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The Performance of Greenhouses in Ghana: Cost-Benefit Analysis of Amiran and EnviroDome Models

Greater Accra Region, Ghana

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The GhanaVeg Program

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Greenhouses in Ghana

A booming sector, but a successful one?

Protected cultivation is gaining ground rapidly in Ghana. It is believed that across the country, over the last years, hundreds of tunnels and greenhouses have been built. The sector's impressive growth can be explained by the high market prices for vegetables, and the increased interest in modern, capital intensive technologies from both the private and the public sector. In the case of the private sector, our day to day contacts with vegetable farmers indicate that there is a 'buzz' in the sector that tunnels and greenhouses are highly profitable.

Also, the public sector increasingly wants to stimulate protected cultivation. It is seen as a good way to get youth involved in agriculture and produce more and better quality vegetables. In the words of a representative of the government: "Greenhouse technology provides high economic returns by maximizing the production area. In doing so, the technology also works toward food security in Ghana". As a proof of the government's interest to promote protected cultivation 150 greenhouses were financed in 2015 alone[1]. More projects are expected in 2016 and 2017.

At the same time, we also hear that farmers have difficulties in attaining stable and high yields, and that they face difficulties in pest and disease management. Already a significant number of greenhouses have been abandoned because of management problems. With the first greenhouses running now for the fifth or sixth year, the data published so far suggest that the productivity remains low. Indications are that yields of 15-20 kg m2 per year are attainable in Ghana. Slightly higher figures are reported for Kenya which fluctuate between 20 and 25 kg per year (having an 8-month production season).

Earlier studies[2] point out that successful greenhouse cultivation requires a combination of a good design, quality inputs, and adequate crop management (including production planning). This discussion paper takes that debate one step further and tries to evaluate the profitability of the two most popular greenhouse/tunnels in Ghana: the Amiran Farmers Kit and EnviroDome. Both models present a different design, i.e. in the type of ventilation, netting, height, medium for cultivation and irrigation; and hence, realize different yields and profits.

It becomes apparent that the sector demands evidence on the performance of the current greenhouse models in Ghana. Since its inception, GhanaVeg has been providing evidence based information and studies on issues like the performance of the export sector, the status of the sanitary and phytosanitary system in the country, developed business cases on an export farm and distribution centre. This study investigates the actual costs and revenues obtained in the two mentioned greenhouse models, and provides recommendations on how to make the greenhouse sector more successful.

Specifically, this discussion paper aims to:

- Evaluate the economic performance of the two most used greenhouse designs in Ghana:

1 http://mofa.gov.gh/site/?page_id=14370

2 E.g. Elings A, Y Saavedra, GO Nkansah, 2015, Strategies to support the greenhouse horticulture sector in Ghana, Wageningen UR, GhanaVeg Series No.3.

  - The Amiran type, commercialized by Dizengoff Ltd; a tunnel with top ventilation through nets.
  - The EnviroDome, developed by Stevicksen Ltd., a greenhouse with top ventilation through passive vents (round chimneys or windows).
- Develop a number of scenarios that evaluate the influence of other management and design choices.

Background

Basic design and production principles of greenhouses in Ghana

Protected cultivation provides two significant advantages as compared to open field: i) protection against adverse weather conditions; and ii) protection against pests. A well-thought design ensures the desired protection against these two natural hazards. The parameters to consider when designing a greenhouse are temperature, wind, radiation, CO^2 and relative air humidity. All these variables, together with the selection of inputs like media, seeds, crop protection products, water and nutrients, determine the profitability of a particular crop at a given location.

Most greenhouse farmers grow tomatoes since they can fetch high prices in the dry season and production can be prolonged up to six months with indeterminate varieties. Other crops grown in greenhouses are cucumber, bell peppers and okra.

