Optimizing water use in the Central Highlands of Viet Nam

Focus on the Robusta coffee sector

Dr. Dave A. D’haeze

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List of abbreviations

CHYN	Centre for Hydrogeology and Geothermic (of the University Neuchâtel)
DARD	Department of Agriculture and Rural Development
FCV	Farmer Coaching Visits
FFS	Farmer Field School
GAP	Good Agricultural Practices
GCP	Global Coffee Platform
HRNS	Hanns R. Neumann Stiftung
IPSARD	Institute of Policy and Strategy for Agriculture and Rural Development
ISLA	Initiative for Sustainable Landscapes
IWMI	International Water Management Institute
MARD	Ministry of Agriculture and Rural Development
MONRE	Ministry of Natural Resources and Environment
MoU	Memorandum of understanding
SDC	Swiss Agency for Development and Cooperation
ToT	Training of trainer
VCCB	Viet Namese Coffee Coordination Board
VnSAT	Viet Nam Sustainable Agriculture Transformation Project
VNU	Hanoi University of Science
WASI	Western Highlands Agro-forestry Sciences and Technical Institute

1 Context

The objective of this assignment is to prepare an investment strategy for coffee and cash crop production in the Central Highlands of Viet Nam which complies with the nexus principles of maximizing economic benefits across the Srepok and Sesan river basins.

In particular, the following key questions will be addressed in this report

- What is the **current status of coffee production in Central Highlands** in terms of economic benefits, environmental impacts, water and land usage and stakeholders involved?
- If **Viet Nam's coffee production is to be doubled** by 2030, how much land is involved and where is it? How much water is needed? Where is that water going to come from, how will it be delivered and if water budgets are available, do they already include the water needed to expand the coffee area?
- Will **climate change** be a threat to the coffee production and what are the impacts?
- What is the **government and big corporates'** reactions and plans for coffee production in the future given climate change impacts?
- Are there any possibilities to **intensify coffee production** in less water consuming ways amid climate change context? Quantifying the benefits if possible and what are associated cost for technology, trainings in order to do so? What are enabling conditions and policy support needed?
- Are there any possibilities to **replace coffee with other crops** that are less water demanding in some areas? If yes, what are those crops, where should they be planted, what are benefits and costs for such conversion and crops diversification? What are enabling conditions and policy support needed to do so?

2 Current status of coffee production in the Central Highlands of Viet Nam

2.1 Economic highlights

- Viet Nam is the world's leading Robusta coffee producer with an output of ~29.5 mio bags green bean equivalent (gbe) in 2017/2018 (ICO, 2019; http://www.ico.org/new_historical.asp).
- Coffee is Viet Nam's largest export earning crop, generating a value of ~3.3 billion USD/y (Table 1).

Table 1: Most important agricultural export products in Viet Nam; Viet Nam Customs, 2016

Export product	Quantity 1,000 Mt	FoB Value million USD	Unit Price USD / Mt
Coffee	1,782	3,336	1,872
Cashew nut	347	2,843	8,193
Fruits and vegetables	n/a	2,458	n/a
Rice	4,836	2,172	449
Rubber	1,254	1,672	1,333
Pepper	178	1,429	8,028

- A global coffee supply deficit of 60 million bags gbe is expected by 2030 (Figure 1). This is equivalent to double Viet Nam's coffee production in 2017/2018.

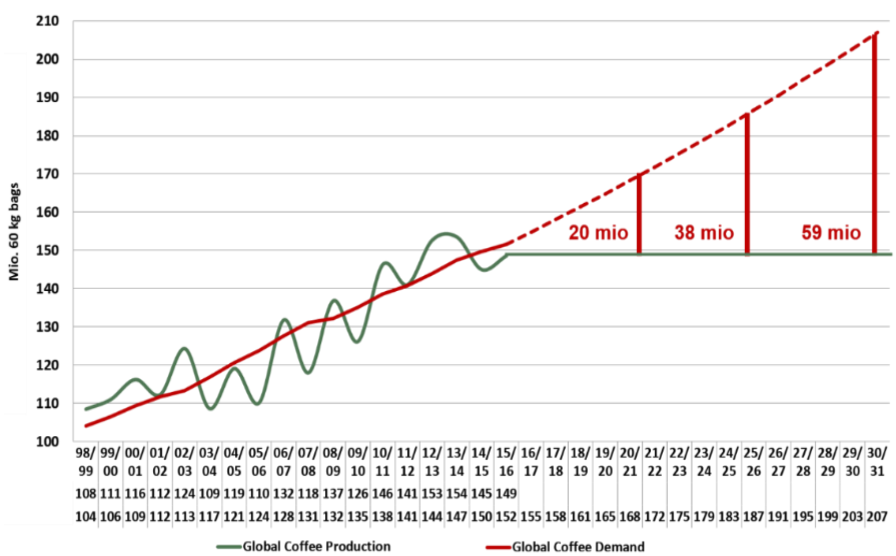

Figure 1: Global coffee production and consumption – historic trend and forecast until 2030 (in mio 60 kg bags gbe); Neumann Kaffee Gruppe, 2016

- Viet Namese coffee sector offers jobs for circa 620,000 coffee farming households; assuming 4 members per family this adds up to ~2.5 million people or ~40% of the entire population in the Central Highlands. In the Srepok and Sesan river basins (2S) circa 236,000 ha are planted with Robusta coffee (i.e. 38% of the total production area).
- During the 2016/2017 season average production costs were ~1,761 USD/ha (@ current exchange rate of 23,274 VND per USD, 28.03.2019), revenues (based on farm gate prices) were 6,058 USD/ha and net profits 4,297 USD/ha or ~1,718 USD/Mt (assuming 2.5 Mt/ha as a national average); Agri-Logic, 2018, p42[1].

2.2 Environmental impacts

- Coffee production in Viet Nam requires water for irrigation in the dry season to produce yields up to 4 Mt/ha for the current coffee variety (i.e. an inhomogeneous tree stock originating from the Congo basin). Farmers are irrigating excessively, mainly using groundwater resources, leading to seasonal water shortages in the dry season (drying up of wells).
- These water shortages appear related to power supply in urban areas like Buon Ma Thuot where regularly power cuts are observed during the dry season.
- Based on MARD data (2018; Figure 2), the yield per ha in relation to dry versus normal years seems to be 10% (data 2010-2017) on average. There appears no clear trend in productivity decline vs. drought events.

