installed, this board will coordinate and manage innovative agricultural activities, among them horticultural activities. Agricultural extension staff will be trained in this project, reorganization of the extension service is still needed. The agricultural research sub-department vegetables unit needs to be strengthened. The laboratory for residue analysis, under construction, should be in operation as soon as possible to monitor food safety for the own population and for export.

Market information is needed by farmers and extension staff to make better decisions in the management and planning of their farms.

Barriers still exist for exporters, including the handling of produce on the airport and the bureaucracy with three ministries and banks involved.

Greenhouse production systems are in the lift, new private investments in structures and technology are made. Professional colleges now have courses on greenhouse production and in debates on climate change the need to change our food production systems is stressed.

More consultations and more cooperation in and between public and private partners is needed to strengthen this positive innovative trend in the country. Well documented experiments and field trials will convince more farmers to choose for innovation by greenhouse production systems adapted to the farming environment of Suriname.

Introduction

This study was done as part of the COMCEC project *Good Agricultural Practices (GAP) for Greenhouses vegetables crops; Principles for Tropical Climate areas (Suriname)* which aims at "*increasing the quality and effectiveness of the public services to support and train farmers in growing crops in a responsible manner taking the tropical climate into account".*
The Ministry of Agriculture, Animal Husbandry and Fisheries (MAAHF) is project owner.

Protected Agriculture (PA) is *modification of the natural environment to achieve optimum plant growth.* It is an intensification of the traditional open-field agriculture (OFA). Several methods are used: greenhouses, tunnels and shade houses are examples. The greenhouse is recently a part of the horticultural production systems in Suriname and most greenhouse growers have less than ten years' experience.

The term greenhouse was defined as:

> **greenhouse** – *building with glass sides and roof, for growing and protecting plants*
>
> (Penguin Wordmaster Dictionary, 1987)

Although the definition is for temperate climate zones, the meaning of the word and the structure itself have evolved for use in other climates including the humid tropical zone. The purpose is still to grow and protect plants.

This study is linked to a training of senior extension staff in greenhouse production systems, main subjects will be general greenhouse management and plant propagation & nursery management. Six foreign participants (3 from Turkey and 3 from Guyana) will also be trained in this 'Train the trainers' activity for twenty technicians of Suriname.

The technicians of the ministry will transfer the acquired knowledge to the other extension officers and farmers in their region. In general farmers and consumers are interested in greenhouse production of vegetables, creating more controlled growing conditions for crops. Less impact of adverse weather conditions will lead to more and better quality produce year-round.

Together with this study a manual will become available dealing with greenhouse production of vegetables crops in the humid tropical climate areas. Overlap of topics of this study and the training manual is evident and practical subjects are dealt with more extensive in the manual. An important source is the greenhouse manual published by CARDI in 2014. This Caribbean manual is not yet well known in Suriname, despite its relevant content.
Other important and practical works on growing vegetables and their pests & diseases will be digitally available for the participants of the training.

1 General information on Suriname

The Republic of Suriname is located on the northern coast of the mainland of South America. The country is a member of the Union of South American Nations (UNASUR) and also one of the larger members of the Caribbean community (CARICOM). So potentially the country could play a role in promoting more trade and services between South America and the Caribbean economies. The republic with an area of approximately 164.000 sq. km is formed by 10 districts with the southern district Sipaliwini covering nearly 80% of the total area. Suriname borders the French department Guyane in the east, Brazil in the south, Guyana in the west and in the north the northern Atlantic Ocean. A map of the country is shown in Figure 1.1.

The population was 541.638 on August 13, 2012 and which increases each year by 1.2 %. The population is mostly concentrated in the coastal belt with the district of Paramaribo having 1323 persons / sq. km. The southern district Sipaliwini, 80% of the country, has only 0.3 persons / sq. km. Most populated areas are situated in the coastal lowlands, with about 90% of all people living and working at less than 10m above the (rising) sea level. Highest peak in the country is 1230m, less than 2% of its area is more than 750m above sea level.

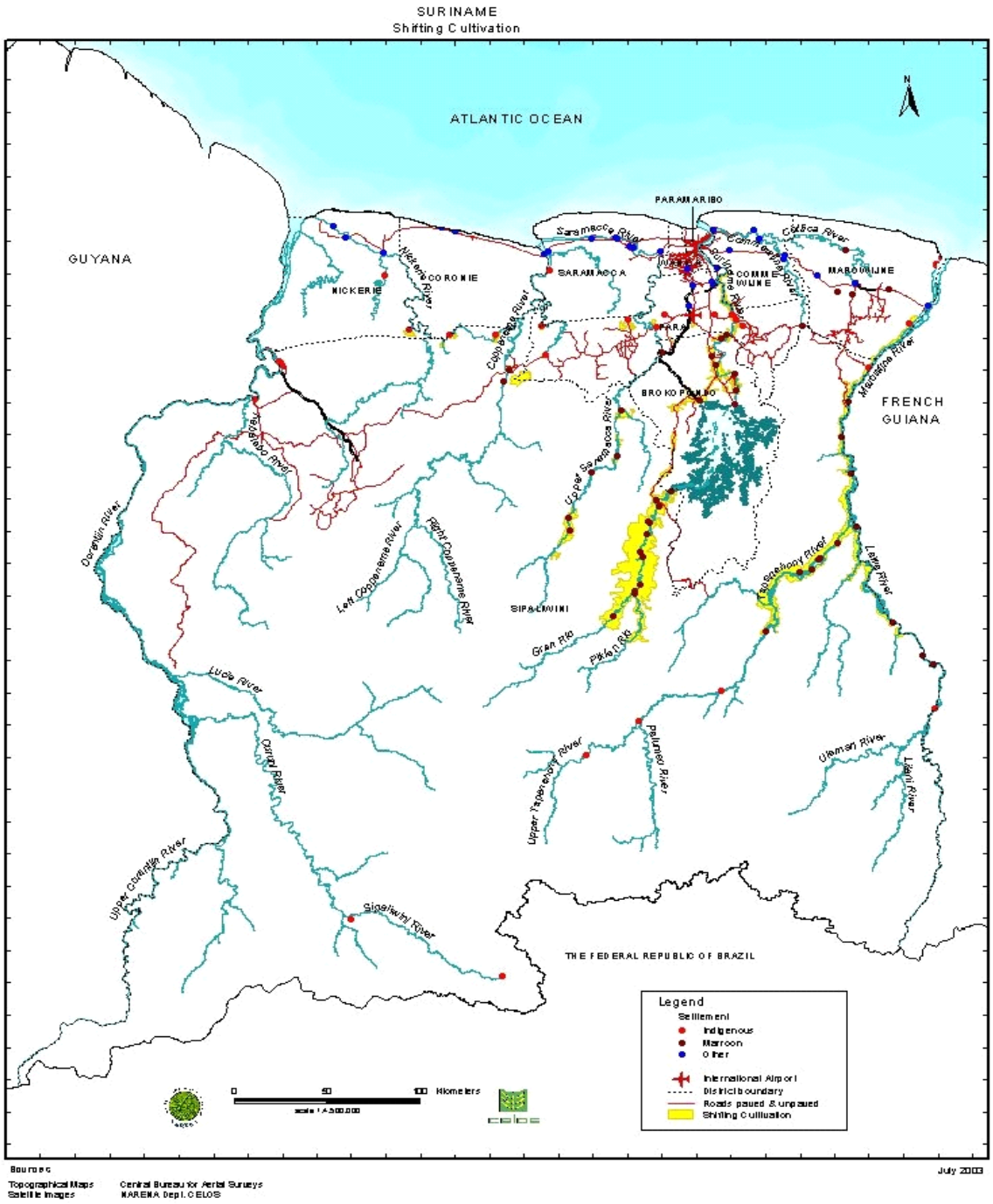
The average age of 30 years indicates a rather young population, mostly living in urban areas (70%). About 81% is economically active, with 17% in agriculture. The government employs a great part of the workforce, at least 54.000 people, despite long-standing efforts to reduce the number of workers in the civil service. The official language is Dutch and at least 15 other languages are spoken. Lingua franca is Sranan, which most people command.

1.1. Economy

The gross average national income per capita was in 2014 USD 10.337 (CBvS, 2015), which is about the mean figure in CARICOM. This is an average and the income distribution is rather skew. Oil, gold and ore are the most important sources of income, these three contribute to 95% of export earnings (ECLAC, 2015). The annual economic growth over the last 5 years was 3.8%, this figure was last year (2014) still 3.4%, despite dropping prices for oil, gold and alumina/aluminum on the world market.

The alumina operations of ALCOA were dozens of years the most important source of income and export earnings. The alumina operations of ALCOA will shortly be transferred to a new state owned company. The global financial crisis since 2008 was less manifest in the country. With the start of a new gold mine operation of the US firm Newmont in 2016 and the expansion of the state owned oil refinery (expected to be in full operation end of 2015) the outlook for the coming years is reasonable good. Post- May 2015 elections statements show less favorable trends hinting at more structural adjustments in policy the coming years, while prices of most minerals are on the decrease.

Figure 1.1. Map of Suriname (CELOS, 2004)



Suriname is part of CARICOM Single Market and Economy (14m people) since 1995, the economic integration in the region is yet meager. Only 14.6% of export of goods from Suriname goes to Latin America and the Caribbean. Main trading partner are the United States. Agricultural products as bananas are sold to the EU, the export of rice is in the last years becoming problematic. Major foreign investments of the last years have been the expansion of the Iamgold Rosebel goldmine and the new mining operations by Newmont.

Import and export data are shown in Table 1.1. Major items in exports (2014) are metals, oil derivatives and alumina. Main import products were mineral products, (electrical) machinery and transportation.

Table 1.1. Exports and imports from/to Suriname in period 2010 – 2014 in USD. (Source: CBvS, 2015)

	2010	2011	2012	2013	2014
Merchandise exports (USD m)	2.084,1	2,466,7	2.694,8	2,394,3	2.145,1
Merchandise imports (USD m)	-1.397,9	-1.679,1	-1.993,5	-2.173,7	-2.012,3

Suriname ranks 110 in the Global Competitiveness Index 2014-2015, in previous years the ranking was rather similar. Some scores in this index are hard to improve like *market size* but others should improve. Some indicators to enhance competitiveness of the Suriname market are slightly better than the countries in the region: *macroeconomic environment*, *health and primary education* and *technological readiness.* Most problematic factors for doing business, as seen by business executives, are *inefficient government bureaucracy*, *corruption*, *access to financing* and *inadequately educated workforce* (World Economic Forum, 2015).

Compared with most CARICOM countries electricity costs are still low. More realistic rates are announced. Fuel prices have risen since a levy, 'the government take', was introduced and twice increased. Agricultural enterprises are not exempted from this levy.

1.1.1. agricultural import and export

Main agricultural export products of the country are rice, bananas, fish & fish products and shrimps. Total agricultural exports in the period 2007-2011* were SRD 248.338.000 a year on average. In 2013 total agricultural exports reached SRD 373.967.000, continuing an upward trend since 2010. Fresh vegetables and tubers/roots had in 2007-2011 an average export value of SRD 4.747.000 (2.888 ton) and in 2013 the export value was SRD 4.123.000 (2.806 ton).

Import of agricultural products is substantial higher than export results. Import of food, beverages, vegetable oil, processed meat& fish etc. was in 2007-2011 on average SRD 467.726.000 a year. In 2013 more import, SRD 1.039.204.000, was reported. Specific data on import of fresh vegetables is difficult to obtain, since fresh vegetables, potatoes and onions are mixed up in the customs data.

A research in 2011 (Grauwde, 2011) reveals the specific data on fresh vegetables, given as an average per year in the period 2005-2010 (Table 1.2.). Separating items like onions, potatoes and processed vegetables results in net SRD 1.3m for fresh vegetables instead of more than SRD 18m a year. The value of imported fresh vegetables is an average over 2005-2010, imports over recent years will probably have increased.

* data of 2012 were not complete due to technical problems

Table 1.2. Breakdown of imported fresh and cooled vegetables and roots / year, over 2005-2010.

Vegetables and roots	***Value in SRD (x 1000)***	***Remarks***
Imported fresh/cooled vegetables in total	18.774	
Potatoes and onions	15.557	*Yams, sweet potatoes, cassava etc. are alternatives. Local onions cultivation is not profitable.*
Processed vegetables	1.895	*Local processing is limited*
Fresh vegetables, partly suitable for substitution by local PA	1.321	*PA produce like tomatoes, cabbage, lettuce, broccoli form opportunities*

Adapted from: H.J. Grauwde (2011) (source: import statistieken Ministerie van LVV, 2005-2010).

Destination markets of bananas is the EU, of fish and shrimps the EU and USA. Main markets for rice are the Caribbean and the EU, both on average buying half of the export (IDB/FAO, 2013). The export of vegetables is mainly to the Netherlands and sales are limited to Asian stores and market vendors.

1.2. Climate

Suriname has in general a humid tropical climate (*Af* according Köppen classification). In the tropical lowlands temperatures are fairly constant year round. From December till March mean minimum temperature is 22° C and in the other months 23° C. Average maximum temperatures vary between 29° C from December till March and 33° C in September and October. In the hinterland the daily temperature amplitude is greater, particularly in the dry season up to 12° C.

Sunshine duration and direct solar radiation are affected mostly by the cloud cover, air moisture content and the angle of the sun over the year. In Figure 1.2 data is given for Paramaribo in 2005, indicating higher levels in the second half of the year. Radiation data is limited to one series in 2005 (Fig. 1.3.).

Figure 1.2. Sunshine duration in hours per month in Paramaribo in 2005

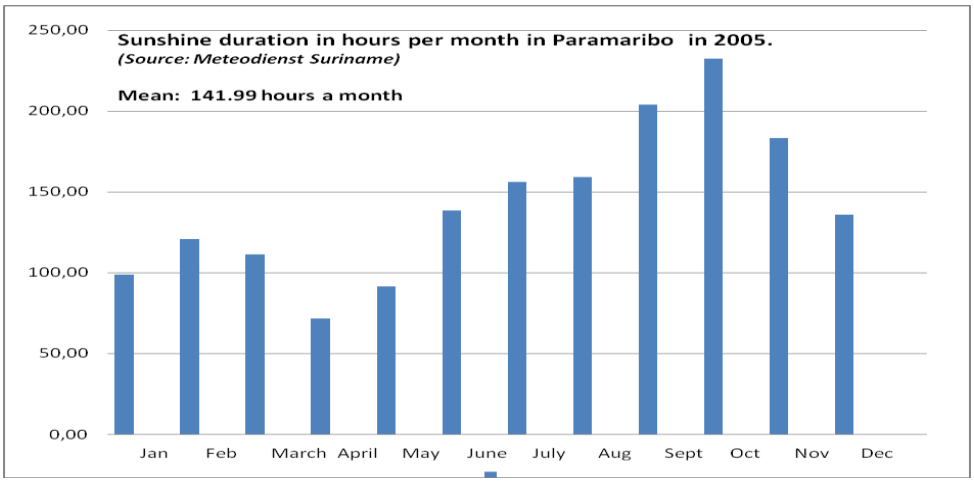
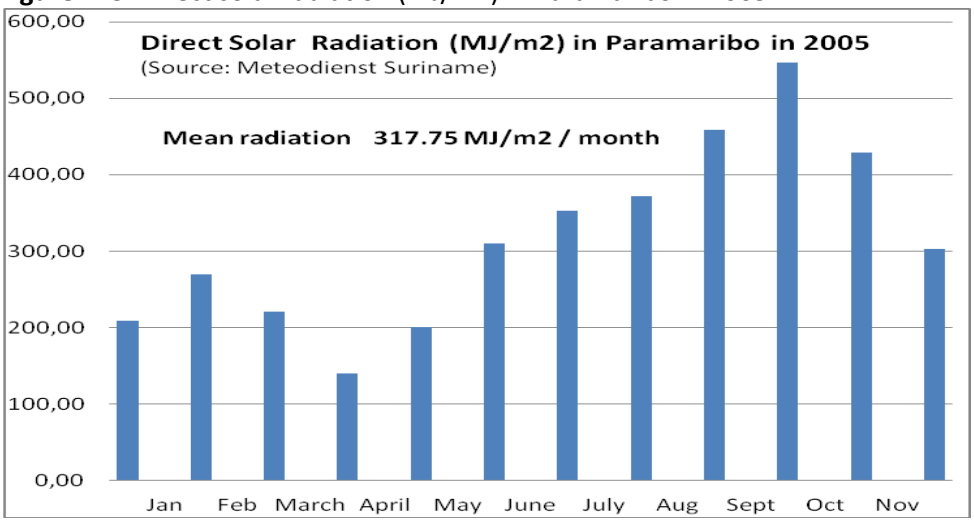


Figure 1. 3. Direct solar radiation (MJ/m2) in Paramaribo in 2005



Available meteorological data of most locations are limited to daily rainfall, which has the greatest variability and is the most decisive factor in determining the seasons. Long uninterrupted series of data are scarce, due partly to the internal war and economic woes in the 1985-2000 period.

Suriname has four seasons a year: the long rainy season, the long dry season, the short rainy season and the short dry season. Some years the short dry season is not pronounced, in these cases the short rainy season gradually becomes the long rainy season. The center of the Inter Tropical Convergence Zone passes the country twice a year, creating a northeast trade wind in most months and a southeast trade wind in the long dry season (Fig 1.4.)

