Water use and Nexus opportunities in the Central Highlands of Viet Nam:

An overview

Phillip Riddell

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Part 1: Background

Context

Nexus is being promoted as a process that allocates investment and natural resources for development by an ever-growing population at a time of climate change, land use change, economic diversification and the need to make development pay.[1] It does so by identifying opportunities for trade-offs, compromise and synergies between the competing sectors and accordingly at its heart is a robust understanding of the interdependencies between them. Nexus was first suggested at the Bonn Nexus Conference in 2011 and in theory could provide a crucial framework for sustainable development and/or economic planning across the board.

Nexus has its problems, however, and there is a vast and expanding body of literature examining them, explaining their provenance and attempting to solve them. They include: i) persistent sector silos that still constrain the win-win-win solutions needed going forward; ii) difficulties in applying essentially technocratic solutions to problems of policy or political economy; iii) a diversity of objectives; iv) elusive stakeholder agreement with respect to definitions of the most appropriate analytical boundaries which could be natural as in a river basin, or political as for instance in the case of a regional grouping like SADC or the EAC; and v) the need for greater trade-offs or compromise[2] between competing interests.

Demand for water, energy, and food are increasing rapidly in Cambodia, Laos, and Viet Nam (CLV) all of which are experiencing rapid economic growth. The Sekong, Sesan and Srepok (3S) rivers, which area major tributaries of the Mekong have been called the “last frontier” of development in all three countries and are of special interest from the perspective of water, energy, food security and environmental sustainability. This is not least because the region is rich in natural resources that governments are seeking to harness to drive national development.

The Lower Mekong Initiative (LMI) is a multi-donor, but country-owned platform, and is predicated on the assumption that development challenges in the Lower Mekong Basin will depend in part on stronger regional cooperation and sustainable economic growth in the region. One of the LMI’s components is an Environment and Water Pillar. Its focus is the advancement of sustainable economic growth through targeted policy dialogues and capacity-building programs that improve water security and natural resources management. As such it responds to the cross-cutting potential of the water, energy, food and environmental security nexus.
Of particular relevance here is the Nexus Futures Program (NFP) which is a subset of the LMI. It has three objectives thus: i) the advancement of sustainable economic development; ii) strengthened regional integration, and iii) resilience to the impacts of climate change, all in the Lower Mekong countries.

These goals are to be achieved in particular by strengthening regional discussions that advance integrated planning and development in the 3S sub-basin and focused indeed on the water, energy, food and environment nexus.

In support of NFP, IUCN, ICEM, and IWMI prepared a nexus assessment of the 3S.

1.1. Current Objective

Based on the nexus assessment results, it was decided to take a “deeper dive” into water allocation and management in Viet Nam’s Central Highlands (CH). Although building on the results of the assessment, it is not limited to nexus solutions but rather considers optimisation opportunities within and between the irrigation and hydropower sectors with a focus on the costs and benefits of different investment strategies.

The government of Viet Nam began seriously to develop these resources in the early 1990s with the intention of driving national development on the backs of large-scale investment in agriculture, mining, hydropower.

The intended output of this phase of the work has two deliverables: an investment strategy comprising a set of investment options in the 3S that could attract domestic and/or international financing and would form the

1 Riddell 2015

2 For the purpose of this study: “trade-off” refers to a situation where one objective is sacrificed in favour of another; and “compromise” refers to a situation where a less than ideal result is accepted in order to achieve a better, common good. Synergy of course, describes a win-win between competing (sectoral) objectives.

basis of trilateral discussions between CLV; and the provision of training on nexus principles and practice for policy makers and practitioners at national and local level for CLV.

1.2. This Document

This report is offered as the first deliverable and responds to the call for a report on potential investments in improved water resources management in the CH that increase benefits in the Sekong and Sesan. For each investment it describes the upstream and downstream benefits in terms of:

- water, food, energy and the environment,
- costs and benefits quantified (to the extent possible with the available data and information), and
- risks.

The report continues in ***Part 2*** by analysing the dangers inherent in an uncoordinated, single sector approach to regional development. It does so by suggesting a generic analytical framework that identifies the hazards inherent in a silo'd approach and possible ways by which a selected trade-off, compromise or synergy[3] might reduce overall costs and increase overall benefits.

Part 3 begins by focusing the generic analytical framework onto the pertaining policy framework's specific sector objectives for the CH. It uses the result to identify to identify and develop strategic investment opportunities which it then examines in terms of their costs, benefits and risks.

[3] For the purpose of this study: "trade-off" refers to a situation where one objective is sacrificed in favour of another; and "compromise" refers to a situation where a less than ideal result is accepted in order to achieve a better, common good. Synergy is achieved when a nexus solution is identified requiring neither trade-off nor compromise.

Part 2: Challenges and opportunities accruing to water allocation in the central highlands

Nexus Oriented Analytical Framework

A recurring theme running through the emerging nexus literature is that Nexus itself can be thought of as a response to perceptions[4] of insecurity on the part of various classes of stakeholder.[5] Clearly therefor, any system intended to increase stakeholder security by mobilising trade-offs, compromise and synergies along The Nexus must be based, at least in part, on a consideration of the issues at stake.

With this in mind, four classes of stakeholder have been identified:

- ***State Entities***, which are concerned about:
  - secure factors of production and output markets in order to catalyse socio-economic transformation and maintain economic growth
  - regional peace and stability
- ***Populations***, which are concerned about:
  - secure family lifestyles in terms of shelter, water supply and sanitation
  - income security based on a choice of sustainable livelihoods and equitable and reliable access to the means of production
- ***Private Sector,*** which is concerned about:
  - secure access to the factors of production
  - secure markets and opportunities
- ***Environment***; managers of which are concerned about
  - secure biodiversity, as a result of sustainable habitats
  - sustainable ecosystem services

Water, food, energy and environmental (WFEE) security have relevance to all of these concerns. They are defined differently by different kinds of stakeholders, but for the purpose of **this** report the following widely accepted definitions suffice:

- ***Water security:*** combines "the availability of and access to sufficient water for human and ecosystem use" with "protection from water hazards such as floods.".
- ***Agricultural security:*** is "the availability of affordable agricultural commodities necessary for healthy, productive lives and profitable agricultural value chains."
- ***Energy security:*** is "access to clean, reliable and affordable energy for cooking, heating, lighting, communications and other productive uses."
- ***Environmental security:*** is "sustainable ecosystems and ecosystem services accruing to safety from potential environmental dangers caused by natural or human processes and arising from ignorance, accident, mismanagement or design and originating within or across national borders".

The problem arises from the possibility that focus on achieving just one of these security dimensions threatens achievement of one or all of the others. Possible threats are explored in the analytical framework in Annex 1. In line with the LMI, this framework's sectors are limited to water, food, energy and the environment. However, since navigation is an important water dependant sector in both Cambodia and Viet Nam, the framework includes it as an issue within the water sector.

Noting also that "nexus" is as much about alternative thinking as well as alternative investments, the analytical framework shows that not all of these threats have obvious nexus solutions. But for those that do, it is possible to transform them into opportunities in terms of trade-off, compromise or synergy. Table 2.1 shows that some nexus solutions are common to several threats. This confirms the utility of a nexus approach, while

[4] The term "perceptions" is used advisedly here because people have a tendency to look at symptoms not causes. In "development speak" this used to be described as "perceived needs versus the macro-forces". For instance, politicians may consider that constrained rural livelihoods can be fixed with more irrigation, whereas the actual problem could be a lack of off-farm livelihood opportunities arising perhaps from inadequate energy or high perceptions of investment risk by the commercial sector. Against such possibilities, nexus provides a useful lens through which to look at things differently.

[5] E.g., Bromwich 2015, Pegasys 2014, Riddell 2015.

equally it can be seen that there are alternative, complementary measures that are of an institutional or non-nexus nature.

NEXUS APPROACHES		NON-NEXUS APPROACHES	
Multi-purpose dams (existing)	10	Mixed power plan	12
Multi-purpose dams (new)	9	Regulation of farm chemicals	3
Less water intensive farming systems	4	Restore/use flood plains	1
Change farmlands to artificial wetlands	3	Agroforestry	1
Increase return flows	2	Organic farming systems	1
Multi-purpose paddy fields	1	Cap and trade	1
Multi-purpose recycling infrastructure	1	PES	1
Bioenergy rather than food crops	1	Farming system change	1
Sediment capture/flood attenuation dams	1	Low tillage/conservation agriculture	1
Increase culture fisheries	1	Improved on-farm water management	1
Increase capture fisheries	1		0

Table 2.1. Applicability of Generic Nexus and Non-Nexus Approaches

The following section assesses the relevance and functionality of these generic approaches with respect to the specifics of water allocation and management objectives in the CH, and does in a way that attempts to "optimise" water use in the CH. First, however, it is necessary to propose a suitable metric for capturing optimisation.
Usually, optimisation of the use and allocation of multiple resources against multiple objectives requires a highly quantitative approach, but this is not possible at this stage due to a lack of data.

