Theme 2: Inclusive and sustainable SEAP

**Discussion Paper No. 4**

# Promoting Synergy between Sustainable Agriculture and Food Safety:

## Experiences on Green Water Management and Nitrogen Use Efficiency in the Greater Mekong Subregion*

The Discussion Paper Series of the Greater Mekong Subregion's (GMS) Core Agriculture Support Program Phase 2 (CASP2) is a platform for stakeholders of the GMS to examine the current and emerging development concerns affecting the subregion especially on but not limited to, food safety and quality assurance, environmental sustainability, and inclusive agro-based value chains. The papers are posted at the GMS Working Group of Agriculture's (GMS WGA) website (www.gms-wga.org).

# Contents



Figure

Tables

# Abbreviations

| | | |
|---|---|---|
| AINS | — | Agricultural Information Network Services |
| ADB | — | Asian Development Bank |
| ASEAN | — | Association of Southeast Asian Nations |
| BWM | — | Blue Water Management |
| CASP2 | — | Core Agriculture Support Program, Phase 2 |
| CSA | — | climate-smart agriculture |
| FAO | — | Food and Agriculture Organization |
| GAP | — | Good Agricultural Practices |
| GHG | — | greenhouse gas |
| GMS | — | Greater Mekong Subregion |
| GWM | — | Green Water Management |
| IAE | — | Institute for Agricultural Environment |
| IVY | — | International Volunteer Yamagata |
| IWMI | — | International Water Management Institute |
| Lao PDR | — | Lao People's Democratic Republic |
| LOA | — | letter of agreement |
| MOALI | — | Ministry of Agriculture, Livestock and Irrigation of Myanmar |
| NPK | — | nitrogen, phosphorus, potassium |
| NUE | — | Nitrogen Use Efficiency |
| PGS | — | Participatory Guarantee System |
| PRC | — | Peoples' Republic of China |
| R&D | — | research and development |
| SEAP | — | Safe and Environment Friendly Agriculture Products |
| t/ha | — | metric tons per hectare |
| TA | — | technical assistance |
| USAID | — | United States Agency for International Development |
| VSD | — | volunteer soil doctor |
| WHO | — | World Health Organization |

# Executive Summary

The Core Agriculture Support Program Phase II (CASP2) has a vision to make the Greater Mekong Subregion (GMS) internationally recognized as a hub for safe and environment-friendly agriculture products (SEAP). This paper summarizes the importance of addressing physical environmental drivers of change in order to achieve the CASP2 vision. It does this by highlighting the strong correlation between securing a steady supply of SEAP and the practices of sustainable agriculture. The message is clear: if farmers are producing safe food there is progress toward a sustainable environment. Key issues raised in the paper include

- introducing a conceptual approach that summarizes a cycle of trust and web of connections necessary among all players in the values cycle to build market confidence for SEAP;
- summarizing the breadth of the CASP2 letter of agreement (LOA) activities and highlighting important changes in land and water management approaches that the green water management (GWM) and nitrogen use efficiency (NUE) LOAs have provided;
- using Cambodia as a case study of the current state of play of the LOA activities pursued under CASP2, and the contribution that they are making;
- emphasizing the important dividend that farmers working in groups such as participatory guarantee systems (PGSs) provide toward sustainability; and
- identifying anticipated policy directions, including investments and institutional reforms that are needed to respond appropriately.

Section 2 provides the socioeconomic context. Section 3 posits the holistic approach required for promoting SEAP value chains and the importance of improved land and water management to achieve this goal. Section 4 focuses on measures in GWM and NUE being test cased, and uses the Cambodian case study to identify achievements particularly in smallholders' production and supply of vegetables to markets. Section 5 suggests the way forward with policy recommendations and additional potential actions.

In the last 2 decades the GMS economies have grown rapidly and the GMS population of over 330 million is becoming larger, richer, and more urbanized. Growth is occurring within a context of very tangible social and physical change across the GMS. The GMS economies share common natural endowments suitable for agriculture production and the situation presents a great opportunity for the GMS to be a major supplier of SEAP, but there are challenges. The 5-year GMS Strategy and Siem Reap Action Plan's focus on value chain development, food safety and quality, and climate-friendly supply chains is moving in the right direction.

Existing smallholder production in the GMS is unsustainable, requiring change. The GWM and NUE activities were applied to the case study and assisted in increasing productivity. The GWM activities are more advanced than those of the NUE work, and have combined to improve the vigor and response of soils during the early to middle dry-season period. This was achieved by using micro drip as supplementary irrigation reticulated from on-farm harvesting of rainwater, which is stored in on-farm ponds, and using pumps to gravity feed plants from tanks. The GWM work has also included consideration for planting windbreaks and addressing surface evaporation. All these activities have opened a productivity and small enterprise window that for many smallholders had been nonexistent. Participating farmers have also joined PGS groups and commenced marketing their produce directly.

The initiatives fit into the very holist perspective that is required to link smallholders to what is recognized as an increasing demand for SEAP. Currently there is limited support for smallholders to be involved in mainstream supply to markets, and while the LOAs have increased production potential, there is a clear need to link to markets.

The paper provides 15 policy recommendations, in three categories.

**A. Sustainable production at the farm level—GWM and NUE**

(1) Accelerate opportunities for farmers to implement GWM ponds on their farms.
(2) Promote parallel research and development (R&D) for up-scaling the GWM with appropriate academic partners.
(3) Strengthen and improve extension services and know-how regarding GWM, and enhance capacity building.
(4) Maintain support for the ongoing trialing of NUE, and communicate findings through the Agricultural Information Network Services (AINS).
(5) Consider promoting clustered organic fertilizer production to provide greater availability and access to a quality soil input medium that is important in the SEAP equation.

**B. Market synergies—the product guarantee system**

(1) Develop LOAs for working in collaboration the Pro-GAP “clean and green” outlets in Phnom Penh.
(2) Give high priority to fostering opportunities for urban households to benefit from contracts with farmer groups, knowing where their produce comes from.

(3) Start small, have small targets, and establish links between farmers and consumers whereby the demand for SEAP is successfully satisfied through an acknowledgement of the needs of all parties on AINS.
(4) Acknowledge in a tangible way the achievements of farmers and farmer groups engaged in best “clean and green” practice in member countries.
(5) Provincial and district agriculture departments, along with all the players involved, could consider a roundtable to find ways to secure a range of markets for farmers to sell their PGS produce.

**C. Institutional support**

(1) Initiate one major GWM program in each member country to roll out simple initiatives that can make a huge difference in food security and livelihoods.
(2) Dedicate an LOA to examine and develop relevant metrics and data, and use AINS to communicate this data.
(3) Support farmer groups that are producing clean and green food by giving them the highest priority at formal “state” functions, etc.
(4) Provide explicit support and overt acknowledgement of R&D in promoting involvement of research institutes and universities in the GMS to engage with the issues highlighted.
(5) Explore import-substitution strategies in situations such as Cambodia where smallholders are predominantly locked out of market dynamics by an imbalance in trade from neighboring countries.

The recommendations promote the need to up-scale GWM; seek ways to exploit market opportunities for smallholder involvement by strengthening the link with the consumer; and facilitate the important role of government in promoting GWM, PGSs, and AINS. Within the category of Institutional support, there are also recommends for members to consider promoting SEAP by explicit use at government functions, and applying appropriate import-substitution strategies to assist in greater productivity for smallholder involvement in SEAP.

# 1. Introduction

The Core Agriculture Support Program Phase 2 (CASP2) is committed to achieving a vision to make the Greater Mekong Subregion (GMS) internationally recognized as a hub for safe and environment friendly agriculture products (SEAP). The GMS economies comprise Cambodia, Guanxi and Yunnan provinces in the Peoples' Republic of China (PRC), the Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, and Viet Nam. In the past 2 decades, these economies were growing (and they continue to grow) rapidly (ADB 2017). Their present population of over 330 million is becoming larger, richer, and more urbanized. This growth is occurring within the context of very tangible social and physical changes occurring across the GMS; change in the characteristics of the market and the intentions of consumer demand; more integration of sectors (e.g. food–energy–water) and stakeholders (farmers, traders, food manufacturers, hoteliers, supermarkets); changes in climate conditions, which include an increase in uncharacteristic weather events; and of course the steady change in population numbers, which generates a need for a greater volume of food production.

These changes also create a great opportunity for the GMS to be a major supplier of SEAP both domestically and increasingly elsewhere. From an export perspective, the GMS is strategically located next to the PRC market, the Indian subcontinent, and the major transport corridors linking the Association of Southeast Asian Nations (ASEAN) to Central Asia and South Asia, as well as the Pacific Ocean and the Indian Ocean. The continuity of the GMS landmass, rapid development of its economic corridors, and diversity of its agroecological environment uniquely place the GMS within ASEAN to accelerate the path toward recognition of a region that proudly produces SEAP.

This paper will summarize the importance of addressing the physical environmental drivers of change in order to achieve the CASP2 vision. It will

- highlight the need for change in approaches to land and water management;
- introduce a conceptual approach that summarizes a cycle of trust and web of connections necessary to build market confidence for SEAP;
- look at the state of play and current situation of the letter of agreement (LOA) activities pursued under CASP2 and the contribution that they are making; and
- identify policy directions, including investments and institutional reforms, that are needed to respond appropriately.

The paper is divided into five sections. Section 2 provides the socioeconomic context and the drivers of environmental transformations accompanying the growth pathway. Section 3 posits the physical environmental dimensions of the situation, and the holistic approach required when looking at the development of safe and environment friendly agro-based value chains in the subregion. This is consistent with the ensuing 5-year GMS Strategy and the Siem Reap Action Plan that is proposed to be endorsed by the GMS Agriculture Ministers on 6–8 September at the second Agriculture Ministers' Meeting. Section 4 focuses on climate smart agriculture measures that are being test cased in the GMS through the LOA arrangement between the Asian Development Bank (ADB) and the GMS agriculture ministries. Two specific areas of "on-the-ground" activity are highlighted—examples of innovations that benefit production and resource management, namely the Green Water Management (GWM) and the Nitrogen Use Efficiency (NUE) initiatives. At the same time, the holistic context into which the GWM and NUE fit will be emphasized and the early findings from the LOAs discussed. The fifth section suggests the way forward with policy recommendations and additional potential actions, and the last section concludes.