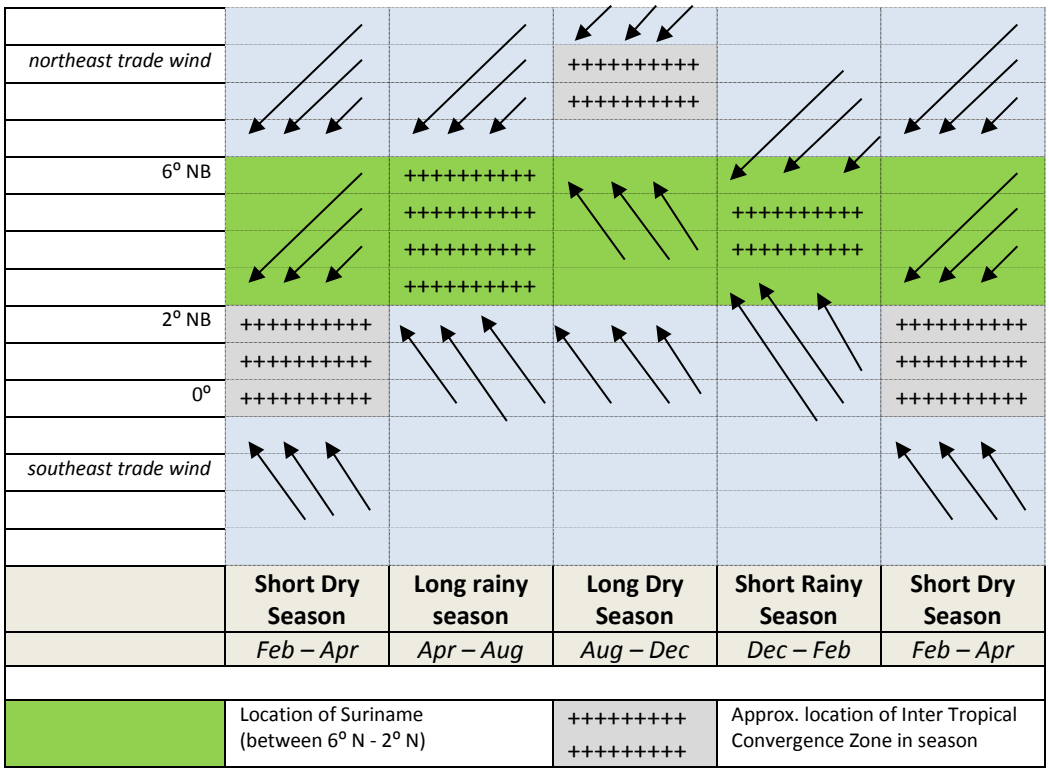


Figure 1.4. *Position of Inter Tropical Convergence Zone and dominant trade winds in seasons. (Adapted from SPS / OAS, 1989)*

In most parts of the country yearly rainfall is between 2000 and 2500mm. The wettest months are May and June and the driest months September and October. The northern part of the Coronie district, the zone of the coastline, has traditionally less rain, about 1500 mm.

The mean wind force is 1.3 Beaufort (~ 0.7 m/s) with a maximum of 1.6 Beaufort (~ 1 m/s) in February and March and a second peak in September and October (SPS/OAS, 1989). Wind force is strongest in the dry season. During the day wind speeds of 3.0 to 4.0 Beaufort (3.5 - 7 m/s) are regularly measured. In the evening and at night the wind usually grows calm. Wind direction depends on the position of the Inter Tropical Convergence Zone (ITCZ), most frequent wind directions vary between east-northeast and east-southeast. Climate change is likely to cause more extreme weather conditions, in particular storms / gusts of wind. In combination with sea level rise this will affect the agricultural activities. Up to now most activities are done in the low lying coastal plains with complex water management issues.

1.2. Agriculture

The agricultural sector is still important for its contribution to the national economy. The share of agriculture in Gross Domestic Product (GDP) was calculated at 6.8% between 2005 and 2009. The table reflects the contribution of the agricultural sector to the national economy between 2009 and 2013. With a contribution of 55% the sub-sector fisheries showed the best results and agriculture and animal husbandry registered 34% and 11% respectively. In 2013 the most important export products were rice, banana, fish and shrimps.

The export value of the agricultural produce was 115 million US dollars, the value of imported agricultural products was estimated at US$ 320 million.

Table 1.3. Contribution of agricultural sector to the national economy in 2009-2013 (x1000 SRD)

Description	*2009*	*2010*	*2011*	*2012*	*2013**
Agriculture	217.333	214.333	211.002	216.413	207.260
Animal husbandry	74.273	83.291	76.438	81.358	68.880
Fisheries	268.958	287.275	298.898	302.365	329.630
Agricultural sector	560.564	584.899	586.338	600.136	605.770
Total GDP	8.648.292	9.005.523	9.427.129	9.861.187	10.144.938
Share of agricultural sector in % in national GDP	6.5	6.5	6.2	6.1	6.0
Imports of agricultural products	446.650	433.825	605.718	605.923	1.039.204
Exports of agricultural products	219.860	267.213	331.011	396.123	373.967

Source: Algemeen Bureau voor Statistiek & statistieken Ministerie van LVV * preliminary figures

1.3.1. Farming Areas

Suriname covers some 16 million hectare of land of which 1.5 million hectare of land is considered suitable for agriculture. Of this suitable land 85% is part of the coastal plains and 15% is formed by river terraces in the hinterland.

Rice is the main crop in the western region, paddy production is concentrated in the Nickerie district where intensive mechanized monoculture of paddy prevails. In three other districts mechanized rice was cultivated, but most of this production has stopped. Only in Saramacca and Coronie some farms still produce paddy. Two crops a year are feasible, but cropping intensity dropped from 1.5 in the eighties to just over 1.0 in 2014.

Table 1.4. Rice acreage planted in main districts; period 2010- 2014.

		Planted acreage in ha		
district	Standing acreage in ha	2010	2012	2014
Nickerie	50.800	51.660	50.435	60.103
Coronie & Saramacca	9.020	1.895	944	2.108
Total	59.820	53.555	51.379	62.211

Source: statistieken Ministerie van LVV

The banana industry recently has been privatized and is producing well again after poorly performing around 2000. The banana firm is operating on two estates: one in Nickerie (1012 ha) and one in Jarikaba (1253 ha) near Paramaribo. With a workforce of around 2500 people, production at 40 ton/ha and a major investment plan of EU being implemented the export of bananas to Europe is preserved and export to the Caribbean is developing.

The livestock sector is characterized by large numbers of small producers, only some poultry, pig and beef producers have larger integrated operations with farms, processing and retail shops in and near Paramaribo. Poultry farms still struggle to improve their market share of just 30-35% after losing ground in the economic crisis in the eighties and nineties. Eggs, pork and beef have a much larger market share, only in the catering industry imported pork and beef is used. Poultry is the main meat source for consumers in Suriname, around 50 kg poultry per person a year is used (LVV, 2011c).

1.3.2. Water management

Our coastal area is characterized by low and flat alluvial land, which is affected by high and low tides in the river estuaries. The agricultural land consist most of polders, these land areas need good drainage systems to manage the water levels in canals and ditches. Water management infrastructure with canals for drainage and irrigation, sluices and pumps has been constructed. This infrastructure needs proper maintenance to make maximum use of the fertile alluvial and marine soils for the agricultural production of the country.

The older polders originate from the former plantations, each plantation was an entity and the maintenance of the polder infrastructure an essential part of the system. Reclamations and part of the old polders are divided in lots for individual farmers, since then maintenance has to be organized by cooperation of the owners or the government.
High costs of this maintenance has forced government to make a major effort to (re-) establish so called water boards for certain drainage areas. These boards which are administrated by elected committees have the responsibility to organize maintenance of the main infrastructure of their area and collect taxes of landowners to finance the operations.

The water boards should also improve the quality of irrigation water for farmers by separating drainage and irrigation water properly. The efforts to (re-)establish water boards have been delayed, partly because three ministries are involved: the ministry of agriculture, the ministry of regional development and the ministry of public works. Not all farmers are aware of the need to improve water management in their production area in a decentralized approach.

Maintenance of drainage infrastructure is mostly still done by these three ministries. Lack of funds, poor coordination and different priorities result for parts of some farming areas in inundations of farmland in the rainy season and lack of irrigation water in dry periods of the year. Innovation of agricultural production systems will not succeed if water management in rural areas is poorly organized, investments in better production systems will be (too) risky for farmers.

1.3.4. Farmers Profile

Figures of the Agrarian Census of 2008/2009 are used for this profile. Suriname had 10.244 farms in 2008, near all were family farms (10.188). The main objective of 57% of these farms was selling the produce to the market. Overall men were the head of the farm (65%), in the tribal areas women managed two third of the farms. In most cases the age of the manager of the farm, men and women, was between 45-54 years.

Most farmers have lots of less than 0.5 ha and up to 2 ha. Only 14% of the farms use hired labor, in most cases rice farms that use temporary workers during peaks in the season (harvest). Most farmers only had primary education or less, farmers with higher education (university and 18+ professional training) are a minority of just 3% (~ 300 farmers).

Most farmers in the coastal area are part time farmers, combining farm work with other jobs that provide the farmer and his/her family social benefits. Combined with their overall poor education it is clear that farmers' organizations do not prosper in these circumstances. The few active cooperatives are mostly focused on sale of input for their members.

2 Protected horticulture in Suriname

Since few data were available on protected agriculture in Suriname a limited survey was done to get basic information on these increasing activities. Data gathering was done together with the extension service of the sub-directory agriculture of the ministry using short questionnaires. In session with the (senior) staff of the extension service the purpose of the project was explained. The next steps of preparing a manual, the training of senior staff, training of other staff members and, most important, support and train greenhouse farmers were discussed.

Small shadow roofs mostly with leaves as cover and used as nursery were known for generations. Use of shadow roofs/houses increased with the introduction of synthetic screens which made larger shadow structures more feasible and durable. More extensive structures were set up and mainly ornamentals and green vegetables (celery and tannia) grown.

Within the ministry greenhouse activities were initiated in 1999 by a paper of staff members of the agricultural research station. In 2004 within a FAO CARICOM Food security program a project *'Improved vegetable production'* started with IPM and protected horticulture components (FAO, 2004). Vegetable production was characterized as predominantly labor-intensive on small-size plots, with large consumption of pesticides and artificial fertilizers and with a great risk of crop failure. Five greenhouses were set up to acquire experience with new vegetable production technologies. In 2015 three of these greenhouses still are in production: one at the agricultural research station, one as nursery for an agricultural cooperative and one used by a lettuce & herbs grower.

In 2007 extension staff started with the Surisombra greenhouse, an adapted model using local materials for the structure and soil as growth medium. This cheap type (~ SRD 6.000, 120m2) was later introduced in nearly all districts by making model greenhouses near the field offices of the extension service. A few private growers begun around fifteen years ago with (simple) greenhouses and successfully tried to adapt techniques from other countries like Nutrient Film Technology for innovative vegetable production in Suriname.

2.1. Data

In the Agricultural Census of 2008/2009 no distinction was made between Protected Agriculture (PA) activities and Open-field Agriculture (OFA) activities of farmers in the different districts (LVV, n.d.). Data on greenhouses as such was not gathered and in the regular data collecting process this distinction is not made up to now. A complicating fact is the disparity between the administrative boundaries used by MAAHF and the other government institutions. The administrative center of Wanica is in the division of MAAHF the 'domicile' of the field office of another district (Para). In this report the PA activities around this town were incorporated in the data of the district of Wanica.

The data presented here was gathered with assistance of the extension service of MAAHF, with field offices and staff in all coastal districts (Annex 1).

This service has been working in most rural areas of the coastal districts for dozens of years and the knowledge of the (activities of) farmers was important for this study. For a lasting impact on the improvement of PA activities this extension service will have to cooperate close with these farmers. Some field offices were performing well, data was obtained timely and the staff was familiar with the situation in the area. The response of other field offices was less, probably indicating a lack of involvement in the (protected) agricultural activities in their district. Some field staff was unaware of all (activities of) PA growers and on the other hand some PA growers were not willing to give information to MAAHF staff. In some areas less than expected PA growers were located, in other cases structures turned out to be abandoned. In a few cases data of growers in the capital of an updated survey of 2012 were used. Data of (demo) greenhouses of the ministry itself were not included in total areas with PA of the different regions.

However, the situation was more complex. In the planned data collection period (April – May) other public activities involving MAAHF staff were staged. In April the *Agro / Made in Suriname Fair* mobilized most of the management and workforce of the field offices in order to make the stands of the ministry successful. The Fair was in a way part of the mobilization efforts for the elections for parliament and district councils on May 25, 2015. In rural areas extra efforts were made by the government to make (last-minute) improvements on the rural infrastructure and donate input. These circumstances made it for some extension officers difficult to fully engage in the data gathering process.

2.2. Greenhouses

Greenhouses were developed in more temperate climate zones to grow plants in the colder seasons or from tropical origin by retaining the warmth of the sun. A greenhouse is a structural building with different types of covering materials, such as a glass or plastic roof and glass or plastic walls; it heats up during daytime because incoming visible sunshine is absorbed inside the structure. Air warmed by the heat from warmed interior surfaces is retained in the building by the roof and wall; the air that is warmed near the ground is prevented from rising indefinitely and flowing away.

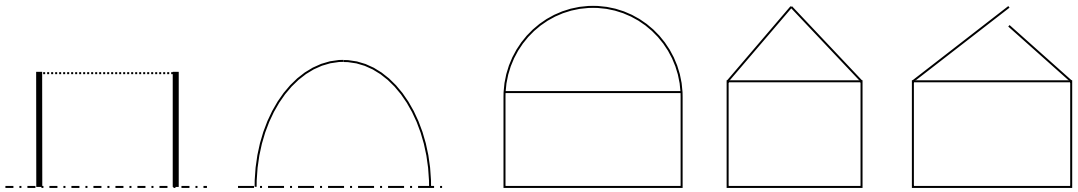
From this first concept adaptations were made to create a better growing environment in other climates where other aspects of climate were adverse to optimal plant growth. In the humid tropical regions greenhouses were introduced to control adverse aspects of the climate resulting in a better environment for crop production. Excessive rainfall in the rainy season and subsequently a favorable environment for diseases are the main reasons for growing crops in these structures. In the dry season excessive sunshine and/or drought may have impact on crop production. These aspects of the humid tropical climate make production volumes and produce quality less predictable what could result in dissatisfied local and overseas customers. Better control of the microclimate favors the quantity and quality of the produce.

The term greenhouse is every now and then used in a broad sense covering all PA structures. A distinction should be made:

Greenhouses have waterproof roofs and in most tropical countries insect proof netting around the sides. Height of the side walls should be 3.50m or more. Within this group a further distinction is made between the types of roof: a *gable* roof or an *arched* roof. If these roofs are provided with vents they are called *split gable* and *split arch.*

Tunnels have also waterproof roofs and may have insect proof netting on the sides. The distinct feature with greenhouses is the height of the sidewalls which is (much) lower. For this reason they tend to be warmer.

Shade roofs / houses are shade providing structures which allow rain to reach crops and soil.



Before discussing the main types of PA structures in Suriname the basic aspects of the greenhouse environment are treated. Optimum plant growth conditions should be managed by growers in a timely and economic manner in order to achieve maximum yields. Plant stress is limiting growth and development of crops resulting in suboptimal yields and returns.

2.2.1. temperature

Temperature is important for plant growth thus for time to maturity. Round the equator there is no or little variation in temperature and maturity time of vegetables is in general more or less constant throughout the year. Non-heading lettuce is mature in Suriname in 5-7 weeks and at 25 degrees latitude in spring it takes 8-10 weeks.

High temperatures form a great threat to production in tropical greenhouses. High temperatures above 30^{o} C to 35^{o}C will cause all sorts of damage to crops from slowing its development to even death. Fruit abortion may occur in these circumstances. Problems caused by temperatures lower than optimum, like slow growth and minimal fruit setting, are unknown in Suriname.

The effects of high temperatures depend on the type and cultivar of plant. Less productivity caused by problems with fruit setting is well known. Lettuce can taste bitter caused by high temperatures. Day as well as night temperatures influence the performance of the plant. For most vegetables a day temperature 5^{o} to 8^{o} C higher than night temperature is beneficial to get their maximum yield.

2.2.2. light

Suriname has during all seasons a short day length. On most of the days (continually) overcast conditions prevail, average sunshine duration is 4.7 hours. Maximum sunshine duration is about 8 hours around October, minimum on average about 2.5 hours around April, depending on the location of the ITCZ. These two facts combined can reduce light levels available for crop growth to below optimal levels. Light levels fluctuate during the day and also between the seasons. High light levels occur on bright sunny days, most in the dry season.

Even during the morning or afternoon in the rainy season high light levels could last several hours. In the rainy season overcast conditions may occur several days on a row resulting in low light levels affecting crops like tomatoes. Radiation can be as low as 150 MJ/m2/month in the rainy season and may reach more than 600 MJ/m2/month in October (Figure 1.3. in § 1.2. climate). In agronomic terms the average direct solar radiation is 1060 Joules / cm2/ day, with peaks around October of 1.800 Joules /cm2 / day and lows around April of about 450 Joules / cm2 / day.

