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University Education and Research for Climate Change Responses in Vietnam

Ground-truthing of their simulation model by researchers and students of HUAF Crédit: Duong Quoc Non, 2015

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Supporting the integration in Agricultural Curricula of Climate Change concerns
at Universities of Agriculture: Vietnam National University of Agriculture (VNUA)
Hong Duc University (HDU) and Hue University of Agriculture and Forestry (HUAF)

et / and / en

Wageningen University & Research

SOMMAIRE / INHOUD / SUMARIO

ABSTRACTS/ABSTRACTS/ SAMENVATTINGEN/RESÚMENES

EDITORIAL **EDITORIAAL** **EDITORIAL**

Vietnamese Universities Transform Agriculture Curricula and Research

This special issue of **TROPICULTURA** is a fruit of the long-term collaboration of several Vietnamese universities and **Wageningen University & Research** (WUR). Most of the papers report on activities that were carried out by the NICHE-VNM-105/ACCCU project since 2012. ACCCU supported three Vietnamese universities: **Hue University of Agriculture and Forestry** (HUAF), **Hong Duc University** (HDU) and **Vietnam National University of Agriculture** (VNUA) to move away from "learning to recite" to "learning to perform" in agricultural curricula. Simultaneously, where most appropriate, ACCCU integrated gender and climate change issues in some courses. Next to WUR, the project was supported by **Maastricht School of Management** (MSM), **Can Tho University** (CTU) and the **Regional Office for Asia of SNV** (Netherlands Development Organisation). At the three universities, in total seven curricula were adjusted: Agronomy at HDU, Aquaculture at both HUAF & VNUA, Environmental Sciences at VNUA, Horticulture at both HUAF & VNUA, and Land Management at HUAF. The first two papers discuss the curriculum reforms and provide recommendations on developing students' competences to enable them to perform in society. The present tendency of universities to cater to the "learning to recite" curricula has contributed to a rising unemployment rate among their graduates. At present, employers prefer hiring undergraduates and give them training while they are doing their actual jobs, and then retain the best performers. The authors recommend that government enunciate clear strategies for an educational system that crafts out critical thinking skills as early as in the primary and secondary schools, and prescribe overall learning outcomes instead of lists of courses. Such learning outcomes will allow universities to aggregate closely related courses in interdisciplinary modules, which may, at the same time, prevent repetitions and allow active skill and competency learning activities. However, such undertaking requires training of the lecturers' pedagogical skills and raising their awareness on the necessity to teach skills and attitude.

The other papers and the abstracts report on climate change adaptation research. The first describes a seven-step approach that identifies responses to climate change impacts. This is followed by four results of this approach: the paper on Melon cultivation and the abstracts on a water-sharing mechanism, sedge culture and three adaptations in the Mekong delta. The remaining four papers present the results of studies focusing on specific climate change adaptation and mitigation measures: autonomous adaptation by sugar cane growers, breeding of saline-tolerant climbing perch, pollution mitigation from shrimp farming wastewater and Payment for Ecosystem Services for forest conservation to compensate CO_2 emissions. The decision making for adaptation of pangasius farming is an invited paper from a lecturer of **Nha Trang University** who defended his PhD at WUR. In these studies, the lecturers were able to strengthen their skills in conducting stakeholders' consultations and other participatory research methods. Part of the methods and results documenting lessons and actual field experience were captured in video clips as support materials for classroom purposes.

Although long and winding, the journey towards transforming Vietnamese agriculture curricula from theory to skills-based has started, and lecturers are using their experiences from field work in their classes. In the near future, students will be better able to respond to the demands of the World of Work in the region.

Dr. R.H. Bosma, Editor
Prof. Dr. Le Van An, Project focal point
Prof. Dr. Johan A.J. Verreth, Project director

Les universités Vietnamiennes transforment leurs programmes d'enseignement et de recherche agronomiques

Ce numéro spécial édité par la revue **TROPICULTURA** est le fruit d'une longue collaboration entre plusieurs universités vietnamiennes et la **Wageningen University & Research** (WUR). La plupart des travaux de recherche publiés dans ce numéro spécial ont été réalisés dans le cadre du projet NICHE-VNM-105/ACCCU depuis 2012. L'ACCCU a financé trois universités Vietnamiennes: la **Hue University of Agriculture and Forestry** (HUAF), la **Hong Duc University** (HDU) et la **Vietnam National University of Agriculture** (VNUA). La philosophie d'enseignement dans le cadre du projet était d'évoluer de l'approche «apprendre à réciter» à celle d' «apprendre à faire» dans l'enseignement des sciences agronomiques. Les autres sponsors du projet, à part la WUR, ont été la **Maastricht School of Management** (MSM), la **Can Tho University** (CTU) et le **bureau régional pour l'Asie du SNV** (organisation néerlandaise de développement). L'ACCCU a intégré, dans certains cours, les questions relatives au genre et aux changements climatiques quand cela était jugé pertinent. Dans les trois universités, sept programmes ont été adaptés: l'agronomie à l'université HDU, l'aquaculture dans les universités de HUAF et de VNUA; les sciences de l'environnement à l'université de VNUA, et l'horticulture dans les universités de HUAF et de VNUA. Les deux premiers articles publiés dans ce numéro spécial traitent des réformes des programmes d'enseignement et proposent des recommandations concernant les compétences à acquérir pour agir dans la société. La tendance actuelle des universités Vietnamiennes est focalisée sur l'apprentissage par cœur de connaissances. Cela a contribué à un taux de chômage croissant parmi les jeunes diplômés. À l'heure actuelle, les employeurs préfèrent embaucher des étudiants de premier cycle, les former, puis ne garder par la suite que les meilleurs. Les auteurs recommandent au gouvernement d'adopter des stratégies de réforme du système éducatif centrées sur l'acquisition des compétences de réflexion critiques depuis l'école primaire et secondaire. Ils recommandent également de prescrire pour la suite du cursus une approche d'apprentissage global au lieu d'imposer des cours typiquement théoriques. Ces résultats d'apprentissage permettront aux universités de dispenser des cours avec des modules interdisciplinaires dont la synergie permettra une meilleure pertinence de formation. Ce qui peut, en même temps, prévenir les répétitions et permettre des activités d'apprentissage actif des aptitudes et attitudes. Toutefois, une telle réforme académique nécessite la formation en compétences pédagogiques des enseignants et leur sensibilisation à la nécessité d'enseigner d'autres compétences que celles de nature cognitive.