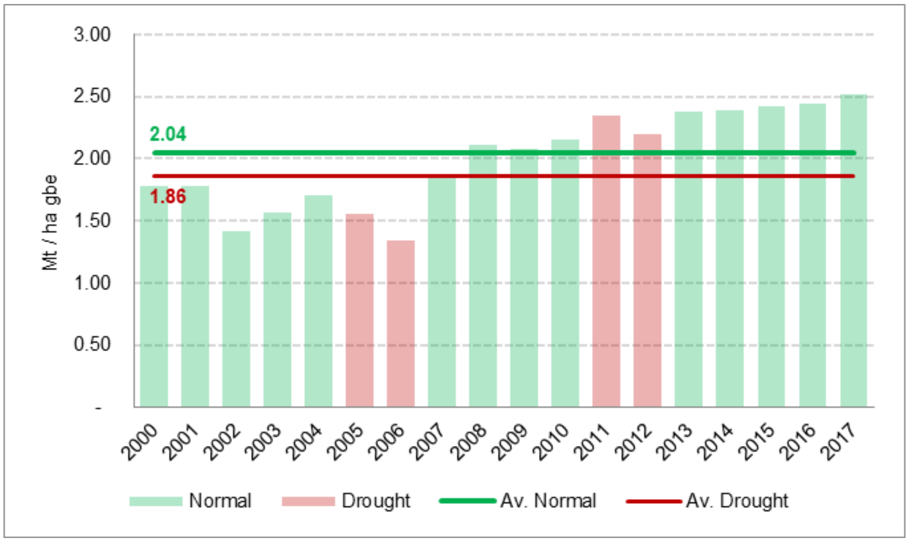

Figure 2: Yield per ha (gbe) per year. Red bars indicate dry years (MARD, 2018)

- In case of water scarcity 6-8 weeks after flowering the coffee cherries will not grow to their full extent (cherry swelling stage). As a consequence, the green beans will remain smaller than normal, which reduces the overall tonnage per hectare. On top of this, smaller bean size is considered lower quality by the industry, fetching lower prices which reduce the potential gross income of the farmers.

[1]The Agri-Logic, 2018 report, assesses farmers' performance based on farmer field book records in the supply chains of trading companies under the IDH/ISLA program These farmers (900 in total) produce on average 4.13 and 3.05 Mt/ha gbe respectively in Lam Dong and Dak Lak province; p8.

- Farmers usually fertilize excessively with soil acidifying (urea based) fertilizers (IDH, 2013). As consequences:
  - ✓ More nematode infestations are observed; these creatures feed on the coffee roots and can kill coffee trees.
  - ✓ Intercrops such as pepper cannot survive on very acid soils.
- Large scale deforestation happened over the last 40 years in order to grow coffee. As a result, some new pests arose such as cicadas. These insects feed on the roots of plants and can kill coffee trees. These insects are very mobile and can potentially affect large coffee areas.

2.3 Water & land usage

- Table 2 below presents an overview of the coffee areas and coffee production in Viet Nam broken down per province.
- The 2S cover mainly Dak Lak and Gia Lai provinces with a total estimated coffee area of 236,000 ha (estimation made by Daniel Constable, 20/03/2019).

Table 2: Overview total coffee area (ha), total productive area (ha), total production (Mt gbe) and average yield (Mt / ha gbe)

Province	Total Production Mt	Total Area ha	Total Productive Area ha	Average Yield Mt / ha
Dak Lak	459,785	204,808	187,279	2.46
Lam Dong	495,744	173,872	162,857	3.04
Dak Nong	291,513	131,108	122,775	2.37
Gia Lai	222,700	94,900	80,763	2.76
Kon Tum	43,390	20,613	17,321	2.51
Total	**1,513,132**	**625,301**	**570,995**	**2.63**

References:

Dak Lak	Report on Evaluation of the 2017-2018 Coffee Crop, No. 332/BC-UBND dated 26th November 2018 by Dak Lak PPC.
Lam Dong	Lam Dong Statistic Office, March 2019.
Dak Nong	Report on the Evaluation of the Agriculture and Rural Development Activities, No. 2894 of 19 April 2018 by Lam Dong DARD
Gia Lai	Announcement on Socio-Economic Development Targets in 201, No. 2134/KHDT
Kon Tum	Report on the Socio-economic Situation in 2018; Tasks and Orientations toward 2019, No 266/BC-UBND of 16 January 2018.

- It is estimated that circa 1.32 billion m^3 of water is used for irrigating coffee in the entire Central Highlands. This is excessive and it is estimated that this can be reduced by ~40%. More information on water use and potential water savings for the 2S river basin is provided in Chapter 5

2.4 Stakeholders involved in the coffee sector[1]

- The coffee sector involves multiple stakeholders. Figure 3 shows a schematic overview of the Robusta coffee supply chain in Viet Nam. Most coffee is exported as green bean and farmers fetch 90-05% of the FoB price in the farm gate.

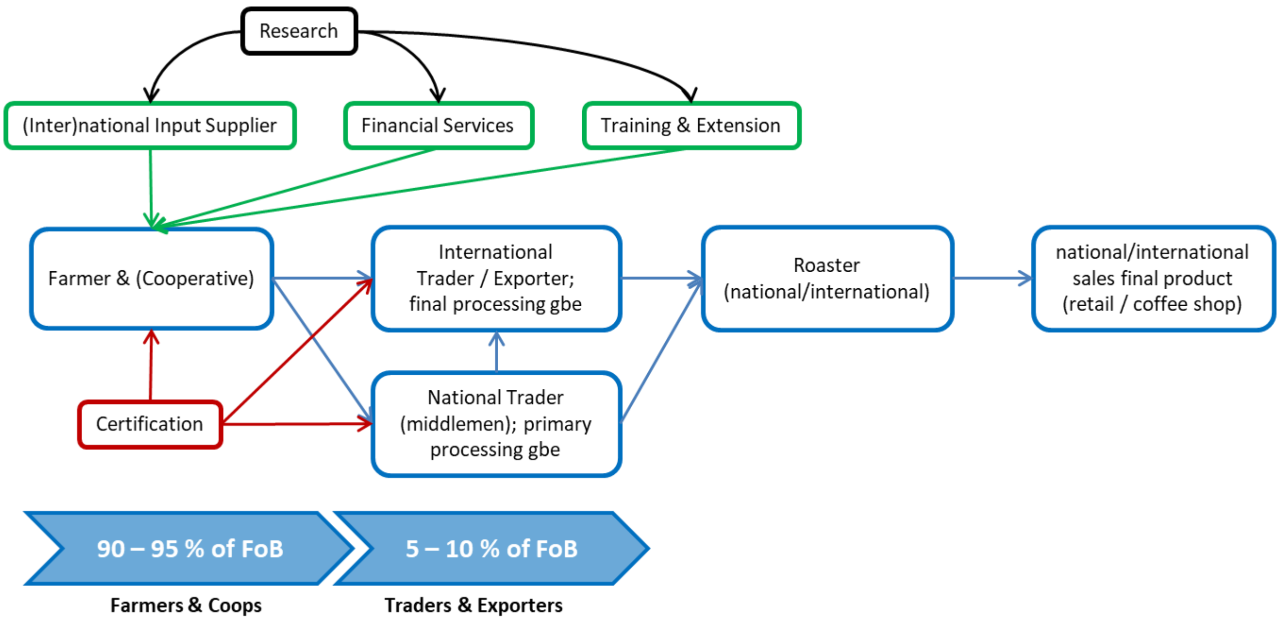

Figure 3: Overview Robusta coffee value chain in Vietnam

- Short summary of the main players is provided below and a more detailed stakeholder analysis is presented in Annex 1.
  - ✓ Farmers: it is estimated that circa 620,000 smallholder farming households produce Robusta coffee in the Central Highlands
  - ✓ Government:
    - ➢ Ministry of Agriculture and Rural Development (MARD) and provincial departments
    - ➢ Extension: Viet Nam has a well-organized extension network, stretching from the national level down to the provinces, districts and communes.
  - ✓ Associations:
    - ➢ Viet Nam Coffee and Cocoa Association (VICOFA)
    - ➢ Viet Nam Coffee Coordination Board (VCCB)
  - ✓ Roasters both international and domestic such as:
    - ➢ Nestlé, Jacobs-Douwe Egberts, Trung Nguyen, Vinacafe, etc.
  - ✓ Traders:
    - ➢ National: e.g., Intimex, Simexco, Vinacafe, International: e.g. Volcafe, Olam, Acom, Neumann Gruppe.