It is proposed to use the concept of "Basin Welfare" as an indicative metric for optimisation. Although there are various definitions of basin welfare, in this context it is taken to mean the ratio of the economic efficiency of water use in the basin to the levels of conflict over water in the basin. If economic efficiency goes up, and conflict goes down, welfare increases.

As such, "Basin Welfare" can be used to forecast what is likely to happen as a result of a given strategy without the need for detailed quantitative analysis.

2.1. Applying the Analytical Framework to the CH

Viet Nam's objectives for its WFEE sectors are specific as compared to the generic objectives used for the analytical framework. However, the objectives, along with those of Cambodia, can be used to populate a cross reference linkage matrix that identifies potential areas of conflict or inconsistency in line with the challenges and opportunities raised in the analytical framework.

The red cells in Figure 2.1 identify potential conflicts between two objectives. Although this report is about the optimisation of water use in the CH any attempts at optimisation must acknowledge the externalities involved. These externalities are captured by Cambodia's own objectives for its own WFEE sectors, and by Viet Nam's objectives for these sector when applied to the Mekong Delta.

In other words, Viet Nam's WFEE objectives in the CH must not be achieved at the cost of Cambodia's own objectives for the sectors or in ways that limit Cambodia's ability to pass water into Viet Nam at the levels of flow, quality and turbidity needed to achieve these objectives in the delta.

With this in mind, and noting that the proposed metric for now is all about the productivity of water and competition for/conflict over water, it is possible to assess the issues arising against clear criteria.

2.2. Issues Arising

Figure 2.1's red cells are populated either by a "P", a "C" or to identify whether the issues is about productivity, competition or both:

- 25 are about potential conflict or competition
- 12 represent a combination of constrained water productivity and potential conflict and/or competition
- 6 are about water productivity alone.

Taking each in turn, Tables 2.2 to 2.14 identify the issues arising.[6] The tables address potentialities not certainties. Many are effectively trivial or negligible. These are identified by grey. These would have limited to nil relevance to any strategic plan going forward. But those that are not trivial or negligible have significant potential for constraining basin welfare, constraints that an ideal strategic plan would seek to obviate. These are identified by bold text.

			VIET NAM'S RELEVANT SECTOR OBEJECTIVES						
			WATER (W)	**FOOD (F)**			**ENERGY (EN)**	**ENVIRONMENT (EV)**	
			Increased water service to both urban and rural users	Increased area of rice production	Existing rice area protected	1.2 million ha of aquaculture	Prioritise hydropower development	Improved climate change resilience	Reforestation
POTENTIAL CONFLICTS BETWEEN SECTORS AND/OR OBJECTIVES IN THE CH	**W**	Increased water service to both urban and rural users		C		C	C		
	F	Increased area of rice production, which can be assumed to require irrigation	C&P			C&P	C&P	P	
		existing rice area protected	C&P					P	
		1.2 million ha of aquaculture	C	C&P	C&P				
	EN	Prioritise hydropower development	C	C	C&P			C	C
	EV	Improved climate change resilience		P	P		C		
		reforestation					C		
POTENTIAL CONFLICTS BETWEEN VIET NAM'S AND CAMBODIA'S OBJECTIVES	**W**	Integrated management in a basin context	C	C&P			C&P		
		Prioritise river basin and aquifer conservation		C					
		Improve access to improved water services in the rural areas	C	C		C	C		
	F	Significant (25%?) increase in irrigated area	C	C		C&P	C		
		Protect ecosystem to support capture fisheries		C					

[6] These tables are intended very much as a point of departure for a more detailed, consultative, multi-stakeholder and quantitative assessment in the intended follow-on stage, see PART 4.

	EV	Ensure climate resilience of critical ecosystems		C&P					
POTENTIAL CONFLICT BETWEEN VIET NAM'S OBJECTIVES FOR CH AND SAME OBJECTIVES FOR MEKONG DELTA	**W**	Increased water service to both urban and rural users		C		C	C		
		1.2 million ha of aquaculture	C	C&P					
	EV	Improved climate change resilience		P	P		C		

Figure 2.1. Analytical Framework Applied to the CH and Externalities Involved

2.2.1. Tables Relevant to Conflict and Competition

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	1.2 million ha of aquaculture	Allocation of water for urban and rural use may reduce its availability for aquaculture. However, this threat may be minimal in CH because the 1.2 million ha is a national objective and will include fisheries on the brackish margins. Also, aquaculture potential in CH is likely to be a very small part of the overall total.
	Prioritise hydropower development	Allocation of water for urban and rural use may reduce its availability for hydropower generation. However, since most urban and rural use will be largely non-consumptive, it could be used by both sectors. However, in closing catchments there a possibility albeit minor that the operating rules for hydropower may conflict with demand patterns for urban and rural water supply and sanitation. This could be easily addressed by multi-purpose operating rules at the hydropower dam.
Cambodia	Integrated management in a basin context	One riparian's plans to increase urban and rural water services may not be compatible with another riparian's concept of integrated management.
	Improve access to improved water services in the rural areas	There is a possibility that abstractions for urban and rural water services in the CH could reduce availability for improved access to rural areas downstream in the Srepok
	Significant (25%?) increase in irrigated area	There is a possibility that abstractions for urban and rural water services in Viet Nam could reduce the availability of water for irrigation use in Cambodia. But this is unlikely because most would be returned to the natural system, and in any case the proposed increase in Cambodia's irrigated area is not going to take place in locations affected by any plans in Viet Nam.
Mekong Delta	1.2 million ha of aquaculture	As above.

Table 2.2. Potential Conflict Arising from Increased Water Service to Both Urban and Rural Users in the CH

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	Increased water service to both urban and rural users	There is a possible risk that the allocation of water for urban and rural water services could be constrained by an increase of the area of rice production, especially if wetland rice is assumed. However, wetland rice is not the only irrigated crop in the CH. The risks for urban and rural water supply could be considerable on a localised basis if both irrigation and water supply are supplied from overdrawn groundwater. Possible solutions could lie in the choice of farming system, or the promotion of per-urban irrigation of high value crops using urban run-off (with the choice of crop depending of course on the level of treatment given to the water before it is discharged into the natural environment).
	Prioritise hydropower development	There is a very significant likelihood of conflict between expanded irrigation and the prioritisation of hydropower. There are two reasons for this. The first is that hydropower is a consumptive user of water, and second is that the operating rules for hydropower are not consistent with the water demand schedules for irrigation. And this is especially true of wetland rice because of: i) of the pre-season saturation requirements; ii) the high crop factors associated with standing water; and iii) depending on the husbandry practices, there

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
		may be a need to re-establish the standing water between applications of agricultural chemicals. Also the establishment of diked paddy fields at land scape scale upstream of the dams could seriously compromise in-flows to existing dams. Possible solutions include alternative power plans; alternative farming systems or changed operating rules at the dams.
Cambodia	Prioritise river basin and aquifer conservation	Excessive abstractions for irrigation, especially (but not only) in the case of wetland rice could potentially threaten achievement of this objective.
	Improve access to improved water services in the rural areas	Ditto
	Significant (25%?) increase in irrigated area	Depending on how much new irrigation is planned for new irrigation in both countries share of the Srepok basin, there could be significant competition for water arising from an increase in wetland rice production in Viet Nam. The obvious solution in both cases is to avoid wetland rice in favour of either SRI rice, or other dry-root crops, ideally higher value crops with local added value potential and to irrigate them efficiently.
	Protect ecosystem to support capture fisheries	There is a risk that agro-chemical run-off in Viet Nam could pollute water to such an extent that it affects the downstream capture fisheries. Options to avoid this include built wetland between the irrigated fields the natural streams, a combination of regulation and awareness raising with respect to the use and storage of agro-chemicals and the cautious adoption of organic farming systems.
Mekong Delta	Increased water service to both urban and rural users	Although in terms of quantitative usage terms, large abstractions of water for wetland rice in the CH are unlikely to compromise the availability of water for urban and rural use on the delta. However, a combination of storage based hydropower development and large irrigation abstractions upstream could increase the risk of saline intrusion in the delta, which would threaten urban and rural water supply.