Les autres articles et les résumés, publiés dans ce numéro spécial, font état de la recherche sur l'adaptation au changement climatique. Le premier article décrit une approche en sept étapes qui identifie les réponses locales aux impacts du changement climatique. Il est suivi par quatre applications de cette approche: un article sur la culture du melon et trois résumés concernant un mécanisme de partage de l'eau, la culture du papyrus et trois adaptations dans le delta du Mékong. Les articles restants présentent des résultats d'études axées sur des mesures spécifiques d'adaptation et d'atténuation des impacts du changement climatique: l'adaptation autonome par les producteurs de canne à sucre, l'élevage de perches tolérantes à la salinité, l'atténuation de la pollution des eaux usées de la production des crevettes, et le paiement des services d'écosystème pour la conservation des forêts afin de compenser les émissions de CO_2. Le texte concernant la prise de décision pour l'adaptation de l'élevage du pangasius est un article invité d'un conférencier de l'**Université Nha Trang** qui a défendu son doctorat à la WUR. Lors des études réalisées dans le cadre du projet, les intervenants ont pu renforcer leurs compétences en matière de consultation des parties prenantes et dans d'autres méthodes de recherche participative. Une partie des méthodes utilisées et les résultats obtenus sur le terrain ont servi à monter des clips vidéo qui sont actuellement utilisés comme matériel didactique. Bien que long et difficile, le chemin menant à la transformation de l'enseignement universitaire agricole d'une approche basée sur la théorie à une approche basée sur l'apprentissage de compétences a débuté au Vietnam et les professeurs utilisent à présent leur expérience de terrain dans leurs cours. Dans un proche avenir, les étudiants seront mieux en mesure de répondre aux exigences du monde du travail dans la région.

Dr. R.H. Bosma, Editor

Prof. Dr. Le Van An, Project focal point

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ARTICLES ORIGINAUX
ORIGINAL ARTICLES

OORSPROKELIJKE ARTIKELS
ARTICULOS ORIGINALES

Making Curricula Competence-oriented at Vietnamese Universities

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Keywords: Education- Skills- Attitude- Lecturers- Curricula- Vietnam

Summary

Many academic curricula suffer from a teacher-centred focus on knowledge transfer and do not consider the societal needs for competences. This paper reflects on the transformation from theory-centred towards competency-oriented curricula at three Vietnamese Agriculture Universities with support of a Netherlands-funded project. Experts guided the implementation, from analysis of labour market to evaluation of new courses. Based on students' evaluation and lecturers' experiences, both types of respondents reported that after having been exposed to a series of trainings and hands-on experience in and outside classrooms, they gained new sets of knowledge and skills. However, some issues emerged in the process. Among these are the lack of competence among lecturers to design curricula based on outcomes, particularly addressing competence of students' knowledge, skills and attitudes; lack of staff to develop and implement a competence-based curricula; non- aggregation of closely related courses in modules that avoid repetitions and provide time for training of skills and attitudes. There is also a need to train students for competency in performing more complex learning outcomes, such as critical thinking. For this change to happen, lecturers need continuous training in didactics for active teaching, and universities need to provide means for participative learning.

Résumé

Orienter des programmes universitaires sur base de la demande des compétences dans les Universités Vietnamiennes

Beaucoup de programmes universitaires sont orientés vers un enseignement des connaissances cognitives négligeant les besoins réels de la société. Cet article reflète la réforme des programmes académiques dans trois universités d'Agronomie au Vietnam. Ces réformes visaient de baser l'apprentissage des compétences en matière de cognition, aptitude et attitude par rapport à la demande de ces compétences par la société. Un projet appuyé par les Pays Bas a été initié où des experts ont mis en œuvre cette réforme à partir de l'analyse du marché de travail jusqu'à l'évaluation des nouveaux cours. Après le projet, l'évaluation des nouveaux programmes par les étudiants et par les professeurs a confirmé qu'ils avaient acquis de nouvelles compétences. Néanmoins, quelques contraintes ont été signalées. L'étude confirme l'insuffisance de capacités des professeurs à définir des programmes de cours et des modules basés sur les objectifs de formation des compétences. Cela ne permet pas un apprentissage actif des trois compétences. Il a ensuite été révélé que les institutions ne facilitaient pas la définition des programmes organisés en modules thématiques ce qui n'arrange pas l'apprentissage de ces trois compétences, et entraîne des répétitions. De plus, il y a un besoin d'enseigner aux étudiants des compétences plus complexes telle que l'analyse critique. Dans ce but, les professeurs doivent suivre des formations continues en didactique de l'enseignement actif et les universités doivent fournir les moyens nécessaires pour un apprentissage participatif.

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Introduction

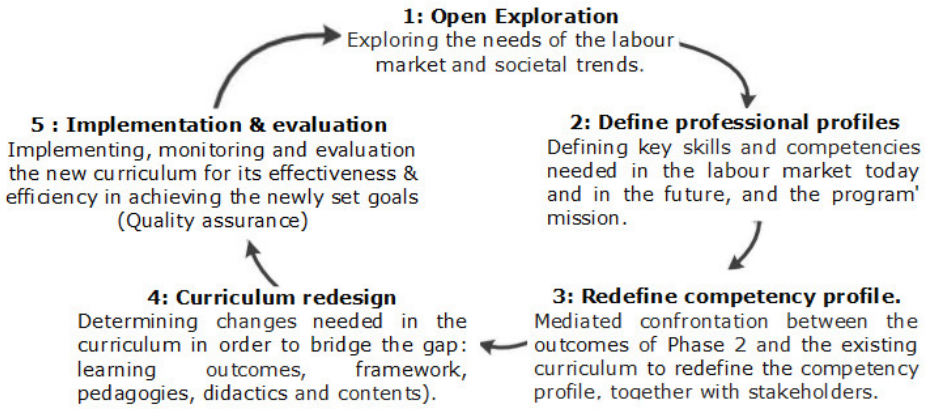
According to recent reports both from donors and governments, most curricula of Universities in SE Asia suffer from a teacher-centred focus of knowledge transfer and do not consider the needs of the world of work (WoW) for knowledge, skills and attitude. We give some examples: rarely Bachelor or Master include an internship that would familiarise the students with their future employment; most lecturers read mainly their notes and include no skills training in their pedagogy. For example, physiology students merely copy pictures but cannot use a microscope; students do not work on group assignments. Both program and pedagogy are failing with regard to teaching other than cognitive competences. Consequently, (i) the universities deliver graduates who can repeat learned knowledge only, but hardly have other competences relevant for their future employers (6; 2), and (ii) the rate of underemployed young graduates is higher than that of non-graduates (7).

The problem of mismatch between higher education outcomes and societal needs for skills and attitude is not restricted to Asia. A recent study on European graduate programs for aquaculture concluded, among others, that the fast changes in IT create new skills demands and recommend to focus on learning both generic and job-specific skills (4). These and other studies related to higher education mention that students need to acquire more generic skills, such as writing and presenting reports in English, working in teams, information processing and higher order thinking. To overcome the mismatch, large private companies hire groups of potential undergraduates, provide on-the-job trainings and employ the outstanding candidates, thus leaving behind the graduate students unemployed. However, smaller companies and public organisations can't do so, and thus are hampered in their development through an increasing gap in competences.

By 'competence', we refer to the integrated use of head (knowledge), heart (attitudes) and hands (psychomotor skills) in professional settings (both in routine and in critical job situations). These three: knowledge, skills and attitude are categories to guide and verify the learning goals, and are used in program qualification frameworks and descriptions of curricula and courses (modules). Instead of these classical competency categories, some qualification frameworks use mixed categories: Knowledge and Skills, Application and Competencies, and Responsibility, which we will discuss later.