[1] A full contact list can be shared upon request.

- ✓ Research:
  - ➢ Western Highlands Agro-Forestry Sciences and Technical Institute (WASI)
  - ➢ Viet Nam Academy of Agricultural Sciences (VAAS)
  - ➢ Soil and Fertilizer Institute
- ✓ Recently, a research group was established under the Viet Nam Coffee Coordination Board. This group includes CGIAR centers like ICRAF, CIAT, CIRAD, WASI, VAAS, etc.

3 Doubling Viet Nam's coffee production by 2030?

3.1 Government planning

- Dak Lak is the major coffee producing province in the 2S river basins, contributing ~30% of the national Robusta production (table 2)
- According to Decision Nr. 2811/QD UBND dated 10 October 2017 by Dak Lak People's Committee, the province plans to:
  - ✓ Gradually reach a stable coffee area of 170,000-180,000 ha by 2030
  - ✓ Achieve a provincial production of 450,000 Mt/year (i.e. ~2.5 Mt/ha)
  - ✓ Achieve a productivity of 2.8 Mt/ha by 2030

3.2 Coffee rejuvenation with improved varieties

- Productivity per land area can be increased. Currently the average national productivity per ha is ~2,8 Mt/ha (GAIN report, USDA, 2018; p4).
- Below Table 3 shows an overview of the new coffee varieties including their quality characteristics, water requirement and production potential. On average the new varieties have a production potential of 6 Mt/ha. According to WASI the water requirements would remain at 400 liter/tree/round for the higher yielding new varieties.

Table 3: Robusta coffee varieties and their characteristics, recommended by WASI; pers. comm.

Robusta variety	Potential productivity	Weight of 100 beans	Bean size over screen 16	Water requirement
	Mt/ha	G	%	Liter/tree/round
TRS1	>7	17	71	400
TR4	7.3	17	71	400
TR9	5.5	24	98	400
TR 11	4.5	19	96	400
Average	**6**	**19**	**84**	**400**

- A coffee rejuvenation program started in 2011. In 2017 about 22,000 hectares were rejuvenated in Dak Lak (DARD Dak Lak, 2018). According to the plan (Decision 54 QDUB of 6 January 2014 regarding the Dak Lak PPC approval of the Coffee Rejuvenation Program, 2013-2020 period), ~28,000 ha are targeted by 2020.
- Based on the suggested water requirements for the new coffee varieties (WASI, 2019; pers. comm.; Table 3), the water demand for monocrop coffee would not change.
- Under optimized conditions 400 liter/tree/round is required at 3 rounds per year (on average) to support blossoming. Assuming hose irrigation only in the entire 2S region, the total estimated water requirement is 314 million m^3. Assuming only overhead sprinkler the required water volume would be 45% higher or 472 million m^3 per annum. More information on potential water saving for different investment scenarios is provided in chapter 6.2.
- Doubling the productivity of coffee in Viet Nam appears not feasible over a 10-year time span (2020-2030). Figure 4 presents a scenario whereby the entire 2S area would be rejuvenated over 10 years. Given the fact that it takes 8 years to reach maximum productivity for the new varieties (5 Mt/ha), there will be an overall reduction in production until year 5 (red dashed line). In year 10 the regional production in the 2S would be 12% higher compared to the current situation (i.e. 661,000 vs. 590,000 Mt gbe).

- **Figure 5** is identical to Figure 4 but for the entire economically viable lifecycle for Robusta coffee (i.e. 20 years). This graph shows that production can theoretically be doubled compared to BaU (590,000 Mt gbe) in year 17. Note that a new rejuvenation cycle would start in year 21.

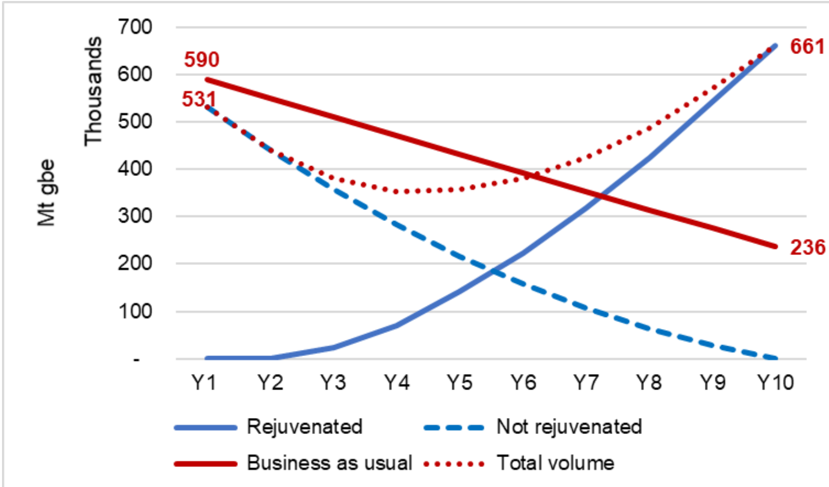

Figure 4: Forecasted coffee production trends in the 2S river basins

In the BaU scenario, it is assumed that there is no coffee rejuvenation and hence productivity will gradually decline to 1 Mt/ha gbe by year 10. The second scenario assumes full rejuvenation with new coffee varieties over a 10-year horizon without intercropping. By year 10 the total area is rejuvenated (hence the production in the non-rejuvenated areas turns zero). The red dashed line simulates the total annual coffee production under a rejuvenation program. It is the sum of the blue full (rejuvenated) and blue dashed lines (not yet rejuvenated) in the graph.

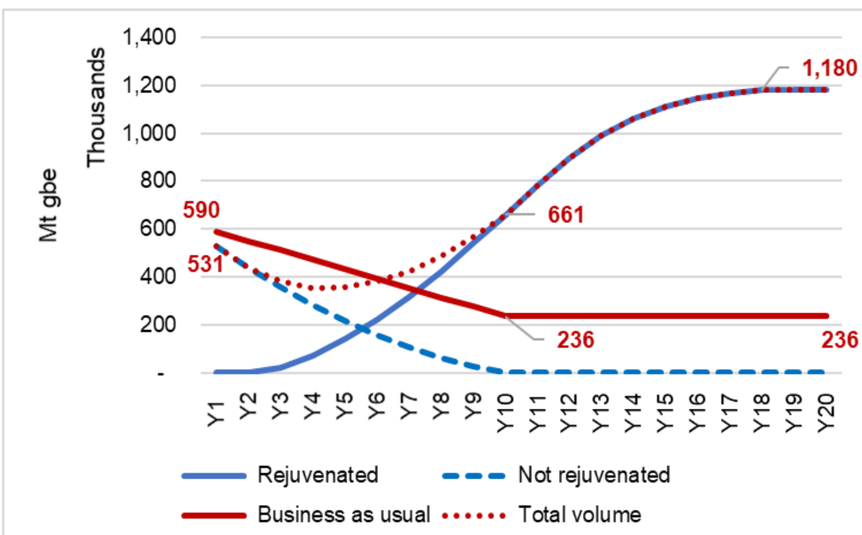

Figure 5: Forecasted coffee production trends in the 2S river basins. This graph is identical to Figure 4 but simulated over a 20-year horizon (i.e. the productive lifecycle for Robusta coffee).