## 2. Setting up the Context

### 2.1. Historic agricultural advantages for the GMS

For about a century, the GMS possessed a natural advantage in agriculture and rice production, compared to its neighboring island economies of Malaysia, Indonesia, and the Philippines (Dawe 2013). The GMS economies share common natural endowments suitable for agriculture production; a contiguous arable landmass with porous borders, and good river systems such as the Mekong and the Ayeyarawady rivers that also serve for transport between and among the GMS economies. Through ore business friendly policies in terms of foreign direct investments, trade, and connectivity of agro-based supply chains, these natural advantages have been transformed to have a comparative edge in agriculture production, spearheaded by more advanced economies such as the PRC, Thailand, and Viet Nam. The less-advanced agriculture based economies (Cambodia, the Lao PDR, and Myanmar) are catching up so that, overall, the GMS economies have become net suppliers and exporters, particularly of rice and many agriculture products.

Growth in the agriculture sector has contributed to steadfast and strong expansion of the GMS economies in the last 2 decades, resulting in a decline in the share of the gross value add of agriculture and a rise of the services and industrial sectors. Economic growth has been at an annual rate of 7.5% per capita since 1992, and is characterized by rising intra-trade in the GMS. Poverty has declined significantly in Cambodia and the Lao PDR largely because of the dynamic expansion of agriculture and rice production; for Cambodia, 63% of its poverty reduction was linked to the robust growth of its rice subsector and the liberal trade that boosted its rice export potential, while for the Lao PDR, about 44% of its poverty reduction was due to the growth of the agriculture sector (World Bank and IFC

2016). Incomes have risen, resulting in the emergence of the more affluent middle and urban residents, with urbanization growth rate averaging at 3% yearly.

## 2.2. Cost of an agroindustrial–compromised environment

Agriculture growth in the GMS has been attributed to the efforts of the “Green Revolution” wherein dramatic increases in food production were accelerated through a more intensive model of agricultural inputs; introduction of new varieties from research and development (R&D), availability of synthetic fertilizers and pesticides, increased availability of formalized irrigation schemes, and greater focus on agricultural extension services. While the supply has not entirely matched the demand, with surplus in some areas and seasonal to chronic food insecurity in some undeveloped regions, the achievements of the Green Revolution are outstanding, resulting in higher staple productivity and more stable food prices (FAO 2004).

While the green revolution pathway has successfully achieved an astonishing turnaround in food production and productivity globally and in the GMS, it has come at a high price. The major challenges concern equating sustainable resource use with greater productivity. The negative result of high-input agriculture has seen impacts on the biology of waterways, degradation of arable land, serious degradation of groundwater quality, and threats to human health.

Rice production is also the second largest emitter of greenhouse gases (GHGs) from agriculture, contributing about 10% of GHG emissions, with more than 90% coming from Asian agriculture. Mitigation and adaptation measures are urgently required to abate the adverse environmental effects of climate change.

The predominant smallholder farming methods in the GMS present a case in point of the unsustainable pathway of production. Existing smallholder farming systems are commonly based upon a very rudimentary approach to intensive cultivation, routinely growing a limited range of species, having incomplete or limited knowledge of soil nutrient cycles and plant requirements, requiring very labor-intensive methods when delivering supplementary irrigation, and a generally lacking knowledge about safe and appropriate pesticide and herbicide usage (often promoted by unscrupulous traders). The combined negative impacts of the predominant cultivation practice are profound, most particularly on soils through excess nitrogen dispersal, which ultimately leaches into water bodies and the atmosphere. In addition, performing supplementary irrigation on cropping areas can absorb up to 3 hours a day for smallholders, a labor requirement that increasingly falls upon women.[1]

Out-migration from rural areas to larger urban areas is increasing, particularly of younger men chasing more lucrative employment. This has also included leaving for employment in other countries. The ripple effect of this change has seen a diminishing supply of male labor in rural areas, which has cast more responsibility onto the shoulders of women, who, more than ever before, carry the burden of the agricultural cycle. As a result, the need for labor saving initiatives that are also gender sensitive is critical.

### 2.3. Weak links for small farmers

Small-scale farmers especially in the less-developed GMS economies (Cambodia, the Lao PDR, and Myanmar) are weakly linked to the end markets, resulting in their receiving lower shares of the agro-based value addition. The lack of cooperatives, which could combine small production quantities into larger volumes, also prevents the farmers from reaping the benefits of successfully intersecting with the market and operating sustainably.

Sustainability of SEAP supply equally hinges on the profitability of small-scale farmers and small- and medium-size enterprises that handle the postfarm activities. More efficient and effective value chain links that enable farmers to respond to the changing consumer preferences will be instrumental. Effective partnerships of the public and private sectors as well as bilateral agreements with the advanced GMS economies may be strategic for building these value chain links, especially in R&D for sustainable production, branding and marketing, and food safety.

The synergy of food safety and sustainable management of natural resources for agriculture is becoming increasingly pronounced. The Southeast Asia Region is second to the African Region in death rates, including among children under the age of 5 years, from unsafe food produced by a combination of overuse of fertilizers, pesticides, and herbicides, and poor water quality (Akter 2015).

### 2.4. The Value of a shift to SEAP

Shifting to high-value, safe, good quality, and environment-friendly agriculture products may be a good strategic move for the GMS economies, especially for the less-developed economies. The envisaged 5-year GMS Strategy and Siem Reap Action Plan's focus on value chain development, food safety

[1] Personal communication with a former USAID Harvest staff member.

and quality, and climate-friendly supply chains is in the right direction. Trade and value chain of the less advanced economies are increasing their ties with the more advanced PRC, Thailand, and Viet Nam and are paving the way for stronger economic connectivity. The regional and global demand from fast urbanizing and industrializing economies for safe, good quality, and sustainably produced agriculture food products is rising phenomenally, offering opportunities for locally produced and "no-frill" agri-based products.

# 3. A Holistic Approach to Sustainable SEAP

## 3.1. Sustainable Agriculture, Climate Smart Agriculture, and Food Safety

There is a large body of literature regarding sustainable agriculture and how to achieve and maintain it. From the physical perspective, answers to the core questions revolve around themes of resource stewardship and a balance of inputs to outputs. However, the overwhelming common element in successful practice of sustainable agriculture is farmers working in groups, sharing knowledge, adopting new practices, and maximizing postharvest benefits (Pretty 2007; Leach et al. 2012; Scoones, 2009).

The negative effects of high-input agriculture can place unsustainable pressure on resources, and to achieve the CASP2 vision for SEAP, there is clearly a need to explore alternative approaches to farm production, ones that (1) maximize production of limited resources; (2) combine to prioritize and facilitate inclusion and greater opportunities for poor families; and at the same time (3) improve land and water management and assist in nurturing greater climate resilience. The array of sustainable practices should aim to contribute within a holist "cross-cutting" landscape approach—one that includes environmental, economic, and social dimensions. Focus is needed on resource conservation and stewardship and the implications that can impact the whole environment. This includes the physical and the social issues associated with agriculture, geo and biodiversity, gender inclusion, and the growing niche markets generated by (for example) ecotourism.

A sustainable agriculture strategy that tackles sustainable food security within the context of climate change is termed "climate-smart agriculture" (CSA). CSA aims to tackle three main objectives: (1) sustainably increasing agricultural productivity and incomes; (2) adapting and building resilience to climate change; and (3) reducing and/or removing GHG emissions, where possible.

CSA activities include Good Agricultural Practices (GAP), which promote specific ways to produce food for consumers that is safe and wholesome. GAP addresses environmental, economic, and social sustainability for on-farm processes. The objective of GAP codes, standards, and regulations include

- ensuring the safety and quality of produce in the food chain;
- capturing new market advantages by modifying supply chain governance;
- improving natural resource use, workers' health, and working conditions; and
- creating new market opportunities for farmers and exporters in developing countries (Chan 2016; FAO 2011).[2]

GAP is supported by "Good Handling Practices," which are voluntary audits that verify the way that fruits and vegetables are produced, packed, handled, and stored as safely as possible to minimize risks of microbial food safety hazards.[3] In addition, rolling out a participatory guarantee system (PGS) provides farmers with a mechanism to voluntarily agree on a set of standards, a process that eclipses the expensive and time-intensive steps of gaining organic certification.

### 3.2. Sustainability tools

are The GWM and NUE technologies and practices are key tools for sustainable agriculture that are CSA compatible, and have been test-cased under the CASP2.

Soils contain a combination of four components: (1) mineral matter, which makes up the largest proportion; (2) water and (3) air, which are present in roughly equal volume; and (4) organic matter, the smallest but most dynamic soil component (Roychowdhury et al. 2013). The CASP2 activities placed a large importance on the relationship between (1), (2), and (4)—water (GWM) and the components that deliver nutrients through minerals and organic and inorganic matter (NUE). Water, nutrients organic matter, and minerals service a considerable amount of plant requirements. Maintaining soil health, as with any resource, requires regular monitoring and maintenance, particularly when the annual cycle of production is an exercise in extraction. Where nutrients and moisture are constantly being used, they need to be replenished, and sustainable farming practices aim to do this.