Insufficient light levels regularly occur in structures, partly because the roof material is not clean. Predominately plastic films are used as roof covering, which transmit 85-90% (PVC) and > 90% (PE) of the light. Maintenance of the covering by cleaning them regularly is very important, depending on the circumstances at least 1-2 times a year. Only clean coverings of roof or both roof and (partial) sides of the greenhouse transmit enough light over the years they function (good quality PE and PVC film may last 4 to over 5 years).

Other causes of insufficient light levels could be the use of improper plastic film covering and/or shade netting. Vegetation or structures near the greenhouse can cast shadows on the greenhouse. Situated near the equator this could mean no radiation during the morning hours, for the metabolism of crops the crucial period of the day. Within the greenhouse the plant density can be too high, reducing the amount of radiation that reaches the leaves. Using white materials for grown bags and ground cover may improve light quality in the greenhouse.

Efforts to reduce heat in a structure might result in a reduction of light intensity. Heat is the infra-red part of light, so separating them is difficult in the management of a greenhouse. Mist or fog systems can be used to reduce the temperature in the structure without reducing the light.

Some plants, ornamentals as well as (leafy) vegetables, thrive under reduced light conditions in shade houses. Shade cloth is used in nurseries and growers of green vegetables like tannia leaves and celery use it by choice. **Shade cloth** is sold in different colors, shade densities and qualities. In Suriname plastic shade cloth is popular, a brand from Italy is favorite and durable (> 15 years). Shade densities vary between 30% and 80%, meaning a 30% shade screen has 30% light exclusion and 70% of the light passes through. A clear indication which density is best for which crop according growers was not found: the range was 30% to 75% with the two extremes mostly used for both main shade house crops (tannia and celery).

2.2.3. ventilation

Ventilation is one of the most important aspects in a greenhouse structure. Ventilation means the exchange of air within the structure with air from outside the structure.
If there is no proper ventilation in greenhouses in the tropics heat and water vapor accumulate during daytime hours. Even carbon dioxide may reach suboptimal levels. In closed structures with sides of plastic film and/or fine mesh screening the rate of fresh cool air entering the structure is mostly insufficient. Conditions with high temperatures and high relative humidity will develop within hours. Vegetables 'growing' in such an environment get stressed, what ultimately results in problematic plant growth or even worse. Detailed research was done in Indonesia regarding ventilation capacity, mesh width of screens and the microclimate in structures (Campen, J.B., 2005; Harmanto, M., 2006).

As indicated wind speed is limited in most parts of the country. Normal wind speed near the ground is low to very low, so replacement of hot and saturated air in any greenhouse structure is slow too. During daylight the sun warms up the air under a structure and the hot air rises to the roof. It is important that the height of the crop is well below the height of the structure. In most cases a height of at least 5m and of side walls of 3.5m is advised. Vents in the roof construction can make the hot air leave the greenhouse creating a lateral movement at lower levels of cool air from outside into the structure. This lateral movement should be nearly unhindered. Obstruction of wind flow can be caused by buildings or vegetation near the structure or by (fine mesh) screens and/or plastic foil side walls. The sides determine the minimum height above the crop, which is important in hot humid areas as day temperatures rise above 30^{o} C. A temperature air buffer of at least 1.6m height above the crop for open side structures and for closed structures >3m is recommended.

Most farmers in Suriname prefer open structures. In other regions the use of fine mesh screening to prevent pests from entering structures is a common method. This causes ventilation problems, a balance between pest prevention and ventilation has to be found. One major reason for open structures might be the complex and expensive problem of using forced ventilation in the structures. In Suriname forced ventilation is rarely practiced. The quest for better control of the growing environment might ultimately force growers to use fans during warmer periods. Most structures are rather isolated from other similar activities and this may diminish the risk of pests and diseases.

In some areas farmers use nets to prevent iguanas and birds from damaging crops. The nets used mostly have a wide mesh size, so wind speed will only be reduced slightly in the structure.

Location and orientation of the greenhouse must be careful decided on. Maximum light intake, a must in the rainy season, and good ventilation by the trade winds have to be achieved. Vents in the roof are usually located in such a way that passive air movement out of the structure is achieved.

2.2.4. moisture

In a tropical greenhouse high temperatures and low humidity form daily problems. Most crops prefer a humidity level between 50% and 70%. In closed structures this level may rise above 70% causing fungal diseases.

Most greenhouses are open to half-open structures and in general less than 10m wide, resulting in moderate differences between humidity of the outside air and the inside air. However, essential moisture of plants is lost, plants may dry out and wilt. Especially in the dry season an adequate humidity level must be maintained.

Greenhouses have a waterproof roof, so part of controlling the environment has to be irrigation. A variety of systems is developed from the manual hosepipe to drip irrigation, mini sprinklers and overhead misters. The hosepipe is not unusual in simple greenhouses, especially those who evolved from shade houses. Water from ditches is hosed to the crops using a (gasoline/diesel) water pump. Creative farmers did build small water pumps on rafts, which float in the ditches between the beds while the farmer spreads the water on the soil underneath the crops.

The system of **drip irrigation** is increasingly used, being economical and better available in shops. Two types are used, one for cultivating in soil and one elongated dripper with fine tubes for 4-8 plants in soilless media in pots.

Sprinklers are popular but increasingly the negative aspects of their use are mentioned. The system uses more water and has the inability of precise delivering the water to all plants. It also waters the whole plant, leaves & stem, thus inviting more fungal diseases in the warm (humid) greenhouse.

Mist or fog systems are used to reduce the temperature in the structure without reducing the light. Small droplets of water are sprayed with high pressure nozzles, the evaporation of the droplets results in cooler conditions and increased relative humidity.

The availability of **water of good quality** is a major condition for agriculture, in particular for successful growing of vegetables. In the manual for the greenhouse training course basic information on the production factor water is given. Water quality, water needs, water storage, water application techniques, fertilization etc. are dealt with. The CARDI greenhouse manual discusses the various aspects of water in the production system.

If more technology is used water parameters like electrical conductivity (EC) and pH are important. Optimum pH range is 5.2 to 6.8, tap water in the coastal area ranged between 5.2 and 7.8 (PROPLAN, 2004). EC is a measure of total dissolved salts in water and should be less than 1.5 mmhos/cm for irrigation purposes and in specific cases with germinating plants less than 0.6 mmhos/cm. The CARDI manual deals with management and treatment issues.

If used for greenhouse production systems water should be tested for the presence of nutrients, soluble salts, etc. Water quality may influence the availability of fertilizers and other chemicals, influence the growth and quality of crops and also clog nozzles.

Levels of CO2, HCO3, iron and chloride vary in tap water and water of other sources. A study of the water works (SWM) in 2003 determined the chemical levels of tap water in coastal areas, the range is given in Table 2.1.

Table 2.1. Average chemical quality of SWM water plants in and around Paramaribo (2003).

parameter	CO2 mg/l	HCO3 mg/l	pH	Fe mg/l	Cl mg/l	CaCO3 mg/l
range	5-40	8-180	5.2-7.8	0.08-1.97	9-290	76-282

Source: adapted data from PROPLAN (2004).

Water treatment like reverse osmosis is recommended in technologically advanced systems.

2.2.5. media

Growing media provide the plants

- a place to anchor
- nutrients for its development and growth
- a water reservoir between the times water is applied
- gas exchange between root and atmosphere (roots need oxygen for respiration)

Growing systems are the local soil, soilless media in pots and cultivating in water (hydroponics).

Most PA farmers use the local **soil** as growing medium for their crops like in open field agriculture, 64% of the total area. To improve the quality of the soil measures are taken like adding extra organic matter. Reasons for using soil as medium are obvious. Less financial input is needed to prepare the medium by adding manure and /or compost, fertilizers and raising beds for drainage, etc. The traditional system of using open field soil has evolved in order to get more control of the growing environment of the crop and thus better control of the production. Each step to improve the control requires financial input.

A first step to improve (the control of) the growing medium is to use soil in **pots or plastic bags**. It reduces spread of diseases. Heat treatments to sterilize soil might be needed if weed problems, pests and/or pathogens occur. Pots are preferred to plastic bags, but more financial input is needed to buy (hundreds of) pots. Especially pots / pails are used when nematodes did occur before. In areas with poor drainage or liable to inundation in the rainy season and also farms close to the ocean with brackish soils switch to pots for cultivation of plants.

A second step is to use pots / bags with **organic or inert media** like coco peat, compost, peat moss, sand, perlite (crushed rock) and vermiculite (heated sand). Coco peat and other organic material 'deteriorate' slowly and need replenishment. In particular compost, what decomposes at a faster rate.

Hydroponics is the process of cultivating plants in nutrient enriched water, two main groups can be distinguished: solution culture and medium culture. Medium culture uses a solid medium for the roots like sand culture and gravel culture. Solution culture uses a nutrient solution for the roots and three types are distinguished: static solution culture, continuous-flow solution and aeroponics.

Static solution culture is applied in **raft** techniques, plants are placed in a sheet of buoyant plastic that floats on the nutrient solution basin. This way the solution level keeps in contact with the roots. Raft technique is now being applied in Suriname on a larger scale, it is less sensitive for power outage than the nutrient film technique (NFT) culture.

In continuous-flow solution culture the nutrient solution flows constantly along the roots. In Suriname the **nutrient film technique** (NFT) is popular, especially for lettuce production. In plastic channels a very shallow stream of nutrient solution is circulated along the roots of plants. On the bottom of the channels roots have contact with water and the moist top of the roots is in contact with air, so plant roots have adequate supplies of water, nutrients and oxygen. Design of a NFT system is crucial: using the right channel slope, the right flow rate and the right channel length. A major disadvantage is the need to monitor very closely, interruptions can be fatal in hours and diseases can spread between plants as the water is shared. NFT production sites range between 70m2 and 1500m2 in area.

Aeroponics is a system where roots are kept in an environment saturated with fine drops, a mist, of nutrient solution. Excellent aeration is the main advantage and the technique uses at least 50% less water than hydroponics.

In more than 11.000 m2 of structures soilless production was practiced, in over half (6.000 m2) a NFT system was used.

2.2.6 shade roofs / houses

Shade roofs / houses are shade providing structures which allow rain to reach crops and soil. These structures are simple and easy to construct with modest investments. For the construction of mainly shadow roofs in Suriname posts of walaba (*Eperua* spp) hardwood are mostly used, which in general resist termites and are durable. For the roof structure (painted) (hard) wooden slats, iron wire or nylon wire are used. The shade screens are available in different qualities and grades.

Within PA in Suriname shadow roof / house cultivation of vegetables and flowers is popular, more than 15.000m2 was observed. A relatively modest investment results in better (quality) production compared to open field cultivation. Of all the farmers with shadow house activities about a third indicated that they wanted eventually to improve their structures by replacing the shade screens by plastic film. Yet replacing screens by plastic film is complex. The structure, mostly 1.30 – 2.20m in height, needs to be adapted. First in height, otherwise the temperatures will rise too much. Next step is making a (gable) roof construction. In case the shade roofs have a width of > 8-10m, dividing in two structures is practiced to solve problems with ventilation and more expensive constructions.

2.2.7. tunnels and greenhouses

Tunnels have waterproof roofs and may have insect proof netting on the curved sides. The distinct feature is the height of the sidewalls which is (much) lower compared with greenhouses. For this reason they tend to be warmer and not suitable for all type of crops. A minority of the structures was of the tunnel type, made mostly of galvanized iron with plastic film as roof. Height 3-4m and width of 8m.

The (**split) arch** greenhouses were mostly imported kits with partly screens and partly plastic film as side wall material. An arch type kit, imported from Australia, is designed for other climate conditions. The ventilation capacity is too small, it has to be adapted for the humid tropical climate conditions of Suriname. Panels in the side walls or vents should be installed to improve ventilation resulting in lower temperature levels inside the structure. Plant growth was hampered even in the rainy season. Aspects of closed structures on production in lowland humid tropical climates are discussed in Annex 2.
The **(split) gable** type is mostly chosen by people who build the structures themselves with timber. With special care the slats are made smooth and no plastic solving coating is used to prevent the plastic film to tear easily.

Though most structures didn't have **guttering**, it is recommended because

- collection of rainwater for irrigation purposes
- the drainage on the surroundings of the structure can be better organized preventing water-logged conditions around / in the greenhouse
- and in case of a closed structure: with no runoff falling on the screens of the sides the growth of algae & moss is much less; this growth can restrict ventilation substantially

On different sites we saw identical split arch models where the use of a bent profile to strengthen the structure underneath was questionable. This profile looks like a gutter element and guttering was not installed on all of them.

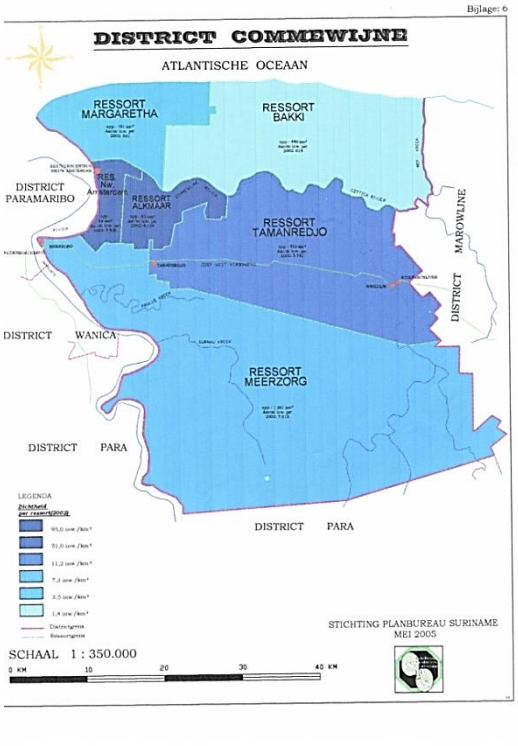
2.3. Main regions with protected horticultural activities

The main data of the survey are given per sub-region in the back of the report. In total 32.269 m2 were surveyed for protected horticultural activities, 15.362 m2 under shade and 16.907 m2 in greenhouses. Soil was the main growing medium, 20.791 m2. The area with non-soil production was 11.478 m2, of which 6024 m2 was used for NFT production.

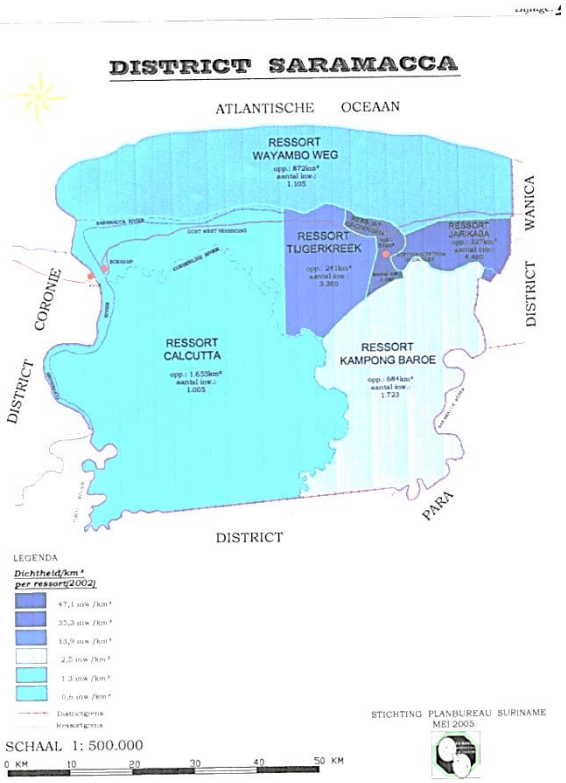
The results of the survey indicate three major areas within the coastal districts. The districts of Saramacca and Commewijne and within the Wanica district the Santo area are leading in number of growers and/or in PA area. More technology was found in and around Lelydorp with, in Surinamese context, advanced systems / items like raft, deep water, use of reverse osmosis water filters, daytime extension with light bulbs and mechanized shade screens.

Some characteristics of the three major PA areas are given in Box 1 – Box 3. A comparison between these major PA areas is made in Table 2.2.