4 Impact of climate change on coffee production

4.1 Recent studies on climate change vs. coffee production

- Several studies have been conducted regarding the potential effects of climate change on coffee production in Viet Nam. A report by CIAT (2012) analyzed future climate trends based on global climate models. The study used historical climate data from the www.worldclim.org database (Hijmanset al., 2005) to define the 2012 climate baseline and future trends. This study suggests the following:
  - ✓ In Viet Nam, the yearly and monthly rainfall will decrease by 2020 and progressively increase by 2050. The yearly and monthly minimum and maximum temperatures will increase by 2020 and progressively increase by 2050.
  - ✓ The seasons will be more pronounced; the dry season will be drier and hotter and the rainy season will be wetter and hotter.
  - ✓ The optimum coffee-producing zone is currently at an altitude between 300 and 900 masl and will by 2050 increase to an altitude between 600 and 1000 masl.
  - ✓ Land suitability is expected to decrease by 2050 compared to the 2012 situation (Figure 6). No information is presented in terms of current coffee acreage decrease.

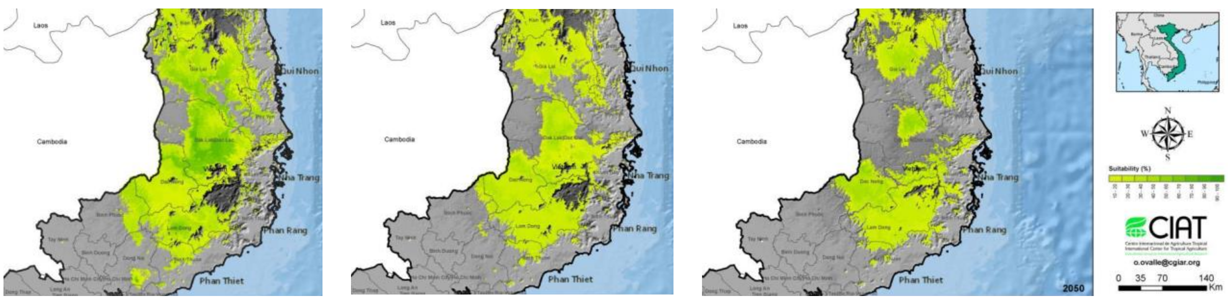

Figure 6: Land suitability forecast for Robusta coffee production in Viet Nam; from left to right 2012 (baseline), 2020, 2050; CIAT, 2012

- The report mentions that likely a shift of coffee production will have to take place to higher altitudes, but does not mention soil suitability and water availability at those new locations.
- Another study, which assessed historical climate trends in the Central Highlands based on daily climate data for all weather stations since the start of data collection, conducted by the Viet Nam National University (Phan Van Tan, 2013 & 2016, Baker, 2016) in Hanoi (**Error! Reference source not found.**) suggests:
  - ✓ Total annual rainfall remains stable
  - ✓ Length of the wet season remains unchanged
  - ✓ Maximum daily temperature remains stable
- The VNU study reports following threats for coffee production in relation to climate change:
  - ✓ It is expected that an increased number of wet weather outbreaks will occur in the dry season in the south Central Highlands which is likely to affect flowering patterns.
  - ✓ Diurnal temperature changes i.e. higher minima and less change in maxima leads to a reduced diurnal range. This is very likely to favor some pests and diseases. For example, fungal diseases mostly prefer a ‘not-too-hot; not-too-cool’ regime that reduces likelihood of drying out and low temperature inhibition of the delicate germination process.

- ✓ On top of this, higher average temperatures mean that insects like the coffee berry borer may be able to complete an extra life-cycle and therefore exert greater economic loss.
- ✓ Higher temperatures may also stress the trees: it is well-established that many insects find it easier to overcome the defenses of weakened trees. For example, cicadas have become abundant in the Central Highlands in recent years; a possible reason for this is that they find it easier to attack trees stressed by drought and/or higher temperatures.
- ✓ Last but not least, increasing temperatures, together with high fertilizer use, may accelerate the breakdown of organic matter and provoke changes in the microbial balance of the soil which may affect a range of 'friendly' microbes that tend to control soil pests and diseases such as nematodes and mealybugs.

Table 4: Historic climate trends in Viet Nam's Central Highlands

Climate variable	Tendency	Variation	Potential effect on coffee production
Minimum temperature	↗		Increases of pest and disease
Maximum temperature	→		
Diurnal temperature range	↘		Increases of pest and disease
Total annual rainfall	→		Increased variation makes planning farm management & coffee drying more difficult
Length of wet season	→		
Heavy rain	↗		Possible effects on flowering and tree damage
Continuous dry days (CDD)	↘		
Continuous wet days (CWD)	↘		
Outbreaks of wet weather in the dry season (ORD)	Mixed		Potential inhibition of pollination after flowering

- According to a report made by the University of Neuchatel (Milnes et al., 2015):
  - ✓ Historically no long-term historical declining groundwater level trends are observed in Dak Lak; this seems to confirm the research of VNU indicating that annual rainfall remains unchanged and fully replenishes the aquifers during the rainy season.
  - ✓ Excess irrigation water for coffee is temporarily trapped in the soil (i.e., between lower end of the root zone and the aquifer) and not available for use during the current dry season.
- According to a study made by IWMI (Figure 7), the overall irrigation water requirement is only 21% of the total annual available ground and surface water available (Viossanges, 2018; unpublished project report[1]).

[1]This study was conducted by IWMI in the project "Viet Nam to produce more coffee with less water - towards a reduction of the blue water footprint in coffee production" which is co-financed by Nestlé/Nescafé and the Swiss Agency for Development and Cooperation. Implementation lies with the foundation Hanns R. Neumann Stiftung. The project duration is 5 years (2014-2019).

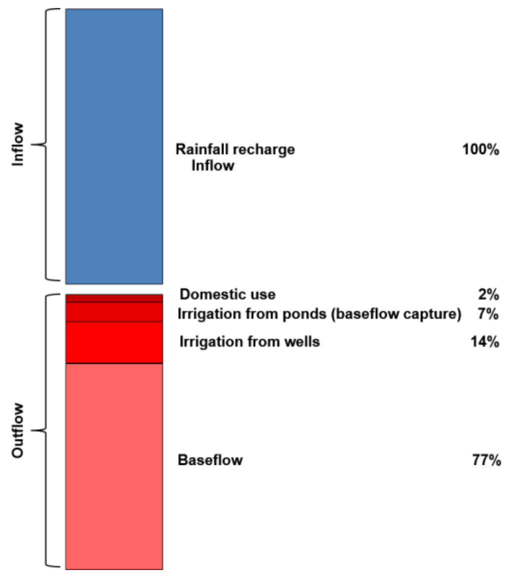

Figure 7: Annual water balance for an experimental water catchment in Krong Nang, Dak Lak

- Therefore, based on the different literature sources, it appears unlikely that there will be a significant effect on coffee production in relation to climate change in terms of water availability in the mid-term.