Ghana, being a lowland tropical country, experiences high temperatures throughout the year and throughout the day (both day and night temperatures are high). This affects crop photosynthesis, flowering and pollination. As a rule of thumb production experts advise not to grow tomatoes when night temperatures come above 24°C. If not properly managed, high temperatures can cause a reduction of plant growth and fruit production. As such ventilation is key; in principle, the greenhouse should try to create a climate with lower inside than outside temperatures. The first designs in Ghana allowed for ventilation through the side nets. As the industry grew, designs with top ventilation through nets or passive vents became available. The latest models include top ventilation through one-sided or two-sided openings.

Preventing pest incidence is of crucial importance in protected cultivation. In recent visits to a number of greenhouses many pests were observed. Pests could enter the greenhouse because of holes and ruptures in the plastic or netting; and because of the absence of a two-door sluice system (with disinfection in between). The most common pests and diseases observed were:

- **Tomato:** white fly, damping-off and bacterial wilt.
- **Sweet pepper:** white fly, black mold, aphids.
- **Cucurbits** such as cucumber, marrow, sweet melons and turia: leaf miner, wilt, and white fly.

The 2015 study concluded with five key design elements that are recommended for Ghana:

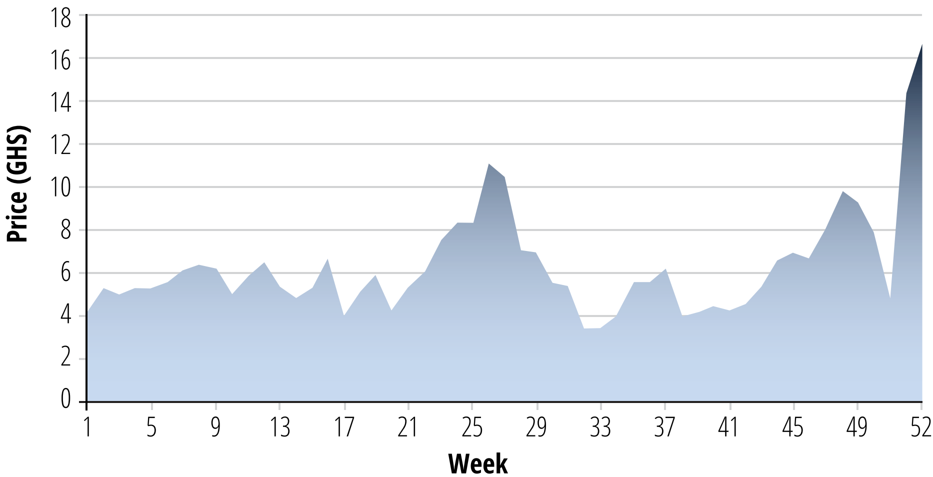
1. Cooling must occur through natural ventilation. Flexible window openings are not required since cold periods rarely take place.
2. Top windows for ventilation are necessary.
3. Fertigation can be gravity-based. An automated fertigation system can be installed when electricity is available.
4. A healthy growing medium must be used.
5. Well-trained management staff is instrumental.

Methodology

Assessing the performance of greenhouses in Ghana

First, the Amiran and Envirodome models were selected because they are the most popular models

Figure 1. *Weekly wholesale tomato prices at Agbobloshie in 2015 (in GHS, source: Esoko 2016)*



and sufficient data was available to evaluate them. Initially, data from four farmers per type were collected, and out of these four the two most reliable data sets were selected. All of them were located in Greater Accra. Data were triangulated with the information provided by the two companies, and our own judgment. In addition, data were compared with recent research in Kenya (especially in terms of input use and prices). The resulting information, although limited, is deemed best available knowledge.

The survey included:

- **General aspects:** location, greenhouse design, growing seasons and production model.
- **Capital investments** like the greenhouse itself, office, borehole and tanks.
- **Operating costs** like inputs (growing medium, seeds, fertilizer, crop protection), utilities (mobile, internet, electricity) and labour (salaries and casual labour).
- **Financing costs** (own capital and bank loans).
- **Revenues:** production and market prices.