Box 1. Characteristics of district of Commewijne

district of Commewijne **Population in 2012:** **31.420** (in 1980 20.063)	Agriculture in Commewijne	Agro Census 2008 mentions in total 1060 farms: 94 grew green vegetables, 257 fruit vegetables (*Solanaceae*, *Momordica*, etc.) and 119 legumes. For all annual crops 89.7 ha was in use.
	Main soils used for agriculture	Ripe polder clay, sometimes loam Ridges with shells and sand
	Number of identified PA growers	17
	Type of greenhouses	shade roof (66% of area) gable and arch (34% of area)
	Mean area /greenhouse	141 m2
	Total area with PA production	2.394 m2
	Main PA crops (area) Main growth medium	tannia leaves (> 53%) celery (> 22%) paprika (12%) Soil is used as medium in 97% of PA area
		***Particulars*** ** the water supply system for the greater part of this district is not functioning properly yet, farmers have major problems, especially in the long dry season* ** a firm specialized in in-vitro planting material is simmering after problems with replanting plantations of the local banana company (2200 ha)* ** a small scale private initiative tries to stimulate greenhouse production with local small farmers, claiming a market for vegetables in the Netherlands. They started with small pilot greenhouses.* ** the district is booming since a bridge replaced the ferry to Paramaribo in 2000. Traffic jams near the bridge hamper good access during peak hours.* ** at a distance of 120 km along a good paved road is French Guyana, part of the EU. The capacity of the ferry connection to French Guyana is restricted to passenger cars and small trucks.*

Box 2. Characteristics of district of Saramacca

district of Saramacca **Population in 2012:** **17.480** (in 1980: 10.808)	Agriculture in Saramacca	Agro Census 2008 mentions in total 893 farms: 122 grew green vegetables, 221 fruit vegetables (*Solanaceae*, *Momordica*, etc.) and 185 legumes. For all annual crops 893.5 ha was in use.
	Main soils used for agriculture	Ridges with sand and shells, Ripe marine clay Ripe polder clay, sometimes loam
	Number of identified PA growers	15
	Type of greenhouses	shade roof (64% of area) split arch (36% of area)
	Mean area /greenhouse	747 m2
	Total area with PA production	11.205 m2
	Main PA crops Main growth medium	tannia leaves > 50% lettuce (NFT) 27% Main medium is soil (73% of area), NFT is 27%
	***Particulars*** *. the water supply system in some farming areas is absent or insufficient to deliver in the dry season* *. a local firm, in process of GAP certification as grower, also is (export) trader. Some farmers grow vegetables on its lands. PA part of production is small, but growing.* *. in this district less farmland is converted in housing areas .*

Box 3. Characteristics of district of Wanica

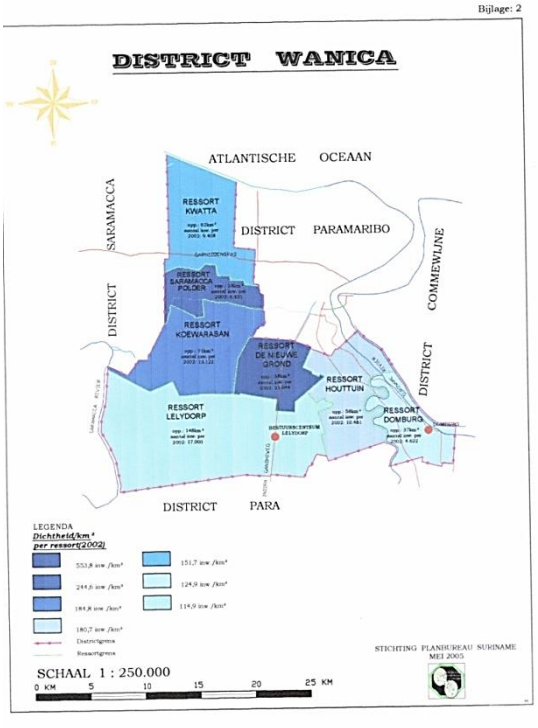
district of Wanica **Population in 2012:** **118.222** (in 1980: 60.725)	Agriculture in Wanica	Agro Census 2008 mentions in total 2016 farms: 288 farms grew legumes, 257 green vegetables and 399 fruit vegetables (*Solanaceae*, *Momordica*, etc.) For all annual crops 165.3 ha was in use.
	Mains soils used for agriculture	Ripe marine clay, Ridges with sand and shells, Ripe polder clay, sometimes loam
	Number of identified PA growers	Wanica-A: 5 Wanica-B: 4 Wanica-C: 14 Lelydorp: 3 In total 26 PA growers
	Type of greenhouses	shade roof (60% of area) greenhouses (40% of area)
	Mean area /greenhouse	607 m2
	Total area with PA production	15.796 m2
	Main PA crops Main growth medium	Wanica-A (Kwatta) : several Wanica-B (Houttuin) : tomatoes / tannia leaves Wanica-C (Santo) : celery Wanica/Para (Lelydorp) : lettuce Main used medium is soil (58%). Non-soil media (raft, coco peat, NFT) reach **42%**!
	***Particulars*** *. the water supply system in some parts of the district is not functioning properly yet* *. a grower just expanded his greenhouses to 5000 m2 with medium technology. A young entrepreneur with drive, a competitor for growers with basic technology and less controlled growing conditions* *. Wanica is situated between the capital with the seaport and the international airport. Some 70% of the population lives in the capital and its outskirts in Wanica, giving this district a logistical advantage.*

Table 2.2. Comparison of Protected Agriculture activities in three districts and Suriname

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aspect	*Commewijne*	*Saramacca*	*Wanica*	*Suriname*
Number of PA growers	17	15	26	72
Mean area / PA grower (in m2)	141	747	607	448
GH as part of PA (%)	34	36	40	52
Total GH area in m2	806	4040	8912	16.907
Non-soil media (% of area)	2	27	42	36

In Commewijne the PA areas are smaller and the cultivation methods still rely on soil as growing medium. In most cases land will be available to increase PA activities. Anticipated problems with marketing extra produce could be one of the reasons for the limited PA plots. The near absence of soilless cultures will be related to the traditional crops and the unreliable water supply. Producers don't want to depend on expensive water delivery with water trucks in the dry season. Soil as medium is a better buffer in times of water shortage.

In Saramacca soil is also prevailing as a medium, here two NFT growers with each 1500m2 lettuce raise the soilless presence substantially. One NFT grower complains about water shortage and expensive water supply by trucks.

Wanica is leading in PA area and also in soilless cultures. More populous, close to the markets and better infrastructure are some of the advantages of this district.

2.4. Crops

A variety of crops are grown in the PA structures. The vegetables types are less than in OFA, some vegetables are not grown (yet) in more controlled conditions. Okra and bitter gourd were among them. Other crops seem limited to greenhouses, herbs like basil, mint and coriander have niche markets as they are mainly used in restaurants.

Celery and tannia leaves are 'traditional' shade house crops, greenhouse growers with soil and soilless try to grow celery also. Given the (persistent) problems with leaf spots they might succeed in producing better quality celery and so get their share of the market.

Typical greenhouse crops are lettuce (NFT), tomato, paprika and herbs, a smaller number of growers also produce cauliflower, broccoli and Chinese cabbage varieties. In Table 2.3. the incidence of crops in greenhouses is given. In Annex 3 a fact sheet of tannia is given. Information on pests and diseases is dealt with in the training manual and also the CARDI manual gives a good and well-illustrated survey of the pests and diseases in vegetables.

Table 2.3. Incidence of vegetables types in different PA structures* in Suriname

Type of vegetable	***Shade house w. soil***	***Greenhouse w. soil***	***Greenhouse w. soilless c.***	***Remarks***
Celery *(Apium graveolens)*	+++	++	++	*problems with brown spots on leaves (Cercospora apii)*
Tannia leaves *(Xanthosoma sagittifolium)*	+++	++	-	
Paprika / sweet pepper *(Capsicum annuum)*	++	++	++	
Chilies /pepper *(Capsicum annuum)*	+	+		
Tomato *(Lycopersicon esculentum)*	+++	+++	++	*Beefsteak and plum model, in 2 cases the cherry type*
Eggplant *(Solanum melongena)*	+	++		*elongated purple fruit*
African Eggplant *(Solanum macrocarpon)*		+		*round white fruit*
Lettuce *(Lactuca sativa)*	+	++	+++	*Most lettuce in NFT cultures, Vera variety popular*
Cabbage *(Brassica oleracea var. capitata)*		++		
Cauliflower *(Brassica oleracea var. botrytis)*		++		
Broccoli *(Brassica oleracea var. italica)*	+	+		
Chinese cabbage (amsoi,kai choi) *(Brassica chinensis)*	+	++	+	
Chinese cabbage (kailan) *(Brassica alboglabra)*		+	+	
Various herbs	+	++	++	*Basil varieties, mint, coriander,*
Cucumber & Gherkin *(Cucumis sativus)*		++	+	*Cucumber more cases, gherkin in 2 cases (raft and NFT)*

+ - few cases ++ - regularly +++ - common *(incl. LVV / ODL structures)

2.5. Technology

Technology level in most PA activities on farms is low. Most shade house growers and greenhouse growers using soil as medium do the cultivation manually. Watering of the crop is done with sprinklers / drip irrigation by some growers, but many others apply pumps to get water from ponds and ditches and use a hose. Most activities in these production systems still are labor-intensive. Most farmers focus at low cost production and low external input. The model greenhouse of the extension service, introduced in 2007/2008, uses these facts as a starting point by promoting 'inexpensive' greenhouse models with soil as medium to get more farmers interested in innovation.

Monitoring the parameters of the microclimate in structures is seldom done. In the open structures there is enough supply of fresh and cool air from outside. In nearly closed structures the minimal supply of air from outside could change the parameters like relative humidity and temperature in a short time. Up to now the group of growers involved can take few actions to improve a stressful situation for their crop.

Basic parameters for environmental conditions are light, temperature and relative humidity. The instruments used for measuring these parameters are still improving and some new devices can measure several parameters. Data loggers are capable of measuring and storing all the environmental parameters.

Other important measurements are in the root environment: soil pH, soil moisture and electrical conductivity (EC). In modern soilless systems the environmental monitoring and control can be integrated with the use of among others extractor fans and irrigation/ fertigation controllers.

Items like data loggers and the use of forced ventilation and misting systems are not common yet in Suriname. Soil analysis is done by some farmers, using the soil diagnostic service of the MAAHF research sub-department. Hydroponics growers do have equipment for EC and pH measurements to adjust the nutrients solution regularly.

Prolonging daylight hours is done in rare cases for some ornamental production. General use of these techniques is not foreseen. Misting to lower temperatures within structures will be applied more in new greenhouses.

Within the research station greenhouse technology is used, primarily adapting existing techniques for the greenhouse growing environment in Suriname.

The total area with PA activities is still rather small and most growers use on average no or limited technology. Most farmers involved however express a desire to improve and/or enlarge their structures. A desire to increase the use of technology was in most cases not expressed.

NFT and other hydroponics growers are liable to disasters if monitoring of the growing environment is not done well. For that matter they are interested in using more technology. Farms are often classified according their use of technology in low-, medium- and high-technology farms. It might be better to use instead of medium- and high tech the description *best-fit* technology taking the whole environment and gradual improvements in account.

Mentioned were some imported greenhouse kits with fine mesh screens and no other ventilation devices. These structures are not apt for growing crops in the local conditions. Individual growers mostly won't be able to monitor the conditions and the impact of 'do-it-yourself' adaptations. Assistance is needed to adapt these structures in a way they will eventually function properly in our humid conditions. Adaption to improve ventilation & cooling needs should be based on actual readings of key parameters, assistance of MAAHF staff seems appropriate.

2.6. Productivity

Recent data on productivity in (protected) horticulture in Suriname are scarce. Individual growers mostly do not collect and process data, sharing them is also not common. In the statistical data of MAAHF production from protected cultivation are mixed with open field production. The different types of protected production systems will have other levels of productivity.

Production levels of crops are strongly influenced by the chosen variety, the period of the year (sub-optimal light) and overall the growing conditions, dependent on used type of production system. Within protected cultivation the production levels are strongly influenced by the level of control. The traditional passive growing system has changed in an active system influencing the growth conditions of the crop. Optimal water and fertilizers for the root system, optimal ranges for humidity, light and temperature will boost production in quantity and quality.

Data on production in MAAHF Surisombra greenhouses show significant higher production levels, details on the trails and data for a prolonged period are not available.

Table 2.4. Production of vegetables in Surisombra and open field conditions.

Crop	*Variety*	*Surisombra production*	*Open field production*
Cauliflower	Green seed	2.0 kg/plant	1.2 kg/plant
Broccoli	Sunny	0.8 kg/plant	0.3 kg/plant
Tomato	Headmaster	8.7 kg/plant	5.1 kg/plant
Tomato	Hybrid 1	13.9 kg/plant	4.7 kg/plant
Paprika	Giant Bell	53 fruit/plant	12 fruit/plant

From: Grauwde (2011) based on MAAHF / field office Kwatta data

Some varieties are developed for greenhouse conditions and produce less in open field conditions. Data on tomato production per m2 in the world range from 4-5 kg in open field conditions to over 70 kg in high-tech greenhouses. Quality will vary also, depending on the microclimate, levels of protection, etc.

Factors affecting production in Suriname are among others heavy rainfall and waterlogged situations, water stress and diseases & pests. Only part of these factors are better controlled in most greenhouses in Suriname. Limited sunlight levels might even affect production if the maintenance of the roof material is overdue. More data on the production of vegetables in different protected horticulture systems are necessary for good analysis which production systems are best adapted to innovate our horticulture.

2.7. Horticultural policies

In the 2010-2015 government statement '*Crossroads – Together towards better times'* increasing the food production was among the key priorities, focusing both on food for local consumption as well as for the international, in particular the Caribbean, markets.

After a sector wide Policy Note of the ministry in early 2011 white papers were prepared in the second half of 2011 for the main agricultural subsectors with priorities for development and growth of these subsectors namely: Rice, Bananas, Livestock, Horticulture, Fisheries & Aquaculture, Agribusiness, Agricultural Health & Food Safety and the Agricultural Development of the Interior.

Issues in the white paper Horticulture are:

…. Increase in productivity, more products per unit area, will necessarily lead to increasing export, because the local market for agricultural products in Suriname is limited. ….

…. The modernization and optimization of the Surinamese horticulture can only be manifest through an integral value chain approach. A profound analysis of the existing situation, which preferably should be based on standard methods, is a prerequisite for an integral value chain innovation and optimization …..

…. Innovation of agriculture, together with sustainability is the main challenge for the agricultural sector to maintain the strong competitive position …..

(MAAHF, White paper Horticulture, 2011)

Among the strategies:

- Increase the awareness of the farmers of international standards and technology transfer in the field of Integrated Crop Management (ICM), Integrated Pest Management (IPM)and Good Agricultural Practices (Gap, Global Gap and HACCP)
- Stimulate the production of non-traditional crops (cauliflower, leek, paprika, carrots and lettuce) and other production methods (organic crops, greenhouses)
- Increase the acreage with vegetables for prioritized vegetables (long bean, okra, hot pepper, eggplant, tannia leaves, bitter gourd), the precise crops to be determined after a detailed market survey.
- Create a board for all stakeholders in vegetables production and marketing

In 2013 the ministry prepared the National Agricultural Innovation Strategy of the Republic of Suriname (LVV / IDB, 2013). Recognized is that, with the exception of rice, production volumes of agricultural commodities are too small to generate own technology. The strategy is to focus on import of agricultural technologies and their validation, adaptation and transfer to farmers. Key reforms are needed to implement the innovation agenda.
Not only staffing and infrastructure, also better coordination and collaboration within the system between research actors, between research and extension and between public and private sector need to be addressed. Integration of 'innovation-oriented research' and 'extension' activities into joint agricultural innovation projects with emphasis on concrete innovation results is seen as the proper way to act in the coming years.

In the pipeline are agricultural programs and projects with among others IDB, EU and Kaplan/Israel. The EU program 2014-2020 of EUR 13.8m will focus mainly on strengthening public and private capacity in the horticultural sub sector. Emphasis will be on safer, more sustainable and competitive production of horticultural (niche) products.

2.8. Research and knowledge

Agricultural research is spread over four centers in Suriname. The agricultural research facility of the ministry has a long tradition and has responsibilities for a range of topics. Among them is horticulture and this implemented by a staff of two. Greenhouse production is since 2005 part of the activities with the completion of a greenhouse. Research is among others done on hydroponics cultures. For contact with (potential) greenhouse growers a tour in the premises is organized every week. Though the section had no direct involvement in the extension model greenhouses activity, cooperation with the extension sub-department is good. Other sections of this research sub-department are important for vegetable production: entomology, nematology, mycology/bacteriology and soil & agro hydrology.

Two research centers, the Faculty of Technical Science and the Center for Agricultural Research (CELOS), are part of the Anton de Kom University of Suriname (ADEKUS). Their research role is not directly related to (greenhouse) vegetable production. The remaining research facility is the rice research institute ADRON in the western district of Nickerie, engaged in rice breeding, crop management and post-harvest research.

In our education system three institutes offer training in agricultural subjects. Two offered more recently courses on greenhouse cultivation of crops. NATIN, technical and vocational training for 18+, offers these courses. The Polytechnic College (PTC) has courses on greenhouse production as part of the agribusiness stream. In October 2015 a knowledge center for greenhouse production will be started, a first structure of 500m2 is ready and this area will be extended.

The Caribbean Agricultural Health & Food Safety Agency (CAHFSA) is based in Suriname. The MAAHF laboratories for analysis of agricultural produce, destroyed in a fire in 2010, have been rebuild. Equipment will be installed after the power supply is in place. Measurements of residue levels in produce is necessary for export, import and local produce. Residue levels of pesticides is an issue in export as regulations in (EU) countries are stringent and maximum levels low. Local produce and vegetables imported should be examined in a similar way to protect local consumers as well.

2.9. Finance

In the context of anticipated transition to more greenhouse production of vegetables potential new starters need cash to make the necessary investment. Furthermore they need finance to cover expenses, related to the running costs of the operation. Farmers cultivating (greenhouse) crops should monitor production costs and market prices consequently.

Greenhouse vegetable producers must supply products that meet consumer needs in order to achieve good market prices and control production costs. Producers must keep accurate records of their production costs to (help) develop pricing strategies for their products and monitor the profitability of their greenhouse enterprises and the level of technology used.

When cultivating greenhouse crops farmers have to deal with **variable** and **fixed c**osts.