4.2 The government and big corporates' reactions and plans regarding climate change

- Viet Nam Coffee Coordination Board (VCCB)
  - ✓ VCCB was established in July 2013. It has 15 representatives, 1 chair (Vice Minister of Agriculture), 7 from the public and 7 from the private sector.
  - ✓ VCCB identified the following key constraints regarding water management in its strategy proposal “Sustainable development of Viet Nam’s coffee sector until 2020 and vision to 2030”:
    - ➢ Pilots on water saving technologies and water harvesting are implemented, but feasible and cost-efficient models for up-scaling have not yet been identified.
    - ➢ Lack of incentives for farmers to make investments in water saving systems.
    - ➢ Lack of means to monitor water availability for coffee production
  - ✓ VCCB’s intervention plan regarding water management includes:
    - ➢ Evaluate efficiency and study the scalability of water harvesting models and water saving technologies applied to different geo conditions
    - ➢ Support the development of policies that promote the adoption of identified technologies and systems
    - ➢ Support for water monitoring system pilot to give advice to farmers about water use in coffee production
- Private and public actors are concerned about Viet Nam’s long-term productivity in the light of climate change. Programs are conducting interventions towards sustainable production and trade, including the Sustainable Coffee Program by the Initiative for Sustainable Trade in cooperation with Nestle, Jacobs Douwe Egberts and Tchibo, and the Global Initiative for Coffee and Climate, initiated by private roasting companies and recognized by the International Coffee Organization.
- Over 25% of the Vietnamese coffee is certified / verified through standard programs such as Rainforest Alliance/UTZ Certified, 4C and Fair Trade, which all strive to make coffee production more resilient to the effects of climate change.

5 Potential water & cost savings for coffee production in 2S

- In a current project on water management in the coffee sector[1] implemented by the Foundation Hanns R. Neumann, measurements[2] were made to understand actual water use in the coffee sector and surveys were conducted to understand current irrigation methods.
- Empirical research shows that the maximum irrigation volume per tree per round required is ~400 liters for hose irrigation (D'haeze, 2003). It remains unknown whether this is the actual crop water requirement. Hose irrigation is quite efficient as it extracts water directly from the source with insignificant losses before reaching the tree. Nevertheless, it is more labor intensive and therefore costlier.
- For overhead sprinkler (less efficient in terms of water extraction) a benchmark of 600 liter per tree per round is recommended[3] as it wets the entire field and canopy.
- More and more farmers shift to overhead sprinkler irrigation to save on labor time and costs. Below pie chart (Figure 8) represents the current shares of overhead sprinkler versus the traditional hose irrigation or the combination of both[4].

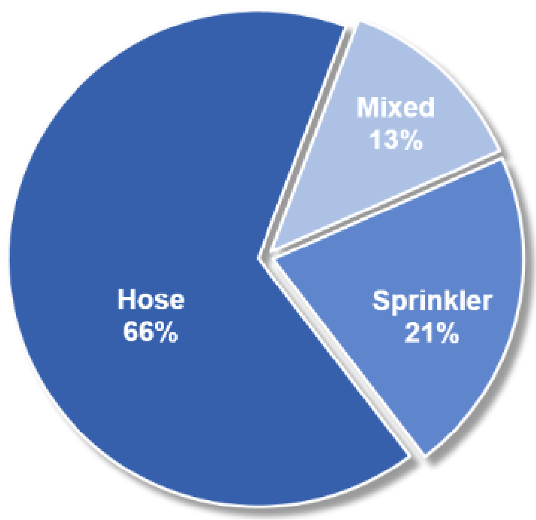

Figure 8: Breakdown of irrigation methods in the Central Highlands of Viet Nam

[1]The project "Viet Nam to produce more coffee with less water - towards a reduction of the blue water footprint in coffee production" is co-financed by Nestlé/Nescafé and the Swiss Agency for Development and Cooperation. Implementation lies with the foundation Hanns R. Neumann Stiftung. The project duration is 5 years (2014-2019).
[2]Sample size 74 in 2017 and 346 in 2018; overall this is statistically representative for a population size of 620,000 farmers (equivalent to all coffee farmers in the Central Highlands).
[3]For hose irrigation the water is conveyed directly from the source to the individual coffee tree without significant losses. Hence the crop water requirement of 400 liter/tree/round is equal to the water extraction volume. Assuming that the dimensions of each basin around an individual coffee tree are 2.5 by 2.5 m, then the wetted surface is 6.25m^2. For overhead sprinkler the entire field is wetted. Given the plant spacing of 3 by 3 m, this is equivalent to 9 m^2 per tree. Therefore, without taking into account water losses on the canopy, the sprinkler method requires about 45% more water to provide the crop 400 liter/tree/round net.
[4]Based on a survey sample of 14,592 project beneficiaries; location: Gia Lai, Dak Lak, Dak Nong and Lam Dong

- In the above-mentioned project, intensive training was provided to farmers on optimized water management. While it takes time to convince farmers to reduce water amounts as they believe that it will affect coffee productivity and product quality, 4 years of project interventions show adoption rates of 55% and 53% for respectively hose and overhead sprinkler irrigation (Figure 9).

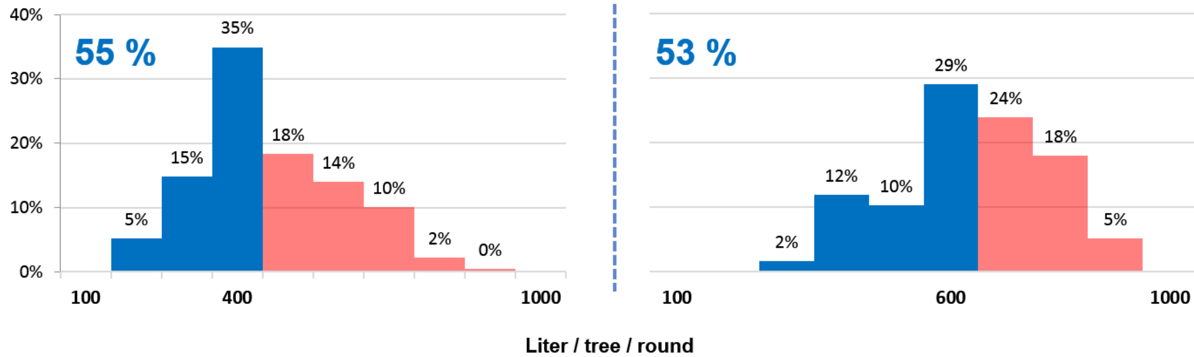

Figure 9: Adoption rates on good irrigation practices in 2018 (expressed as a percentage i.e. number of adopters over the total sample).

Hose irrigation (left), overhead sprinkler (right); the blue bars indicate the number of farmers (as a percentage over the total sample size) which irrigate water volumes per tree per round lower than the recommended optimum of 400 and 600 L/tree/round for hose and overhead sprinkler respectively)

- Currently farmers apply on average 581 L/tree/round, 787 L/tree/round and 684 L/tree/round for respectively hose, overhead sprinkler and a combination of both methods. The recommended water volumes per tree are respectively 400 L/tree/round, 600 L/tree/round and 500 L/tree/round.
- Extrapolation of the above information to the entire Srepok and Sesan river basins shows that about 143 mio m^3 of water can potentially be saved per year (Table 5)

Table 5: Potential water savings for coffee production in the Srepok and Sesan river basins

Item	Unit	Hose	Sprinkler	Combined	Total
Share of users by irrigation method	#	66%	21%	13%	
Current irrigation volume	L/tree/round	581	787	684	
Recommended irrigation volume	L/tree/round	400	600	500	
Potential water saving	L/tree/round	181	187	184	
Potential water saving[1]	m^3/ha	603	623	613	
Potential water saving Srepok & Sesan river basins	**mio. m^3 / y**	**94**	**31**	**19**	**143**

Notes:

1. 3 irrigation rounds; 1,110 trees/ha

- Assuming all farmers use diesel as energy source an estimated 20 million USD can be saved per year in the 2S river basins (table 6).