Table 2.3. Potential Conflict Arising from an Increased Area of Rice Production in the CH

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	Increased water service to both urban and rural users	It is difficult to discuss this meaningfully in the absence of data concerning what exactly is intended, if anything for expanded aquaculture in the CH.
Cambodia	Improve access to improved water services in the rural areas	Ditto
Mekong Delta	increased water service to both urban and rural users	Ditto

Table 2.4. Potential Conflict Arising from Expanded Aquaculture in the CH

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	Increased water service to both urban and rural users	There is a slight possibility that water storage for hydropower might reduce the amount available for water service to urban and rural users but this would be highly localised. And in any case, it may be that the storage of water for hydropower, could increase supplies for urban and rural water service.

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
	Improved climate change resilience	Locking large amounts of water into storage based hydropower would significantly limit its potential for allocation to climate change resilience measures, while reducing the overall amount of water supplied due to evaporation and possibly seepage losses. Equally, the resilience measures that are lost to hydropower may significantly increase the opportunity cost of the water involved.
	Reforestation	Inundation of reforested area would be counterproductive, while increasing greenhouse gas emissions from the reservoir.
Cambodia	Improve access to improved water services in the rural areas	Same as CH above.
	Significant (25%?) increase in irrigated area	Locking large amounts of water into storage based hydropower would reduce the amount available for irrigation downstream, while reducing the overall amount available due to evaporation and possible seepage losses. Also, given the alternatives available for energy production and a potential oversupply of energy, the lost opportunities for agriculture could increase the opportunity cost of the water involved.
Mekong Delta	Increased water service to both urban and rural users	Large scale storage of water for hydropower development in the CH is unlikely to compromise the availability of water for urban and rural use on the delta. However, a combination of storage based hydropower development and large irrigation abstractions upstream could increase the risks of saline intrusion in the delta which would cause problems for urban and rural water service.
	Improved climate change resilience	The risks of saline intrusion caused by the impoundment of large volumes of water could not only increase the risks of saline intrusion, the trapping of sediment could introduce serious morphological threats to the delta that in turn increases the likelihood of cyclonic surge damage. Reduced turbidity would also have negative implication for marine and other important aquatic food chains.

Table 2.5. Potential Conflict Arising from Prioritised Hydropower Development in the CH

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	Prioritise hydropower development	It is most unlikely that water can be allocated to both productive opportunities in the context of climate change resilience and hydropower. Hydropower itself cannot be posited as a climate change resilience measure because of the increased (cascade) flood risks caused by climate change. Equally, claims that hydropower helps to mitigate climate change are considered spurious by an increasing number of experts.

Table 2.6. Potential Conflict Arising from Improved Climate Change Resilience in the CH

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	Prioritise hydropower development	There is a possible conflict between the allocation of land for economic reforestation and for hydropower development. But this would not apply to reforestation for watershed for the purposes of watershed rehabilitation.

Table 2.7. Potential Conflict Arising from Reforestation in the CH

2.2.2. Tables Relevant to Constrained Water Productivity and Potential Conflict and/or Competition

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	Increased area of rice production, which can be assumed to require irrigation	There is potential competition for water between service delivery and irrigation. But this would be minor and could be solved by improved recycling of urban and rural wastewater. However, if water service can be taken to include the supply of water to other uses, then there is a possibility that water consumed by a low value crop such as rice, would have a higher opportunity cost than water used in industry, including the agro-processing industry.
	Existing rice area protected	As above for industrial use of water

Table 2.8. Potential Conflict and Reduced Productivity Arising from Increased Water Service to both Urban and Rural Users in the CH

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	1.2 million ha of aquaculture	The matter of conflict was addressed above, relevant here is the economic return on rice as compared to fisheries, which is likely to be highest?
Cambodia	Integrated management in a basin context	The matter of conflict was addressed above, relevant here concerns the relationship between an integrated, multi-use assessment of the economic productivity of water and the allocation of large amounts of water to a low value use – especially as the opportunity cost of water will increase with distance away from the sea.
	Ensure climate resilience of critical ecosystems	There is a well-researched and confirmed positive correlation between economic efficiency in water use and increased environmental stream flows. The allocation of large amounts of water to a low value use may seriously compromise economic efficiency and environmental stream flows in the Srepok.

Table 2.9. Potential Conflict and Reduced Productivity Arising from Increased Area of Rice Production in CH

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	1.2 million ha of aquaculture	As above, except to ask, what is the economic argument for protecting a low value, but thirsty sector?

Table 2.10. Potential Conflict and Reduced Productivity Arising from Protection of Existing Rice Area in CH

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	Increased area of rice production, which can be assumed to require irrigation	The matter of conflict was addressed above, relevant here is the economic return on rice as compared to fisheries, which is likely to be highest?
Cambodia	Significant (25%?) increase in irrigated area	Ignoring no doubt important issues of transboundary politics, the question here concerns whether or not it makes more economic sense to allocate water for fisheries in the CH or to irrigation in Cambodia's share of the Srepok. And this depends on what crops are intended; the scale of any proposed aquaculture in the CH and the level and quality of return flows from the fisheries.

Table 2.11. Potential Conflict and Reduced Productivity Arising from Expanded Aquaculture in the CH

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	Increased area of rice production, which can be assumed to require irrigation	Prioritisation of hydropower and increased rice production are almost certainly incompatible, hence the questions: is prioritised hydropower the best pathway to energy security and is rice the best crop to allocate water to?
Cambodia	Integrated management in a basin context	As for Table 2.9 above.

Table 2.12. Potential Conflict and Reduced Productivity Arising from Hydropower Development in the CH

2.2.3. Tables Relevant to Constrained Water Productivity

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	Improved climate change resilience	Economic growth and increased, diversified livelihood opportunities are key determinants of climate change resilience. Are these determinants best served by large allocations of water to a low value crop? That being said, rice does have significant value added potential, which is relevant to the economic productivity of the water needed to grow it, especially if the rice could be grown under the SRI.
Mekong Delta	Improved climate change resilience	Is the allocation of water for the irrigation of rice in the CH going to improve or decrease climate change resilience on the delta? Salinity and loss of the delta may be the key determinants.

Table 2.13. Potential Productivity Reduction Arising from an Increased Area of Rice Production in the CH

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	Improved climate change resilience	Economic growth and increased, diversified livelihood opportunities are key determinants of climate change resilience. Are these determinants best served by continuing to allocate large amounts of water to a low value crop? The point about value addition is also relevant here.
Mekong Delta	Improved climate change resilience	Is the continuing allocation of water for the irrigation of rice in the CH going to improve or decrease climate change resilience on the delta? Salinity and loss of the delta may be the key determinants.

Table 2.14. Potential Productivity Reduction Arising from Protection of the Existing Rice Area in the CH

REGION	POTENTIALLY AFFECTED OBJECTIVE	DISCUSSION
CH	Increased area of rice production, which can be assumed to require irrigation	If it can be agreed that rational and economically advantageous use of the total factors of production is an essential building block of climate change resistance, then it is very difficult to see where protection and expansion of a low value sector with high water demand might fit in, particularly in the CH where the rice sector is traditionally small and hence does not have the same cultural cachet as it does on the coastal lowlands where it might be a good use of the factors of production, and the opportunity cost of water might be negligible.
	Existing rice area protected	

Table 2.15. Potential Productivity Reduction Arising from Improved Climate Change Resilience in the CH

2.3. Consolidated Hypotheses

The basic hypothesis that emerges from these tables is that Basin Welfare is constrained by a combination of:

- an inadequate regulatory framework, and as a result

- economically immobile water
- unnecessarily low economic productivity especially in agriculture, and
- excessive dependence on and prioritisation of hydropower.

These issues are briefly explained, **as they relate to the CH**, in the following Sub-sections, while PART 3 suggests an investment strategy[7] for transforming the potential losses they represent into Basin Welfare gains.

2.3.1. Regulatory Framework

Irrigation is and will remain by far the greatest consumer of water. But at present there is no limit on how much an irrigator may abstract. Although there to an extent a surrogate limit on abstractions by irrigators incurring a cost for pumping, pumping for rice is very uncommon. Ideally irrigation abstractions should be limited to a maximum permitted amount per season. Such permits are not to be confused with rights. This is because a right has to be supplied, whereas a permit simply specifies the maximum that an irrigator can abstract within a given time period, when there is sufficient water in relevant catchment.

But in cases where medium to long term forecasts suggest that there will not be as much water as expected, or that dams did not fill up as much as expected in a previous season, only a portion of the permit can be allocated.