From 2012 to 2016, the Netherlands Initiative for Capacity development in Higher Education (NICHE) supported several Vietnamese universities to make their curricula more competence-based. NICHE supported projects to align curricula with demands for competences from the labour market for the graduates. The NICHE projects mostly have four components: strengthen institutions, train human resources, reform curricula and invest in equipment. All have a transversal gender component, and some included activities to link research to education and development, and to stimulate business incubation.

In this paper we focus on the curriculum redesign framework of two Vietnamese NICHE projects (ACCCU[1] and POHE[2]), the results of ACCCU's first student evaluations and the challenges identified at the closing workshop of ACCCU. ACCCU supported three agricultural universities in North Vietnam, and POHE focused on horticulture in its first phase and broadened scope to training of lecturers at universities throughout Vietnam. Both projects did build on the theoretical framework of curriculum development designed, among others, by Wals *et al.* (8).



[Adapted from Wals *et al.* (8)].

Figure 1: The five-step curriculum development cycle used by POHE and ACCCU.

To redesign curricula, this framework proposes a cycle with five steps:

(1) Explore societal trends and needs of the labour market;

(2) Establish key skills and competences needed in the labour market today and in the future;

(3) Mediate between the outcomes of step 2 and the existing curriculum;

(4) Determine changes needed in the curriculum in order to bridge the gap (learning outcomes, pedagogy, didactics and contents);

(5) Implement the new curriculum, and monitor and evaluate its effectiveness & efficiency in achieving the newly set goals. This framework was also implemented by the POHE project (Figure 1).

The latter and the projects supporting education in agriculture and forestry funded by the Swiss cooperation (www.helvetas.ch/Vietnam) compiled several guidelines in both Vietnamese and English languages. These guidelines supported the training of lecturers in designing competence- based curricula and modules.

The process of developing competence-oriented curricula

ACCCU supported the process of developing competence-based curricula through the following project activities:

1/ Train faculty members in key principles of competence-based education, participatory curriculum development and its didactical implications, and prepare a market assessment.

2/ Meet the WoW to assess the potential labour market, the key-job profiles (required competences), and the changes (key-trends) in science and society that may affect the teaching practice.

3/ Conduct workshop(s) to convert the key competences of the job profiles in the mission of the education program and its overall learning outcomes, and in an overall curriculum with specialisations. Thereafter, the curricula with modules can be defined based on the job profiles and general societal competences required by the society.

4/ Conduct workshop(s) to describe the learning goals, assessment methods and learning activities of the various modules, and cross-check if all expected competence outcomes will be reached.

5/ Provide feedback on e.g. the insertion of gender in the new or redesigned courses;

6/ Provide training of trainers for student-centred teaching activities.

7/ Support the evaluation and organise curriculum network meeting among the partners to learn from the evaluations.

Hereafter we review the integration of these activities in the five-step approach.

Step 1: The market demand

Competence profiles were defined through a labor market review and thereafter aggregated to match an education program with specialisations. The profiles described the roles, tasks and responsibilities of the various professions (jobs) that have employees in the specific market sector aimed for by the education institute, while giving the key knowledge areas, attitudes and skills needed for successful performance in both routine and critical job situations. The routine competences can usually be trained in simulated conditions, while the critical ones are only developed through experience and feedback in real-life situations. For example, a competent stewardess in an airplane is not only capable of routine job, such as giving safety instructions and serving food; but is also capable of handling unexpected or stressful critical situations, such as dealing with an obnoxious passenger or with a medical crisis (8).

ACCCU grounded the competence-oriented curriculum into the needs of society by capturing the different views and interests of a broad range of stakeholders during labour market assessments. These stakeholders were local, regional and national government officials, and future employers, such as schools, vocational education institutions, local development agencies and small-and-medium private enterprises in rural communities within the food and land-use chains. Also former students and staff of the three universities were involved. Individual employers were identified through the graduate's network, employer's associations, professional associations, government bodies, research organizations and public institutions. Given the project's objectives, ACCCU assessed the sectors for three existing curricula: agriculture, aquaculture and horticulture, and two new: environmental management and land management. The assessments of these sectors aimed at (i) defining the labour market profiles, i.e. what different types of jobs the graduates are likely to pursue and what competences are needed for these different jobs; (ii) describing the changes and their drivers in the sector that influences the graduate's competence needs. At the first workshop, the faculty leaders and staff involved in the process listed the persons to be contacted, the questions to be asked and the way of documenting the review. The workshop included a training on the focused group discussions and on the personal interviews to be used for the market assessment. Thereafter these key stakeholders of the WoW were interviewed to discuss key changes in science and society that affect the teaching practice; describe the potential labour market and key-trends; and list the key-jobs and related key competences of themselves and their staff.

Labour market reviews can be elaborate and costly as implemented by POHE at first, and also concise and embedded. ACCCU chose for the latter because of the complaints from the Vietnamese partners about the first. Well-designed on-line surveys among graduates; interviews with some representative employers; and focused group discussions with employers, government and professional organization provided sufficient information for designing a new curriculum. The outputs of the market assessment were the present and future job profiles of which an example is given in Table 1.

Step 2: Targeted professional profiles

ACCCU reviewed the outcomes of Step 1, i.e. graduate competence profiles in workshops with staff members and key administrators for each of the faculties. First the closely related competence profiles were aggregated to make the basis of the curriculum concise, and then used to formulate learning outcomes and if still required a mission statement for each of the curriculum. In particular, ACCCU considered the needs related to Climate Change Adaptation (Table 2), gender inclusion and sustainable rural development in the learning outcomes because of the present societal context (Table 2).

Table 1

An example of the knowledge, skills and attitude required for a BSc Environmental Science according to employers from one of the sector assessments.

Knowledge	-Multiple disciplinary aspects of environmental management -ISO, and environmental laws, regulations and policies - Fundamental and practical understanding about waste water treatment technologies, solid waste management and treatment, environmental quality analysis and monitoring, land-use and land management, pollution control, social issues in environmental protection and land management
Skills	- Collecting and analysing environmental data, using modern machines and equipment - Specialized computer skills (GIS, remote sensing, Photoshop, Arcgis, Arcview) - Environmental analysis and management - Environmental consultancy and counselling - Environmental project launching and management - Communication in local and foreign languages while considering the cultural settings of Vietnam, the region and the globe
Attitude	- Enthusiastic and passionate with the job, and having good manners and correct office behaviour - Be creative, have good work ethics, and able to work hard - Have the ability to gather people.

Table 2

Selected courses at VNUA in which Climate Change (CC) issues were integrated.

Module	Some typical CC integrated content
1. Basic Ecology	The distribution of ecosystem in conditions of CC and biodiversity The impact of climate CC on the material circulation
2. Modeling for environmental management	Modeling climate change, greenhouse effect and global warming
3. Principle of meteorology	The phenomenon of CC: causes, manifestations and effects The impact of CC on water cycles The impact of CC on the thermal regime of the soil and air Meteorological disasters in Vietnam
4. Aquatic Ecology	The impact of CC on ecological factors of aquatic ecosystems The impact of CC on species group in aquatic ecosystems The impact of CC on the sustainability of aquatic ecosystems The impact of CC on farming activities aquaculture
5. Aquatic Pathology	Fish Diseases occur when CC affects salinity or parasitology
6. Water quality management in Aquaculture	Water quality when climate changes Changing Aquaculture season in flooding
7. Specialized vegetable crops	The impact of CC on vegetables production and management
8. Flower and ornamentals production	The impact of CC on production and adaptation of flowers Characterization of resistant varieties of flowers and plants
9. Landscape plants production and maintenance	Negative impacts of ecological factors on landscape plants and solutions

The proposed curriculum learning outcomes were reviewed by experts from the ACCCU project. Thus, the professional competence profiles made up the core of competence-oriented curricula which were used to define the learning outcomes of the graduates needed by the labour market.