Table 6: Potential irrigation cost savings for coffee production in the Srepok and Sesan river basins assuming only diesel use to pump water

Water Extraction Costs (only diesel use)	Unit	Hose	Sprinkler	Combined	Total
Current total cost	USD/ha	302	231	278	
Optimal total cost	USD/ha	208	176	204	
Total potential cost saving	USD/ha	94	55	75	
Labor cost[1]	USD/ha	41	-	21	
Energy cost [2]	USD/ha	53	55	54	
Potential irrigation cost saving Srepok & Sesan river basins	**mio USD/y**	**15**	**3**	**2**	**20**

Notes:

1. Assume 25 USD for 24 hours
2. Assume 2 liter of fuel per hour @ 0.68 USD/L

- On the other hand if only electric pumps are used an estimated 12 million USD can be saved (Table 7).

Table 7: Potential irrigation cost savings for coffee production in the Srepok and Sesan river basins assuming only electricity use to pump water

Water Extraction Costs (only electricity use)	Unit	Hose	Sprinkler	Combined	Total
Current total cost	USD/ha	201	93	159	
Optimal total cost	USD/ha	139	70	116	
Total potential cost saving	USD/ha	61	23	43	
Labor cost[1]	USD/ha	41	-	21	
Energy cost [2]	USD/ha	20	23	22	
Potential irrigation cost saving Srepok & Sesan river basins	**mio USD/y**	**10**	**1**	**1**	**12**

Notes:

1. Assume 25 USD for 24 hours
2. Assume electricity cost @ 80 USD per ha

6 Investment options

6.1 Method and assumptions

- In this chapter 4, “theoretical” investment scenarios are compared. Table 8 gives an overview of the basic assumptions applied.

Table 8: Assumptions for 4 investment scenarios

Assumptions	Number	Unit
General		
Coffee area Sre Pok/Sesan	236,000	ha
Water scarce areas	14,590	ha
Time horizon	10	years
Product prices		
Coffee	2,000	USD/Mt
Pepper	5,668	USD/Mt
Avocado	2,400	USD/Mt
Durian	1,800	USD/Mt
Number of intercrops		
Coffee (monocrop)	1,110	trees/ha
Coffee (intercrop)	985	trees/ha
Pepper	55	trees/ha
Avocado	35	trees/ha
Durian	35	trees/ha
Scenario specific assumptions		
Monocrop coffee (Business as Usual)		
Linear coffee productivity decrease from 2.5 to 1.0 Mt/ha		
No rejuvenation		
Coffee remains in water scarce areas		
Monocrop coffee rejuvenation		
Linear coffee productivity decrease from 2.5 to 1.0 Mt/ha for not rejuvenated areas		
Full rejuvenation of 23,600 ha/year (10 %/y)		
Coffee remains in water scarce areas		
Monocrop coffee rejuvenation, no intercrops + only alternative crops in water scarce areas		
Linear coffee productivity decrease from 2.5 to 1.0 Mt/ha for not rejuvenated areas		
Only coffee rejuvenation in suitable (not water scarce) areas 22,141 ha/year (10 %/y)		
Rejuvenated coffee plantations 100% monocrop		
Coffee replaced by 100% alternative crops in water scarce areas 1,459 ha/year (10 %/y)		
Monocrop coffee rejuvenation, intercropped + only alternative crops in water scarce areas		
Linear coffee productivity decrease from 2.5 to 1.0 Mt/ha for not rejuvenated areas		
Only coffee rejuvenation in suitable (not water scarce) areas 22,141 ha/year (10 %/y)		
Rejuvenated coffee plantations 100% intercropped		
Coffee replaced by 100% alternative crops in water scarce areas 1,459 ha/year (10 %/y)		

6.2 Value creation, coffee productivity & water saving potential for 4 intervention scenarios

- Figure 10 presents value creation (using farm gate prices) for the 4 scenarios as described above in Table 8.
- In the business as usual case, without coffee rejuvenation, it is expected that yields will decline from the current average of 2.5 Mt/ha to just 1 Mt/ha. Assuming a constant coffee price of 2,000 USD/Mt (for all scenarios) and no water savings, it appears that the overall coffee value in the 2S basins will decline by 59% in year 10 (Figure 10; red line).
- In scenario 2, the assumption is to rejuvenate coffee areas at a rate of 10% per year over 10 years. The old coffee stock would gradually be replaced with new high yielding varieties. It is assumed that these will produce 5Mt/ha in year 10. As coffee starts to produce ("economically") from year 3 onwards, there will be a loss of value until year 6 compared to BaU. In year 10 the overall value generated would slightly surpass the BaU case at the start i.e. year 1 (+8%).
- In the third scenario, the water scarce areas as identified by Milnes et al. (2015), are gradually (10% per year) taken out of coffee production (~15,000 ha or 6% of the 2S basins) and replaced by black pepper (circa 800 poles/ha), durian (circa 90 trees/ha) and avocado (circa 65 trees/ha). In parallel the remaining coffee areas (suitable in terms of water availability) are rejuvenated (10% per year). In this case the value addition in year 10 is 17% higher compared to BaU year in year 1.
- The fourth scenario is similar to the third, but it focuses on crop diversification with black pepper (55 poles/ha), durian (35 trees/ha) and avocado (35 trees/ha), in the coffee growing areas which are not (yet) affected by water scarcity. In this case the number of coffee trees reduces from the traditional 1110 trees/ha to 985 trees/ha (-11%). In this scenario the value addition is a factor 3.6 higher in year 10 compared to BaU in year 1.