A combination of permits and allocations is a stepping stone to increased economic productivity of water because a farmer can plan on the basis of what is available not on what is hoped for, with resulting crop loss.[8]

However, there is no system of permits currently in operation in the CH.

2.3.2. Economically Immobile Water

In this context and simply stated, the opportunity cost of water is the economic return of its most lucrative potential use minus its return from an actual use. Water is economically mobile when the pertaining legal, regulatory and institutional framework allows water to be allocated to uses that minimise its opportunity cost. It should be self-evident that where water governance is strong, the need for economic mobility applies only to the water left over when societal and environmental needs are satisfied.

Wherever there is competition for water, an entity[9] with a permit to use a given amount of water may decide to use only a percentage of the total amount permitted and sell the unused balance to an entity that needs it more than he or she does.

See Sub-section 3.1 below for more on this.

2.3.3. Economic Productivity of Water in Agriculture

The economic productivity of water is simply the amount of cash that the use of a given quantity of water produces. This is effectively zero for subsistence crops, especially where labour has an opportunity cost. But for crops with high value added potential the same quantity of water, embedded in the commodity, gains value with value addition. And this has transformative socio-economic benefits because of the increased and diversified livelihoods created along the value chain.

A combination of economically mobile water and increased productivity of water in use clearly increases the numerator of our proposed optimisation metric.

Studies in the late 1990s by IWMI and in the early 2000s by the International Food Policy Research Institute confirmed that when economic productivity of water is increased at basin level, access to water by the poor and environmental stream flows both increase.[10] This is because economically mobile water is also physically mobile. This explains the increased access and environmental stream flows, but it also means that the water can be used for economically significant non-consumptive uses on the way from one user to the other.

This has very important ramifications for initiatives intended to increase physical water use efficiency. This is because without institutional and regulators measures to reduce permitted abstractions in line with the new technology, there is a tendency for irrigators either to shift to higher value irrigated crops that use more of the permit, or the existing farming system is expanded spatially such that more of the permit is used. This means that the return flows actually decrease and water insecurity increases downstream.

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7 Both infrastructural and institutional

8 There are also market based ramifications that speak to the subject of economic productivity, but these are not relevant at this stage of the exercise.

9 "Entity" is used intentionally because the user could be an individual, a cooperative, an industry or other commercial enterprise, a utility or a public authority etc.

10 See Keller and Keller, 1995; Keller *et-al*, 1996 and Cai *et-al*, 2001

2.3.4. Prioritisation of Hydropower

The prioritisation of hydropower in the CH is bewildering unless the objectives are not about energy but more about concrete monuments, large budgets, and political hegemony in the case of transboundary waters.

If on the other hand, a hydro-based power plan really is about energy then:

- hydropower is expensive (in financial, economic, social and environmental terms), while experience tends to confirm that the economic performance assumed during pre-investment appraisal is rarely achieved in reality
- there could be a high opportunity cost on stored water
- there are increasing concerns in the Lower Mekong that dry season flows are declining in comparison to assumptions made during pre-investment appraisal
- storage based hydropower has long lead times, which could be incompatible with Paris Agreement timetables, even if hydropower is genuinely clean
- but it is not clean, it contributes to greenhouse gas emissions and heavily so in early years of operations, which again speaks to the Paris timetable, it also not clean because it reduces the absorptive capacity of downstream flows
- operating rules that require dams to be kept as full as possible are likely to increase the risk of catastrophic flooding, especially where cascades of dams are involved, and where spillway designs are based on historic design flood which are now becoming more frequent and more severe as a result of climate change, and
- the benefits are not well distributed when compared to more decentralised options such as solar, wind or bioenergy.

Add to these drawbacks, the facts that:

- assumptions concerning the regional markets for hydropower may become invalid
- it is difficult to optimise water use in a way that favours both expanded irrigation and prioritised hydropower, and
- there are alternative energy pathways that do not require hydropower (and hence stored water); have potential for private sector financing; can be decentralised and are more advantageous from an economic perspective

Then there are valid grounds for questioning the wisdom of a hydropower dominated power plan.

Part 3: Nexus oriented investment strategy

Policy, Legal and Regulatory Framework

It should be clear from the conclusions emerging from PART 2 that the outline investment suggested below is likely to question the objectives calling for hydropower to be prioritised and for protected and/or expanded rice production. It may also be clear that the proposed strategy seeks to fill certain gaps in the Viet Namese policy, legal and regulatory framework (hereafter "The Framework").

With respect to the determinants of Basin Welfare It is therefore necessary to understand,

- what The Framework requires;
- what The Framework allows;
- what The Framework forbids; and based on what emerges;
- the extent to which, if any, The Framework needs enhancement, expansion or revision.

The key documents needed for a comprehensive Framework review would normally include everything of current relevance to climate change, agriculture in general, irrigation in particular, water and development in general, etc. Since a complete suite of such documents is unavailable, the review has been limited to the:

- 2012 Law on Water Resources
- 2017 Law on Irrigation
- 2017 Decree on Providing for Calculation Methods and Charge for Granting Water Rights
- 2014 PM Decision on Protocols for Inter-reservoir Operations in the Srepok River Basin
- 2018 PM Decision on Protocols for Inter-reservoir Operations in the Sesan River Basin

Articulation of the ***indicative*** strategic investment plan proposed below was undertaken in a way that asked if it:

- supports or is supported by the Framework
- challenges the Framework, and hence
- the extent to which the Framework itself needs enhancement, expansion or revision.

Before proceeding however, it is stressed that the material which follows is limited to a statement of strategic investment opportunities in the CH's agriculture and energy sectors for increasing overall Basin Welfare. Data and other resource limitations mean that it is not offered as a detailed plan, complete with quantitative, economic arguments. Rather, it remains generic for time being and is offered as little more than a guideline for the formulation of the actual investment strategy.

Steps needed to transform the generic into the specific are suggested in PART 4.

3.1. Agriculture, Energy and the Enabling Environment for Basin Welfare in the CH

Section 2.3 above argued that the issues arising from the Analytical Framework included two issues of a largely institutional nature: the need for a better regulatory framework and the need for economically mobile water. In simple terms, what is needed is a combination of regulatory and institutional arrangements that prevent water being used unproductively in one location if it could be used more productively in another.

"Productive" in this context is a somewhat loaded term because of social and environmental needs that are not easily captured by an economic concept of productivity.[11] Accordingly, "productive" is intended here to refer to water that is surplus to social and environmental imperatives.

In irrigation, the variables are:

- crop type: low value, water intensive, largely subsistence crops versus high value crops with local/domestic added value potential with low water requirements
- consumption: how much of the water abstracted is actually transpired by the crops?

[11] Actually, both social and environmental water access and use do have economic characteristics. For instance, there may be an economic cost accruable to limited access to water by the poor, while ecosystem services definitely have economic values, and there are economic costs accruable to environmental degradation. But these are beyond the scope of the current study.

- Return flows: how much of the non-consumed portion of the abstracted water get back into the natural surface or groundwater systems, and at what levels of quality?

In terms of the enabling environment therefore, needed to facilitate an increased agriculture sector contribution to basin welfare, is a combination of:

- irrigation abstraction permits, supported by appropriate monitoring facilities, ideally cumulative flow meters
- irrigation return flow monitoring, again, ideally comprising cumulative flow meters, these would allow permits to be predicated on consumption, rather than abstractions
- incremental increases in physical water use efficiency, but regulated by means of a cap and trade system that maintain or increase return flows
- a system of seasonal allocations as a subset of the permit system
- awareness raising with respect to crop diversification opportunities supported by time based stepped subsidies that allow Government to share farmers' perceived risks

There is a parallel study underway with respect to energy.[12] Accordingly, there is no intention here to pre-empt or second guess its results and conclusions. Even so, in a discussion around the concept of basin welfare such as this, the following principles may be considered relevant to energy sector planning:

- multiple use of existing hydropower dams
- removal of hydropower as a prioritised investment class from the Law on Water Resources except as a regulatory or operational issue
- a quantitative understanding of:
  - water consumed by hydropower
  - the pollution costs of hydropower
  - the opportunity costs of stored water
- establish a mixed, policy-level power plan that is consistent with the need to increase Basin Welfare by fully acknowledging:
  - that there is a choice of alternative options to storage based hydro: wind, solar, biofuels, run-of-river hydro, zero-head hydro, etc.
  - the full costs and benefits (including externalities) of each option, i.e., social, economic and environmental costs and benefits (including any externalities) of each option; and potential for innovative financing.