The interrelationship between GWM and NUE and their combined potential impact on sustainable agriculture can be expressed from a number of perspectives:

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2 http://www.fao.org/docrep/010/ag130e/AG130E12.htm
3 http://www.fao.org/prods/gap/

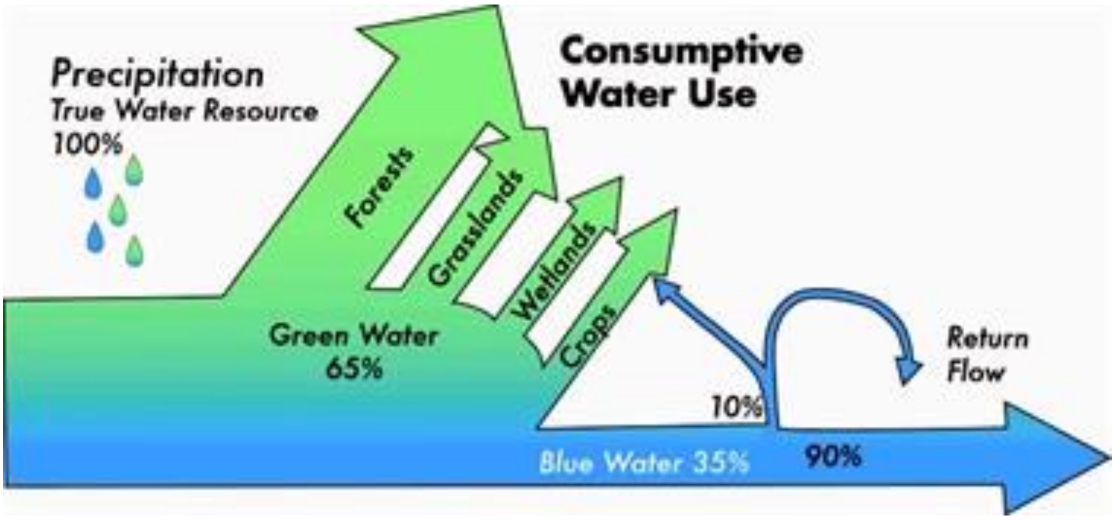
- promoting the prism of soil health and its importance for sustainable agricultural output throughout the GMS, most particularly for rainfed agriculture;
- the threat that overuse of nitrogen has as a GHG, as well as on people's health;
- the relationship of agriculture and its contribution to global concerns of climate change; and
- for maximum impact, farmers benefits from working in groups (such as the PGS).

### 3.3 Green water management

GWM encompasses practices that improve stewardship of a critical resource in all farming systems, but most particularly in rainfed ones. Globally, rainfed agriculture constitutes over 80% of the world's agricultural area and produces 62% of staple foods. It is estimated that food from rainfed areas will need to meet 75% of the global increase in food production required to avert hunger. Water scarcity faces nearly 60% of humanity, and, with demand for water fast outstripping its supply, efficient and effective water management technologies and practices are needed to ensure that present and future generations have sufficient water (Mekonnen and Hoekstra 2016).

Conceptually, green water constitutes 65% and blue water 35% of fresh water resources. Figure 1 illustrates the link of the two types of water. The green water rainfall footprint provides essential moisture, which is stored in the root zone of the soil and is evaporated, transpired, or incorporated by plants. It is particularly relevant for agricultural, horticultural, and forestry products. Green water also performs critical "environmental services" across all landscapes. The blue water footprint is water that has been sourced from surface (rivers, lakes) or groundwater resources and is taken from one body of water and returned to another.

**Figure 1: Green and Blue Water and their Links**




Source: Falkenmark and Rockström (2010).

The amount of green water available and the efficiency of its use is a product of two things: (1) the occurrence of rain events and the capacity of soil to capture and store that rain, and (2) appropriate farming practices that can optimize this precious resource. Green water plays the role of replenishing soil moisture from precipitation, and is used by plants via transpiration. To understand the importance and potential of GWM, compare it conceptually against blue water management, which overwhelmingly receives the greatest share of attention. Table 1 summarizes the major differences between the two at a resource planning and design level.

**Table 1: Conceptual Differences between Blue and Green Water Management**

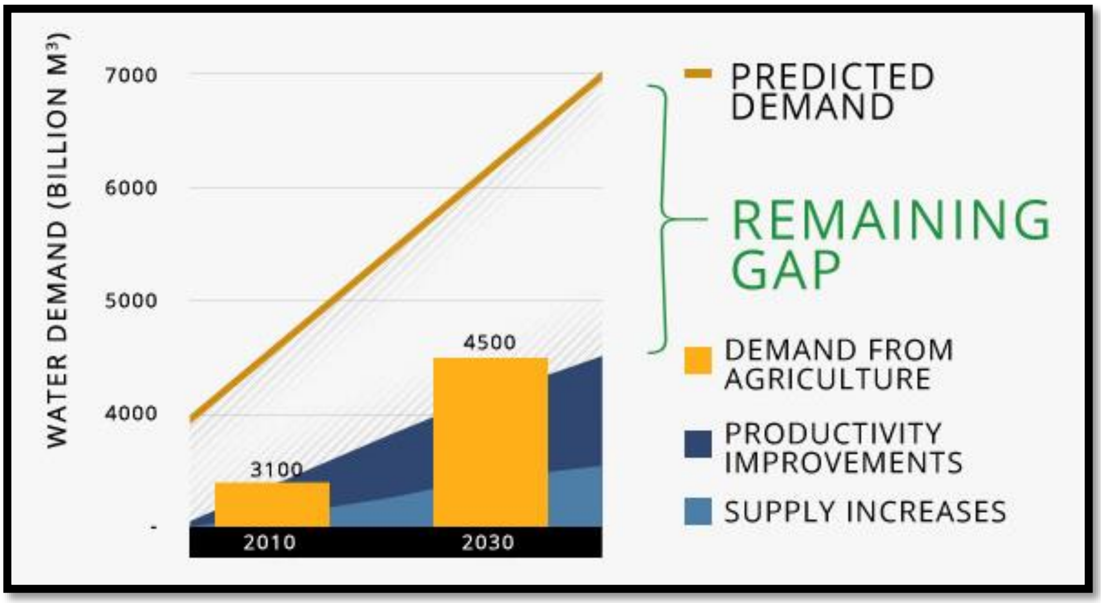
| | Conventional Blue Water Management | Green Water Management |
|---|---|---|
| **Resource Planning & Design** | Macro-scale plans and optimization at a broad river basin level. | Micro-scale focus at the local farm level, from river basin and catchment to the farm unit. |
| | Large-scale integrated water resource management. | Small-scale optimization of land and water resource management |
| | Macro resources: water in rivers and aquifers and crop efficiency maximized with permanent water. | Micro resources: opportunistic harvesting of rainfall, micro reticulation, and agronomic enhancements. |
| | Planning focus on water allocations for irrigation, industry, and domestic water supply. | Basic extension of management options from rainfed to supplementary irrigated agriculture. Emphasis on small rice/vegetable production enterprise. |
| | Institutionally managed supply to multiple farmers. | Single farm driven utilization of harvested water for multiple uses. |
| | Design requires high-level engineering for impounding and control of water flows | Design and implementation are farm-based; a convenient harvest pond and distribution system. |
| | Constant supply, on demand as per agency. | Initiating greater seasonal opportunity through supplementary irrigation. |
| | Labor required to access supply. Supply extends period and amount of water availability. | Major labor saving compared with previous methods; however, no water, no crop in dry season |
| | Estimated share of farm production using brown water management across region is 25% | Estimated share of farm production using green water management across region is 75% |

Source: Authors.

The gap between the amount of water available and the demands for its use have been growing, and as population continues to rise the demands on water will increase. Globally, water scarcity currently affects over 2.7 billion people for at least 1 month each year, and projections using current trends without changes indicate that the gap between supply and demand will be a global challenge (Hoekstra and Makonnen 2011). Figure 2 illustrates the aggregated growth and water deficits that can be expected up to year 2030 compared to 2010. This deficit can only be made up by more astute use of existing resources. GWM aims to do that.

The water footprint over production and harvest areas is a credible indicator on which to assess water use efficiency, and GWM aims to make more efficient use of that rainfall. Due to the large rainfed character of the farming system in the GMS, the subregion can be observed to have a very efficient footprint where the soil productivity is generated by green water. The techniques promoted as part of the GWM offer a broad spectrum of measures that can be applied to address this anticipated deficit.

**Figure 2: Projected Water Deficits Based on Current Demands**



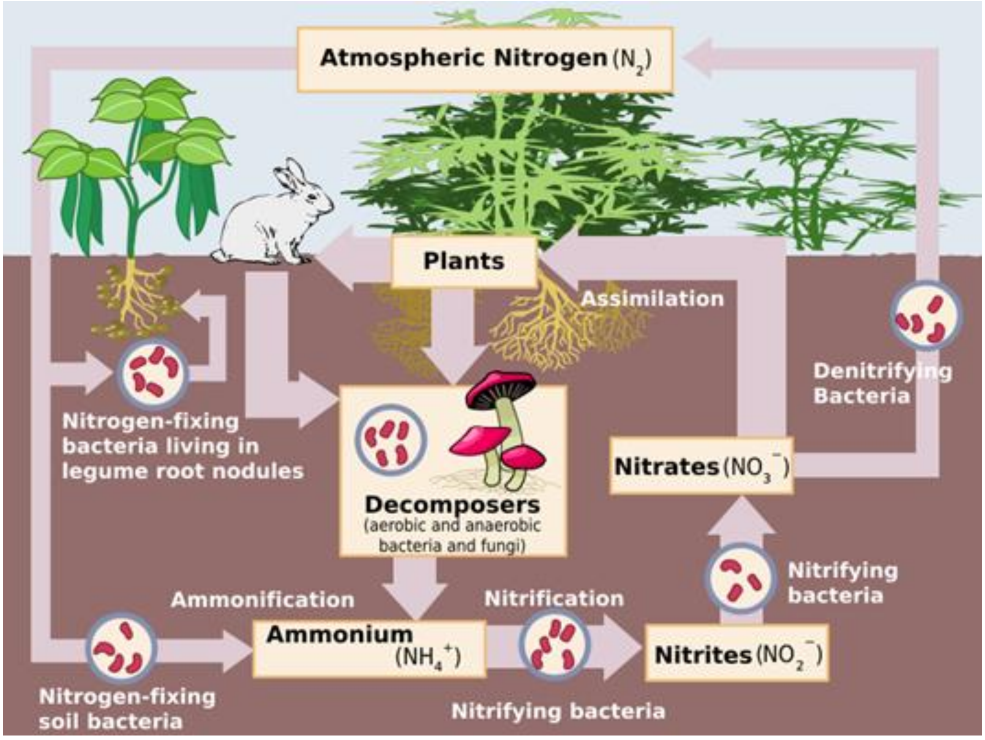

Source: Farming First: Sustainable Development Goals Toolkit. https://farmingfirst.org/sdg-toolkit#section_2

## 3.4. Nitrogen use efficiency

NUE provides an additional platform of actions that can contribute to improving the production of SEAP. Acceleration of artificial nitrogen fertilizer use in the GMS has greatly increased food production. Increased use of inorganic nitrogen fertilizers can take credit for reductions in starvation and famine in many parts of the world, especially in Asia in the last decade; indeed nitrogen fertilizers have bridged the gap between malnutrition and adequate diet (Roy et al. 2006). Nitrogen is a component of chlorophyll, the compound plants use to convert sunlight energy to produce sugars from water and carbon dioxide, and thus complete the important process of photosynthesis. The nitrogen compounds cycle through the air, the aquatic systems, and soil, and globally the nitrogen cycles have been altered more than any other basic element cycle. Efficient use of nitrogen is generally site-specific and can vary by soil type, cropping regime, climatic conditions, incidental weather events, and localized ecology. The natural nitrogen cycle and its compounds are interconverted in the environment and in living organisms. Knowing the baseline soil status along with the specific crop need is important. Plant requirements and benefits derived from inputs of nitrogen follow a bell curve, and overuse can have detrimental effect on soils, water bodies, and human health.