For market prices, we used a premium to cater for the higher quality of the greenhouse tomatoes. As a base we used wholesale market prices at Agbobloshie (Figure 1) and assumed that transport from the farm to the high-value-market was offset by a premium price for greenhouse tomatoes (hence equaling the wholesale Agbobloshie market price). An average farm gate price of GHS 6.35 per kg was used. This balances the lower prices of January and February with spikes in July and November/December. We also assumed production planning was organized in such a way that the highest production periods coincided with these spikes.

Interestingly, our study found that most greenhouse farmers produce in two cycles of around four months. This is different from East Africa where often one longer production cycle per year is used. Still, yields are similar or even lower in Ghana, indicating more difficult production conditions than in the cooler Kenyan highlands. Roughly yields were around 10 kg/m^2 per season in Ghana, totaling 20 kg/m^2 per year. The other assumptions for the two models are provided in Table 1 on the following pages.

Table 1. *Major assumptions of the greenhouse models*

		Amiran Farmers Kit	EnviroDome
General			
Exchange rate	GHS/USD	0.26	0.26
Inflation		Same for income & costs	Same for income & costs
Production			
Location		Greater Accra	Greater Accra
Growing seasons / year		2	2
Tomato variety		Eva	Eva
Growing medium		Cocopeat	Cocopeat
Area	m2	135.0	271.2
Effective area	m2	120.0	240.0
Yield per growing season	kg/m2 effective area	9.7	8.0
Turnover			
Farm gate price	GHS/kg	6.35	6.35
Cost of Sales			
Seed	GHS/growing season	241	520
Growing medium	GHS/growing season	50	99
Fungicide, insecticide, fertilizer	GHS/growing season	725	1,509
Electricity	GHS/growing season	140	402
Salaries			
Staff position 1: Greenhouse Manager			
Annual salary growth above inflation	%	3%	3%
Opening salary & benefits	GHS/month	600	600
Staff number	FTE	0.15	0.25
Staff position 2: Manual labour			
Annual salary growth above inflation	%	3%	3%
Opening salary & benefits	GHS/month	540	540
Staff number	FTE	0.83	1.00
CAPITAL EXPENDITURES & OTHER OPERATING COSTS		See “Cost and investment overview”	

Table 1. *Major assumptions of the greenhouse models, continued*

	Amiran Farmer Kit	**EnviroDome**
Depreciation		
4 years	Plastic cover, side net	
5 years	Furniture & IT, production equipment	Furniture & IT, production equipment, ground cover, side net
7 years		Soilless Growing System, irrigation equipment, trellising twine
10 years	Greenhouse tunnel kit structure, ventilator, genset, water pump	Greenhouse structure, installation, shipment, transportation, genset
25 years	Borehole	Borehole, stones and gravel, grading and leveling
Working Capital		
Debtor account	50% at farm-gate, 50% pay after 1 month	50% at farm-gate, 50% pay after 1 month
Creditor account	In general 0 days, except 30 for electricity	In general 0 days, except 30 for electricity
Stock account	Stock fully acquired at start of growing season	Stock fully acquired at start of growing season
Taxation		
Income tax (%)	0% during years 1-5, 25% afterwards	0% during years 1-5, 25% afterwards

View of two Amiran greenhouses.

Results 1. Costs and benefits of the two greenhouse models

Our analysis of the models covers costs-benefits (Tables 2 and 3) and revenues (Tables 4 and 5).