Step 3: Curriculum design

Then, a curriculum with courses was designed or redesigned, considering also specific learning outcomes related to knowledge, skills and attitude. These specific learning goals were attributed to specific courses. The coverage of all expected competences was cross-checked in a spreadsheet. Then the lay-out of the curricula was reviewed during a workshop with experts from Wageningen UR.

The ACCCU partners chose not to modify all courses for the existing curricula, but to insert the learning of skills and attitude, and aspects on gender and climate change in some courses only. In particular, non-disciplinary courses, such as English were not modified. In some cases, stakeholders' workshops were held to reflect on the proposed curricula and their learning goals.

Step 4: Module design

After the curriculum was set, the lecturers started to (re)design the courses/modules. Developing the courses included decisions on which didactical principles were needed to be used to reach these competences (Wals *et al.* 2004). Features, such as interdisciplinary integration were also addressed. Individually and in workshops, the lecturers developed the courses/modules in seven steps. They:

(i) defined the contribution of the course to the curriculum learning goals and the preconditions, (what students need to know before starting this course) and making these fit into the curriculum;

(ii) formulated clear learning outcomes referring to one of the six cognitive levels, to a skill or to an attitude;

(iii) formulated the strategy (procedure & criteria) to assess students' performance on the learning outcomes;

(iv) identified learning and teaching strategies (i.e. students' activities) and aligning these with outcomes and assessment;

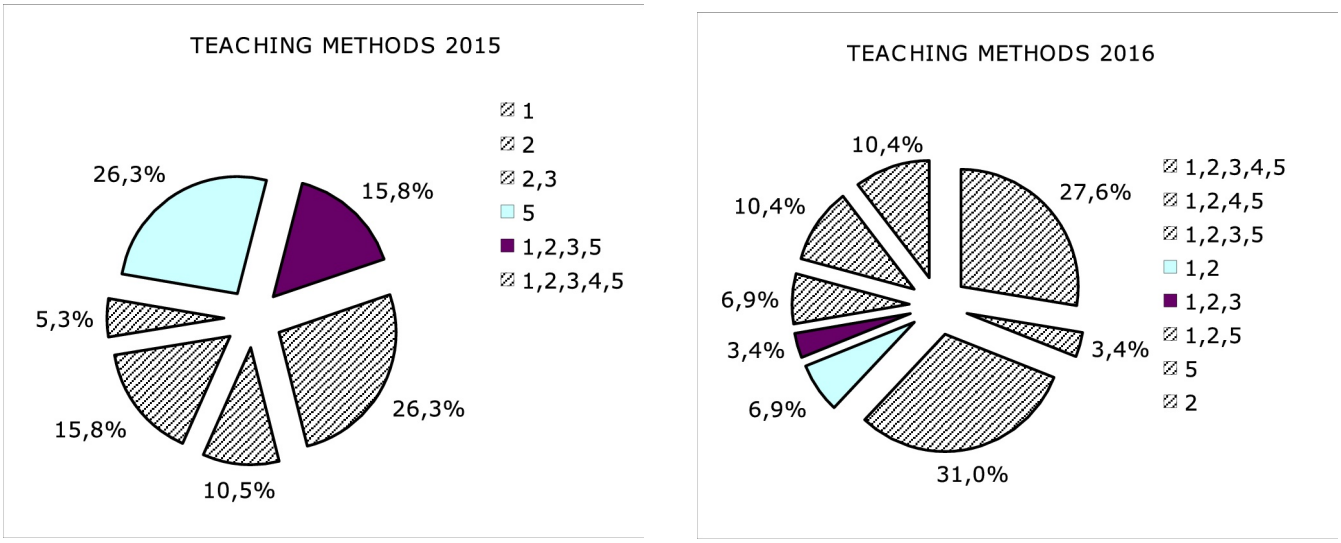
(v) defined the equipment needed and other practical points such as the course coordinator;

(vi) established the course content (syllabus) that enables students to attain the learning outcomes;

(vii) wrote the exhaustive course description for approval by authorities. In Vietnam, the student guide includes profile, learning outcomes, learning and teaching methods, assessment strategy, content outline and time schedule. The results of steps i to v were reviewed and discussed in workshops, together with disciplinary experts from Wageningen UR. For the curricula on aquaculture and horticulture, discussions concerning two universities were done collectively.

The duration of these workshops depended on the complexity of the courses, the teachers' knowledge and experience in designing competence-based courses and the agreement on the descriptions and the distribution of tasks. The workshops were guided by an experienced lecturer. In particular, the design of the course aiming at learning skills and attitude next to knowledge required new skills for most lecturers of the modules. ACCCU assumed that the training of such skills was covered by POHE, but the students' evaluations (see next section) demonstrated that complementary training was required for the design of active teaching/learning activities.

The learning outcomes of the various courses were cross-checked with the list of all expected competence outcomes in order to make sure that all would be reached. The issues on gender and CC were integrated in selected courses. All courses were reviewed to determine the necessity of including gender aspects; after the lecturers had reformed the course content, this was reviewed by a gender expert provided by the project. CC issues were integrated in three modules for each of the three curricula at VNUA for example (Table 2).



(1= power-point presentation; 2= seminar/group discussion; 3= practical; 4= field trip; 5= self-learning); the combinations of numbers represent methods used in one course).

Figure 2: Methods used in instructions of the climate change-integrated courses according to HUAF's lecturers involved in 2015 and 2016.