The nitrogen cycle is one of the most important nutrient cycles found in terrestrial ecosystems. Figure 3 illustrates the complexity of the nitrogen cycle, and the important function it performs. Living organisms use nitrogen to produce a number of complex organic molecules such as amino acids, proteins, and nucleic acids.

**Figure 3: The Complexity of the Nitrogen Cycle**




Source: http://www.barnstablecountyhealth.org/health-topics/wastewater/the-nitrogen-cycle

When any element is altered at rates above ecological or agronomic needs, the result can become an environmental concern, leading to a host of problems, ranging in this case from eutrophication of terrestrial and aquatic systems to soil acidification (Vitousek et al. 1997). Excessive nitrogen use will manifest quickly in the basic aquatic food chain or ecosystem. In addition, high nitrate concentrations accumulate in the edible parts of leafy vegetables, particularly if excessive nitrogen fertilizer has been applied (*Science Daily* 2008). Consuming such crops can harm human health (Liu et al. 2014). Such impacts are the result of nitrogen being used at the wrong time, at the wrong rate, and put in the wrong place or in the wrong form.

NUE aims to be a workable indicator to assess and monitor sound fertilizer use, and can be described as the fraction of fertilizer nutrient removed from the field through the crop harvest. The goal is to optimize nitrogen's beneficial role in sustainable food production and minimize nitrogen's negative effects on the environment. Successfully addressing NUE contributes to SEAP and a value addition manifesting as improved farmer income.

The provision and delivery of SEAP to end markets can be vastly enhanced by combination of (1) GWM and NUE approaches, (2) enhanced by PGS as means of consolidating farmers producing environment-friendly agriculture products, (3) coupled with the tools that ensure food safety from production (GAP, PGS, Good Handling Practices) to midstream value chain segments of agro-based value chains (Good Handling Practices, GMP).

### 3.5. Toward a holistic landscape

**Growth in demand for "clean and green."** Continued economic growth across the GMS and the emerging greater numbers in the middle classes have led to change in market demand for food, particularly for fruit and vegetables with "clean and green" characteristics. This includes items that maybe "organic" by certification; free from overuse or contamination by herbicides or pesticides; and in a highly subjective way, considered in the market place to be more flavorful. The growth in market demand for "clean and green" across the GMS is currently anticipated at 12.5% yearly, and as household incomes increase, the drivers of the growth will only increase in profile and number.[4]

This demand is being driven by families in their homes, in restaurants, and in hotel kitchens across the subregion. The demand assumes that farmers will be committed to responsible production of food, where the physical resources and the output are treated with business acumen combined with the aforementioned stewardship.

Food production therefore has to increase to both meet the demand of a growing population as well as the change in the market expectations. In light of the high energy costs and finite resources, future agricultural systems have to be more productive, and adoption of practices such as GWM and NUE will contribute to this. The question that can therefore be posed is: How can we improve resource management while maintaining productivity within what is seen as a highly dynamic set of variables.

### 3.6. A holistic landscape—value chain as a cycle of trust

To increase the availability of SEAP there is a clear need to address both the supply and demand sides of the entire agrifood equation, as well as to promote efforts that place practical importance on

[4] http://www.fareasternagriculture.com/crops/fertilizers-pesticides/precision-farming-market-to-reach-us-6-43bn-by-2022

achieving environmental sustainability goals. It is clear that clean and safe produce will come from environments that are agriculturally and environmentally sustainable. To achieve both, a holist approach is necessary: at one end of the spectrum, soil health is an indicator; at the other end, it is sustainable markets. The CASP2 approach has targeted understanding and improving both the supply and demand of SEAP, while contributing to improved farmer livelihoods. The conceptual approach being put forward is one of an interactive web of relationships, where the value chain is underwritten with the important link of trust and confidence among all the players in a cycle. It assumes a sharing of knowledge as well as an appreciation of the contribution of other players in the cycle.

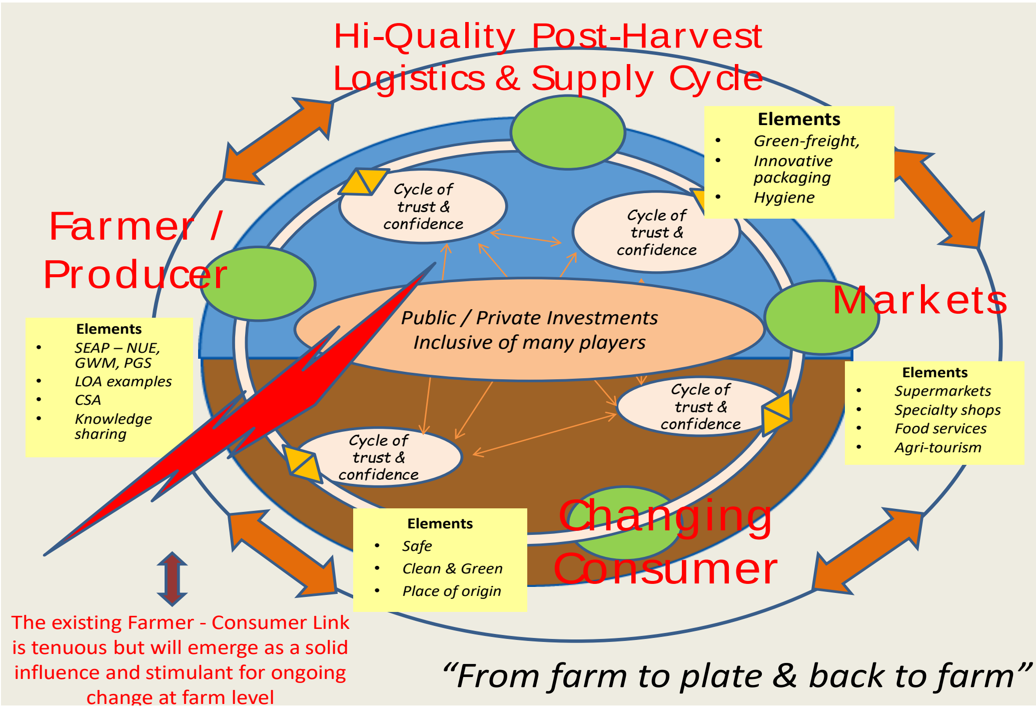
### Linking all the Variables in the Cycle

Figure 4 aims to illustrate both the simplicity and the complexity of the food cycle from farm to consumer plate, and assumes sustainable land-use practices by farmers whereby they produce SEAP and deliver it to consumers who appreciate the importance of "clean and green" food. This further assumes an understanding at the farm level that changing consumer demands present farmers with an opportunity to be rewarded for embracing change, as well as a scenario of "continuous improvement." Figure 4 is not so much a value chain, but a values cycle— where all the key four nodal points have an influence and a relationship with each other: (1) food production, (2) postharvest logistics, (3) market demand, and (4) consumer confidence.
Figure 4 emphasizes the importance of linking all the variables, and presents this as a process, a cycle where each step, to be successful, requires a firm degree of trust and confidence in the players in the cycle, and where, increasingly, the link between consumers and farmers, although not as well established as the other links, could have a large impact on the production and supply of SEAP, most particularly where farmers achieve a growing demand and greater return for their efforts. The red lightning bolt aims to illustrate a current gap in the link between consumers and farmers, a gap that when bridged has increasingly been acknowledged in European and North American markets as a driver of change at the farm level. To successfully facilitate and strengthen this highly dynamic and interrelated cycle requires that all the players involved have a role, including of course the public and private sectors.

The market, which wants to respond appropriately to the growing change in consumer demand, must have trust and confidence in the on-farm efforts to produce high-quality, safe food for consumption. The market will recognize this effort with a greater demand for a product, and potentially pay a higher unit price.

The conceptual roles of each player in the cycle are logical. What has increasingly become apparent is that effective linkages and partnerships between private and public players can very quickly foster and facilitate opportunities for greater SEAP. An additional significant factor—and one considered to be growing with huge potential—is associated with tourism and the role it plays in the food values cycle. Apart from the simple increase in tourist arrivals that need food, the cycle recognizes that many travellers want to engage in cultural experiences such as, for example, the growing number of visitors interested in an authentic culinary experience, or wanting to “give back” to local communities, a phenomena increasingly referred to as agrotourism where people visit or stay in a rural/farming community and become familiar with the production cycle.