Table 2. *Cost and investment overview for the Amiran Farmers Kit greenhouse*

Year	1	2	3	4	5	6	7
Cost of Inputs							
Seed	0	125	125	125	125	125	125
Growing medium	0	13	0	13	0	13	0
Fungicides, insecticides, fertilizer	0	377	377	377	377	377	377
Electricity	36	73	73	73	73	73	73
Total cost of inputs	**36**	**588**	**575**	**588**	**575**	**588**	**575**
Operating Costs							
Staff costs	2,752	1,822	1,877	1,933	1,991	2,051	2,112
Start-up expenses	400	200	0	0	0	0	0
Rent (part of) office	240	240	240	240	240	240	240
Land lease fees	100	100	100	100	100	100	100
Water & electricity**	180	180	180	180	180	180	180
Fuel & travel	600	600	600	600	600	600	600
IT & telecom	120	120	120	120	120	120	120
Office supplies	50	50	50	50	50	50	50
Maintenance	90	90	90	90	90	90	90
Bank charges	120	120	120	120	120	120	120
Bad debt	49	96	74	76	76	76	76
Contingencies	75	75	75	75	75	75	75
Total operating costs	**4,775**	**3,693**	**3,526**	**3,584**	**3,642**	**3,701**	**3,763**
Capital Expenditures (Capex)							
Furniture & IT (lump sum)	400					400	
Greenhouse tunnel kit	6,027 (excluding plastic cover & side net)						
Plastic cover	520				520		
Side net	453				453		
Ventilator	1,200						
Genset	520						
Water pump	520						
Production equipment (bags, trays, crates etc.)	200					200	
Borehole	6,500						
Total Capex	**16,340**	**0**	**0**	**0**	**973**	**600**	**0**

** *Part of office*

Table 3. *Cost and investment overview for the EnviroDome greenhouse*

Year	1	2	3	4	5	6	7
Cost of Inputs							
Seed	135	270	270	270	270	270	270
Growing medium	26	51	51	51	51	51	51
Fungicides, insecticides, fertilizer	392	785	785	785	785	785	785
Electricity	105	209	209	209	209	209	209
Total cost of sales	**658**	**1,316**	**1,316**	**1,316**	**1,316**	**1,316**	**1,316**
Operating Costs							
Staff costs	3,243	2,328	2,398	2,470	2,544	2,620	2,699
Start-up expenses	400	200	0	0	0	0	0
Rent (part of) office	240	240	240	240	240	240	240
Land lease fees	100	100	100	100	100	100	100
Water & electricity**	180	180	180	180	180	180	180
Fuel & travel	600	600	600	600	600	600	600
IT & telecom	120	120	120	120	120	120	120
Office supplies	50	50	50	50	50	50	50
Maintenance	90	90	90	90	90	90	90
Bank charges	120	120	120	120	120	120	120
Bad debt	79	157	121	124	124	124	124
Contingencies	75	75	75	75	75	75	75
Total operating costs	5,298	4,260	4,094	**4,169**	**4,243**	**4,319**	**4,398**
Capital Expenditures (Capex)							
Furniture & IT (lump sum)	400					400	
Grnhs. structure (271 m^2)	5,061						
Soilless growing system	140					530	
Ground cover	530					939	
Side net	939						
Stones and gravel	150						
Irrigation	1,841 (including pipes/pumps/tanks/fixing, etc.)						
Installation	1,600						
Shipment	800						
Trellising twine	80						
Transportation	300						
Grading & leveling	200						
Production equipment	250 (including uright bags, trays, crates, etc.)					250	
Borehole	7,000						
Genset	520						
Total Capex	19,811	0	0	**0**	**0**	**2,119**	**0**

The main cost components for both models are:

- The structure itself, the borehole and the irrigation equipment (around US$ 15,000 for both models). This already equals a cost of US$ 125 and US$ 62.50 per m^2 effective production area for the Amiran Farmers Kit and EnviroDome respectively.
- The staff and operating costs, the combination of salaries for staff and day-to-day expenditures on electricity, travel, office supplies and maintenance (around US$ 4,000 for each from the second year onwards). Costs for inputs and operating costs were cross-checked with similar studies in Kenya and were found to be rather similar[3].