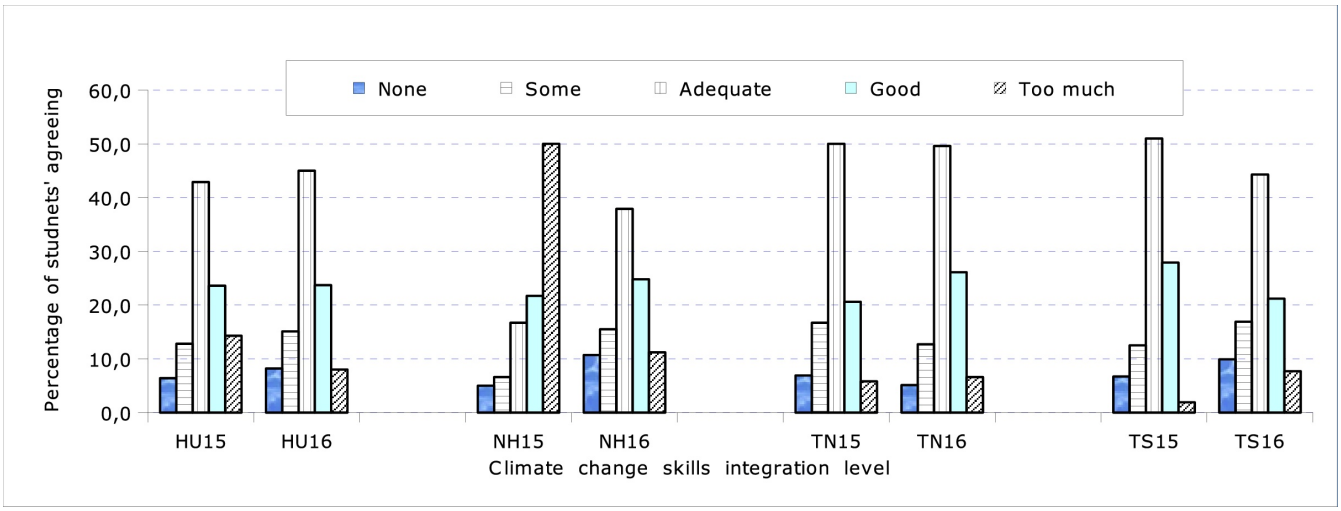


Figure 3: The level of integration of training on Climate Change-related skills according to the students of three curricula in two subsequent years (2015 and 2016): aggregated for the three (HU15 and HU16) and separated for the faculties of Agronomy (NH15 and NH16), Land Resources and Agricultural Environment (TN15 and TN16) and Aquaculture (TS15 and TS16).

Step 5: Evaluation

To evaluate the quality of the new courses, ACCCU collected feedback from the students and lecturers through surveys in 2015 and 2016. At Hue University of Agriculture and Forestry (HUAF) 266 and 1072, at Hong Duc University (HDU) 38 and 40, and at Vietnam National University of Agriculture (VNUA) 261 and 270 students replied; respectively, in 2015 and 2016. At HUAF 19 and 29, at HDU 36 and 25, and at VNUA 27 and 30 lecturers replied to the questionnaire; respectively, in 2015 and 2016.

Evaluation at HUAF

Lecturers at HUAF said that they used more types of teaching methods in 2016 than in 2015 (Figure 2). However, the students judged the integration of skills training in the courses as remaining about the same for Aquaculture and Land resources and agricultural environment; they said it was even lower in 2016 for the one of Agronomy than in 2015 (Figure 3). This may be subjective as the appreciation of opportunities for skills training in the agriculture curricula was evaluated as being too much in 2015 (Figure 3). The results of the surveys among students indicate that "repetition" of course content had occurred (see Discussion).

The changed appreciation on skills training may mean that either the didactical method used was not yet well developed in 2015, but improved in 2016, or that the students were better prepared for this new type of activity in 2016 compared to 2015. Indications for the first are the replacement by the lecturers of self-study opportunities with other active learning activities as shown in Figure 2. Indications for the latter are the shift in judgement from too much towards adequate for both the integration of CC-related skills of the Agronomy students (Figure 3) and the availability of self –study time in general (Figure 4).

Evaluation at VNUA

At VNUA, climate change issues (CC) had been implemented in nine courses since 2013. In 2015, issues on CC were included in 45% of the exams of the nine courses of the three curricula (Table 3). Both lecturers and students agreed that integrating CC into training programs was necessary to meet the requirements of their future jobs.

However, the number of courses in the three curricula that became more skills-oriented is small (3 on 60 for the total BSc), and will have little impact on the learning attitude of students who are used to passive learning (2). The survey showed that the ACCCU-trained lecturers scored better on the use of learning methods recommended for the competence-oriented, credit-based system (Figure 5). The students' habit will not change after only one semester of being taught by one or two lecturers trained by ACCCU, especially in the context of the existing lecturers who are not trained by ACCU or POHE, but are still actively using the traditional teacher-centred approach.

The results of the survey among students indicate "repetition" as a problem. Moreover, according to the students, the number of credits attributed to the courses is too small for the total content to be studied. Together, the findings plead for the aggregation of several courses in modules in which skills training can be combined with a reduction of the content.

Evaluation at HDU

The reform at HDU was evaluated for three courses in 2013-2014. The survey of 2014-2015 reached fewer lecturers (38 vv 25) as the students followed two instead of three adjusted courses; however the number of students increased. In the first year, HDU's evaluation included many yes/no questions, which were replaced by scaling questions in the second year.

The three courses of 2013-2014 integrated climate change issues, and the syllabi gave the learning goals. The modules included "practicals", "field-trips", "self-study" and "group discussions"; but no "individual assignments" or "group assignments". The latter assignments are the ones that most likely allow to train skills and attitude. Nevertheless, HDU students and lecturers scored "high" the achievement of skills training. These high scores might be related to their classification of the learning outcomes; e.g. "Describe main pests and their symptoms on several major crops" is classified as skills, while this is typically the lowest level of the cognitive learning outcome, "remember" in Bloom's taxonomy (Table 5).