**Figure 4: From Farm to Plate and Back to Farm**



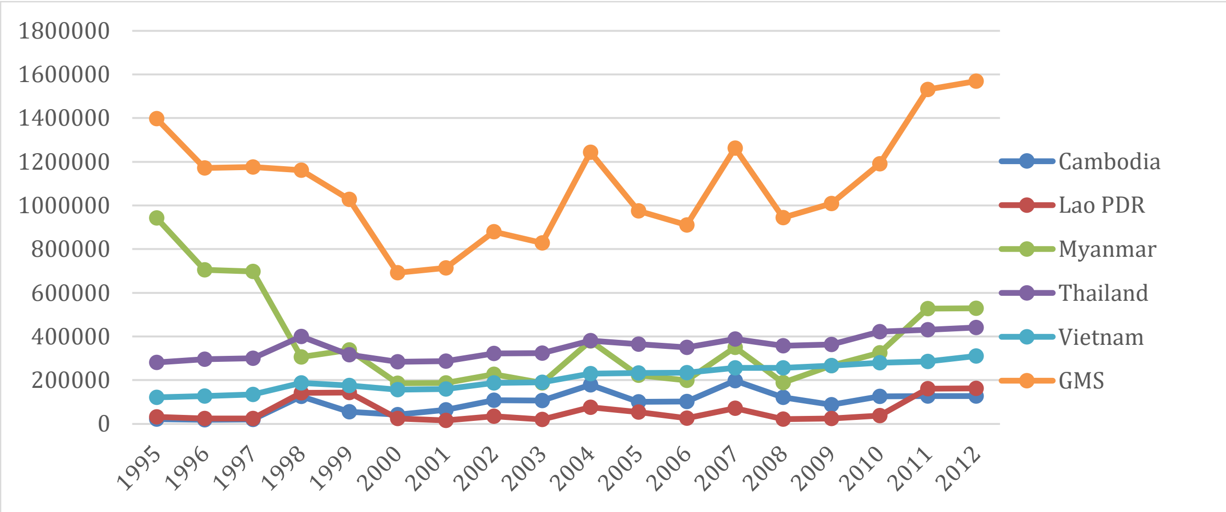

Source: Authors

## Green Water Management and Nitrogen Use Efficiency experiences

### 4.1. State of play

Agriculture in the GMS is the cornerstone of many families’ livelihoods; however, agricultural intensification, large-scale monoculture cropping, and the inappropriate use of agrochemicals have incurred a high environmental cost, especially land degradation, without significantly reducing rural poverty (ADB 2015). Agricultural production is also a climate change contributor (Figure 5), and in turn is directly affected by it through higher temperatures, seasonal shifts in rainfall, and rising sea levels, among other things. Given the growing population of the GMS and the associated increased demand for land and water for urban and industrial development, the subregion faces a high risk of increased food insecurity, and the loss of potentially being seen as a food safety hub. Future agricultural systems will need to be flexible and diverse to withstand and respond to climate change; water shortage; low soil fertility; and other environmental, social, and economic drivers.

**Figure 5: Total Greenhouse Gas Emissions from Biomass Burning (kilotons of $CO_2$-e)**



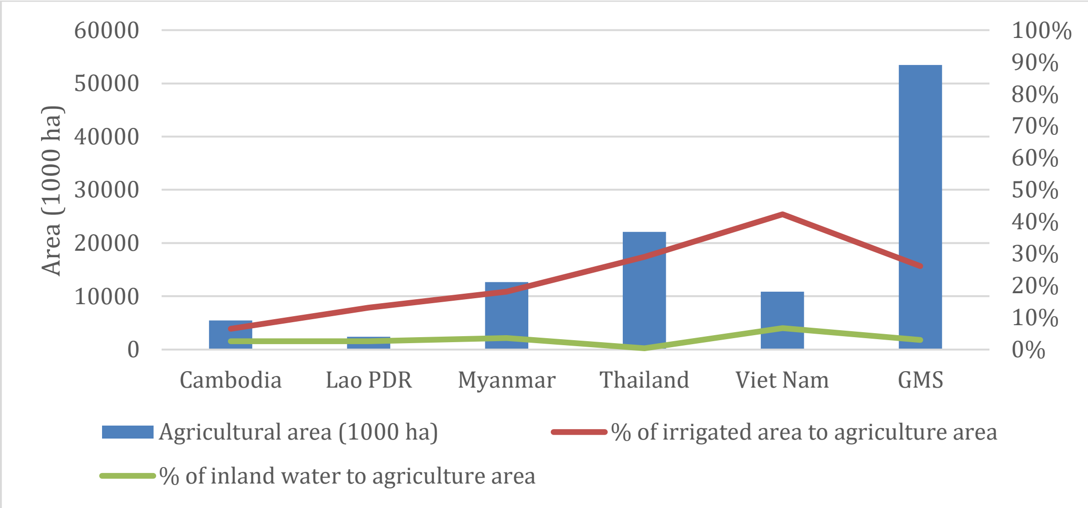

$CO_2$-e = carbon dioxide equivalent.

Source: ADB GMS Statistics 2016.

### 4.2. Water and Agriculture

Using water efficiently is the key to future food security and food safety. Agriculture is by far the largest consumer of water in all GMS countries, estimated to account for 68% of total withdrawals in the PRC and Viet Nam and 98% in Cambodia (IWMI and Worldfish Center 2010). Despite this, the proportion of irrigated land used for agriculture in GMS countries is relatively low by world standards (Figure 6), ranging from 7% of total cropland in Cambodia to 31% in Viet Nam (World Bank 2009), and approximately of 75% production is rainfed. Agriculture in the GMS is thus particularly vulnerable to climate change, with significant risk from floods and droughts even under current climate conditions. Safeguarding production will require improved water management in both rainfed and irrigated systems (IWMI 2010).

**Figure 6: Agriculture and Water for Agriculture**




Source: GMS ADB Statistics 2016.

In many areas, introducing formalized irrigation is not technically or economically feasible, so improving on-farm water management is essential. Using conservation farming or climate-friendly techniques, plus harvesting and storing run-off on farms can achieve this (IWMI 2010). As outlined in the previous section, the practice of harvesting rainwater, using the stored water for crop irrigation with water saving techniques, and subsequent improvement of soil properties to increase water absorption, retention, and nutrient availability are among activities that cumulatively contribute to what is called GWM.

## 4.3. Soil fertility management

Nearly 65% of the soils in the GMS have physical and/or chemical limitations on their agronomic use for crop production. The important soil constraints include shallowness, poor structure and high incidence stones and rock, low fertility, acidic pH, and low availability of phosphorus. About 25% of the GMS soils comprise the region's key agricultural soils. The inherent fertility of these soils varies from low to moderate in most cases.[5]

People and governments in the GMS are working to develop agricultural practices that simultaneously conserve land and water resources, mitigate environmental impacts, increase resilience to climate change impacts, and simultaneously increase the productivity and profitability of agriculture, particularly for small-scale farmers. There is an urgent need to manage soil fertility if food production is to meet the increasing demand for safe and environment-friendly product. Annual cropping regimes such as rice deplete soils of nutrients, and thus there is a need to replace them as a part of the growing cycle. Nitrogen is an essential element and improving the efficiency of its use to increase economic return and help mitigate climate change has a critical role to play in production of SEAP.

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[5] ICEM, 2015 http://icem.com.au/biochar

## 4.4. CASP2 and the testing of sustainable-cum-CSA innovations

Beginning in 2015, CASP2 introduced the first round of LOAs for delivering CASP2's Output 3, the adoption of gender-responsive SEAP. This first round was implemented by the GMS governments between mid-2015 and the end of 2016. The following has been achieved

(1) (162 demonstration and pilot sites were set up, comprising good agronomic practices on climate friendly agriculture and PGS;
(2) (more than 80 training activities were held at regional, national, and local levels, coupled with field visits for farmer-to-farmer learning, with over 6,000 farmer participants (35% of them women) being trained in CSA practices;
(3) (simple sheds in some of Myanmar's demonstration farms served as multipurpose meeting place for capacity building activities; and
(4) extension-related communication materials and visuals were produced.

A set of subprojects under the LOAs included piloting the use of the PGS as a mechanism for quality certification of organic products produced by smallholders and linking them to new market opportunities. About 16 PGS pilots were developed with technical assistance support for IFOAM, the internationally known organization on PGS.

Progress reports on the subprojects recorded some positive economic impacts, including reduced farm production costs (especially from reduced agrochemical use) increased turnaround of farm produce, and improved incomes. Environmental benefits included improved soil nutrient levels and physical conditions, improved pest resistance, and more efficient water use.

The outcomes reported come from a very short period of recording. Because of the nature of agriculture and the variables involved, a little more than a 1-year implementation period is not sufficient for claiming a rigorous method and findings, or objectively determining if the demonstrated experiences provide justification for their scale up or replication. While there are no agreed criteria for identifying whether the activities are suitable for up-scaling and replication, and the specific roles of government, private sector, and other institutions could vary by country and crop, certainly all signs indicate support for scaling up.

Good agricultural practices gleaned from the pilot trials are

- reduced use of agrochemicals (including synthetic or chemical fertilizers, pesticides, and fungicides);
- enriching soil fertility by applying compost (including bokachi compost, biochar mixed with animal manure and compost, and vermiculture compost);
- application of liquid biofertilizer (including fish amino acids, fermented fruit juice, liquid from vermiculture);
- application of liquid biopesticides to control insect pests (including biopesticides made from ginger, chili, tobacco, and neem);
- application of beneficial fungi to control fungal disease (including *Trichoderma* fungi to improve seedling resistance to disease);
- promotion of multiculture (including crop rotation, integrated farming with crop and livestock or fisheries) to replace monoculture; and
- lessening of soil erosion from rain and improvement of soil moisture retention (e.g. mulching, increasing soil organic matter through application of compost, and planting wind-breaks such as bamboo).

## 4.5. Green Water Management and Nitrogen Use Efficiency

Following the assessment of the first trials, which identified lessons and developed recommendations, the way forward was identified. LOAs for Cambodia, the Lao PDR, Myanmar, and Viet Nam have been amended to initiate GWM practices, and additional funds were earmarked for the three countries to undertake NUE activities.

Associated with these two initiatives has been the promotion of biochar use for soil enhancement and carbon sequestration and promotion of organic farming. An important step has been the successful formation of PGS groups, which have strengthening farmer group engagement. There are numerous overlaps and reinforcing commonalities between these initiatives, which can all combine to achieve the SEAP vision. Tables 2 and 3summarize the specific GWM and NUE activities.