Importantly, we have used an approach of full cost accounting. This means that e.g. costs for utilities like electricity, fuel and mobile/internet; and transport are all included in the cost-benefit analysis and so are the costs for related, much needed, equipment like a borehole and pump (as all the interviewed greenhouse managers used a borehole). In many other studies these costs are incorrectly left out. This was also evidenced by the visits and discussions with greenhouse operators, of which all mentioned high levels of operating costs and additional expenditures on hardware.

3 *GSK, 2016, Growing Solutions Kenya – Cost Benefit Analysis, unpublished data.*

An EnviroDome greenhouse.

Table 4. *Revenues of the Amiran Farmers Kit greenhouse*

Year	Unit	1	2	3	4	5	6	7
Production								
Effective area	m^2	120	120	120	120	120	120	120
Yield per season	kg/m^2	9.7	9.7	9.7	9.7	9.7	9.7	9.7
Growing season	Season/year	1	2	2	2	2	2	2
Annual yield	kg	1,167	2,333	2,333	2,333	2,333	2,333	2,333
Efficiency	%	70%	90%	100%	100%	100%	100%	100%
Volume produced	**kg**	**817**	**2,100**	**2,333**	**2,333**	**2,333**	**2,333**	**2,333**
Turnover								
Volume unsellable	%	10%	8%	4%	2%	2%	2%	2%
Volume sold	kg	735	1,932	2,240	2,287	2,287	2,287	2,287
Farm-gate price	GHS/kg	6.35	6.35	6.35	6.35	6.35	6.35	6.35
Farm-gate price	US$/kg	1.65	1.65	1.65	1.65	1.65	1.65	1.65
Turnover	**US$**	**1,213**	**3,190**	**3,698**	**3,775**	**3,775**	**3,775**	**3,775**

Table 5. *Revenues of the EnviroDome greenhouse*

Year	Unit	1	2	3	4	5	6	7
Production								
Effective area	m^2	240	240	240	240	240	240	240
Yield per growing season	kg/m^2 effective area	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Growing season	Growing season/annum	1	2	2	2	2	2	2
Yield per annum	kg	1,910	3,820	3,820	3,820	3,820	3,820	3,820
Efficiency	%	70%	90%	100%	100%	100%	100%	100%
Volume produced	**kg**	1,337	3,438	**3,820**	**3,820**	**3,820**	**3,820**	**3,820**
Turnover								
Volume unsellable	%	10%	8%	4%	2%	2%	2%	2%
Volume sold	kg	1,203	3,163	3,667	3,744	3,744	3,744	3,744
Farm-gate price	GHS/kg	6.35	6.35	6.35	6.35	6.35	6.35	6.35
Farm-gate price	US$/kg	1.65	1.65	1.65	1.65	1.65	1.65	1.65
Turnover	**US$**	1,987	5,222	**6,055**	**6,181**	**6,181**	**6,181**	**6,181**

Important notions here are that:

- The model takes into account that often in the first two year lower yields are recorded than later, in years 3 and beyond. This relates to the 'growing pains' that take place when starting greenhouse cultivation; e.g. in terms of fertilization, variety choice or pest and disease management. Also, because of construction and land preparation the first year only has one season; making the second year the first real year for revenues.
- Yields for both models are similar at around 10 kg/m^2 per season. This was cross-checked with a number of greenhouse operators and experts (agronomists, consultants) and deemed realistic. The small differences in yield as a result of difference in design, are further confirmed by research done in Kenya. There, 3 models were compared, with various levels of technology ranging from basic to advanced. Results showed yield differences were small, ranging from 21 kg/m^2 (basic) to 22 kg/m^2 (plus) and 28 kg/m^2 (advanced).
- Apart from design, the major difference between our models is size (effective area of production), with the Envirodome having an effective area of 240 m^2 and the Amiran Farmers Kit having 120 m^2.

Results 2. Profitability of the two greenhouse models

By combining the cost structure and revenue model we can come to a better understanding of the overall profitability of the two greenhouse models. Table 6 below serves as a summary of the most relevant categories.