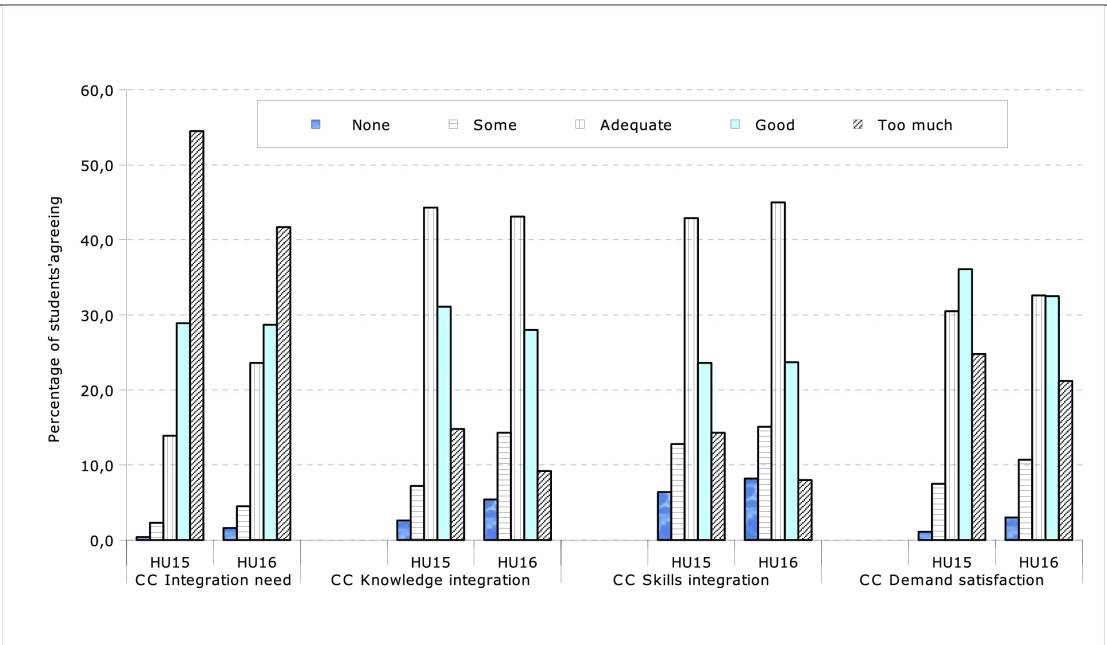


Figure 4a: Curriculum quality categories

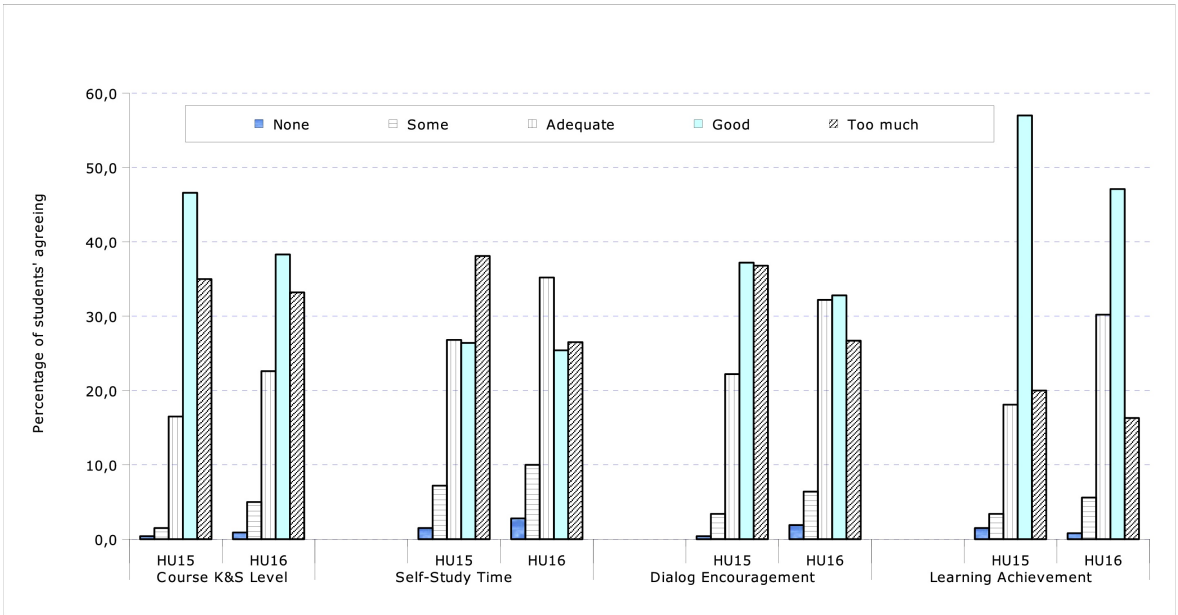


Figure 4b: Teaching staff quality categories

Figures 4a and 4b: The opinion of students on the quality of the syllabus (4a) and on the quality of instructors (4b) at HUAF for 2015 and 2016 (HU15 and HU16, respectively).

Table 3

The evaluation of VNUA students on four topics regarding the quality of the lecturers.

Evaluated indicator	Results	Notes
Lecturers use audio-visual techniques	100%	
Suitability of class size with course's contents	3,7 on a 5-point scale	Over-crowded
Suitability of class size with the infrastructure	3,8 on a 5-point scale	Over-crowded
Question on Climate Change in examination	45%	

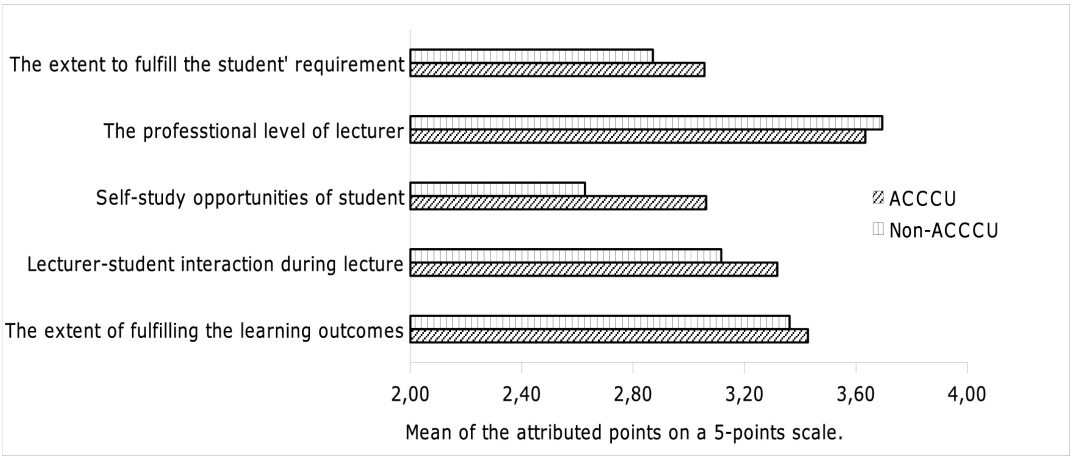


Figure 5: The effect of VNUA lecturers' participation in an ACCCU activity (ACCCU), compared with those who did not (non-ACCCU), on the appreciation by the students of five indicators for active learning and reaching learning outcomes, on a scale of 1 to 5 (5 being highest).

Table 4

Constraints to the introduction of Competence-based Curricula (CBC) at the level of the human resources and strategies to overcome these constraints.

Constraints / Challenges	Strategies to overcome the constraints
Knowledge, skills and awareness of part of the lecturers do not meet the requirements for CBC, because:	
- the number of enrolled students is too high for the number of lecturers	- Set up, implement, monitor and evaluate the programs on building the KS&A capacity of the lecturers, especially the young ones
- No effective system yet for monitoring and evaluating the KS&A of lecturers	- Set up evaluation system for courses and lecturers
- A proportion of lecturers do not try to build their KS&A	- Set up an incentive system
- Income of lecturers, especially the juniors are too low for them to love their jobs	- Strengthen the cooperation with WoW to increase practical knowledge, skills of lecturers and feedback
- the direct investment for training and education (practical, field trip) is only moderate.	- Increase the training facilities to improve the lecturer's skills
Lack of experience in developing curricula and courses oriented towards skills training	- Provide regular training arrangement on pedagogy; - Use experienced shadow lecturers of high standard; - Exposure to the WoW through internships in the private sectors - Develop central facilities/institutions serving several faculties or universities
Staff's resistance to change	- Teacher assessment - Peer level team teaching - Appoint teacher on a contract basis - Link career opportunities and rewards based on objective assessments.

(KS&A = Knowledge, skills & attitude)

Table 5

Six levels of learning outcomes based on Bloom's taxonomy, as modified by Anderson and Krathwohl (1) to match with active learning, and some related methods for learning and assessment.