As identified in Table 2, GWM activities have included constructing on-farm rainwater harvesting structures, introduction of water saving irrigation facilities, and innovations to minimize water loss through evaporation by using windbreaks (Mayaud et al. 2017). Plants that improve water surface cover and soil surface transpiration (mulching) were also promoted. In addition, GWM includes climate-friendly practices learned from the earlier work, such as applying biochar and biopesticides, using PGSs, and facilitating market linkages.

**Table 2: Green Water Management Practices**

| GWM Practices | Cambodia | Lao PDR | Myanmar | Viet Nam |
|---|---|---|---|---|
| Farm pond to harvest rainwater | X | X | X | X |
| Drip irrigation | ✓ | Some | Some | Some |
| Windbreak plants/trees | ✓ | ✓ | ✓ | ✓ |
| Surface water cover to minimize evaporation loss | Some water surfaces planted with water lily and morning glory. | Not yet initiated | Under experiment | Not yet initiated |
| Fish raising in farm pond | ✓ | ✓ | ✓ | ✓ |
| Diversified farming with crops, livestock | ✓ | ✓ | ✓ | ✓ |
| Biochar application | ✓ | ✓ | ✓ | ✓ |
| Compost application | ✓ | ✓ | ✓ | ✓ |
| Bio-pesticides application | ✓ | ✓ | ✓ | ✓ |
| Mulching | ✓ | ✓ | ✓ | ✓ |
| Participatory guarantee systems | ✓ | No | X | No |
| Market linkage facilitation | ✓ | ✓ | ✓ | ✓ |
| Conduct policy study and recommend policy directions | ✓ | ✓ | ✓ | ✓ |

GWM = green water management, Lao PDR = Lao People's Democratic Republic.
Source: LOA Project Proposals for GWM.

Some innovations that are still being trialed, such as techniques to minimize evaporation loss (which has been conducted in Myanmar) growing water plants in ponds (in Cambodia) will be useful for other countries, such as the Lao PDR and Viet Nam. The policy study on GWM will also enhance policy development to support the up-scaling of practices on a wider scale.

**Table 3: Nitrogen Use Efficiency Practices**

| NUE practices | Cambodia | Lao PDR | Myanmar |
|---|---|---|---|
| Crop: Rice | ✓ | ✓ | ✓ |
| Another crop: Vegetable | ✓ | ✓ | No |
| Another crop: Corn | No | No | X |
| Split application of N fertilizer as the crop needs (instead of single or one time application) | ✓ | ✓ | ✓ |
| Reduced N fertilizer but added biochar | ✓ | ✓ | ✓ |
| Reduced N fertilizer but added biochar and manure | ✓ | ✓ | ✓ |
| Application of neem cake to minimize N2O emissions | No | No | ✓ |
| Plan to measure CH4 and N2O emissions from different NUE practices | No | No | ✓ |
| Conduct policy study and recommend policy directions | ✓ | ✓ | ✓ |
| Market linkage facilitation | ✓ | ✓ | ✓ |

$CH_4$ = methane, Lao PDR = Lao People's Democratic Republic, N = nitrogen, $N_2O$ = nitrous oxide, NUE = nitrogen use efficiency.

Source: CASP2 LOA Project Proposals for NUE

The NUE subprojects (Table 3) aim to identify innovations that can help reduce application of chemical fertilizer without affecting cash crop yields, while mitigating GHG emissions. Myanmar has proposed more detailed studies on GHG measurement and the effectiveness of applying neem cake to retard GHG emission. Neem cake is naturally made from the neem tree *(Azadirachta indica);* and was developed by Myanmar's Department of Agriculture, Ministry of Agriculture, Livestock and Irrigation (MOALI).

To enhance up-scaling of good practices in NUE, a policy study with recommendations is being carried out in all participating countries.

In addition, and based on the experience from the first trials, there have been regional initiatives to promote regional knowledge and resource sharing across the GMS, facilitated by the Working Group on Agriculture Secretariat.

(1) A regional NUE training workshop was held in in Guangxi, PRC, for 25 participants—5 each from Cambodia, the Lao PDR, Myanmar, Thailand, and Viet Nam;

(2) A regional GWM training workshop was held in Kunming, PRC, for 15 participants—3 each from Cambodia, the Lao PDR, Myanmar, Thailand, and Viet Nam;
(3) Regional training on biofertilizer and soil management was provided in Bangkok for senior government officials in the six GMS countries, for approximately 20 participants.
(4) A regional training-of-trainer course on biofertilizer making and application was held in Bangkok for 60 participants from the six GMS countries.

Additional bilateral initiatives by individual country members include the Thai Department of Land Development providing

(1) exchange of knowledge and experience for soil doctors in the Lao PDR, and
(2) technical assistance in the development of a soil museum for Myanmar participants.

### 4.6. Additional findings

CASP2, despite the limited samples, has demonstrated appropriate pathways to support more sustainable farm production practices, especially for high-value crops like fruits and vegetables. While some countries have been observed to adopt the practices quickly and others more slowly. Not all member countries have been embarking on the same activities. There has for example, been shared learning and support from the more agriculturally advanced economies such as the PRC and Thailand to the other economies. This effective cross-border knowledge facilitation for expanding SEAP practices is critical and ongoing. A brief summary of activities follows.

**The PRC Workshop** in Nanning gave 26 representatives an intensive discourse on efficient fertilizer use; the cycle of major and minor elements; improved utilization rate of chemical fertilizer and pesticide through R&D; application of biological fertilizers and pesticides; the importance of fertigation, composting, and management of soil and water conservation; and the importance of the "4Rs practices" of nitrogen management—*right product, right rate, right time, and right place*—and techniques to measure GHG in the field, and integrated management of nitrogen and ways to measure it in rice growing regimes. The messages of this NUE seminar included the need to promote

- climate-friendly agriculture through a market-based strategy to ensure food security, while rewarding farmers for their ecosystem services;
- a harmonized certification system for food produced across the GMS; and
- agriculture as a leader in providing clean renewable rural energy through efficient use of biomass for bioenergy, while ensuring food security.

**In Viet Nam,** the Institute for Agricultural Environment (IAE) applied different mitigation techniques in pilot farm trials including (1) recycling crop residues to reduce fertilizer use and (2) identifying appropriate farming techniques to sustain yields and rice incomes while improving soil fertility, and reducing GHG emissions. IAE also trained rice farmers to shift from conventional agrochemical-dependent rice production and adopt biofertilizer (including biochar) from recycled crop residues. The key findings generated from the research-cum-extension work were that

- rice farmers currently use large to excessive amounts of fertilizers, mainly urea, and a compound fertilizer of nitrogen, potassium, and phosphorus (NPK);
- a majority of farmers were aware of biochar and composting but few used them;
- farmers were aware of climate change—the increased frequency of flooding, drought, and salt intrusion in farmland;
- farmers were not knowledgeable regarding the contribution that an appropriate mix of synthetic and bio-fertilizers could offer their farming practices;
- application of biochar and compost increased plant yield by 2.7%–14.5% over the conventional approach of intensive agrochemical use in rice cultivation; and compost mixed with 75% NPK yielded the highest productivity rise, followed by biochar mixed with compost and NPK;
- among the four treatments examined, combined composting and biochar increased yield significantly over the conventional rice production method using only NPK; and
- GHG emissions declined significantly when biochar was mixed with 75% NPK, followed by the composting and biochar method.

**Thailand** has supported “Volunteer Soil Doctors” in the Lao PDR by training the volunteers with a specific focus on improving vegetable and rice production. Laotian farmers were trained with hands-on practical sessions and returned to their communities to assist fellow farmers to adopt the practices they had learned. Establishing and maintaining soil health requires baseline data and knowledge of what farmers should be aiming for through the assistance such as the volunteer “soil doctor” program should be a high priority if member countries are serious about sustainable agriculture goals.

**The Lao PDR and Myanmar** have both been active participants in program. Myanmar has adopted some solar energy for pumping, an initiative that has applications elsewhere.

**The Agricultural Information Network Services (AINS)** is a knowledge platform supported by CASP2. Information on AINS can be freely accessed by all participants in the values cycle. AINS can provide farmers with a source of agronomic and market information, and link farmers directly to consumers. AINS can help disseminate the benefits from the trials and information about the steps taken and the practices adopted. The service has to be relevant and accessible to farmers, and the next iteration of AINS aims at that.

**Institutional issues and legislation:** Public agencies in the GMS are committed to expanding good agronomic practices and the value chains of safe and environment friendly agro-based products. Some countries (the PRC and the Lao PDR) have national policies to encourage promotion of biofertilizer and regular organic markets in urban areas. In other countries, legislation for organic and reduced agrochemical farm production is being prepared, including disseminating the potential of promoting PGS nationwide. If the GMS wishes to emerge as a producer of SEAP, GMS governments need to develop appropriate policy, legislation, and ways to facilitate change using public–private partnerships. Having safe places of production applying sustainable agricultural models is one starting point.

### 4.7. Cambodia as a case study

To communicate the range of issues found and the early findings and achievements of the trials, activities observed in Cambodia are presented as a case study. The Cambodia National Secretariat Specialist office responded promptly to the letter of agreement requests, and thus implementation has progressed well in the country. As Tables 2 and 3 indicate, Cambodia has been pilot testing almost the entire range of activities. The successful expediting of implementation is attributed to clear presence of strong and enthusiastic ownership by government agencies at national, provincial, and district levels; careful selection of farmers with whom to collaborate; and the attentive and vigorous approach taken by the Cambodian National Secretariat Specialist office.

Although the timelines have been short, the LOA pilot subproject innovations introduced have resulted in positive outcomes, with increased yield and lower economic costs for farmer inputs. In addition, activities that are still at early stages demonstrate all the initial signs of success as well. The activities have targeted predominantly poor smallholders, who have benefited from positive economic and social outcomes through the introduction of a variety of climate-friendly and gender-sensitive agronomic practices, and to that end the trials have been successful.