Variable costs are costs specific to the production and marketing of a particular product, like:

- Labor;
- Materials and supplies (planting material, fertilizers & agrochemicals);
- Transportation;
- Repair and maintenance;
- Marketing;
- Miscellaneous (legal and accounting fees, office supplies, etc.);

Fixed costs include ongoing costs that occur whether the farm is in full production or not.

- Land value;
- Depreciation;
- Utilities (electricity, water, telecommunication);
- Property and building taxes;
- Administration costs;
- Interest on investment.

The greenhouse farmer should strive towards a situation where the price obtained when selling a product should cover all the variable and fixed costs and yield a profit.

A common misconception about **capital for investment** and **credit** exists that if only sufficient credit is made available to farmers, the lagging agricultural sector could be regenerated. This belief stems from the basic misunderstanding of the concepts of credit and capital. Many reckon the two as identical concepts and assume that through additional supply of credit additional capital necessary for development can be created.

Capital is not created merely by increasing the supply of money. Capital cannot be used as developmental tool if farmers are permitted to use their borrowings for consumption. Capital can be increased only through saving part of what has been produced.

Farmers in traditional settings have acquired amounts of capital that are consistent with their technology, land, buildings and labor capacity. This low level equilibrium can be broken only when there are profitable investment opportunities.

Greenhouse technology is an improved technology, superior to traditional methods and as such could be a profitable investment opportunity. Progressive farmers will understand this and become confident of using it in their operations. Preconditions are that associated support services and infrastructure facilities are present. A major problem in Suriname is that well documented field trails are not available yet for interested farmers.

One of the preconditions is credit to provide the required liquidity to farmers lacking sufficient funds to exploit the opportunity. Since 1972 Suriname has a (state-owned) bank providing loans particularly to the agricultural sector. This “Landbouwbank” manages since 2007 a new fund, the Agricultural Credit Fund (AKF), to accommodate small farmers. The maximum loan is SRD 200.000 (USD 59.700) with an interest rate of 7% and a grace period of six months.

This fund is successful in providing loans, however lagging repayments, shortage of funds and inadequate service to some subsectors indicate that adjustments are needed. The government has already promised adjustments like longer grace periods for some subsectors like fruit and cattle and also substantial extra funding in the coming years.

2.10. Economics

As indicated earlier data on the economics of greenhouse production of vegetables are scarce. Some indications were given by part of the farmers of the costs of their structure in case of shadow roofs and of greenhouses plus other investments in case of more sophisticated production units.

Costs of shadow roofs and shadow houses varied from SRD 2.50/m2 to SRD 27/m2, depending on many factors of the construction. Better quality of used materials, important to improve durability, will make it more costly. The surface area of the structure will influence the price per m2, more area will in general lower the costs per m2. Cheapest per square meter was an area of 2.000 m2 (40m x 50m) and most expensive a shadow roof area of 27 m2. All these structures have no technology. The average price was SRD 12.97 / m2 for shadow roofs. In Annex 4 some details of a production unit are given.

For greenhouse structures with NFT systems the costs ranged from USD 47 to several hundred of US dollars per m2. A greenhouse complete with NFT system, made in Suriname, area of 7m x 21m, costs SRD 28.800 (USD 58.50 / m2). In Annex 5 details are given of costs and returns with NFT lettuce production.

Galvanized greenhouse structures, made in Suriname, are now available. Also different imported kits of up to 250-300 m2 area, these are closed structures. The imported structures were not yet on display, ventilation capacity is unknown.

Grauwde (2011) made an analysis on basis of production observations with different vegetables in a Surisombra greenhouse (Table 2.4, page 33). The conditions of the experiment in the greenhouse, neither the open field conditions are clear. Although he warns to be careful with the figures, given the minimal experience with greenhouses yet, he concludes that

- the estimated farm gate prices make import substitution not feasible yet
- higher productivity and lower production costs are necessary to improve the competitiveness of local produce
- if local produce is competitive he expects importers will buy these vegetables locally

The costs and returns of a NFT lettuce unit in a ‘made in Suriname’ greenhouse, as mentioned in Annex 5, explain why this specific protected horticulture system is growing in popularity. With their experience in growing lettuce some growers already switched successfully to other crops like herbs and a variety of Chinese cabbages. Fears for over-production stimulate diversification of crops, which broadens the NFT crops spectrum.

A useful example of a greenhouse cost of production data template is given in CARDI (2014).

2.11. Organizations

Within the horticultural subsector few organizations exist, this year a group of hydroponic growers started with a new initiative to form a cooperative with emphasis on improving input supply. With support of MAAHF staff members and other advisers they already held meetings and training sessions. In Nickerie two groups of market gardeners are active, doubts over the title of their lots seems the main force for clustering. Within the remaining small group of vegetables exporters an association was formed, which represents the interests of the group.

Agrarian cooperatives in all parts of the country exist, most are (nearly) dormant. The farmers' cooperative of Kwatta is more active in running an input shop, a nursery and also working with other stakeholders in horticulture to promote farmers interests. Efforts of the Poly-technical College to set up a knowledge center for greenhouse production are supported by this cooperative by making land and other means available.

2.12. Quality management aspects

The processes of quality management focus on meeting the requirements of the customer by implementing standards for the production, harvesting, post-harvest handling and packaging in the successive greenhouse operations (CARDI, 2014).

Harvest

Harvesting the crop without damage and get it in the best possible condition to the market is the objective. Apart from production volume, labor situation and kind of produce, basically the following factors must be fulfilled in the planning of the harvest

- The available equipment must be appropriate
- Labor must be trained and organized
- For optimal timing of the harvest and the removal of the field clear maturity signs have to be known

Only experienced and/or trained staff will lead to an efficient harvest operation, all the time taking market requirements in account

Post-harvest

Maintaining quality from production to consumption is crucial in post-harvest handling. Efficient and swift field operations, cooling & storage, primary processing and packaging are needed before proper transport of produce is organized.

Field handling

The priority is to minimize stress on the produce by reducing the number of handling steps to a minimum and reducing the time between harvest and first treatment to an agreed period of time. Standards in this stage are shade and shelter, no storage on the ground and no piles of produce. Short distances to collecting spaces and swift transport for further handling are required.

Grading
Grading is an essential system for marketing of produce and will improve operational and pricing efficiency by providing buyers with clear information on price and product quality. The producers get also information what buyers require and what prices they are willing to pay for which grades. Grading of products has to be done according a system that punctually describes them in a uniform and significant way. Supply and demand for each grade could influence prices of more grades. Disputes are easier to solve as the value of a product is directly related to its grade.

Packaging
Market research should determine the type of packaging to be used. In most cases this type is aimed at either sale to wholesalers / distributors (plastic crates) or to the final consumer (shrink wrapping etc.). Packing facilities, for individual farms or for a group of producers, form a key step in quality management where selection, grading and quality control must be successfully implemented. Depending on the produce and the scale of the industry the operations in the facility may include

- Take delivery: receipt, checking and unloading of produce
- Treatment: washing, waxing, fungicide, grading, sizing and packing
- Storage: fumigation, ripening and cooling
- Dispatch: loading, checking and dispatch

Transport
The perfect mode of transport is a cooled van. Given the size of most farms transport in a chilled vehicle is usually not feasible. Mostly it is transported by a pick-up or open truck. Using these vehicles should meet standards like the produce is packed properly, the truck is clean and not overloaded. Transport itself should not take place during peak heat periods and during traffic congestion hours.

Standards need to be set and implemented
Record keeping and analysis of data: all technical and financial data have to be collected and processed to get new data that ensure effective management of costs and improve the quality of the produce

Training: every employee needs training in greenhouse production techniques and be stimulated to join forces to improve the production

Successfully implementing the above mentioned steps is the challenge for the horticultural sector in Suriname. Cooperation and discussions with all stakeholders and interventions from organizations in and outside the country will lead to a successful adaption of general ideas to make horticulture an important subsector in the economic development.

The efforts to implement Good Agricultural Practices in Suriname are summarized in Annex 6.

3 The market

The market in Suriname consists of just over 0.5 million consumers. Volumes and quality of the year-round local produce are fluctuating and standards for the production and handling are not available or not applied. Use of pesticides is by most growers not seen an emergency measure, but is still part of growing vegetables. Overall awareness about the risks of applying pesticides is growing, but the actual change is rather slow. Training in GAP standards is organized in most rural areas. Trade in vegetables with neighboring countries is minimal. Recurrent over-production periods occur every year and no alternative markets are available. Processing of vegetables is still done on a small scale.

Sale of vegetables by growers to wholesale buyers and at markets and outlets to consumers is mostly not based on weight of produce. The wholesaler buys 'sacks', 'bundles' and 'crates' as unit of produce and on the markets 'heaps' of fruit vegetables and small 'bundles' of long beans, amsoi, etc. are sold as unit. Weight (and prices) of all these 'units' may change every day. If prices are high heaps and bundles shrink, disguising part of the price hike. Some of the (larger) outlets have switched to packing vegetables like tomatoes, eggplant and beans in plastic bags, but a standard weight is mostly not packed / indicated.

As production of vegetables is fluctuating, so are the prices. In the rainy season prices are usual higher, in some years prices are up 200-300% for 4 - 8 weeks. In long dry periods supply is also affected and prices of some vegetables may soar.

Mainly supply and demand determine price setting, making prices change daily. Wholesale buyers are not willing to share information on margins.

3.1. The inland vegetables market

In the marketing of fruit and vegetables the Central Market along the Suriname River in central Paramaribo has traditionally a major role. It is the center of the trade in fresh fruit, vegetables and fish. Basically the market compound has two functions at the same location, wholesale and retail. Between three and six o' clock in the morning market vendors, retailers, supermarkets, hotels & catering industry buy produce. After six o' clock the market vendors take over and sell to consumers.

The role of this market is now dwindling. In the last decades a strong growth of the population of the district of Paramaribo occurred, also spreading to the neighboring district of Wanica and more recently to Commewijne. This urbanization and the soaring number of private cars make this market less accessible. New initiatives started along major roads and also in (new) neighborhoods. Some are farmers' markets which are open for business twice a week. Other smaller roadside outlets are operated by one family and open 6 days a week.

A steep rise in the number of supermarkets in nearly all neighborhoods, mostly run by recent immigrants from China, 'diluted' the grocery sales over more stores. In order to attract customers many shop owners broaden their selection and create in or outside their shop a 'vegetables' corner' with local produce and (in coolers) imported vegetables & fruit.

A new important channel to market vegetables is the result of a change in policy regarding the length of schooldays for primary school pupils. The extension of school hours for these pupils is meant for activities like extra lessons and sport. It is offering the pupils a meal in the afternoon. Families and firms near schools did cater these meals in the pilot stage since 2012/2013. The planning is eventually to establish kitchens within all primary schools.

Countrywide some 70.000 pupils attend primary schools. Data on the number of prepared meals are not public. Assuming that about 70% of the pupils are covered by now, this would mean some 50.000 meals every school day. Applying dietary rules for these kids' meals would mean the use of at least 300g of vegetables and fruit a day, net. Depending on the type of vegetables this means 115 – 130+% gross weight.

Assuming 225g of vegetables and 75g fruit and a gross weight of 130% for vegetables this school meals initiative could create a demand of some 15 ton of vegetables a school day. Actual schooldays in Suriname amount to about 180 days a year. These numbers illustrate that the impact on the local vegetables market is significant. Assuming a yearly production of around 12.000 ton of vegetables for the local market, of which an unknown part is not sold. In the school meals program an amount of 180 x 15 ton making 2.600 ton would be purchased. Roughly 20% of the yearly demand is generated by this school meals program.

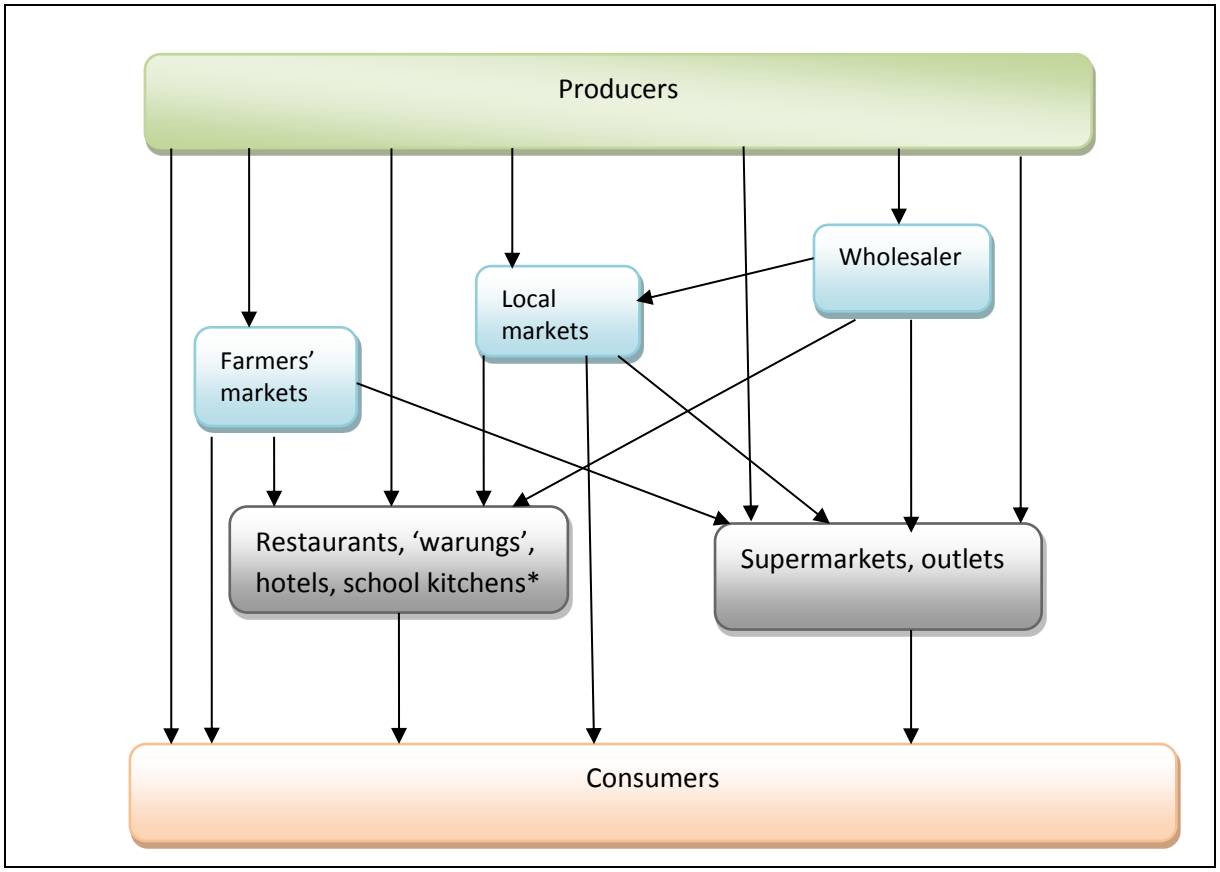
Mining activities in the hinterland attract thousands of direct and indirect workers. The international companies have many hundreds of workers, especially in the construction stage of the mines. US Newmont goldmine in the East just started and Canadian Iamgold Corp is expanding. These mining operations have catering facilities for their own workforce and contractors. Initiatives to stimulate vegetables production by farmers in the vicinity of the Iamgold site have not resulted in year-round, diversified and sustainable production of quality vegetables yet. Most of their vegetables are still bought in the coastal area. Small scale, mostly illegal, mining is done by thousands of workers in the hinterland, most of their vegetables and fruit is bought also in and around Paramaribo.

Other marketing initiatives have emerged, like a weekly vegetable basket of organic produce, delivered at your home. For the group of organic producers a good outlet, on the whole production this model is not substantial yet. Operators in the catering industry tried, in collaboration with a horticultural women cooperative, to obtain organic vegetables on a daily basis.

In Figure 3.1. main channels of produce for the local vegetables market are shown.

In some segments of the local vegetables and fruit market imported produce reduces the market share of similar local products. Imported potatoes are most of poor quality and consequently cheap. The market of more expensive local tubers & roots will be affected. Imported onions dominate their segment, local onion production proved not to be feasible in the eighties. Only niche items like red onions are local. In Table 3.1. volumes and value of imported fresh and cooled vegetables and roots are mentioned.

Figure 3.1. The main channels of local vegetables marketing in Suriname



** an estimated 20% of produce is processed by these kitchens*

In the period 2005-2010 on average a total value of SRD 18.8m a year was imported of fresh vegetables and roots. Less than 8% of this amount was spent on fresh vegetables. In recent years the total value of imported fresh vegetables & roots has risen. In 2011 total value was SRD 32.452.000 and in 2013 SRD 36.278.000. Probably fresh vegetables did keep up proportionally with the total value.

Table 3.1. Survey of imported fresh and cooled vegetables and roots / year over 2005-2010.