Taxonomy of Bloom	Learning method *	Assessment method
Remember (Recognizing or recalling knowledge, facts or concepts)	Note-taking pairs	Multiple choice
Understand (Constructing meaning)	Think-Pair-share	Test with open questions
Apply (Using ideas and concepts to solve problems)	Buzz Groups; Role play	Case studies, Essays, Project performance assessment
Analyze (Breaking something down into components, seeing relationships and structure)	Critical verbal and oral debates	Case studies, Essays, Project performance assessment
Evaluate (Making judgments based on criteria and standards)	Paper seminar	Case studies, Essays, Project performance assessment
Create (Reorganize diverse elements to form a new pattern or structure)	Project assignments	Case studies, Essays, Project performance assessment

*See: Barkley E.F., Cross K.P., & Major C.H.,, 2005, Collaborative learning techniques: A handbook for college faculty. San Francisco: Jossey-Bass. Paperback (320 pp). ISBN: 978-0-7879-5518-2.

In 2014-2015, the small number of lecturers was more critical about the performance, in particular those involved in the Integrated Pest Management course. In general the lecturers for this course scored the achievement of the goals about half a point lower; while those involved in 'Food crops' already scored lower than that in the previous year. For example, on a scale of 1 to 5, the question, "Whether the contents of the course inspired self-learning or not," students scored the lecturers 4.1 in year one, but in year two, they scored these lecturers 3.5. Likewise, the score for the rate of integration of CC issues went down from 3.9 to 2.9. We assume that the level of awareness and knowledge of the fewer lecturers on the pedagogical methods for actively teaching skills was better, and they were more critical. More training events using participatory techniques and focusing on climate change and gender are needed for lecturers to be capacitated when confronted with these possibilities.

General evaluation issues and stakeholders' inputs

The HUAF team noticed that for the second survey, the students became less afraid to be critical. They gave lower scores to the lecturers; a higher number of the students requested more "practicals". Stakeholders review and input closes the cycle (Figure 1). To receive the input of stakeholders, instead of professional advisory committees (PAC) composed of stakeholders, the three universities organised feedback sessions during the employers' market days. Most Vietnamese universities organise such days to increase the employment opportunities for their graduates. At these sessions feedback from employers on the recently hired graduates and the need for skills were collected with the goal in mind: to educate graduates qualified for the labour market.

Challenges of competence-oriented curricula

The introduction of competence-oriented curricula in Vietnam is confronted with challenges in three levels: the design, the institutions (management and infrastructure), and the lecturers (human resources). Below we present details of the challenges and some of the strategies to overcome the detailed constraints suggested at the project workshop.

Curricular design

Four constraints were listed for the curricular design:

(i) the unfamiliarity with curricula building on learning outcomes;

(ii) the lack of staff with experience in designing such curricula;

(iii) the insufficient combination of knowledge, skill and attitude in the courses;
(iv) the incomprehension about the module structure compared to a course program. All these require training of the lecturers.

The first constraint relates to the unfamiliarity with constructing a curriculum that builds on learning outcomes according to the taxonomy of Bloom (Table 4). This is due also to the custom of talking about disciplinary knowledge (topics / courses) and not about learning outcomes relating to the three competences (see Discussion). The second constraint is related to the first. The lack of staff with the special competences and experience in designing such curricula, can find temporary relief by hiring experts.

The third and fourth constraints both relate to the structure of the learning activities in either courses or modules; lack of structure leads to lack of understanding the connections among subjects, repetition among the subjects, unclear credit distribution among the subjects, and skewed relation between fundamental and major knowledge credits. The description of courses or modules aims to provide this structure, i.e. how various teaching activities allow the students to learn all three competences (knowledge, skills and attitude) related to the content of the course. A 'course' tends to be related to lecturing one subject in a series of lectures given by one person only. Modules tend to be larger units in which students participate during 3 to 6 weeks (half or whole day) and learn through carefully chosen activities guided by a team of lecturers, with a coordinator. In principle, in modules it is easier to avoid repetition, and more importanty, include a variety of student-centred activities allowing to reach the learning outcomes relating to all three competences and levels of Bloom's taxonomy. The design of the latter may require guidance by experienced persons for a period of time.

Institutional challenges

There are three categories of constraints at the institutional level:
(i) involvement of the ministry and coordination between universities;
(ii) infrastructures;
(iii) workload and quality of lecturers,

The inappropriate workload and quality of the lecturers will be discussed below (Human resources).

Four key solutions to these three constraints include:
(i) having clear objectives,
(ii) providing more decision power to the universities,
(iii) respecting the rights of lecturers and
(iv) providing flexible mechanisms and coordination within the institute.

For the first constraint at the institutional level, participants agreed that the educational programs proposed by MOET are too closed and leave little room for adaption. Solutions could be to distinguish between hard or compulsory courses/topics on the one hand, and on the other hand, elective or soft topics that could be filled in by the faculties or departments. Stimulating more active discussion between universities (see Discussion) to allow more flexibility both in the teaching schedules and cross enrolment of students between universities of their choice would be helpful. With an open mind, universities can be in a better position to design more flexible regulations that cater more to the demands of students.

For the second and third constraints, lack of qualified staff and lack of infrastructure/facilities, respectively, suggested solutions were to:
(1) present evidence to convince government to increase the funding,
(2) engage private sectors both for finance and knowledge with the assistance of alumni,
(3) improve inter-university collaboration in cities with more universities,
(4) support the transport of unused or second-hand laboratory equipment from other locations. Although increasing facilities may contribute to solving the issue on large classes, reducing class size requires also more lecturers and more student assistants.

However, reducing the contact hours by introducing more independent learning activities for students to be more active might relieve the pressure. The present solution to provide the same subject several times by different lecturers leads to other problems, such as the divergence on the quality of lecturers and the difficulty on the development of the subject due to a lack of coordination between and among the different lecturers. Other solutions would be to limit the number of students, or design modules with a variety of activities, or provide a limited number of lectures by leading professors in a large auditorium, with very well-prepared individual and/or group activities guided by assistants. Evaluations by the students of courses and lecturers should include all activities and assistants and not just consider a sample.

Human resources

There are many solutions and strategies to overcome the constraints at the level of the human resources (Table 4). Many of these refer to training and improving contacts with the WoW. One crucial aspect might be the creation of an independent and objective monitoring system of the lecturers that could guide the individual training plans. The participants noted the resistance to change at the level of the lecturers; the solutions proposed were all administrative, while motivation, and thus understanding the reasons for the change might be important too.

Not included in Table 4 is a question on the time to start implementing the changes in a curriculum. First of all the change requires training that would also motivate the lecturers. An entirely new curriculum should start in the first year, but considering the lack of trained lecturers, a gradual transition by adapting some courses or transforming one semester in modules for training skills & attitude, is an option. Offering these courses or modules to the students in the higher years aligns with the increasing level of learning in Bloom's taxonomy that is aimed for in the curricula. The universities could offer these courses or modules as refreshment trainings to their alumni.

Discussion

We discuss here some issues on ACCCU's implementation, epistemology and ministerial leadership.

Didactical skills

In general, the evaluation indicated that the modified courses gave more attention to skills training but that its didactics still needs to be improved, either by training and informing the students, or by training the lecturers. Although the faculty members' participatory didactics was assessed at the start, with some related trainings provided in between, the evaluation shows that there is still room to improve the "Activities for Participatory Learning". However, such assistance will develop or enhance the skills of the lecturers only if (i) universities make such training compulsory for their lecturers and for the full professors, and if (ii) these are embedded in a continuous training program for all staff. The latter requires a separate section inside a university or a link with a specialised pedagogical institute.