Table 6. *Cost-benefit analysis of the two greenhouse models (in US$)*

Analysis	**Amiran** (135 m^2)	**EnviroDome** (271.2 m^2)
Medium-term* revenue per annum (US$)	3,800	6,200
Medium-term cost of inputs per year (US$)	-600	-1,300
Medium term gross profit per year (revenue less cost of inputs)	3,200	4,900
Medium term operating costs per year (US$)		
Medium term operating profit per year (US$)	-3,700	-4,300
Medium term depreciation per year (US$)	-500	600
Medium term taxes per year (US$)	-1,400	-1,800
Medium term net profit per year **(US$)	0	0
7-year Internal Rate of Return (IRR)	**-1,900**	**-1,200**
Project payback period	**N/A**	**N/A**

* Medium term amounts are obtained by calculating the average over years 4-7

** To facilitate easy comparison between types, debt financing hasn't been taken into consideration in the analysis.

The major findings of the above analysis are that:

- Both greenhouses are not profitable, even not when we take a 7-year period for calculations. The medium-term net profit (average of years 4-7) is in both cases negative.
- The EnviroDome model is less negative than the Amiran model. The advantage of the EnviroDome is mainly its larger size and related lower cost per m^2 effective production area.
- Key variables that have been decisive for the outcome of the analysis are: the size of the greenhouse, yields and price per kg, and the inclusion of a number of capital expenditures (borehole, pump, generator, office).

Raising an Amiran Farmers Kit greenhouse.

Results 3. Scenario analyses of yield, size and capex

In order to find out which variable is most decisive we have run three scenario analyses; each looking at a different aspect:

- **Scenario 1:** For both models the yield was increased by 50% to around 12-15 kg/m^2 per season and 24-30 kg/m^2 per year; this level of yields is seen as the maximum realistically attainable yields in Southern Ghana (Elings et al, 2015).
- **Scenario 2:** A reduction of the capital expenditures, considering that the owner already has a borehole and an office in place.
- **Scenario 3:** An increase in size. For both models the size was increased by a factor 4, making the Amiran close to 500 m^2 and the EnviroDome more than 1,000 m^2.

The results of these scenario analyses are presented in Table 7.

Table 7. *Scenario analysis for the greenhouse models (in US$)*

		Medium term revenue per annum	*Medium term cost of sales per annum*	*Medium term gross profit per annum*	*Medium term total operating costs per annum*	*Medium term operating profit per annum*	*Medium term depreciation per annum*	*Medium term taxes per annum*	*Medium term net profit per annum***	*7 year IRR*	*Project payback period (years)*
Amiran	Basis	3,800	-600	3,200	-3,700	-500	-1,400	0	-1,900	N/A	N/A
	Yield +50%	5,700	-600	5,100	-3,700	1,400	-1,400	0	0	N/A	N/A
	Capex – existing assets	3,800	-600	3,200	-3,300	-100	-1,200	0	-1,300	N/A	N/A
	Size *4	15,100	-2,300	12,800	-4,500	8,300	-4,600	-500	3,200	N/A	7.6
Profitable scenario: 1,000 m²		**30,200**	**-5,400**	**24,800**	**-7,100**	**17,700**	**-7,400**	**-1,300**	**9,000**	**9%**	**5.6**
EnviroDome	Basis	6,200	-1,300	4,900	-4,300	600	-1,800	0	-1,200	N/A	N/A
	Yield +50%	9,300	-1,300	8,000	-4,300	3,700	-1,800	-200	1,700	N/A	9.9
	Capex – existing assets	6,200	-1,300	4,900	-3,900	1,000	-1,600	0	-600	N/A	N/A
	Size *4 = Profitable scenario	24,700	-5,300	19,400	-6,700	12,700	-5,600	-900	6,200	4%	6.3
Profitable scenario: 1,085 m²		**24,700**	**-5,300**	**19,400**	**-6,700**	**12,700**	**-6,400**	**-900**	**6,200**	**4%**	**6.3**