3.2. Agriculture

3.2.1. Agriculture in General

Although the need for a trade-off or compromise between irrigation and hydropower has clearly emerged as the critical strategic issue, it is important to take a more holistic view of agriculture. This is because agriculture is a landscape issue with profound implications for catchment sustainability and productivity. In other words, agriculture can either maintain catchment health and contribute to Basin Welfare, or it can cause catchment degradation and constrain Basin Welfare. This does not only refer to catchment stability and hydrology but also refers to the productivity of rainfed as well as irrigated agriculture.

It may for instance be considered strategic to grow rainfed bioenergy crops or industrial crops with added value potential as catchment preservation measures. Rainfed crops such as bamboo or industrial hemp not only have useful soil binding characteristics and (relatively) low water demand, they also have diverse and even sophisticated value chain potential. As such, they represent livelihood based pathways to food security rather than resource intensive, irrigated food security requiring large public investments in irrigation service delivery (with all the sustainability challenges that raises). In other words, such crops provide socio-economic and environmental benefits without needing irrigation, water which would almost certainly have to be supplied at high opportunity costs, especially if allocated to wetland rice, as is currently the priority.

3.2.2. Irrigated Agriculture

With more livelihoods accruing to industrial crops with high local added value potential, large allocations of water with high opportunity costs, that might have been predicated on the need for wetland rice as a food security measure could instead be allocated to less water intensive, high value cash crops with a lower opportunity cost, with a larger unallocated balance left to flow out of the CH with a low resource price. And as re-allocated water flows through the landscape from one use to another, it is available for non-consumptive

[12] The Stimson Centre study refers.

uses such as fisheries, navigation, and amenity, thereby contributing to the overall productivity of water and hence Basin Welfare.

Despite the foregoing argument, important cultural and socio-cultural mores mean that it would be extremely difficult to recommend that rice production should cease in the CH. Even so, a critical assessment of rice in the context of basin welfare would do well to acknowledge two key documents issued in 2012:

- A World Bank report showing that rice in Viet Nam only shows a positive return on investment if three crops per year are possible. And according to the report, this is only possible at a small and specific location on the Mekong Delta. Although other, verbal sources say that this is true also on a small portion of the Red River Delta, no-one is prepared to state that it is possible in the CH. Accordingly, wetland rice constrains rather than facilitates increases in Basin Welfare.
- A Ministry of Agriculture and Rural Development (MARD) white paper argued persuasively for a radical change in the way Viet Nam's agriculture sector performance was monitored. Instead of assessing performance in terms of overall production of various commodities, increasing resource constraints suggested that monitoring on the basis of economic productivity would be more appropriate. Although it would have been politically hazardous to ask the country to rethink rice, for those that had ears to hear, the White Paper may have been all about rice!

So then, how to accommodate rice in strategic investment plan for the CH?

To answer this, it is first useful to understand that rice does not need standing water, it can be grown perfectly well as a normal field crop, and the SRI represents the best way to this, not least because:

- productivity is higher
- irrigation water requirements are less, and hence:
  - new-build irrigation schemes are cheaper, because canals do not have to be so big
  - since there is no need for pre-saturation a far greater are can be planted simultaneously constraining thereby the growth of stage-dependent pest populations
- unlike for wetland rice, an irrigation scheme predicated on the SRI is much easier to use for any crop that a farmer wishes to irrigate
- there is more biomass
- milling quality is better
- there is resistance to logging
- seed rates are an order of magnitude less than for traditional production systems, increasing therefore the affordability of higher yielding and/or pest resistant hybrid seeds
- there are also climate change mitigation claims made for the SRI, and this in fact was the reason that the government has trialled it.

A possible drawback however, may be the higher labour demands of the SRI, although mechanisation options are becoming increasingly available. Also, SRI does best with organic fertiliser, but this is only one of several components of the SRI and can be ignored with only minimal ill effects on the system overall.

Clearly, we are arguing here, for a more flexible concept for new build irrigation. Before doing so, there is the lingering question of what to do with existing wetland rice schemes? There are at least four answers to this crucial question that could be researched in the follow-on work:

- Improve irrigation service delivery, facilitating in-turn on-farm water management[13] and increasing return flow by means of improved drainage infrastructure.
- Laser land-levelling which is a cheap and proven way to increase both the physical and economic efficiency of water use.
- Consider the incorporation of fisheries into the wetland rice system, although is reportedly not encouraged in Viet Nam, the option is there along with its nutritional and/or financial benefits, and indeed its contribution to the economic productivity of water in the basin and hence Basin Welfare.
- Recalling that Cambodia has plans to invest in flood containment dikes,[14] if any of the flooding originates in the CH, diked rice field could be used for flood attenuation, and with the farmers compensated accordingly,[15] perhaps under some sort of PES modality financed by Cambodia.

[13] Farmers are less likely to take too much water if their irrigation service is reliable

[14] Which shift the flood downstream while introducing a habitat hazard by constraining natural flood plain functions.

[15] Wetland rice can in any case tolerate excessive depths of standing water for up to three days with little effect on yields.

Moving now beyond rice, investment in new build irrigation should:

- Ideally provide irrigation-on-demand which is a proven pathway to reducing the wastage of water at farm level because aware and well-trained farmers tend not to over-abstract if they know that water is always going to be there when they need it. Also, if based on downstream level control water management modalities, gravity-fed surface irrigation-on-demand can be cheaper because there is less need for expensive canal embankments.
- As with wetland rice, all irrigation service should include the infrastructure needed to maximise return flows.
- If return flows are captured by decentralised, small-scale water harvesting storage facilities, then the water can be re-used, increasing its productivity thereby.[16] It is re-use of irrigation water in this way, that explains Egypt's high level of economic water use efficiency in the irrigated agriculture sector, possibly the highest in the world.
- Water productivity, Poverty alleviation; socio-economic transformation and economic growth would all benefit from the production of crops with added value potential at both the local and national levels.

It happens that a major irrigation programme, currently under consideration for the CH[17] has the potential to "check some of these boxes". Although there are grounds for questioning some of this program's ideas concerning expanded rice production,[18] it is also predicated on the need for more cash cropping and decentralised water harvesting infrastructure. As such, and given the unavoidable poverty alleviation challenges in the CH and the role that public (and private) investment in improved agricultural support services, including irrigation, could and should play, it would be folly to write off such an initiative without a compelling and robust argument. This current study is not looking for such an argument, but rather seeks to inspire an equally robust conversation about the best way forward.

3.2.3. Coffee in Particular

Coffee is a special case because of its huge economic importance for Viet Nam, which is the world's second biggest producer of Robusta. Average yields at around 2.55 tonnes/ha of green berries[19] are currently within 10% of the world's highest, yet given expected growth in demand the major players involved are looking to increase greatly, the amount grown in the country. However, climate change is already beginning to compromise the areas where coffee can be grown, which currently total some 600,000 ha.

The crop is typically produced under a regime of supplementary irrigation, supplied usually from groundwater. There are considerable uncertainties regarding the actual crop water requirements of coffee, but one source states that typically, around 1,200 litres are applied annually per bush in three applications. At planting densities of 1,100 bushes per hectare, this corresponds to some 0.7 km^3 annually.

If climate change does reduce the productive area as seems already to be happening, and if production is required to increase substantially, then so must yields. New varieties reportedly having yield potentials some 60% in excess of Viet Nam's current average may be available soon. But very little is known about their likely water requirements. But it is difficult to expect such dramatic yield increases to be achieved without at least some increase in irrigated water requirements.

This suggests several unknowns that speak to the question of Basin Welfare:

- How much irrigation water does coffee need in the CH now?
- What options are there for reducing the irrigation water requirements of coffee (agroforestry perhaps)?
- How much water would the new, high yielding varieties need?
- What options are there for increasing the physical efficiency of irrigation?

In addition, there is the interesting matter of deficit irrigation, in other words, how much of the new varieties' yield increment would be traded-off against reductions in the amount of irrigation water supplied? Clemens (2010) applied this question to drip irrigated Arabica coffee[20] in northern Tanzania and found that the water productivity of irrigated coffee was inversely proportional to the amount of water supplied, even though coffee

16 There may be quality implications with this, but the provision of small built wetlands upstream of the storage structures might deal with this, while perhaps even producing some additional economic benefits.

17 ADB program "Water Efficiency Improvement in Drought Affected Areas" and its CH complementary focus, the UNDP program "Strengthening the Resilience of Smallholder Agriculture to Climate Change-induced Water Insecurity in the Central Highlands and South Central Coast Regions of Viet Nam".