Vegetables and roots	***Quantity in kg***	***Value in SRD***
Potatoes, fresh and cooled	7.103.144	8.395.324
Tomatoes, fresh and cooled	8.767	21.203
Onions	4.761.615	7.161.829
Cauliflower, fresh and cooled,	30.848	68.116
Cabbage, other var. , fresh and cooled	362.896	509.755
Lettuce, fresh and cooled	131.291	204.737
Cucumber, gherkin, fresh and cooled	1.456	12.011
Legumes, fresh and cooled	9.944	32.380
Other vegetables, fresh and cooled	228.405	473.236
Processed vegetables	730.358	1.895.372

Source: import statistieken Ministerie van LVV, 2005-2010, adapted by H.J. Grauwde (2011)

Local growers of tomatoes, broccoli, paprika, lettuce etc. should be able to eventually claim the greater part of this market. To become successful they have to produce good quality according GAP/ organic standards and market their local produce professionally.

3.2. The export of vegetables from Suriname

Export is traditionally to the Netherlands, where about 350.000 people of Surinamese descent live since the seventies. Vegetables and fruit from Suriname were in demand since that period. However, vegetables and fruit from other tropical countries have become familiar in the Dutch supermarkets and the strong longing for Surinamese vegetables & fruit has become less in the younger generations of Surinamese descent. The diaspora market and the overall Dutch market for vegetables and fruit have changed, exporters have to adapt and innovate their unique produce from Suriname in order to survive.

The exporters of vegetables and fruit can be classified in three groups (LVV, 2009a):

Exporter	*his focus is on export, all produce is bought from growers*
Grower – exporter	*produces most on own farm, only a part is bought from growers. With this approach the quality of the produce is better monitored is the motive of the exporter.*
Wholesaler –exporter	*all produce is bought from growers, only top quality produce is exported*

Given the complexity of bringing produce of Suriname to the shelves of shops abroad the concept of grower-exporter is likely to become more successful. Control of (nearly) all aspects of the production should prevent problems with residue (MRL), timely delivery of agreed volumes and quality, etc.

In 2000 the number of exporters was more than thirty; it has since dwindled to about five exporters. Quality problems caused unpaid bills and one Dutch importer went broke. In Suriname it is difficult to receive export credits, especially with perishable products.

The exporter is packing the produce himself, transferring the produce from sacks, crates and boxes into export boxes of polystyrene foam or cardboard. Codes of growers are put on the boxes to make the produce traceable. Exporters don't have staff on the airport in the Netherlands, claims for quality loss cannot be verified by the exporter. After a test period the impact of improved packing is clear: physical damage of produce fell from ~ 33% to 10-15%. For export no produce is yet packed in small packages for retailers.

Price-making forces are not transparent. The importer is fixing the price considering the international market of vegetables, not just the supply from Suriname. Growers distrust the exporters for making their margins too generous. Long lasting cooperation between growers and exporters is not common.

The Netherlands are the major destiny for export of vegetables, nearly all transport is done by plane. All cargo is transported with airliners, both by Dutch KLM and SLM of Suriname. In the past Boeing 747's were used, now Airbus 340's and Boeing 7x7's with less cargo capacity are deployed. The SLM Airbus 340-300 has a cargo capacity of 11.550 kg. The frequency has improved, total cargo capacity is slightly reduced. Charges for all-in transportation to Amsterdam are high, exporters from the Dominican Republic and Thailand pay less for air cargo to Amsterdam. Small export quantities are extra charged by applying minimum charges (1-500kg, 501 – 1000kg, etc.) raising the unit price considerable.

On the regional routes two Boeing B 737-300 are used with only 900 kg cargo capacity. On the route Paramaribo - Miami more cargo is possible with special B 767-200 freighter flights, capacity is 40.000 kg.

The handling at the airport is done by exporter's staff. Boxes are labeled, placed on pallets and weighed. Cold stores are available at the airport, but they are located outside the Customs clearing zone. Exporters are forced to park their pallets outside at temperatures of > 30^{o} C for hours, making quality decrease. If flights are delayed the produce may perish. Although these problems existed in 2007/2008 the same complaints were told in 2015 by several growers / exporters.

3.3. Competiveness of protected horticulture products of Suriname

The competitiveness of the country in growing vegetables is limited by its geographic location and the small local market with just 0.5 m people. Experience in export of primary agricultural produce is also limited. The membership of the Caribbean community did not boost export of agricultural produce to the Caribbean yet. The single market has not triggered export of (value added) agricultural products to these mostly on tourism oriented economies. The transport sector is not focused on these Caribbean markets and trade in Suriname is dominated by North American, European and Chinese relations.

In agriculture rice, bananas and marine fish are major export products. Vegetables are still a product of small producers, a substantial level of year-round production of quality vegetables in desired quantities is needed to change the now stagnant export market into an expanding business. Within horticultural production protected systems still have a minor role. A substantial part of vegetables production comes from part time farmers, not able to invest in structures, mechanization and/or technology.

Farms with traditional systems have a higher labor intensity than farms with more technology. The part of labor costs in total costs is large in traditional farms. Labor efficiency is higher in more technological advanced production systems, resulting in less labor costs in total costs. Recruiting staff for open field operations has been for years a problem, in the past foreign workers have been hired in case of larger agricultural operations. The cleaner image of protected vegetables production will help these advanced farms in attracting their staff. A rise in protected vegetables production systems will result in less labor needed for the same output and will slow the labor demand in rural areas.

Variable costs are the areas where competitiveness of the vegetables production in Suriname can be improved. Thus labor, packaging, transport, marketing and fertilizers, all must be scrutinized. Part of the input comes from foreign sources and more efficiency is needed in purchasing these items. Cooperation of growers in purchasing input is required and should be promoted by agricultural policies. Taxes on the import of hardware increase the costs of innovation activities.

Exporters are faced with high costs in the handling of their produce. Reducing (air) transport costs must be part of a successful approach to promote export of vegetables and fruit.

Farmers do have to combine their efforts, with support of the government, in order to make improvements in their inefficient scale of production. There is a need to combine marketing of produce of different farms to improve overall supply and get more trust of important buyers.

The government should improve the availability of market information, data on seasonality of demand in regional markets to support the farmers. Problem is that Suriname has no market position yet on growing/promising segments of export markets (supermarkets groups) and also no position in a differentiated market segment (packed produce, specialties, etc.). Efforts have to be made to create a position on one of the markets to gain recognition as a supplier. Bulk produce is not an option given the transport disadvantage to any substantial market, the inefficiency of input supply and the small margins in these markets.

3.4. The domestic vegetable supply chain

3.4.1. vegetable growers

Like most farmers growers of vegetables tend to have poor schooling and insufficient know-how of farming. Most have another job for social benefits and work part time as farmer. The average farmer is 45-54 years and most lots are less than 1 ha.

Production methods are traditional and labor intensive, mechanization is not common. Good quality machinery is expensive and loans (with high interest rates) are less accessible for producers. Some progress was made since 2007 with a special Agricultural Loan Fund (AKF), providing loans at a lower interest rate. Success made that the fund is short of funds. Productivity of labor is low and wages are low. The few existing larger farms have problems with recruiting and retaining workers. In the past (1970-1985) foreign workers were hired and recently a vegetable grower started hiring workers from Southeast Asia.

Wholesale buyers are manipulating growers, some have outstanding debts of weeks to months to the growers. Still many of the growers in remote areas are in a dependent position having no other market for their produce. Most growers are individually doing business and don't cooperate with other growers. Exchange of experiences and new developments is not done structurally. Contact with extension staff is not usual. Extension using radio, television and social media is rare. Only the rice research station is regularly informing farmers on new developments. Being part timer makes the farmer have less time to spend on farming issues. Commitment to perform optimal as farmer may be reduced.

3.4.2. input supply

Input like seeds, fertilizers, agrochemicals, equipment and packing materials are important for modern production. Failing quality or items out of stock cause problems up in the chain. Most importers fail specific knowledge and are unaware of new developments. With internet ordering merchandise abroad has become easy. Logistically only Miami and the Netherlands do have reasonable frequent lines with Suriname in shipping and in air travel. Lines with the Caribbean (Trinidad) are improving yet.

Specific items for greenhouse growers are mostly imported by growers themselves, surplus is sold to other growers. Growers complained about the quality of seeds and the availability of specific fertilizers and equipment.

Contracting firms for horticulture
Contractors for cultivation of the lots don't exist. Lots with horticultural activities are scattered and size of the cultivated part of the lots is limited. Above all, most growers practice a low external input policy. If a demand exists contractors in related activities will take this opportunity.

Government agencies
Suriname has in short a nontransparent land policy, land use zoning is not implemented and farmers with production initiatives are not accommodated. Data on agricultural activities are either unknown or unreliable. The public information service is basic and data are not public. In export four bodies are engaged: ministries of finance, justice & police, agriculture and the foreign trade banks, making procedures complicated and bureaucratic (LVV, 2011a).

Specific on export: equipment for food safety control of produce is inadequate, the cold stores on the international airport don't perform as result of demarcation disputes. The necessity of narcotics control makes the handling of produce complicated. All these things combined give vegetables from Suriname a bad image. (LVV 2011a).

Supply and demand
Having a small population of half a million people on a rather isolated location makes the potential market for vegetables small. Quality and quantity of production is influenced by the humid climate with severe rain periods and most of the years a modest dry period. Export is hampered by flights with limited cargo capacity and few direct shipping lines. Both local and international markets demand good and constant quality of produce and confidence of (timely) delivery of produce.

Certified growers of reasonable volumes of vegetables are needed to get confidence of important buyers abroad. Some farms are in process of becoming certified organic / GAP vegetable growers. Greenhouse growers' share in production is still modest, yet the existing PA area is extended with middle technology greenhouses. Important development is that greenhouse training facilities are implemented and colleges recently have greenhouse production systems in their curriculum. Young professional staff will be available for this subsector soon.

Table 3.2: Export volume and value of vegetables 2006-2013

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012***	**2013**
Export volume (ton)	2,390	2,783	2,936	2,757	3,239	2.723	2.476	2.806
Export value (x SRD 1000)	3,587	4,408	4,665	4,193	5,289	5.179	3.661	4.123

Source: LVV statistieken * the data of 2012 were not complete due to technical problems

Supply chain development
The development of the vegetable supply chain is in its initial phase in Suriname. The country has seen similar developments in the past. Farmers themselves have evolved: subsistence farming was common a century ago with isolated small settlements scattered over the coastal area. The decaying plantation system gave little opportunities for development in the rural districts. Subsistence farming was the survival mode for decades. Since the sixties this type of farming more or less disappeared in the rural areas and is now even on the retreat in the more isolated tribal areas. Small farmers got other opportunities in mining, trade and public service. Part of the subsistence farms emerged as family farms with strong market orientation. A new round of changes is under way creating a group of motivated and educated farmers who subsequently start agricultural family firms by adding more components of the value chain in the business.

In mechanized rice farms in the western region this type of firms with all components of growing rice to distribution of polished rice in small units to shops around Paramaribo started already in the seventies. In the nineties other sub sector farms started with similar strategies to get better control of the value chain of their produce, for instance in animal husbandry.

Some growers of vegetables now have started to steady implement this innovation in their activities. An export vegetables subsector can only thrive with strong coordination and thus will need dedicated and disciplined growers. Strong cooperation between growers and with exporters is needed. Tensions between production according to a set of strict rules regarding variety choice, planting time, no / restricted use of chemicals, harvest & handling and on the other side most small individual part time growers will develop. Depending on macro-economic circumstances an influx of (cheap) foreign labor for field activities is likely.

3.5. Characteristics of markets abroad

In this section some characteristics of one existing destination market, the Netherlands, and two potential destination markets (Barbados and Trinidad & Tobago) are described. Barbados has an economy that is mostly tourist industry oriented. The catering industry of the tourist sector, 0.5m visitors a year, needs large volumes of vegetables and fruit, about half the volume is imported. Trinidad has a distinct off-season and exports during this period are considerable. Most information in this section is based on the market surveys MAAHF conducted in 2008/2009.

3.5.1 importers

Dutch importers of vegetables and fruit from Suriname mostly have family ties with the country. Some importers have connections with wholesalers in tropical vegetables and fruit. There are no restrictions and no levies on import of vegetables and fruit from Suriname in the Netherlands. On the Caribbean markets Suriname doesn't have a tradition of export of vegetables & fruit, membership of the CARICOM Single Market & Economy didn't ease the complex demands for agricultural produce to reach the Caribbean markets. Rice is sold to a range of countries, but fresh vegetables are not sold yet.

Barbados, nearly 300.000 people on 430 km2, has a strong tourism oriented economy, more than 0.5m tourists a year. GDP per capita USD 15.702 (2015 estimate). Hotels and restaurants buy 40-60% of vegetables & fruit as local products, the other part is imported from the USA, Canada and Europe. The catering imports are more 'exotic' products, which might create opportunities for vegetables from Suriname.

Barbados is not self-supporting in vegetables & fruit, only 50% is local, supermarkets buy foreign produce like tomatoes, eggplant, cucumber, bitter gourd and also cassava, yams, sweet potato etc.

Trinidad & Tobago, 1.3m people on 5.128 km2, has oil and gas and uses it for industrial development of the main island. Its food industries are leading in the Caribbean, agriculture is contributing considerable to the local economy. GDP per capita is USD 21.934 (2014 estimate). Trinidad is a regional hub for airlines and by sea.

Trinidad is not self-supporting though vegetables and fruit are exported to Barbados and the USA. Due to climatic conditions there is a strong seasonal production, resulting in export in the season and import in the off-season to meet demand. Strong protection of local producers of agricultural products is a long standing policy.

3.5.2 retail

The Netherlands

Most sales of vegetables and fruit in the EU and in the Netherlands were accomplished by supermarkets. Market share of supermarkets for vegetables and fruit was 74% in 2006 and has an upward trend. The shelves with fresh vegetables and fruit are the showpiece of supermarkets and important for the profits. Strict rules are applied to quality of produce and Global GAP is mandatory. Issues like residue levels or child labor might taint the image of the (international) supermarket business making them on the alert for danger.

The share of street trading in fresh vegetables & fruit is ~ 10% and sales show a downward trend. The market share of fresh vegetables and fruit of Asian shops / toko's is very small. Up to now these 'marginal' retailers are the main outlet for exporters of Suriname (LVV, 2009a).

The Caribbean

Supermarkets are the main channel to market vegetables and fruit in Barbados. Some supermarkets developed into chains of stores with up to five shops on the island. Farmers' markets are organized in weekends and are important for farmers to market their produce. Supermarkets do have an interest in vegetables and fruit from Suriname, if they comply with the modern set of requirements: price and quality at least like other suppliers and supply and delivery on time guaranteed (LVV, 2009b). Suriname has no direct flights to Barbados, the hub Port of Spain is involved.

In T&T supermarkets are also the main channel for growers, besides farmers' markets and small but well assorted neighborhood outlets. Supermarkets do have an interest in vegetables and fruit from Suriname.

They must comply with the modern set of requirements: price & quality at least like other (existing) suppliers and supply and delivery on time guaranteed. Direct flights are available and shipping fresh vegetables is viable.

3.5.3 storage and transport

An important aspect of all export are requirements for optimal storage of the different types of vegetables and the number of days the produce can be stored without losing its quality. In Suriname the export of vegetables and fruit is done with airfreight and with refrigerated shipping containers. Transport with shipping containers is dominated by the banana company, every 10 days cooled produce is exported to the EU in containers.

Potential export vegetables can be divided in two groups. Short cooled storage of 5 days up to 14 days and longer cooled storage from 14 days up to three months. The first group needs air transport for export, the second group could (possibly) be shipped to Caribbean and EU markets. Regular shipping lines exist and are used by the banana firm. Higher reliability, better control of (loading) conditions and lower costs could lead to an improved position of Suriname export and pioneer for other substantial export contracts in the future. The export to Caribbean destinations could be sent by cooled sea containers more easily given the distances. Reality is that the volume of vegetables and fruit export to the Caribbean is still very low, only marketing bananas is improving.

Table 3.3. Specific storage periods and requirements of vegetables

Storage period	**Product**	**Temp. ^{o} C**	**Rel. humidity %**	
Short				
5-10 days	Long beans	5 – 7	90-95	
5-10 days	Tannia leaves	1 – 5	95-100	
5-10 days	French beans	5 – 7	90-95	
7-10 days	Bitter gourd	8 – 12	85-90	
7-10 days	Okra	7 – 10	90-95	
7-14 days	Eggplant / purple, long	10 – 12	90-95	
7-14 days	Eggplant /white, round	10 – 12	90-95	
7-14 days	Celery	1 – 5	95-100	*Depending on cv*
Longer				
14-21 days	Hot pepper	5 – 10	85-95	
21-42 days	Cabbage	0 – 1	95-100	*Depending on cv*
1-2 months	Manioc	1 – 5	85-90	
2-3 months	Pumpkin	12 – 15	50-70	

Source: Marktstudie Surinaamse / tropische groenten en fruit op de Nederlandse markt (adapted)

Sensitivity for ethylene and ethylene production should also be considered.

4 Perspectives of protected horticulture in Suriname

Greenhouse horticulture is getting more attention the last years and is gaining momentum:

- More farmers get interested in greenhouse techniques, some in basic aspects and others want to know more about technological aspects. Some farmers have invested in simple structures of 100m2, others invested in closed medium technology structures of up to 5.000m2. Know-how from abroad is contracted by private parties to design the system and guide the start of the operations and its certification.

- In climate change discussions aspects of the vulnerable agricultural production are mentioned. Sea level rise, prolonged heavy rainfall and gusts have changed opinion. More action is required to mitigate the impact of climate change on society, including agriculture. Soaring prices of vegetables after a few days of heavy rain illustrate possible impact of predicted changes in our climate.