The observations and findings that follow will describe and present the (1) GWM and NUE outcomes, (2) discuss the postharvest issues associated with “clean and green” qualities that SEAP is aiming for, and (3) outline some marketing issues identified by traders interested in SEAP and the role that PGS has been seen to play in address the issues.

### 4.8. Green water management

As previously noted, the GWM activities combine improved water harvesting, water storage in on-farm ponds, and strategic use of pumps, drip-reticulation, and windbreaks, all of which combine to open a productivity and small enterprise window. For many smallholders, such a window was previously nonexistent, and at the same time, if used well, it could improve the vigor and health of soils.

Improved GWM has been shown to provide smallholder farmers with the ability to store and reticulate water for supplementary irrigation using simple and highly effective drip technology. For a small investment of about $500, farmers in Cambodia have been establishing farm ponds, dug by excavator and compacted and/or plastic lined. If deep enough (~5.0 meters) and well lined, the ponds can hold sufficient water for supplementary irrigation, providing an opportunity for additional dry season cropping. Farmers have achieved a dramatic increase in household incomes over an area as small as a 10x10 meter plot. The investment in microirrigation equipment is commonly paid back in the first year of its use (USAID Harvest, Personal Communication).

Farmers have been enthusiastic about adopting the technology supported by the project, and others have moved forward on their own initiatives. One farmer in Tboung Khmum explained that although he had not received funds from the project, he organized a deal with the company building a district road to dig his pond and take the spoil for the road. Another in Battambang, who is currently an enthusiastic contributor to the GWM initiatives, described how he took nearly 2.5 years to dig his pond by hand, and that, as a result, his farm of approximately 0.2 hectares has been well-placed to take advantage of the supply of tanks and drip irrigation components from the project.

Due to its farm-based activity level, the GWM program in Cambodia has worked well to improve farm output and has promoted alternative pesticide use; biodigesters to maximize recycling of animal manures for energy; and vermiculture, which has had major soil benefits elsewhere. As a result of the small investments at the farm level, some GWM participants in Cambodia report they have a doubled their household food production. The increased growth is occurring with a 2-hour per day time saving on watering of horticultural crops, which is primarily done by women. The GWM promotes mulching mediums, which can cut down the evaporation of precious soil moisture and reduce the need for weeding. In time, it will contribute to improved soil structure and help ameliorate the impacts of heavy rain events. By cutting back on labor, these initiatives assist greatly in offsetting the impact of labor out-migration from rural communities. The labor-saving facet is highly attractive to rural communities, most particularly for women.

### 4.9. Nitrogen use efficiency

NUE subprojects have been producing positive results, if less pronounced than those of the GWM. Achieving the inherent benefits of biochar requires longer lead times, the beneficial results are less obvious, and more time is required to measure benefits. However, early indicators are that results are positive and integration of both NUE and GWM elements will be highly beneficial over time.

In both Svay Rieng and Tboung Khmum, the Cambodian Agricultural Research and Development Institute has conducted field trials to reduce nitrogen application on rice and vegetables. Complete analysis of this research is not yet available, but early findings have identified that

- application of a biochar formula (50% = 2.5 tons per hectare [t/ha]) mixed with slurry or compost or cow manure (50% = 2.5 t/ha) provided better yield than biochar alone (5 t/ha) and control (farmer's practice); and
- rice husk vinegar, a product of the pyrolysis process by which biochar is made, has been fermented and enthusiastically adopted by farmers for use as a natural pesticide.

Findings from biochar work elsewhere include that yield and economic return vary by location and soil type. Time and careful R&D observation is required to identify the differences. Additional systematic research is needed to arrive at recommendations for site- and soil-specific biochar use. The current fieldwork by the Cambodian Agricultural Research and Development Institute supported by the CASP2 LOA projects, will contribute to this knowledge base.

The Cambodian work has revealed a difficulty in accessing sufficient rice husks for biochar production. This is because the larger mills are being approached by traders wanting to purchase large volumes of husk for export, particularly to Thailand. Such a phenomenon reveals that the value of this crop residue may be increasing and the emergence of businesses searching for inputs to produce ready-to-use organic/biofertilizer. The potentially greater availability of these products and natural/botanical pesticide by-products for selling to farmers should be evaluated. Cambodia would benefit from some support in this area.

Analysis of the country as a whole reveals hotspots that could benefit greatly from biochar use, and future work could look at this.

To conclude, the early assessment of the GWM activities is that they are collectively very cost efficient, most particularly for women farmers, offering greater efficiency in water use, productivity, and market opportunities. On-farm, adoption of both GWM and NUE can assist farmers in producing more crops and of a higher quality. Much of what has been piloted could be expanded to numerous other provinces, especially areas that are biochar hotspots, and for niche fruits and vegetable markets for tourism. The steps ahead for GWM and NUE include the needs to

- continue to promote the benefits of GWM and NUE practices in a combined way, linking the on-farm improvements for sustainability with greater opportunity to supply SEAP; and
- explore and adopt approaches that successfully assist in up-scaling ideas and activities that enable change across the whole of the cycle of values.

The last observation concerning both GWM and NUE is that the promotion of farmer accessibility to both these activities has combined to improve productivity, and when that occurs, the critical next step is to secure access to stable wholesale and retail markets that recognize the value of SEAP and ensure some premium price. While some farmers have been supported and secured greater market access, it is a challenge for smallholders to play a viable role in the daily supply of vegetables and fruit in Cambodia. Access to markets that place a value on farmer produce and connect with the growing consumer demand has been seen to be a major gap. The next section will look at this vital step.

### 4.10. Postharvest

Numerous postharvest issues are important for smallholders in Cambodia, including

(1) improved produce care, transport, and selling arrangements;
(2) product loss and wastage across the supply and value chain; and
(3) indifference of others in the value chain to the plight of smallholder farmers.

These issues commonly occur and require attention because farm produce has a diminishing value over time. The more efficient and hygienic the postharvest period is, the better the produce and the return to the farmer. An indicator of continuing success therefore will be to secure improvements in produce care and the logistics involved in moving farm produce.

A small group of wholesale and retail traders in Phnom Penh confirm that shifts in consumer focus are part of a revolution that is looking to a smaller food production footprint, with localized origins and of higher quality. The need for supply of SEAP produce has been a major issue in Cambodia where there has been a very strongly held perception, particularly among the increasingly emergent and predominantly urban middle classes, that farmers overuse agrochemicals (Alliance 2016).[6]

Recent research to understand more about this issue surveyed five commonly eaten market vegetables purchased from a variety of Phnom Penh markets. The limited survey revealed that 75% of vegetable and fruits sampled contained no detectable residues. The 25% was found to be

[6] Alliance 2016 is a network of 7 European NGOs.

contaminated with residue that was over the international standards (Alliance 2016). Although the Alliance study findings are highly qualified, the dimensions of inferior practices are potentially of great concern, and findings like this contribute to fracturing the trust required in the value chain, and are a public health concern (Neumeister 2015). A retailer supplying GAP and SEAP produce in the Cambodian capital says that consumers "needs to be confident food is cultivated, produced, and cared for during transport and at markets, and that it will be nourishing to consume." This current situation of contaminated produce simply cannot continue if the GMS is to be recognized for producing SEAP.

The need for a shift in the quality of market produce has also been the subject of major capital investment. The PRC recently opened a $10.0 million laboratory in Phnom Penh dedicated to elevating food quality standards, and is training staff to operate the sophisticated equipment that has been supplied. The ultimate PRC intention is to export good quality produce from Cambodia to the PRC. It is vital that mechanisms to improve farmers' postharvest and logistical practices, monitor standards, and communicate improvements across the value chains be put in place. This issue is important for all consumers, not only for export opportunity to the PRC but for the daily food supply of all Khmer people. Additional market demand is also coming from other niche groups in Cambodia, for example the emerging ecotourism market with visitors who are keen to experience farming practices and want to have confidence in the food that they eat.

### 4.11. Potential role of the participatory guarantee system

While Cambodians supply some vegetables and fruit to local markets, particularly at the district level in rural areas, the overwhelming supply for the major markets is imported. Over 150 tons of vegetables are imported each day from neighboring countries, the bulk of which is sold in the private and informal wholesale markets of Phnom Penh and then redistributed to outlets in the capital city as well as the major provincial markets.

Cambodian smallholders appear play a tiny role in this supply chain because they individually lack the capacity and resources to produce the volume required, maintain consistent quality, and have limited postharvest logistical abilities and capacity. Further, at the farm, village, and commune level the experience is that traders will give them such a mediocre to almost negative dividend for improving their product, that there is limited incentive to do so. And payments for the produce are very slow to arrive.

However, farmers have found and acknowledged that membership in PGS groups and adoption of the PGS practices can assist in improving cultivating practices and marketing their produce through the support and combine energy the group provides, along with the combined trust and confidence that follows. The PGS trial initiative could prove be a very strong mechanism to address the issues Cambodian smallholders face.

PGS groups led by motivated "lead farmers" have been valuable in giving farmers direction and confidence. There are also Cambodia examples of positive collaboration with provincial agriculture departments assisting PGS groups at district and provincial markets where farmers, particularly women, have confidence in the process and, for example, in receiving the immediate cash from sales. In this situation, the PGS groups have also developed logos for placing onto their food items, and in two cases where LOAs have subsidized and helped to organize support for market space, farmers have successfully been able to market their produce. So PGS groups have been proudly able to get their produce to a provincial market, with their own members cleaning, presenting, and selling it, and the near 50% increase in returns are in their pockets within days and sometimes hours of the sales. This small change has been almost revolutionary for these smallholders!

Improved marketing is now required to help raise the profile of the PGS production groups and the significance they bring to market**.** Greater and more informative use of signage where PGS foods are marketed has been used on a very small scale, and could be greatly increased. For produce raised using GWM and NUE processes, it is appropriate to promote them with signage at markets, to "tell the story***."*** The story behind each shop, the process, the enterprise, and the varieties—such as providing information on where the produce is from, how it is being raised, why this is being done, when it started, and who is involved—can be told to help convince the farmers themselves just as much as the urban-based middle classes.