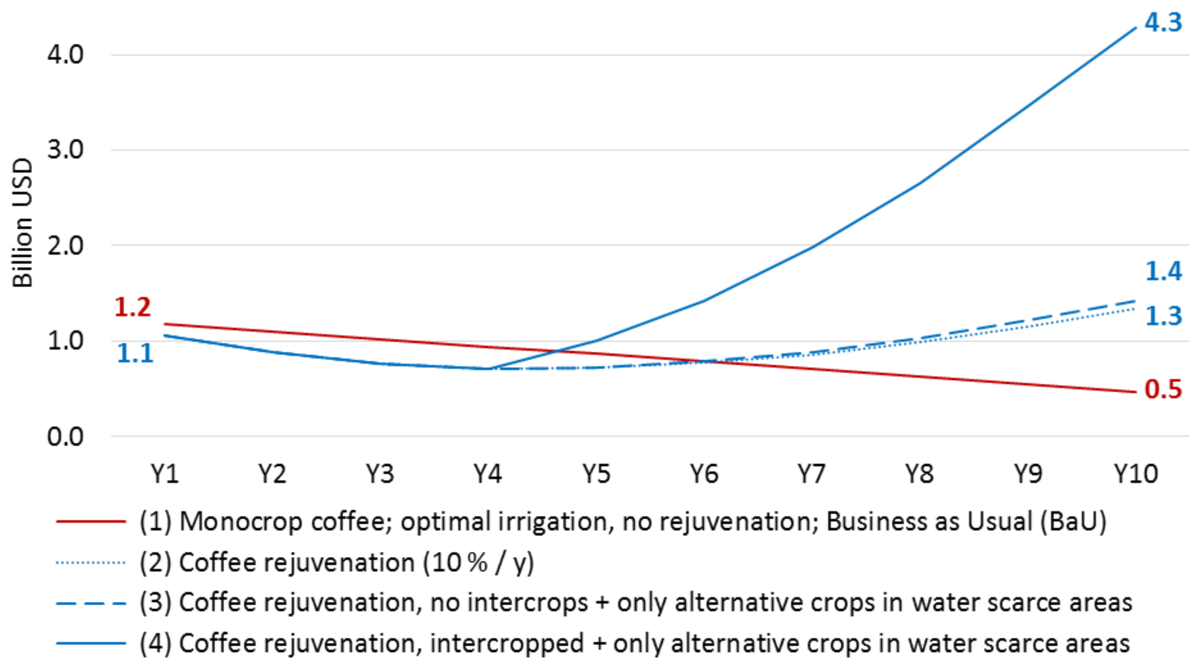

Figure 10: Estimated annual gross monetary value generation over a 10-year horizon in the Srepok and Sesan river basins for 4 investment scenarios

- In terms of annual coffee production (which is an important factor for the coffee industry) the regional productivity would decrease for all scenarios until the 6th to 7th year compared to BaU without rejuvenation (Figure 11).
- In year 10 the yield would stabilize and come back to the current production (550-661 thousand Mt). For scenario 4 the regional coffee yield would be 7% lower than the current situation. However, at year 10, the total rejuvenated area at maximum potential coffee production (5 Mt/ha) is only 20%. Therefore, it is expected that the regional production in the 2S river basins will further increase beyond year 10 and reach levels well beyond the current production of 590 thousand Mt.

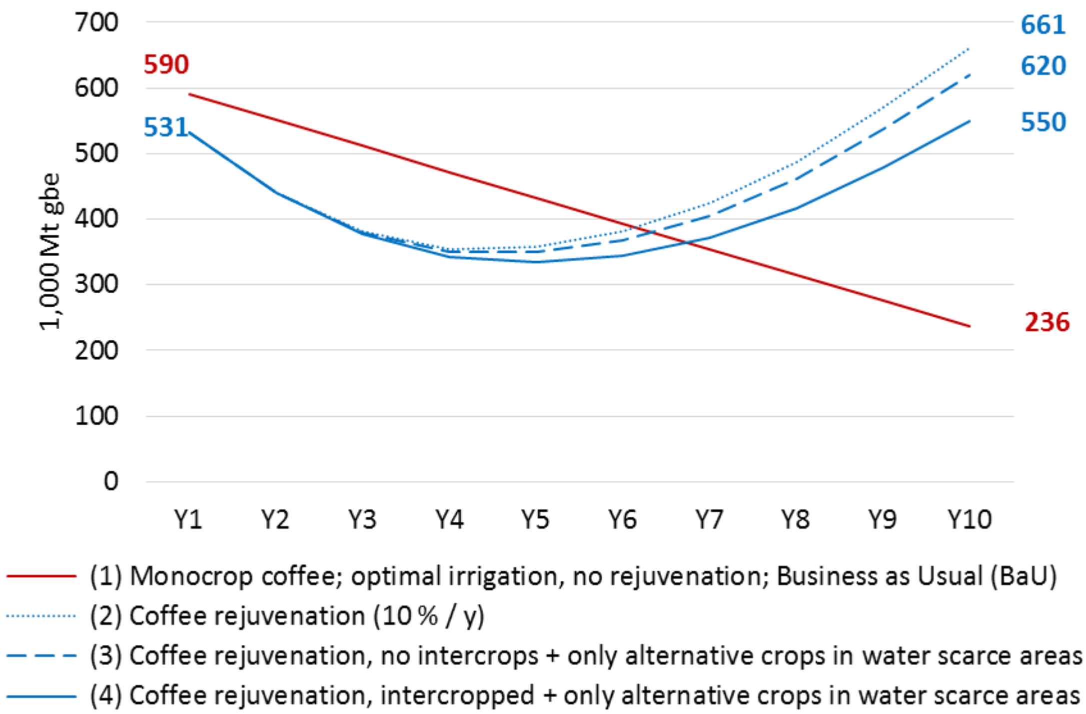

Figure 11: Estimated annual coffee production over a 10-year horizon in the Srepok and Sesan river basins for 4 investment scenarios

Scenario 4 with a focus on intercropping the entire current coffee area in the 2S, seems not only to keep up with regional coffee production compared to BaU, but also saves water. Compared to the BaU, a fully intercropped system could potentially reduce the irrigation water requirements by 10%. Compared to the current practices scenario 4 could lead to water savings of 43% (figure 12).

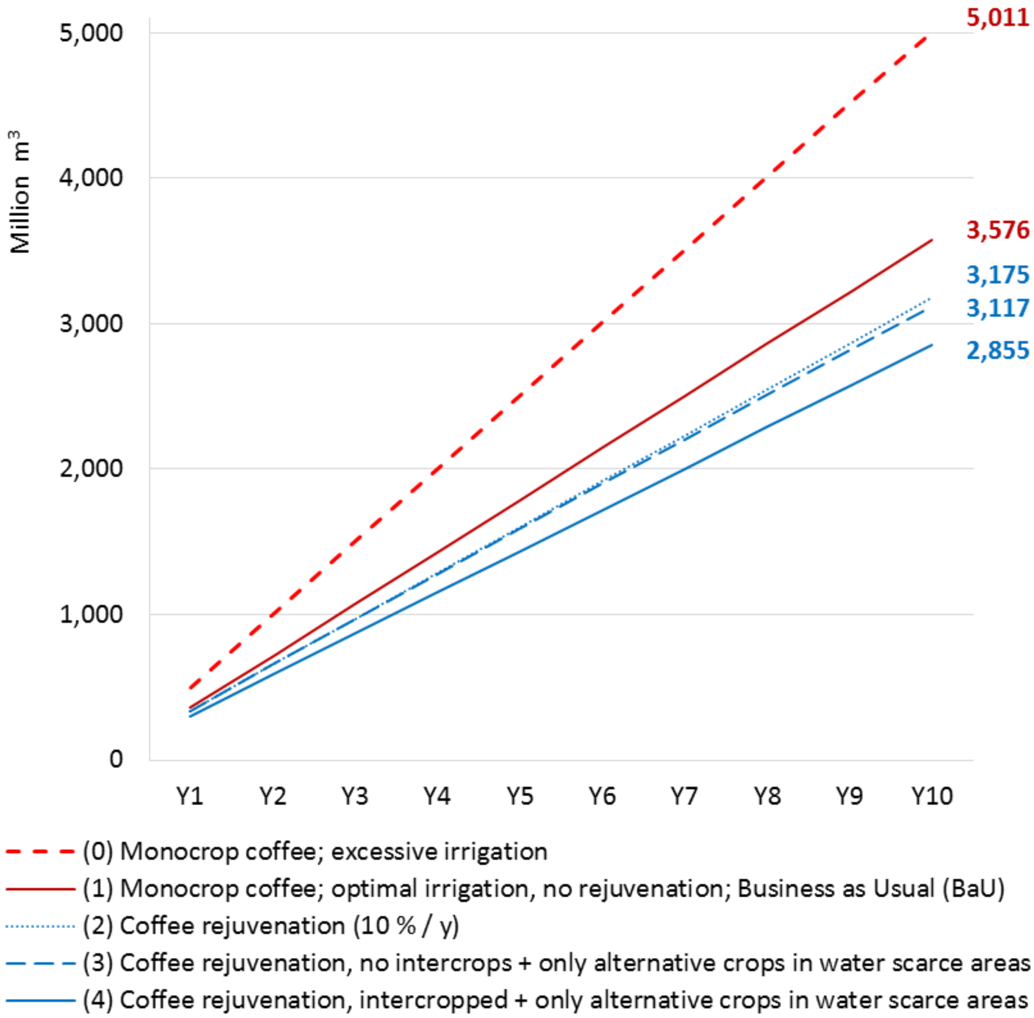

Figure 12: Cumulative current water use for coffee irrigation (red dashed line) and cumulative optimal water needs for 4 different scenarios