18 It is not clear how much of this would be for the South Central coastal region where the opportunity cost of water would be at its least and where there could be sound environmental arguments in favour of wetland rice.

19 FAOSTAT 2017.

20 "Arabica should be OK as a proxy" for Robusta, statement from FAO 18/3/19.

yield were directly proportional. This of course arises from the simple fact that a percentage increase in water applied was less than the percentage increase in yield.

This is a key issue that must be addressed in the context of a strategic investment plan targeted at an increase in Basin Welfare. But this itself raises two more questions:

- If Basin Welfare is the objective, then coffee becomes just another user of competitor for land and water. As such it may indeed be the most deserving. But is there a scale issue? Is there a trade-off between maximum yields and the possible benefits of deficit irrigation?
- Noting that the energy of needs of irrigation are directly proportional to the levels of precision/physical efficiency required, and in fact that there is already a significant energy cost of coffee irrigation because the water is pumped, what is the opportunity cost of the energy used to irrigate the commodity? This feeds nicely into the next sub-section.

3.3. Energy

Energy is the focus of a parallel, complementary study. It is understood that this will cover all possible renewable energy alternatives. Among them, some raise issues of relevance here:

- the allocation of land and possibly water to bio-fuels
- the potential of biofuels for watershed rehabilitation and sustainability
- multi-purpose use of storage based hydropower
- the energy needed for irrigation water supplies, efficiency and precision.

3.4. Consistency and Compatibility with the Framework

A review of the 2012 Law on Water Resources indicates that there are 12 articles of relevance to the preparation of a strategic investment plan. These articles:

- require that:
  - all water use must comply with whatever strategies or master plans are extant at a given time
  - water use is economical (but this term is not defined; it could mean sparingly or productively; neither is clear from the context)
  - water use is multi-purpose and equitable
  - water use contributes to socio-economic development
  - planning is supported by media based and other awareness raising campaigns
  - reservoirs are operated according to rule predetermined by “competent state agencies”
  - water allocation and use is consistent with international cooperation agreements
  - any strategies should be elaborate for a 10-year period and visionary for 20 years
  - water master plans should be carried out in a way that is consistent with land use master plans
  - water resource plans and strategies should acknowledge the results emerging from previous plans and strategies.
- Allow or recommend that:
  - the artificial supplementation of groundwater
  - function based zoning of water resources
  - rational allocations between different uses
  - prioritisation of uses under drought conditions.
- Forbid:
  - unregulated discharge of pollutants into water sources.

A review of the 2017 Law on Irrigation indicates that there are also 12 articles of relevance to the preparation of a strategic investment plan. These articles:

- Require that:
  - irrigation service delivery is able to serve multiple objectives
  - irrigation service delivery contributes to water security and socio-economic development
  - water is used in an economic, safe and effective manner (but once again these terms are not defined, although “safe” should be clear enough)
  - irrigation water is used for “predetermined” purposes; this could be problematic if taken to mean that crop diversification is not allowed once a scheme has been constructed

- legal rights are guaranteed to either/both individuals and organisations in relation to irrigation operation (but the Law is silent on what is meant by “rights”)
- irrigation planning should be based on established water resource inventories
- international obligations should not be compromised by national irrigation development
- irrigation strategies should be detailed for 10 years and visionary for 30 years
- irrigation scheme water use should be reviewed every 5 years and modified in line with any changes to higher level development priorities or security issues
- irrigation scheme operations should be adaptable to climate change
- crop choice reflects local resource endowments
- operations at storage facilities (such as and including hydropower) incorporate supplies for personal, domestic and agricultural production downstream.

- Allow or recommend that:
  - large scale projects are prioritised
  - advanced technologies are used to recycle water
  - irrigation water can be supplied for aquaculture purposes (but not necessarily integrated with crop production as in perhaps the case of wetland rice)
  - irrigation scheme managers have contingency plans for water allocation under conditions of drought
  - irrigation scheme management modalities are adaptable to drought conditions.

- Forbid:
  - illegal abstraction of water for irrigation
  - unregulated discharge of pollutants into water sources.

It can safely be concluded that the expected strategic investment plan is largely consistent with all of the above and hence should not be a “hard sell” if developed and introduced in an open and participatory fashion. There are inevitable of course, some points of divergence or innovations. These include:

- Lack of an obvious permit based governance system, which is serious constraint on economic efficiency and the economic mobility of water.
- Possible inflexibility with respect to farming system choices, which is important if farmers are to take best advantage of changing market conditions (as is anticipated by the proposed UNDP project).
- Viet Namese preference for large projects, which are no longer necessary now that solar pumping is more affordable for the smallholders; such technology facilitates decentralised, farmer financed irrigation, meaning that government’s role becomes that of a regulator and not a financier or service provider.

Part 4: From the generic to the specific

The steps needed to transform the generic investment strategy outline above into an actionable "set of investment option in the 3S that could attract domestic and/or international financing and would form the basis of discussions between CLV"[21] are suggested in Figure 4.1. It may be that some of the activities may not be necessary if relevant and current information and/or data is already available as a result of other studies.

4.1. The Objectives

As is usual with a classic LogFrame, its proposed Overall Objective is one to which the proposed initiative is merely intended to contribute. The Overall Objective proposed here is Viet Nam's national development objective which clearly requires many other initiatives to succeed. Its indicators and means of verification are the same as those promulgated by the national development policy framework.

The initiative under consideration here concerns the development of a strategic investment strategy for the optimisation of water use in the CH. But self-evidently that will not happen until the strategic investment programme is itself completed, or at least well-underway. Hence the need for a Strategic Programme Objective, the implementation of which is also beyond the scope of the current exercise:

"Steadily increasing 3S Basin Welfare accruing to water use in the CH"

Nonetheless despite the fact that this initiative will not achieve this objective, it is possible to suggest possible indicators as follows:

- the economic productivity of water use in the CH, in other words, the Basin Welfare numerator
- the number of reported conflicts over, or the incidence of competition for water in the CH, in other words, the Basin Welfare denominator, and
- the resource price of water flowing out of the CH, which itself combines both quantitative and scarcity issues in a single metric.

In this context, Immediate Objectives are objectives that the initiative in question should be able to achieved. In this case three are proposed:

Immediate Objective 1 is:

"An enabling environment for increased basin welfare in the 3S basins under discussion among key stakeholders"

It has two indicators and is supported by five Outputs.

Immediate Objective 2 is:

"A least-cost and sustainable power generating plan for the CH"[22]

No indicators are suggested for this Immediate Objective because it is the focus of the parallel study underway be the Stimson Centre. Nonetheless, its delivery requires one Output from this study.

Immediate Objective 3 is:

"An investment strategy for increasing the productivity of water use in the CH without compromising the sustainability of water resources in the 3S basins"

It has a single indicator and is supported by four Outputs.

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21 From the ToR. But there is an ambiguity in that the same paragraph of the ToR limits the potential investments to the CH, not the 3S as a whole. This is taken to mean that favourable investments in the CH suggest what might be favourable elsewhere in the sub-basin, and hence that the thinking that arrived at them, could be applied equally throughout the basin.

22 Note that this is not the same as a power plan for the CH because such a plan could include imported power. Rather, this objective is intended to capture: i) the possibilities for generating power not necessarily for, but in the CH; and ii) the social and environment externalities in the "least-cost" concept.

4.2. Inputs Needed

Clearly the proposed follow-on work needs to be financed, and although it is known that some financing will be available from the BRIDGE 4 programme, the actual amount is not known to this writer. Equally, the time available to complete to deliver the Immediate Objectives is also not known.

Accordingly, at this stage it is only possible to suggest the expertise needed:

- a water policy and sector planning expert with significant competence with respect to water use in agriculture and water resource institutions;
- a water resource/agricultural economist;
- an agronomist/land use planner with experience of irrigated agriculture;
- an hydrologist.