- Exports of vegetables is more or less stagnating. In order to revive these exports horticultural production systems have to perform more reliable. In many countries demand for vegetables exists but suppliers have to deliver good quality (organic / Global GAP) vegetables according schedules. Timely delivery of volumes required is a must, our traditional way of producing & handling vegetables for export is outdated.

- Agricultural training institutes (PTC, NATIN) started courses in greenhouse production systems. Young professionals are being educated in protected agricultural production management, gaining practical experience in new greenhouse structures.

4.1. Anticipated changes

Development of protected horticulture is in progress. Given the limited area and basic structures mostly in use now, changes will come in many aspects.

- **Acreage** – more open field plots will be converted to shade – or greenhouse production sites. In 2015 less than 1% of annual crops acreage is for protected horticulture. Subsistence farmers will construct simple structures and firms will start structures with probably more technology.

- **Production** – farmers will switch from shade roof / house to greenhouse cultivation. Use of soilless media will rise, the pace depends on occurrence of problems with pests & diseases, on profitability of new production systems, etc.

- **Crops and quality** – depending on demand and opportunities farmers may choose other crops. In general improvement of produce quality is price driven. Since most local consumers are less quality conscious, improvement might take some time.

- **Greenhouse construction and technology** – performance and profitability of recently erected closed structures with best fit technology will be crucial for further development of the structures used in the near future. Success in both aspects will gradually lift the level of used technology in commercial structures.

- **Management** – influx of professional greenhouse management will gradually result in use of more technology to optimize production in modern structures. Low-tech farms probably will remain low-tech for the coming years.

Produce will be sold to the local market, demand for quality (organic) vegetables exists. Especially restaurants & catering industry create demand but also more consumers are aware of food safety aspects. Depending on economic developments demand will rise. First challenge is to substitute part of import produce in the well assorted supermarkets. Marketing will be crucial to gain that share of the market. Collective marketing is obvious, the local poultry industry has promoted its produce successfully. Greenhouse produce is offered jointly, but varies in quality and is sold by the individual growers. Such an initiative could be a good preparation for the next step, export of greenhouse vegetables.

Export of greenhouse vegetables is a major step, given the elementary facilities in production and handling now in place. Further development for the vegetables growers depends on their capacity to organize for a market, develop distribution / marketing channels and standardize quality. Clustering is required for feasible integration into market chain and investments in packing lines and other postharvest facilities. Farm technology development will be product-specific, aiming at quality standardization for the market.

4.2. Selecting crops for export

Selecting crops for export is limited in choice. Certain crops are produced in bulk in other countries with sophisticated production, handling & logistic systems. Production of standard quality sweet peppers, lettuce, tomatoes, and cucumbers for export to EU or certain Caribbean markets is not viable. Growers in Suriname have to target on niche crops and this production needs to be certified. Growers have to look for product innovation with added value for specific retail niche markets in Europe and the Caribbean. They need support in finding a right product-market combination with best-fit technology. Vegetables farms failing to develop a market position will stagnate.

Selection of type of vegetables for greenhouse cultivation looks premature, because:

- The area with protected agriculture / greenhouses is limited: 30.000 / 15.000+ m2,
- The majority of growers use low tech, shade roofs/houses with soil are dominant
- Market surveys of the Caribbean and the Netherlands are dated (2008). The financial crisis (2008), marketing structure and preferences of consumers, all have changed.
- Knowledge of best-fit technology greenhouse cultivation is limited
- A majority of growers, the subsistence group, is investing at a slow pace in improvements. Growers don't change their system drastically. Substantial increase of protected agriculture only will happen in anticipation of market improvement, if input is readily available and profitability has improved.

- All components in the value chain have to improve. If the government wants export of vegetables to increase, bottlenecks like un-used cold stores and bureaucratic handling should be solved. Residue measurements are required for food safety. Analysis of local and imported vegetables protect local population. Dedicated (organic) growers will get more demand if unsafe food is banned. Local and imported vegetables now may have high residue values without being detected. Adequate residue analysis facilities are urgently needed.

Selection of priority horticultural crops is one of the activities in the new GOS / EU EDB cooperation (2014-2020). The program will focus on horticulture and aims at institutional strengthening of both public and private sector.

The next questions are important for deciding on priority greenhouse crops:

Question	***Present situation***	***Answer***
Are PA structures available? *(If structures are already available, choose compatible crops)*	A wide variety of small (rural) greenhouses, mostly with low levels of technology & utilities Greenhouse area is 1.5+ ha and total protected agriculture area is 3+ ha	**No**, most structures are not suitable *(Otherwise choose crop(s) and then a compatible greenhouse Choosing a crop must be based on market research and preferable tentative contracts with buyers)*
Is sufficient know-how available for the cultivation and marketing of crop(s) chosen?	The MAAHF vegetables research unit needs more capacity to gather know-how on crops and techniques.	In most cases the answer is **no!** Preliminary experiments and training are needed.
Are selected /established cultivars available?	Traditional vegetables are open field crops, selection for growing in greenhouses might be needed	Carry out field tests with local / introduced cultivars

(adapted from: FAO, 2013)

On the short term priority crops for greenhouse production might be those crops that are imported in larger volumes and are suitable for greenhouse growing in our humid tropical climate. Paprika, lettuce, tomatoes and most (Chinese) cabbage varieties are/can be grown, good consistent quality and sufficient quantities are within reach of local growers. The marketing strategy of these local (organic) vegetables will be important for success.

An important role in coordinating and managing activities in this development of protected horticulture is the future National Agricultural Innovation Board (NAIB).

…This Board, appointed by and reporting to MAAHF, will: (i) assume overall coordination within the national agricultural innovation system; (ii) promote collaboration between the different actors; and (iii) provide a platform for all stakeholders to meet and discuss new and ongoing innovation initiatives and exchange information. The NAIB will also be made responsible for: (a) providing policy advice to the government on agricultural innovation issues; (b) monitoring and evaluating the implementation of the agricultural innovation strategy; and (c) initiating the renewal of the national agricultural innovation strategy in due time….

(from: The National Agricultural Innovation Strategy, 2013).

The Board is not installed yet, due to bureaucratic delays. Informal contacts exist and talks on more collaboration take already place. Proposed important horticulture related project activities like *Establishment of Packinghouse*, *Introduction of Greenhouses* and *Introduction of Global GAP* are part of the innovation to be monitored / managed by NAIB.

5 Conclusions and recommendations

5.1. Conclusions

In general data on greenhouse production in Suriname are still scarce. This makes analysis of vegetables production systems laborious. Planning and decision making in innovative production & handling systems is hard for all stakeholders.

Greenhouse cultivation in Suriname is still in the toddler phase, some parts are developed, and others need more attention to make the whole system improve. The survey reveals that only 30.000+ m2 is protected horticulture area, half of this is under greenhouse structures. Mostly simple structures and traditional cultivation methods are used. Soil is the dominating growing medium with the usual threats to production, especially nematodes and inundation.

Most structures are open, which prevents that ventilation & temperature problems prevail. No side walls means no control regarding the influx of pests and diseases. Diseases are less threatening if water gifts are directed to soil or other medium, leaving top parts of the crop, stem and leaves, dry. Pests still occur and (irresponsible) use of pesticides can be contrary to the presumed greenhouse image of clean & good quality crops in marketing. Issues with high residue levels may backfire and chase (potential) local customers away.

The districts with most protected horticultural activities are Wanica, Saramacca and Commewijne. The latter is specialized in shade roofs / houses production of tannia leaves and celery. Most lots are small and nearly all growers use soil as medium. Most consumers are not really quality conscious, making production systems improvements lag behind.

Wanica and Saramacca are more divers in structures, media, crops and techniques. In Saramacca lettuce in NFT systems is a major crop. Wanica is most developed in protected production, soilless media cover 42% of the protected horticulture area and a variety of techniques are used, generating valuable knowledge on greenhouse production in practice.

Few greenhouse growers are in touch with the extension service and few extension staff members are trained to support growers and (help) solve production and / or marketing problems. Extension staff is not eager to visit greenhouse growers, as they are aware of lacking elementary knowledge of greenhouse production. A dialogue with growers about production & marketing problems is impractical. Training of senior extension staff is needed, with items like structure types, media used, microclimate problems, crop production problems and handling & marketing. Staff at a Higher Vocational Education level should be readily available to guide commercial growers in more technical issues. This probably will be the task of staff of the vegetables research unit.

Structural consultations with stakeholders do not take place, the national agricultural innovation board (NAIB) is not installed yet due to bureaucratic delay. Horticultural initiatives are halted for the time. The board will assume overall coordination within the agricultural innovation system, promote collaboration between the different actors and provide a platform for all stakeholders to discuss new and on-going initiatives.

Water is the key for all agricultural production, also for protected vegetable production. Some growers have problems with their water supply and have to reduce production. Other (subsistence) growers use low quality water, often with negative effects on their production. Technical solutions with different types of filters raises the costs. In the process of site selection water supply is important. Given the rural character of most farms research in improving the availability of good water resources is crucial if modern production techniques are to be used. In general better water management on the farm and in these production areas is important to prevent 'traditional' problems with (prolonged) inundation periods and also drought periods affecting crop production.

Input supply is not geared at protected horticulture needs. The size of this input market is still limited, better supply will raise the interest of growers to start these activities. Being a niche market for input suppliers specific items have to be bought by growers themselves and surplus is sold to other growers. Recently a cooperative for hydroponic growers was set up, improving input supply is an important item for this group of vegetables growers.

Vegetables farmers are individual (part time) workers, sharing experiences and new ideas is mostly not done. All other farmers are seen as competitors. Working together on problems is unusual. Initiatives to promote cooperation between farmers should be supported.

Given the limited area with protected horticulture, most initiatives for production and handling of produce are directed at the local market. Substitution of some imported vegetables types and consistent quality production are the first challenges for the medium / best-fit greenhouse firms. With the acquired know-how and experience a next step can be made if other requirements like certification and adequate handling are met.

European and Caribbean markets demand certified vegetables. The production of standard vegetables like tomatoes, paprika, cucumber and lettuce is probably not rewarding. Produce from Suriname should be a niche product with reasonable prices. Special fresh products with preferably special packaging are needed to counter higher transportation fees and more expensive input. The existing connection with the Netherlands as a logistical hub for vegetables in Europe could be an advantage.

Some of the Caribbean islands are already engaged in greenhouse production and increasingly supply their own markets. Also for the Caribbean market niche vegetables produce from Suriname are more likely to succeed.

Handicaps for more greenhouse production are: most farmers are not professionals, most production lots are small, no residue analysis for local and imported vegetables, most consumers are not quality conscious yet or can't afford the higher prices of certified produce. Handling of produce is mostly not appropriate resulting in unappealing vegetables in outlets. Exporters still face problems that were identified already many years ago.

5.2. Recommendations

Promoting (certified) greenhouse production of vegetables is recommended, because

- It provides year-round production of consistent quality vegetables in larger quantities per m2.
- Climatic risks diminish and quality is less affected by adverse weather conditions
- Certified production improves food safety and is imperative for export trade
- Increasing import of fresh vegetables can be diminished and in time export of fresh vegetables could expand after years of stagnant volumes
- Working conditions in protected horticulture are more attractive than in open field activities, making the occurrence of labor shortages less likely.
- Use of agro-chemicals could be less, farms use less water and with higher output per ha the farmland area becomes less, all positive developments in protecting the environment

In general:

The delay in setting up the agricultural innovation board needs to be tackled. The board will assume overall coordination within the agricultural innovation system and, among others, promote collaboration the different actors.

Invest time and funds in solving the existing problems of vegetables exporters to get produce timely and cooled to aircraft and further. All stakeholders had an unfavorable judgment about implementing export of vegetables to the Caribbean.

Expensive input for the subsector requires attention and tax exemption for some input should be considered, like input for other (agrarian) subsectors is exempt of charges.

Clean and sufficient water is an indispensable production factor. Innovative techniques are needed in certain areas where the quality or quantity of available water gives problems. Water management has to improve in production areas to stop inundation of farm land and make water available in the dry seasons. Prolonged inundations of productive farm land is destructive to investments and to entrepreneurial spirit of the agricultural sector. Zoning will be necessary to better secure investments of farmers and other sectors.

For the ministry of Agriculture, Animal Husbandry and Fisheries:

Provide training to all levels of the extension staff, given the reported lack of trained greenhouse specialists in nearly all field offices. Staff with higher vocational education should also be available for commercial growers investing in more technological advanced production systems.

Capacity in staff, equipment and budget of the vegetables research unit and related units in the agricultural research sub-department should be raised to enlarge know-how of protected horticulture techniques, which is to be disseminated by extension service and growers' associations.

Invest in

- national (vegetables and fruit) market information systems, with linkages to int'l market data. Collecting and processing data from field work to handling is a must to analyze the progress of efforts to innovate the horticultural subsector. Combined efforts of the ministry, farmers, university and colleges and consumers are needed.

- research to select greenhouse type with 'best-fit' technology adapted to local conditions. Stimulate efforts to adapt the imported 'under-ventilated' greenhouses, engage university / college students as a practical subject of their study.

- field research of combining agricultural activities in model farms: greenhouse & poultry or greenhouse & fruit, as the overall greenhouse workload may make other activities on the farm possible and the whole operation more feasible.

Stimulate

- entrepreneurs to establish nurseries to produce good quality seedlings of vegetables. Nurseries and production units should be separated. Stimulate planned production of vegetables of the right variety. Data exchange between these firms and an association would help to monitor the overall planned acreages of vegetables, an early warning for under- or over-production in the months ahead.

- greenhouse production units for local farmers in the vicinity of hinterland (mining) activities. Also (clusters of) tourists' lodges could be stimulated to grow more vegetables and fruit. A balanced mix of greenhouse and fruit & vegetables gardens could become an attractive site for tourists.

- courses for farmers on subjects like record keeping, use of pesticides, IPM, GAP. Farmers' associations and other collaboration forms between stakeholders should be stimulated and all similar efforts already in place should be continued.

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Annex 1. Extension service in the rural areas.

Most staff of the extension service has minor education and is poorly trained. Below the situation in December 2014, in the course to the elections of May 2015 dozens of new people got (temporarily) positions at the field offices.

Field offices and extension staff in regions and sub-regions (*situation 14 December 2014*)

Sub-region	offices	Trainee*	Junior	Senior	Senior+
Western region					
Coronie	Totness	8	1	-	-
East 1		-	1	-	-
East 2	Henar	1	2	-	-
Western Polders	Clara	2	-	-	-
Wageningen	Wageningen	1	5	-	-
Middle region					
Para	Lelydorp	5	3	2	-
Saramacca	Groningen & Calcutta	21	-	4	-
Wanica A	Kwatta	11	3	2	3
Wanica B	Houttuin & Domburg	13	-	1	2
Wanica C	Santo	-	1	3	-
Brokopondo	Brokopondo Centrum	7	-	1	-
Eastern region					
Commewijne	Tamanredjo & Nieuw Amsterdam	9	1	3	2
Marowijne	Moengo	2	2	-	-

** Trainee: primary school; junior: secondary school; senior: professional agricultural training*

In general the role of the field offices in guiding farmers to optimize the production on their farms has diminished in the last decennia. Till the sixties and seventies the ministry of agriculture was pivotal in rural development activities. Research on (new) crops was done and the extension service was in close contact with the agricultural research sub-department. New land was brought into cultivation and new crops/varieties and techniques were introduced. The government supervised these activities in agriculture and its role in these development efforts was widely recognized. Since the eighties the role of the extension service gradually diminished. Partly because less senior extension staff was available in the field offices and less input was distributed. Another trend was that less farmers were fulltime on their farms. Fulltime farmers have become a minority, the majority is a part time farmer with another job to secure social benefits. More lately private agro shops were opened where rudimentary advice is given.

Several studies have been done to give advice how to re-vitalize the extension service in the rural areas, the national agricultural innovation study (LVV/IDB, 2013) deals with this issue also. Implementation of the proposals is delayed.

Annex 2. Production in closed greenhouses in tropical lowlands.

In many countries vegetables production is done in closed greenhouse structures, in Suriname with its lowlands and humid tropical climate open structures are dominating in greenhouse production of vegetables. Our climate is the main reason for this situation.

The mean wind force is low, less than 1 m/s. In early morning and late afternoon more wind force is observed, around midday between 10 and 15 hours wind force is minimal. At this period of day solar radiation and air temperature are at their maximum, underneath the plastic film inside the structure temperature is rising even further. Replacement of the accumulated hot air by fresh air is around noon slow, even in open structures.

Ventilation in closed structures is hindered vertically by plastic film and lateral by (fine mesh) screening. As a rule vents capacity in side walls and roof should be at least 35% of the structure floor area. Mesh size of screens determines the rate of exchange of fresh air, with wind speed less than 1 m/s this exchange will be minimal.

Around noon the outside temperatures reach 30+ ^{o}C, so by replacement of air the temperature inside may be reduced but still is above optimal temperatures for plant growth. High temperatures are a climatic fact, lowering the temperatures inside greenhouse structures is desirable. Techniques are developed like forced ventilation and mist or fog systems. These systems require investments, the small scale of greenhouses make the costs even higher per square meter. Solutions for these typical problems of tropical lowlands are yet to be found. Given the small market for such a technology it is not a priority for most research centers. Some research is done however in Europe and United States.