The scenario analyses show that:

- Only by increasing the size of the greenhouse area will the overall project become profitable. This applies to both models, the Amiran and the Envirodome. As a 'rule of thumb' one could say that to make a profit you need to have a greenhouse of at least 1,000 m^2. The main underlying reasons for this are the high operating costs (salaries, utilities, transport) and the high costs for the hardware, including the borehole, office and pumps. Both are reduced substantially when size increases, creating an economy of scale.
- A yield increase of 50% (to about 24 kg/m^2) will lead to a profitability of US$ 1,700 per year in the medium term for the Envirodome model. This is just enough to achieve a project payback period of 9.5 years. Not very profitable for an external investor but possibly enough for a family business in which already owned land, capital and infrastructure is used.
- Only the Amiran and Envirodome models of 1,000 m^2 show a good profitability (e.g., at a level that could interest banks). In this scenario, the medium-term net profit is US$ 9,000 and US$ 10,100 per year respectively for the Amiran and Envirodome model, with a project payback period of 5.6 and 4.5 years respectively, and a 7-year internal rate of return of 9% and 14% respectively.

Conclusions and Recommendations

The main conclusion of this study is that at the moment building single, stand-alone units of greenhouses is not profitable in Ghana. This is mainly influenced by the high initial investment in the hardware (structure, irrigation, borehole) and the relatively high operating costs of salaries, utilities and transport. Our scenario analyses show that if capital expenditures can be brought down to around US$30 per m^2 of effective production area, greenhouses can be profitable. At the current sizes costs per m^2 are US$80 and U$125 for the two studied greenhouses, which makes it hardly impossible to earn back the initial investment.

There are basically two strategies to reduce the price per m^2: the first is to grow bigger (increasing the size of the greenhouse to 1,000 m^2 or more) and the second is to reduce the cost of the materials. The first strategy reduces the amount of steel and other materials, as well as it reduces the relative costs for the other hardware and operational expense; hence, creating economies of scale. The second strategy mainly focuses on the current high costs of tunnels and greenhouses in Ghana. These are also high compared to other places in Africa like Kenya and Tanzania.

Costs could be reduced if more locally available materials would be used. Currently, some experiments are going on with more locally developed and constructed greenhouses, using more domestic, 'raw' steel and welding then the 'plug and play' imported greenhouses from abroad.

Based on these conclusions this study recommends:

- First and foremost, it is important to discuss the prospects of greenhouse horticulture based on evidence-based information of agronomic and economic findings. Too much of the current discussion is blurred by hearsay, ideological considerations and a 'deus ex machina' type of narrative. Taking greenhouse agriculture seriously means knowing the right designs for the right agro-ecological zones, knowing the right production practices and production planning. Greenhouse agriculture should be seen as the most advanced and difficult level of agriculture, also called the 'Champions League of horticulture'; and this requires a similar professional attitude of the farmers, investors, service providers and financing organizations that want to utilize one.

- In order to know more about the right designs and production practices in Ghana, more information is needed on the specific production conditions in the greenhouses (relative humidity, radiation, temperatures, evapotranspiration), so the overall design of the greenhouse can be adjusted and specific agronomic practices can be advised (e.g. in terms of fertigation, pest and disease management, and variety choice). Importantly, the new designs should focus on bigger structures, preferably of 1,000 m^2 but one could experiment with 500 m^2 as well (as long as hardware costs are brought down), while still keeping the old design principles into account (as presented in the background chapter).
- We recommend that a first project starts with a selected group of professional greenhouse growers on record keeping of production practices and operational management. Proper record keeping can be the first step in better understanding where gains can be made and peer learning can take place between the greenhouse growers.
- Lastly, we recommend that a discussion is started with local manufacturing companies and greenhouse suppliers on the use of more local materials to reduce imported hardware requirements. These materials especially include the steel bars, water tanks and possibly cocopeat. ■

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