LEVEL	INDICATOR(s)	MEANS OF VERIFICATION	ASSUMPTIONS/PRE-CONDITIONS
Overall Objective: Sustainable and effective growth …along with social progress and equality, national resources and environment protection, socio-political stability, firm protection of independence-sovereignty-unification and territorial integrity of the country[23]	•	•	• The benefits of livelihood, or trade based food security pathways are understood and promoted at all levels
Strategic Programme Objective: Steadily increasing 3S Basin Welfare accruing to water use in the Central Highlands.	• economic productivity of water	• regional economic data	• Viet Namese authorities are prepared to adopt more productivity based metrics into land and water allocation decisions • Viet Namese authorities are prepared to introduce a system of permits and allocations as part of their water governance concept
	• conflicts or competition over water	• public records	
	• the resource price of water flowing out of the central highlands	• user surveys and estimates	
Immediate Objective 1: An enabling environment for increased basin Welfare in the 3S Basin under discussion among key stakeholders.	• Ongoing meetings with key stakeholder at the centre and in the central Highlands	• Meeting minutes	
	• Level of media coverage	• Monitoring of the relevant media	
Immediate Objective 2: A least-cost and sustainable power generating plan for the Central Highlands	This is beyond the scope of this study except as regards the incorporation of bioenergy into Immediate Objective 2.		
Immediate Objective 3: An investment strategy for increasing the productivity of water use in the Central Highlands, without compromising the sustainability of water resources in the 3S Basin.	• status of the investment strategy	• IUCN records • donor records	
Outputs			**ACTIVITIES**
1.1 An indicative, catchment by catchment water budget for the Central Highlands	• status of the water budget estimate	• progress reports and notes to the file • meeting minutes • a report presenting the	1.1.1 Identify water using sectors in the catchments, consumptive and non-consumptive

[23] Slightly adapted from: http://www.chinhphu.vn/portal/page/portal/English/strategies/strategiesdetails?categoryId=30&articleId=10050825

LEVEL		INDICATOR(s)	MEANS OF VERIFICATION	ASSUMPTIONS/PRE-CONDITIONS	
			water budget	1.1.2	Obtain data and/or estimate water use by each sector, again consumptive and non-consumptive
				1.1.3	Make estimates of how much water is re-used
				1.1.4	Using available hydrological data and or estimates, estimate outflows from the various catchments and express them as annual hydrographs
				1.1.5	Prepare the water budgets (including any use for pollution discharge)
1.2	An indicative estimate of the overall economic productivity of water use in the Central Highlands	• status of the economic productivity estimate	• progress reports and notes to the file • meeting minutes •	1.2.1	Undertake stakeholder consultations as necessary
				1.2.2	Using the indicative water budget, estimate the economic returns on water used
		• Status of the written report	• a report presenting the economic productivity estimate	1.2.3	Write a report setting out and explaining the economic productivity results
1.3	A review of the institutional arrangements (hard and soft) for water resource allocation, management, development, regulation and service delivery in the Central Highlands	• progress with respect to stakeholder consultations and baseline literature review	• progress reports and notes to the file • meeting minutes	1.3.1	Undertake stakeholder consultations as necessary
				1.3.2	Undertake a detailed review of the soft institutions (policies, laws, regulations, markets etc)
		• status of the written review	• a report presenting the institutional review	1.3.3	"map" the relationship between the institutions and the issues faced by the CH water sector
				1.3.3	Write up the institutional review
1.4	An assessment of the social, economic and environmental benefits of a permits and allocations system of water allocation, abstraction and use	• progress with respect to stakeholder consultations and baseline literature review	• progress reports and notes to the file • meeting minutes	1.4.1	Undertake in-depth stakeholder consultations
				1.4.2	Provide case studies on the subject of successful permits and allocations systems

LEVEL		INDICATOR(s)	MEANS OF VERIFICATION	ASSUMPTIONS/PRE-CONDITIONS	
	in the Central Highlands			1.4.3	Convene a stakeholder workshop to discuss and agree possible permit and allocation systems
		• status of the written assessment	• a report presenting the assessment	1.4.4.	Regardless of the results of the stakeholder workshop, provide written recommendations concerning possible permit and allocation systems, including the steps needed to establish one in the Central Highlands
1.5	Draft recommendations regarding measures, costs and benefits of a more enabling environment for water resource allocation, regulation and use in the Central Highlands	• progress with respect to stakeholder consultations and baseline literature review	• progress reports and notes to the file • meeting minutes • a report presenting the economic productivity estimate	1.5.1	Compare the costs and benefits of a functional permit and allocation system with the status quo
				1.5.2	Subject the results to stakeholder consultant, once again in a workshop if possible
		• status of the written recommendations	• a document setting out the draft recommendations	1.5.3	Finalise and write up the costs and benefits of improved water governance in the Central Highlands, paying particular regard to what is perceived as already acceptable, and what remains problematic
2.1	In association with the Stimson Centre an assessment of the options for biofuel production (biomass and/or biofuels).	• consistency with respect to the Stimson Centre's thinking with respect to objectives and options	• an agreed (informal?) Memorandum of Understanding with the Stimson Centre	2.1.1	Discuss and agree bioenergy options with the Stimson Centre
				2.1.2	Establish and informal MoU with the Stimson centre (to delineate roles going forward, to avoid duplication of effort and to set out cooperative arrangements)
		• progress with respect to the assessment	• progress reports and notes to the file • meeting minutes	2.1.3	Identify areas with productive comparative advantage for bioenergy cropping (irrigated or rainfed)

LEVEL		INDICATOR(s)	MEANS OF VERIFICATION	ASSUMPTIONS/PRE-CONDITIONS	
		• status of the written assessment	• a note to the file for sharing with the Stimson Centre	2.1.4	Write a note to the file for use by the Stimson Centre and for the preparation of Immediate Objective 3
3.1	A detailed estimate of the productivity of current agricultural water use in the Central Highlands and its impact on Basin Welfare.	• progress with respect to the detailed estimate	• progress reports and notes to the file • meeting minutes	3.1.1	Based on the indicative results of Output 1.2, prepare a more detailed assessment of the productivity of current water use in the Central Highlands
				3.1.2	Share the results at workshop with key stakeholders
		• status of the written estimate	• a report presenting the economic productivity estimate	3.1.3	Write the report and issue with supporting data
3.2	A critical review of existing water and land use development plans for the Central Highlands, including an estimate of their likely impact on Basin Welfare.	• status of the review	• progress reports and notes to the file • meeting minutes • a report presenting the economic productivity estimate	3.2.1	Obtain available planning documents
				3.2.2	Undertake a preliminary review
				3.2.3	Share the preliminary review with key stakeholders and note their thoughts
		• status of the written review	• a report presenting the results of the review	3.2.4	Write the review which should acknowledge (but not necessarily agree with) the stakeholders' views
3.3	A fully costed strategic investment concept for the establishment of an enabling environment for increase Basin Welfare, including the policy, legal and regulatory ramifications of: • water use permits and allocations • re-use of return flows • multiple use of hydropower dams • multiple use of paddy fields • multiple use of	• status of the strategic investment plan	• progress reports and notes to the file • meeting minutes • a written concept note available for presentation to and discussion with key stakeholders	3.3.1	Compile all necessary data
				3.3.2	As detailed as possible, build an economic/sensitivity model of the Central Highlands water sector and to the best level of details possible, of its knock-on effects downstream
				3.3.3	Run the model under various scenarios, including business as usual, and capturing various combinations of the determinants bulleted in the second column, and

LEVEL		INDICATOR(s)	MEANS OF VERIFICATION	ASSUMPTIONS/PRE-CONDITIONS	
	wetlands			3.2.4	Convene a workshop to present the model and its results to key stakeholders and allow them also to run the model
				3.2.5	Select the most promising scenario and summarise it by means of a simple concept note
				3.2.6	Circulate the concept note to key stakeholders and invite comments
				3.2.7	Incorporate comments as appropriate
3.4	A strategic investment concept ready to write up as Immediate Objective 3, and including: • an implementation plan • an institutional prescription for the enabling environment • possible financing pathways that include both the public/donor and private sectors	• status of the strategic investment concept	• progress reports and notes to the file • meeting minutes	3.4.1	Write a detailed and comprehensive strategy investment plan, addressing both institutional and infrastructural elements) with all supporting information: including: • costs and benefits (with full acknowledgement of recurring costs) • sensitivity • time frame • potential financing options • financing drawdown schedules • institutional assumptions • etc
		• status of the written concept	• a concise written strategic investment concept complete with supporting annexes as required		

Figure 4.1. Logical Framework for Transitioning from Generic to Specific

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GENERIC OBJECTIVE OF PRIORITISED SECTOR	CHALLENGES AND OPPORTUNITIES	SECTOR THREATS AND POSSIBLE NEXUS SOLUTIONS			
		Water	**Food**	**Energy**	**Environment**
For water: the availability of and access to sufficient water for human and ecosystem use – along with protection from water hazards such as floods	Threat		No threat because if water availability is sufficient for "human use" there is by definition, enough for agriculture.	Optimisation of water allocation and use across all human and ecosystem uses may reduce or even nullify its potential for to hydropower production	Certain kinds of flood defence works – such as flood bunds -disrupt aquatic ecosystem services and compromise gene pool integrity of the aquatic biota.
	Nexus solution		Not applicable.	**Compromise:** • multi-purpose dams (new dams) • multi-purpose operating rules (existing dams)	**Trade-off:** • multi-purpose use of paddy fields
	Non-Nexus solution		Not applicable	Adopt a mixed regional power plan using a combination of wind, solar (pv) or bioenergy.	Restore and/or use flood plains
For food: the availability of affordable agricultural commodities necessary for healthy, productive lives and profitable agricultural value chains.	Threat	Excessive allocation for irrigation may increase competition with and between other sectors, including the navigation sector.		Maximised realisation of irrigation potential could reduce hydropower potential.	Excessive allocation for irrigation may reduce the quantity and quality of environmental stream flows.
	Nexus solution	**Trade-off:** • alternative, less water intensive farming systems. **Synergy:** • use of multi-purpose storage infrastructure to recycle irrigation water.		**Trade-off:** • alternative, less water intensive farming systems. **Compromise:** • multi-purpose dams (new dams) • multi-purpose operating rules (existing dams) using multi-use specifications.	**Trade-off:** • allocation of some farm land to artificial wetlands.