6.3 Investment projections

- It is recommended to make investments in a large-scale training program for farmers in combination with regular awareness raising through simple and short TV spots.
- The training program ideally focusses on 2 tiers. On the one hand continuation of traditional Farmer Field Schools for groups of 25 farmers, but additionally and complementary one-to-one Farmer Coaching Visits are recommended. Through the latter approach, the trainers reach out to individual farms where they appraise the farm management conditions in the field and provide ad hoc advice. This approach is envisaged to be more impactful. However, this more intensive approach is also costlier.
- The entire program requires a thorough training of local trainers through professional agronomists.
- In parallel it is suggested to invest in nurseries to produce coffee, pepper, durian and avocado seedlings. Table 9 presents an estimate of the total investment costs for a 10-year horizon. This investment plan is equally valid for any of the 4 scenarios outlined above. The difference between e.g. scenario 2 (coffee rejuvenation only) and 4 (rejuvenation + crop diversification), would be an adaptation of the training curriculum for the beneficiaries with more attention for intercrops in the 4th scenario.

Table 9: Investment projection (in USD) over 10 years for the 2S river basins

Investments	#	Unit	Unit Cost (USD)	Total Cost (million USD)	Notes
Training program				**19**	
Training of Trainers	224	# sessions	1,500	0.34	(1)
Farmer Field Schools	37,760	# sessions	25	0.94	(2)
Farmer Coaching Visit	708,000	# visits	25	17.70	(3)
Awareness raising campaigns				**2**	
TV spots	120	# campaigns	15,000	1.80	
Personnel				**23**	
FFS trainers	2,266	person-months	500	1.13	(4)
FCV trainers	42,480	person-months	500	21.24	(5)
Agronomists	240	person-months	2,000	0.48	(6)
Program manager	120	person-months	3,000	0.36	(7)
Seedlings				**106**	
Coffee	262	# mio seedlings	0.25	65	
Avocado	17	# mio seedlings	0.25	4	
Durian	17	# mio seedlings	0.25	4	
Pepper	130	# mio seedlings	0.25	32	
Other				**39**	
Transport	10	year	745,760	7.46	
Contingency (20%)	1	lump	31,529,998	31.53	
Grand total				**189**	

Notes:

1. 25 participants per session; 4 days per ToT; 373 trainers in total
2. 25 participants per session; 1 day per FFS
3. Required seedlings per year
4. 1 TV campaign per year
5. 19 FFS trainers over 10 years
6. 354 FCV trainers over 10 years
7. 2 Agronomists over 10 years
8. 1 Program manager over 10 years

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8 Annex

8.1 Annex 1 Stakeholder assessment

Stakeholder	Strengths	Weaknesses	Role in Program
Viet Nam Coffee Coordination Board (VCCB) VCCB was established in July 2013. It has 15 representatives, 1 chair (Vice Minister of Agriculture), 7 from the public and 7 from the private sector.	Good knowledge of the coffee sector Direct reporting to MARD Coordination with other line ministries on coffee related items	Limited human resources and time	Support to develop policies Support to scale program impact through alignment with other public and private initiatives
Global Coffee Platform (GCP) The Global Coffee Platform is a new, inclusive multi-stakeholder sustainability platform aligning the activities of a diverse network of stakeholders committed to addressing sustainability issues in the coffee sector in line with Vision 2030. It was established in 2016.	Strong global network with private and public partners Access to additional funding (?) Strong communication at global level	Young organization	Support alignment with other programs in the sector, particularly among private sector GCP members and other international stakeholders Communicate about program impact at global level Support further fund raising to scale the program impact
Ministry of Agriculture and Rural Development (MARD) and provincial Subsidiaries (DARD) Rural development planning Promotion of agriculture and agricultural industry Sectors: agriculture, forestry, aquaculture, irrigation and salt industry	Expertise in Agricultural policy development	Limited human resources and time	Support the analysis of program results and formulation of policies
Ministry of Natural Resources and Environment (MONRE) and provincial subsidiaries (DONRE) State management of geology, land, water resources, mineral resources, environment, meteorology, hydrology, metrology, cartography and management of sea and islands	Expertise in Environmental policy development	Limited human resources and time Competitive relationship with MARD may complicate cooperation	To be assessed in discussion with VCCB
National Agriculture Extension Center (NAEC) and subsidiaries at provincial, district and commune level Development of policies and management mechanisms for extension in agriculture, forestry, fishery and rural	Expertise in Agricultural extension and coffee GAPs in particular Strong network of extension officers until the commune	Traditional top down training approach Mainly theoretical training Requires capacity building on adult teaching methods	Continue with farmer training Assess new Farmer Coaching Approach Support policy development to improve agricultural extension

industry, transfer of advanced techniques through setting up demonstration models, disseminating information and training.	levels close to the coffee farmers		Hosting of the GAP application for smartphones
Institute of Policy and Strategy for Agriculture and Rural development (IPSARD) Research on agricultural commodities and markets, agricultural economic integration, rural farming systems and research on social and economic aspects of resource management and environment protection.	Expertise in Agricultural policy development	Limited human resources and time	Advisory to the Steering Committee through the Coffee Coordinating Board
Private Sector Traders in charge of buying/selling coffee Roasters in charge of preparing consumer end products	Strong expertise in all aspects of the coffee value chain (from seed to cup)	Certification driven (commercial) approach towards sustainability whereby impact orientation may be restrained	Align with and contribute to scale up program lessons learnt beyond the program scope
World Bank Viet Nam Sustainable Agriculture Transformation Project	Strong focus on coffee Outreach to circa 60,000 coffee farming households Focus on water saving (technology)	Policy of subsidized agriculture contrast with the business-driven approach	To be assessed in discussion with the program partners
IDH Initiative for Sustainable Landscapes In the Central Highlands, IDH collaborates with coffee roasters and exporters, the Viet Namese government, research institutions and NGOs towards improving livelihoods, enhancing agricultural production and protecting natural resources.	Well connected to the private industry and national government Focus on water saving (technology)	No clear watershed approach Focus on investment in water saving technology contrasts promotion of water saving through traditional methods	Assess synergies to work at landscape/watershed level Replicate water monitoring and MAR Train companies under ISLA to apply similar training methods on GAP
International Water Management Institute (IWMI) Non-profit, scientific research organization focusing on the sustainable use of water and land resources in developing countries.	Strong water resources management expertise Local network in Asia Close partnership with local stakeholders in the water sector	-	Technical advisory on water monitoring and MAR Acquire additional funding to scale the water monitoring activities Build capacity for local partners

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