Closed structures may prevent that some pests enter the production unit and cause damage to crops. All pests are not prevented, pests like thrips, aphids and whiteflies pass through most screens and may vector diseases. Natural enemies are also prevented from entering the structure which will result in infestations spreading quicker. Parasitic wasps are an example of demobilized assistants of vegetable growers if closed structures are used.

The (closed) greenhouse systems compel vegetable growers to become more active producers. Open field agriculture is mostly done in a passive way, crops are not daily monitored and interventions are mostly rare. Greenhouse growers should daily monitor the performance of their crops and interventions are a routine. Measuring parameters of air, soil and water quality is needed to intervene properly in the microclimate and optimize their crop production system.

Annex 3.

T a n n i a	
Names	English: tannia (leaves) Sranan / Dutch: taya wiri / tajerblad Scientific: *Xanthosoma sagittifolium* Schott., family Araceae
Background info	It is a native to South America, this variety is grown for the leaves. Another variety is 'pomtayer', which tuber is used for a famous Surinamese dish 'pom'. In the same family is dasheen (*Colocasia esculenta*). Both *X. sagittifolium* varieties are popular in Suriname, leaves and in particular tubers are also used in West Africa. Produce is exported, the young leaves are tender and need care.
Propagation	Use suckers / side shoots, separating them from the main corm with care. If more are needed corm can be used by dividing them in parts, each with skin. Cover these with moist soil and straw and transplant them after a few weeks.
Growing conditions	Tannia grows best in warm humid conditions, in the dry season growth is halted if water stress occurs and leaves will turn yellow. It grows well under shade roofs which improves the tenderness of the leaves. Fertilizers, especially urea, can lower the quality of the produce. Manure is preferred and should be given every 6-8 weeks. A spacing of 30 cm apart in rows 40 cm is recommended, leaving paths every 3-4 rows to minimize damage to the tender leaves.
Water *Media*	Good water quality is required. Most in soil, soil in pots also used (with ground cover fabric) if pests, weed and/or drainage problems prevail. Clay and sandy soils are used, soils with shells have a negative impact on taste of the leaves.
Leaves development	Plants can produce leaves up to 20 months and more. When leaves are picked two full grown leaves should be left for a healthy growth. Picking leaves starts after 5-6 weeks. OFA leaves are heavier as from PA, but OFA are less tender.
Pests and diseases	In general few pests and diseases occur, occasionally whiteflies and aphids and seldom mealybugs.
Further reading	LVV, 2005. Land- en tuinbouwgewassen, deel II. Groente- en peulgewassen. Power, R.H. and I.R. Wijngaarde, 1990. De Surinaamse groentetuin. Purseglove, JW, 1972. Tropical crops. Monocotyledons 2.

Tannia *(Photo LVV, 2005)*

Annex 4. Costs of shade roof unit of 400m2.

The costs of shade roofs are estimated, a basic type and a fancier model are mentioned. Some farmers will judge the basic one even luxurious and use less and cheaper materials. Depreciation is not an issue in the decision making process of most farmers, building a shade roof will be a gradual process for (part time) farmers in most cases.

Tannia growing costs were initially intended to calculate, data were scarce and not consistent, making the calculation unreliable.

Item	Basic type	Item price SRD	Quantity	basic type extended price SRD	Fancy type	Item price SRD	Quantity	fancy type extended price SRD
Posts	Split wooden post, 3m	14.00 /each	44	616.00	Wooden 4"x 4" post, 3m	48.00 /each	44	2.304.00
Lateral timber	timber 1"x4", B quality	2.50 /m	200	500.00	timber 1"x4", A quality	5.00 /m	200	1.000.00
Wire	3 mm iron wire	10.00 /kg	10	100.00	3 mm iron wire	10.00 /kg	10	100.00
Shade cloth	Black shade cloth, 50%, width 4m	12.50 / m	121	1.512.50	Green shade cloth, 50%, width 4m	39.25 /m	121	4.749.25
Other materials				500.00				500.00
Labor		6.00/hr	100	600.00		6.00/hr	100	600.00
Transport				250.00				250.00
Total costs				**4.078.50**				**9.503.25**
Costs /m2				**10.20**				**23.76**

	Basic type			***Fancy type***		
	Costs in SRD	Depreciation in five years	Depreciation /year in SRD	Costs in SRD	Depreciation in ten years	Depreciation /year in SRD
	4.078.50	5.346.91	**1.069.38**	9.503.25	1.7466.97	**1.746.70**

Structure: walaba posts, roof: timber & iron wire, shade cloth 50%, width 10m, length 40m and height 2.20m, area 400 m2.

Growing system: soil, bed of 10m, drainage trenches outside and along length of structure, within structure lateral trenches of 4.5m etc. In total 18 rows of plants over the width, 3 plants per meter over 40 meter, makes **2160 tannia plants**.

Annex 5. Lettuce growing in greenhouse (based on data from S. Oosthuizen, pers. communication, 2015)

Structure: built with galvanized pipe, width 7m, length 21m and height 6m / sides 4m.
Growing system: NFT with 3" PVC pipe (120m); own nursery, continuous production.
Total costs of greenhouse of 147 m2 with NFT growing system is SRD 28.800 or USD 8.600.
Depreciation of components is done in three groups, in 10, 5 and 3 years. Correction for inflation to depreciate the replacement costs is an (optimistic) 7% extra a year.

Items	Prices in SRD	Depreciation (dp) groups (10, 5 or 3 yr)	Dp in years		Dp per year in SRD	Remarks
Costs of structure in SRD						
Materials	6.535.07	4.637.07	10	8.522.93	852.29	Galv. iron pipes
		1.898.00	5	2.488.28	497.66	Plastic film, etc.
Welding	1.600.00		10	2.940.80	294.08	
Construction	2.940.00		10	5.403.72	540.37	
Transport	500.00		10	919.00	91.90	
Overhead	1.736.35					
Subtotal structure	13.311.42				2.184.40	
Costs of NFT growing system in SRD						
Materials	6.971.00	5.751.00	10	10.570.34	1.057.03	PVC material
		120.00	5	157.32	31.46	Valves
		1.100.00	3	1.259.50	419.83	Pump, meters
Transport	500.00		10	919.00	91.90	
Construction	6.000.00		10	3.713.95	371.39	
Overhead	2.020.65					
Subtotal system	15.491.65				1.971.61	
Production costs* in SRD						
Depreciation/year	4.156.00					
Inputs/year	6.600.00		Fertilizers, seed, oasis, chemicals for cleaning			
Hired labor	12.000.00		Part time labor for peak in activities			
Marketing	2.600.00		Including transport of produce			
Other costs	4.000.00		Utilities, packing,			
Total prod. costs	29.356.00					
Returns on the greenhouse operations in SRD						
Yield (heads)	24.000		A nearly continuous production is feasible.			
Cost price / head	1.22					
Selling price / head	2.50		Farm gate price, a great part is sold direct to restaurants and consumers for higher prices.			
Sales / year	60.000.00					
Profits** / year	30.644.00		Profits including labor of grower			

* Not included are among others: land cost, costs of working capital, costs for water storage capacity and costs of a small stand-by power unit.

** The activities of the grower could be valued as follows: three hours a day, seven days a week at a rate of SRD 10.00 / hour makes SRD 10.950.00 a year.

Annex 6. Good Agricultural Practices

Good Agricultural Practices (GAP) have in recent years developed in the context of a changing and globalizing food economy. Concerns of a wide range of stakeholders about food production and security, food safety and quality, and the environmental impact of agriculture did force governments and international organizations to act more responsible. Among the stakeholders were governments, food processing and retailing industries, farmers, and consumers, all engaged in securing their objectives of food security, food quality, production efficiency, livelihoods and environmental benefits.

FAO defines it broadly as: GAP applies available knowledge to addressing environmental, economic and social sustainability for on-farm production and post-production processes resulting in safe and healthy food and non-food agricultural products (FAO, 2003). Many farmers already apply GAP through sustainable agricultural methods such as integrated pest management and integrated nutrient management.

The food chain approach to food safety and quality has huge implications for agricultural production and post-production practices. GAP is formally recognized in the international regulatory framework for reducing risks associated with the use of pesticides, taking into account public and occupational health, environmental, and safety considerations. Emerging consumer demand for sustainably produced and wholesome food may create incentives for the adoption of GAP by farmers by opening new market opportunities, provided they have the capacity to respond.

In recent years Suriname has made progress on introducing GAP principles. In all districts meetings with farmers were held to explain the concept of GAP and raise awareness among producers. Training was organized for farmers in all districts on agrarian entrepreneurship, record keeping for farms, etc.

Legislation concerning pesticides were modernized (2005) and a negative list of pesticides published. A set of leaflets with information on related items like *Correct use of pesticides*, *Use of bio-pesticides*, *Use of Crotalaria*, *Safe use of pesticides*, etc. were published and used in meetings with the farmers.

The MAAHF laboratory cluster, with a residue analysis laboratory, opened end of 2009 and caught fire in 2010. A new building was erected, but new equipment is not yet installed. Being the basic component of GAP enforcement the completion of this laboratory is a prerequisite for successful introducing GAP in the country. The food processing and retailing industries, catering industry, farmers, exporters, and consumers, they all need this residue analysis to perform better or get confirmation of the quality of the produce they use / consume.

In the rural areas dedicated farmers are aware of food safety issues and the risks of using pesticides. The use of bio-pesticides is rising and farmers try other / natural methods to protect their crops.

Farmers use neem (*Melia azadirachta* L.) trees and leaves to repel insects, others use temporary inundation of their beds to kill nematodes, rotation or ‘defensive rings’ with

Crotalaria, etc. Some farmers do have records on all their activities, for each crop and bed separately and in detail. This practice of record keeping is not common yet, neither costs accounting.

Applying residue analysis on crop samples will be *'the proof of the pudding is in the eating'*. Marketing should support GAP farmers to boost their sales and get higher prices for their approved produce.

For most farmers it will be a long way to comply with all rules and be GAP certified, like for actors in the post-harvest stages with HACCP certification.

Impressions of some PA structures

A real mixed system with NFT, soil and medium in pots under a mix of structures (galvanized iron, wood) for growing lettuce and different herbs.

A professional NFT system with lettuce *(photo Hakrinbank, 2014)*

Protected agriculture in transition.

On the left the old system shade roof.

On the right the greenhouse with adapted roof construction with plastic film.

The trench was used for watering the crops, using a small floating water pump.

A new watering system was in development.
(Photo: P. Wongsowikromo)

Structures on less favorable location: building on the left and crop in between cast shadow in morning hours and obstruct wind flow. Plastic film of second structure also needs cleaning.

New structures being prepared for the first seedlings *(Photo's: P. Wongsowikromo)*

Main data of April-June 2015 survey.

Data of survey with some additional data of 2012 (partly updated).

GAB gable structure
GRH greenhouse
SHH shade house / roof
SPA split arch structure
SPG split gable structure
TUN tunnel

Regio **Midden,** ressort **Wanica A** (Kwatta) (excl. LVV structures)

number	Type	SHH m2	GRH m2	medium	Crop 1	Crop 2	Remarks
M.WA.01	SPA		420	NFT	Lettuce		
M.WA.02	GAB		120	Soil	Tomato		
M.WA.03	SPG		1292	Soil	Cauliflower		Too hot / vent.
M.WA.04	SPA		600	aquaponics	Lettuce	Paprika	
M.WA.05	SHH and GAB	450	450	Soil	Tomato	Paprika	transit. to GAB
Total	3332 m2	450 m2	2882 m2				

Regio **Midden**, ressort **Wanica B** (Houttuin) (excl. LVV structures)

number	Type	SHH m2	GRH m2	medium	Crop 1	Crop 2	Remarks
M.WB.01	SHH	120		Soil in pots	Celery	Amsoi	
M.WB.02	SHH	400		Soil	Tannia		
M.WB.03	SPA		240	Soil	Paprika	Cauliflower	
M.WB.04	TUN		280	Soil	Tomato		140 fallow
Total	1040 m2	520 m2	520 m2				

Regio **Midden,** ressort **Wanica C** (Santo) (excl. LVV structures)

number	Type	SHH m2	GRH m2	medium	Crop 1	Crop 2	Remarks
M.WC.01	SHH	316		Soil	Celery		
M.WC.02	SHH	1620		Soil	Celery		
M.WC.03	SHH	26		Soil	Celery		
M.WC.04	SHH	150		Soil	Sem		
M.WC.05	SHH	250		Soil in pots	Celery	Tannia	ground cover .
M.WC.06	GAB		39	Soil	Cabbage sp.	Tomato	
M.WC.07	SHH	1200		Soil	Celery	Amsoi	
M.WC.08	SHH	148		Soil, soil in pots	Celery		
M.WC.09	GAB		228	NFT	Kailan / kaisoi	Lettuce	
M.WC.10	SHH	90		Soil, soil in pots	Celery	Lettuce (10)	
M.WC.11	SHH	400		Soil	Celery		
M.WC.12	SPA		288	Soil	--		
M.WC.13	SHH	80		Soil	Tannia		
M.WC.14	SHH, GRH	1079	445	Soil, NFT (445)	Herbs	Lettuce	
Total	6359 m2	5359 m2	1000 m2				

Regio **Midden**, ressort **Saramacca** (excl. LVV structures)

number	Type	SHH m2	GRH m2	medium	Crop 1	Crop 2	Remarks
M.SA.01	SHH	2500		Soil	Tannia		
M.SA.02	SHH	1008		Soil	Tannia	Chin. cabbage	
M.SA.03	SPA		240	soil	Cauliflower		
M.SA.04	SHH	200		soil	Celery		
M.SA.05	SHH	800		Soil	Tannia		
M.SA.06	SHH	600		Soil	Celery		
M.SA.07	SHH	112		Soil	Tannia	Celery 12	
M.SA.08	SHH	480		Soil	Tannia	Celery	
M.SA.09	SHH	25		Soil	Tannia		
M.SA.10	SHH	960		Soil	Tannia	Celery	
M.SA.11	SPA		600	Soil	Lettuce	paprika	300 nursery
M.SA.12	SHH	480		Soil	Tannia		
M.SA.13	GAB		200	Soil	eggplant		
M.SA.14	SPA		1500	NFT	lettuce		Water shortage
M.SA.15	SPA		1500	NFT	lettuce		Problem w sales
Total	11.205m2	7.165 m2	4.040 m2				

Regio **Midden** ressort **Para** / Lelydorp (excl. LVV structure)

number	Type	SHH m2	GRH m2	medium	Crop 1	Crop 2	Remarks
M.Pr.01	SPA		150	NFT	Lettuce		Since 2006
M.Pr.02	SPA		115	Soil	Tomato		Since 2005
M.Pr.03	SPA		4800	Raft, cocopeat	Lettuce	Tomato	
Total		--	5065 m2				

Regio **Midden**, Paramaribo (excl. LVV structures) (data 2012)

number	Type	SHH m2	GRH m2	medium	Crop	Crop	Remarks
M.PO. 01	TUN	40	35	NFT	lettuce	Kailan	
M.PO.02	TUN	240	480	NFT	lettuce	tomato	
M.PO.03	TUN		120	NFT	lettuce		Disrepair
M.PO.04	SPG		80	NFT	lettuce		
M.PO.05	GAB		786	NFT	Lettuce	gherkins	Roof too low
Total	1.781 m2	280 m2	1.501 m2				

Regio **Oost** (excl. LVV structures)

Number	Type	SHH m2	GRH m2	medium	Crop 1	Crop 2	Remarks
O.CM.01	TUN		270	Soil	Paprika		50% in repair
O.CM.02	SHH	280		Soil	Celery		
O.CM.03	SHH	120		Soil	Celery		
O.CM.04	SHH	120		Soil	Tannia		
O.CM.05	SHH	120		Soil	Tannia		
O.CM.06	SHH	318		Soil	Tannia		
O.CM.07	SHH	30		Soil	Celery		
O.CM.08	SHH	254		Soil	Tannia		
O.CM.09	SHH	18		Soil	Tannia		
O.CM.10	SHH	30		Soil	Celery		
O.CM.11	SHH	50		Soil	Tannia		
O.CM.12	SHH	240		Soil	Tannia		
O.CM.13	SHH	8		Soli	Celery		
O.CM.14	GAB		54	Raft	Gherkins	Celery	
O.CM.15	GAB		120	Soil			?
O.CM.16	GAB		120	Soil	paprika		
O.CM.17	GAB		242	Soil	Tomato	Tannia	
O.MA.01	GAB		120	Soil			Petondro
O.MA.02	GAB		120	Soil			Alfonsdorp
O.MA.03	GAB		120	soil			Nason
Total	2.484 m2	1.588 m2	896 m2				

Regio **West** (excl. LVV structures)

number	Type	SHH m2	GRH m2	medium	Crop 1	Crop 2	Remarks
W.W1.01	TUN		120	Soil	Divers		
W.W1.02	SPA		120	Soil	Amsoi	Tomato	
W.W1.03	SPG		63	Soil	-		No crops
W.W2.01	GAB		580	Pots with soil	Gherkin	Tomato	
W.C.01	GAB		120	soil	Paprika		Fruit rot
W.C.02			?	soil	Tomato	Paprika	Partly PA
Total	1003 m2	--	1003 m2				