GENERIC OBJECTIVE OF PRIORITISED SECTOR	CHALLENGES AND OPPORTUNITIES	SECTOR THREATS AND POSSIBLE NEXUS SOLUTIONS			
		Water	**Food**	**Energy**	**Environment**
	Non-Nexus solution	Agroforestry to reduce crop water requirements. Groundwater recharge using either built or natural infrastructure.		Adopt a mixed regional power plan using a combination of wind, solar (pv) or bioenergy	Organic farming systems (but care needed here because some organic farming systems may increase GHG emissions)
	Threat	Unregulated attempts to increase the physical efficiency of irrigation water use is likely to reduce water security and economically efficient water use downstream.		Excessive sedimentation due to poor land use practices could reduce the lifetimes of hydropower dams.	Eutrophication of natural water bodies due to non-point source pollution.
	Nexus solution	**Compromise:** • accept low efficiencies and increase return flows.		**Compromise:** • reduce dependence on hydropower by stabilising watershed with landscape scale planting not of food crops but bio-energy commodities with soil binding characteristics, thereby allowing new operating rules for the dams that increase water supply downstream.	**Trade-off:** • allocation of some farm land to artificial wetlands.

GENERIC OBJECTIVE OF PRIORITISED SECTOR	CHALLENGES AND OPPORTUNITIES	SECTOR THREATS AND POSSIBLE NEXUS SOLUTIONS			
		Water	**Food**	**Energy**	**Environment**
	Non-Nexus solution	Cap abstractions and trade "savings".		Inclusion of other renewables in the power plan. In the context of the 3S basin these comprise: solar (pv), wind and bioenergy. Payment by hydropower operators to farmers upstream for better land management.	Regulate the storage, retailing and use of agricultural chemicals
	Threat	Irrigation of low value crops is likely to reduce basin welfare (*Main Text text box 1 referred*).			Excessive sedimentation due to poor land use practices resulting morphological risk downstream.
	Nexus solution	None			**Synergy:** • Investment in short term sediment capture dams that can be used for agriculture when full of sediment, while attenuating floods in the meantime.
	Non-Nexus solution	Encourage/incentivise higher value farming systems, especially ones that are less water intensive			Change tillage intensive, annual farming systems to appropriate perennial systems and/or shift to conservation agriculture
	Threat				Water logging and other forms of soil degradation.
	Nexus solution				None

GENERIC OBJECTIVE OF PRIORITISED SECTOR	CHALLENGES AND OPPORTUNITIES	SECTOR THREATS AND POSSIBLE NEXUS SOLUTIONS			
		Water	**Food**	**Energy**	**Environment**
	Non-Nexus solution				Improved on-farm water management and drainage (while noting that improved drainage can increase downstream flood risk/intensity)
For energy: access to clean, reliable and affordable energy for cooking, heating, lighting, communications and other productive uses	Threat	Maximisation of hydropower generation is likely to reduce the capacity of reservoirs to attenuate floods and could actually increase the risk of flooding, especially in the case of dam cascades.			Trapping of naturally occurring sediment and hence negative morphological and habitat impacts downstream.
	Nexus solution	**Compromise:** • reduce flood risk by operating dams at lower surface levels. Reductions in generating capacity can be minimised by the use of remote hydro-met sensing upstream.			None
	Non-Nexus solution	Fill energy gap with alternative renewable energy options.			Abandon storage based hydropower and adopt a mixed regional power plan using a combination of wind, solar (pv) or bioenergy

GENERIC OBJECTIVE OF PRIORITISED SECTOR	CHALLENGES AND OPPORTUNITIES	SECTOR THREATS AND POSSIBLE NEXUS SOLUTIONS			
		Water	**Food**	**Energy**	**Environment**
	Threat	Hydropower generation is not a non-consumptive use of water. Water is lost to evaporation and seepage.	Operating rules for hydropower dams could result in competition for water with the irrigation sector.		
	Nexus solution	**Compromise:** • multi-purpose dams (new build), or new operating rules (existing).	**Compromise:** • multi-purpose dams (new build), or new operating rules (existing). • alternative, less water intensive farming systems.		
	Non-Nexus solution	Fill energy gap with alternative renewable energy options.	Fill energy gap with alternative renewable energy options.		
	Threat	Opportunity cost of stored water may reduce basin welfare (including reduced economic benefits of navigation).	Reduced stream flows result in saline intrusion of coastal streams, this affects irrigated areas and cultural fisheries in the brackish margins.		Storage based hydropower reduces downstream absorptive capacity.

GENERIC OBJECTIVE OF PRIORITISED SECTOR	CHALLENGES AND OPPORTUNITIES	SECTOR THREATS AND POSSIBLE NEXUS SOLUTIONS			
		Water	**Food**	**Energy**	**Environment**
	Nexus solution	**Compromise:** • multi-purpose dams (new build), or new operating rules (existing).	**Compromise:** • multi-purpose dams (new build), or new operating rules (existing).		**Compromise:** • multi-purpose dams (new build), or new operating rules (existing).
	Non-Nexus solution	Fill energy gap with alternative renewable energy options.	Fill energy gap with alternative renewable energy options.		Fill energy gap with alternative renewable energy options.
	Threat	Increased flood hazards because of climate change induced reductions in return periods of design floods	Reduced capture fisheries		Habitat degradation, which may have significant economic ramifications and may be due to compromised annual flood and turbidity cycles
	Nexus solution	**Compromise:** • multi-purpose dams (new build), or new operating rules (existing).	**Trade-off:** • increase culture fisheries		**Compromise:** • multi-purpose dams (new build), or new operating rules (existing).
	Non-Nexus solution	Fill energy gap with alternative renewable energy options.	None		Abandon storage based hydropower and adopt a mixed regional power plan using a combination of wind, solar (pv) or bioenergy
For the environment: sustainable ecosystems and ecosystem services accruing to	Threat	Nil.	Prioritisation of environmental stream flows may limit irrigation potential.	Prioritisation of environmental objectives may limit hydropower potential	

GENERIC OBJECTIVE OF PRIORITISED SECTOR	CHALLENGES AND OPPORTUNITIES	SECTOR THREATS AND POSSIBLE NEXUS SOLUTIONS			
		Water	**Food**	**Energy**	**Environment**
safety from potential environmental dangers caused by natural or human processes and arising from ignorance, accident, mismanagement or design and originating within or across national borders	*Nexus solution*	Not applicable	**Trade-off:** • take advantage of the increased capture fishery opportunities as a result of higher environmental stream flows **Compromise:** • adopt less water intensive farming systems **Synergy** • Improved return flows[24] from irrigated land (which itself require a trade-off in the form of built wetlands to reduce pollution in the return flows)	none	
	Non-Nexus solution			Adopt a mixed power plan	

[24] Note that although this usually means improved drainage, such drainage should only be predicated on returning water abstracted for, but not used for irrigation. Drainage as a measure by which to manage floods is a different matter and can actually intensify flooding downstream by changing the intensity of run-off from land that may have had an important flood plain function.

GENERIC OBJECTIVE OF PRIORITISED SECTOR	CHALLENGES AND OPPORTUNITIES	SECTOR THREATS AND POSSIBLE NEXUS SOLUTIONS			
		Water	**Food**	**Energy**	**Environment**
	Threat		Pollution due to poor management and use of agricultural chemicals		
	Nexus solution		**Trade-off:** • allocation of some farm land to artificial wetlands		
	Non-Nexus solution		Regulate the storage, retailing and use of agricultural chemicals		

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