While the PGS culture promotes trust in farm production process, it can also provide farmers with some assurance that they will continue to get an appropriate return for their efforts and link with that pocket of key consumers in the urban areas who increasingly want to purchase SEAP. At this stage, not all outlets, in particular the supermarket chains, understand or accept the significance of PGS. To achieve this, PGS needs to penetrate larger commercial city markets and supermarkets. Successfully addressing this need presents as a unique public–private partnership opportunity.

### 4.12. Summary of the Cambodia case study

**Markets.** The GWM and NUE have helped smallholders produce more product, but the singular greatest issue for farmers is selling the increased produce. Improving farmer market opportunities is an excellent step forward and more needs to be done in this regard. Urban markets are commonly beyond the reach of smallholders, and few traders appear to place any priority on farmers' interests. However, initiatives such as the International Volunteer Yamagata (IVY) center in Svay Rieng Cambodia are offering farmers an important staging point for improved market access, and CASP2

LOA support for market space to sell PGS produce has shown positive results. Finding partners who could help to establish spaces similar to the IVY would be ideal, but there also needs to be recognition of the ability to achieve these standards and practices from within Cambodia.

**Import substitution.** The volume of the daily import of produce into Cambodia indicates the need for a strategy to address the imbalance. Although the subprojects have shown that Cambodian smallholders can and are willing to produce SEAP, they currently play a limited role in the market.

**Inferior handling methods** plus long time periods from farm to market contribute to the deterioration of produce when it finally reaches markets, with additional losses as it is on-traded or retailed. The losses can and should be overcome with introduction of known, proven, and in many cases simple technologies. A simple technique at markets is keeping produce at waist/table height in crates and separated from contamination. Other techniques include introducing refrigerated/cool-chain movement and eliminating harmful chemical use. These are small, and in some cases expensive initiatives, but for the country to be confident it can produce SEAP, these significant steps need to be adopted.

**Dedicated GAP retailers.** One consortium of GAP retailers in Phnom Penh has been exploring ways to join together to share products, adopt joint production plans, identify prices, use certificates (GAP and PGS labels), and cooperate with local distributors and wholesalers to bring GAP products to their customers. The focus is on quality with reasonable prices, affordable by the market and acceptable to farmers. This initiative is very similar to the IVY initiative, and could benefit from further support where appropriate.

# 5. Policy Directions, Investments, and Institutional Reform

This section draws recommendations for consideration at the policy level that could involve the private sector, initiatives with public–private partnerships, and potential investments for the public sector to consider. The recommendations are intended to promote the broad SEAP agenda. The emphasis is on initiatives that are quick, doable, and practical.

Each issue has a number of introductory discussion points, and if relevant public–private partnership aspects are notes, and then the recommendations follow.

## 5.1. Sustainable production at the farm level

**Green Water Management.** The total impact of the subprojects is yet to be assessed, however early findings is that they have had, and will continue to have a positive impact. Scaling them up is the next challenge. Improved GWM is essential for agriculture, particularly fostering increased resilience to stress factors of climate change. Initiatives in this area have been positive. There is a need to offer a vision whereby other smallholders can increase their productivity through better management of green water.

GWM inputs, e.g. excavators for ponds, plastic irrigation equipment, water tanks, simple water harvesting, and mechanized pumping are not capital intensive and the return on investment is positive and has provided farmers with highly beneficial outcomes. Smallholders should choose which options would be best for them.

**Public and private involvement.** Numerous environmental, agricultural, water resource, health, and rural development ministries will be keen to see the benefits of up-scaled GWM, and collaboration with NGOs could be an effective mechanism to assist. University research centers should also be encouraged to collaborate in the initiatives.

**Recommendations:**

(1) Accelerate opportunities for farmers to implement GWM ponds on their farms. This can be achieved through a dynamic program of subsidy supported by microcredit, and delivered through collaboration with NGOs. Selection of candidates should be completed with collaboration of target community members, to select farmers who will readily adopt the method, agree to join a PGS group, and assist others in their community to adopt the practice.
(2) Promote parallel R&D on the up-scaling of the GWM with appropriate academic partners committed to improving understanding of water-use efficiency, and demonstrate this on the AINs. This could, for example, include district case studies whereby the maximum efficiency of using the drip technology and appropriate technology to support sustainable water management are analyzed.
(3) Strengthen and improve extension services and know-how regarding GWM, and enhance capacity building.

### Nitrogen Use Efficiency

There is room to introduce institutional innovations that encourage clustering of organic fertilizer production and logistics services for standardizing production and distribution of these vital inputs. The PGS groups offer a vehicle to promote the presence of GWM and NUE on-farm practices.

Because of the need for labor in producing biochar and compost, adoption of NUE practices will have greater benefits for farmers if they can foresee a long-term tangible benefits, beyond the lower outlays for inputs.

**Recommendations:**

(1) Maintain support for the ongoing trialing of NUE and communicate findings through the AINS.
(2) Consider promoting clustered organic fertilizer production to provide greater availability and access to a quality soil input medium that is important in the SEAP equation.

### Market synergies—Participatory Guarantee Systems and food safety

If farmers are producing more, they need to market their surplus. The single greatest factor for enabling improvements in sustainable farming practices is farmers working in groups. Combining the need to market with membership in a PGS is highly effective in defining the product farmers are producing and improving their marketing "position."

The need for "clean and green" product is well established at the consumer point in the values cycle, but all involved in the agro-based food chain need to be engaged in the cycle of trust. The IVY initiative in Svay Rieng is a good model for replication, but requires considerable investment for buildings, vehicles, and farmer support. The model is very successful in delivering the "trust and confidence," which is important when trying to change production and market behavior.

**Public and private involvement.** The cycle of values is by definition inclusive of all the precursors of successful public–private partnerships. For the business to be successful, markets and entrepreneurs will be anxious to respond to in a positive way.

**Recommendations:**

(1) Develop an LOA for working in collaboration the Pro-GAP "clean and green" outlets in Phnom Penh. Such an activity would promote farm-to-plate with consumers "knowing" the farming group from which they purchase. Consider buyer clubs and "office-to-farm" connections—food

being grown for specific groups, with direct marketing. Enhance this using AINS and media to amplify consumer needs and understanding of farmer perspectives.

(2) Give a high priority to fostering opportunities for urban households to benefit from contracts with farmer groups, knowing where their produce comes from. Such an innovative move could assist confidence building for the important link between producer and consumer.

(3) Start small, have small targets, and establish links between farmers and consumers whereby the "demand" for SEAP is successfully satisfied through an acknowledgement of the needs of all parties.

(4) Acknowledge in a tangible way the achievements of farmers and farmer groups engaged in best practice "clean and green" in member countries.

(5) Provincial and district agriculture departments, along with all the players involved, could consider a roundtable to find ways to secure a range of markets for farmers to sell their PGS produce. Find a way around bureaucratic "turf war" barriers.

### Institutional support

**Benefit–cost analysis.** Discussions of water productivity tend to focus on irrigation efficiency and crop productivity, summarized in the "more crop per drop" paradigm associated with "blue water" schemes. For farmers wanting to improve their livelihoods, techniques and practices that optimize available water use and minimize inputs are important, and it can be clearly argued that GWM will produce very positive returns on much lower levels of investment.

However, GWM schemes currently receive near zero attention and negligible financing, despite being very cost effective, GWM is an institutional "blind spot" that does not get enough attention at the policy or program development level.

**Recommendations:**

(1) Initiate one major GWM program in each member country to roll out simple initiatives that can make a huge difference in food security and livelihoods.

(2) Dedicate a LOA to examine and develop relevant metrics and data, and use AINS to communicate the data.

(3) Support farmer groups that are producing clean and green food by giving it the highest priority at formal "state" functions etc.

(4) Explicitly support and overtly acknowledge R&D in promoting involvement of research institutes and universities in the GMS to engage with the issues highlighted, both the hard and soft sciences, to assist greater productivity with healthy foods and sustainable environments.

(5) Explore import-substitution strategy in situations like Cambodia’s where smallholders are predominantly locked out of market dynamics by an imbalance in trade from neighboring countries.

## Conclusion

Early signs are that the combined LOA activities have demonstrated that greater adoption and implementation of the GWM practices in particular, but also the NUE, can make a very positive contribution to the production of SEAP. In addition, the PGS has been seen as an important tool that gives smallholder farmers the leverage to engage with markets on their own terms and play an increased role in the food production cycle.

With the right approach and combined commitment, the GMS can confidently move toward achieving a vision that it is internationally recognized as a hub for the production of safe and environment-friendly agriculture products. The size and voracity of the potential market for SEAP, while not clearly determined with hard numbers, shows promising signs of being a huge opportunity for all in the values cycle.

The steps ahead will benefit from collaboration between all stakeholders and partners in the cycle of values, particularly securing greater links between consumers and farmers.

The importance of continuing R&D into the spectrum of issues associated with up-scaling what has been seen to be an amalgam of good practice—GWM, NUE, and PGS—cannot be emphasized enough. Routinely this research should be both multidisciplinary as well as singular in discipline. At the same time this research will benefit from being farmer, market, and consumer focused, grounded in the reality of both the importance and the efficacy of the approach.

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**About the Core Agriculture Support Program**

The Core Agriculture Support Program (CASP) supports the GMS in attaining its goal of being a leading producer of safe food using climate-friendly agriculture practices. Now on its second phase, since 2012, CASP2 is committed to increasing the subregion's agricultural competitiveness through enhanced regional and global market integration and subregional connectivity.

The agriculture ministries of the six GMS countries manages the implementation of CASP2 through the GMS Working Group on Agriculture (GMS WGA). A technical assistance (TA 8163) with financing from the Asian Development Bank, the Government of Sweden, the Nordic Development Fund, and the Water Financing Partnership Facility supports the CASP2 implementation. The GMS WGA oversaw the development of the discussion papers.

**About the Asian Development Bank**

ADB's vision is an Asian and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to a large share of the world's poor. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

**Core Agriculture Support Program Phase II**

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