In fact, to achieve an active learning attitude, the entire curriculum approach needs to be changed. At present, updating a syllabus, or changing an exam question requires compliance of Faculty or university leader; lecturers are not fully in control. Leaders may not be aware about the importance of integrating skills training; they may not also be updated with current issues, such as gender and climate change in the courses, or about the need to train their lecturers. In the Netherlands, continuous training in pedagogics is customary for teachers at primary and secondary schools, but was introduced recently for lecturers at Universities.

Competence and qualification frameworks

Instead of the classical three competence categories, Knowledge, Skills and Attitude, some qualification frameworks use mixed categories: Knowledge and Skills, Application and Competences, and Responsibility. The latter, in principle, includes attitude, and is perhaps more straight forward to explain, understand and translate to other languages. The use of the word "competence" in one of the two combinations is a fundamental epistemological issue that may lead to confusion as

most literature uses the word to indicate a set of competences (knowledge, skills and attitude) that graduates need to be able to apply, while application is one of the six cognitive domains as defined by Bloom *et al.* (3). The latter described the application as "Student selects, transfers, and uses data and principles to complete a problem or task with a minimum of direction", and suggested the verbs: use, compute, solve, demonstrate, apply and construct. In our opinion, using the two combined categories underestimates the holistic didactical approach that is required to teach/learn competences; making subsets of words cannot solve this complexity and risks even to deny this complexity; e.g., without a good attitude (sense for responsibility), a graduate scoring excellent on cognitive application and computer competences (skills) will waste his bosses' time by playing games.

Assessment of learning

Regarding exams, students of two universities noted that skills training issues were not well reflected in the assessments. This can be solved by averaging marks from several assignments; e.g., for application of learning goals: a mixture of marks for case-study, essay and performance (Table 5). Within ACCCU this problem may be related to the fact that the basis of the module design was not the assessment method for the defined learning goal, but the learning methods were based upon the learning goals. To prevent this problem, an alternative design approach would be to choose the learning methods based upon the required assessment method; the latter will then be selected first depending upon the expected learning outcome.

Repetition of course content

In the evaluation, the students mentioned frequently that repetition of content across courses had occurred, and also during the cited workshop this was listed among the constraints. Repetition in the course content may occur due to at least two reasons: (i) the different courses have closely related topics with different lecturers who do not consult each other in developing the content and (ii) the learning outcomes of the modules differ – more on learning knowledge in the first semesters, and more on acquiring skills in the later semesters; but the skills part are not developed. Aggregating various closely related courses in modules (Table 6) and focusing on the training of skills in the later semester of a curriculum would reduce the problem of course repetition.

A curriculum may consist of common modules and specialisation modules (Table 6). We purposefully use the word module to indicate that the curriculum needs to step away from credit courses given by individual lecturers. In a two-year curriculum that is built from, e.g., 36 courses given by individual lecturers, the risk of overlap is too high, and each lecturer will have insufficient time to include didactical activities for learning skills and attitudes.

The results of the evaluations demonstrate that the higher level learning outcomes were not yet well included (Table 2). Thus, learning activities for the modules in the later years of the curricula need to be improved. Although the highest levels of learning do not need to be reached in a BSc, the intention to train skills in research sets a high goal to the BSc. Either the latter expectation should be downgraded or more skills and attitude activities should be included in the didactics.

Directives from Ministries

Ministries responsible for the sector's education institutes may either just approve the strategic plan of universities and leave the quality control to an independent institution, or provide exhaustive lists of topics that a graduate should have learned, and take the lead in control. Though in principle the Vietnamese universities have freedom in designing "curriculum", the responsible Vietnamese ministry provided a list with topics the students are required to learn (Table 6, left hand column). Such lists constitute an easy way out for curriculum design but hamper the development of a competence-oriented curriculum, unless the HEIs are creative. One goal of the centrally steered curricula might be to obtain perfectly aligned course schedules and calendars that allow students to shift between universities, for example, to follow a specialization not available at the universities where this student is registered. However, the real situation shows that the actual study calendars among universities hardly align with each other (2).

Table 6

Moving away from knowledge courses towards modules with outcomes aiming at competences.

Ministry's list of specific course topics for the MSc Crop science	Overall learning outcomes of Modules covering the topics and allowing students to develop knowledge, skills and attitude.
	Graduates of an MSc crop science are able to:
1. Advanced Plant Physiology 2. Advanced Biochemistry	- Develop advanced plant nutrition schedules considering 'soil' and 'plant' biochemistry and physiology.
3. Advanced Plant Genetics 4. Advanced Seeding Selection 5. Plant Cell Technology	- Design plant breeding programs and apply seedling selection, cell technology and biochemistry.
6. Plant Nutrition 7. Soil and Plant	- Develop advanced plant nutrition schedules considering 'soil' and 'plant' biochemistry and physiology (see above).
8. Advanced Food Crops 9. Advanced Industrial Crops 10. Advanced Ornamental plants 11. Advanced Vegetables and Fruit crops	- Design climate-smart production plans for food and industrial crops, vegetables, fruit and ornamentals.
12. Advanced Technology in crop production 13. Advanced Cultivation Techniques 14. Integrated Pest Management	- Conceive crop and integrated pest management plans, using advanced cultivation technologies and considering climatic hazards.
15. Management of Agriculture Climatic Resources	- Create and monitor business plans for crop farms, and processing and marketing units.
16. Rural Development Project Planning & Management	- Create programs for extension services and apply extension training programs for farmers.

Nevertheless, the centrally provided lists with topics can be integrated in a curriculum with modules in a creative way (Table 6, right hand column). Considering a 2-year MSc of 64 credits including an internship (12 credits) and a thesis (24 credits), just 28 credits are left for courses. In the proposed learning goals of modules, the word "advanced" is replaced by a verb from the higher levels of Bloom's taxonomy (1). The reformulated program with modules has space for essentials in rural development, such as skills in entrepreneurship and extension.

Closely related topics are aggregated in one module to (i) prevent overlap between the lecturers and (ii) create time for student-centred activities that aim at learning skills and attitudes. We recommend ministries to set an overall mission and overall learning outcomes for the various agricultural faculties, and to provide universities with sufficient means to implement competence-oriented curricula. Higher Education Institutes (HEI) need to continuously determine what society expects from their graduates. A barrier to this may be that staff of HEIs have a different language discourse from that of the employers (4).

We add that also ministries can have a discourse different from that of the HEI, and that although Vietnamese ministries are aware of the urgency for skills development, they seem not to use the appropriate discourse to make the change happen. The ministries continued to give a "list of topics" instead of "learning outcomes"; the change should have been more about "skills-oriented active teaching/learning" rather than "credit-based" (2). If the ministries really want the students to learn skills, they should define the overall Learning Outcomes and the overall program structure (dates for semesters and periods, and the number of credits), and give a free hand to the Universities to design curricula with skills-oriented modules. An overall program structure would impose a parallel programming of the semesters and periods in modules which will enable students to exchange program and to shift between universities without losing time.

Critical factors

In agreement with a recent study in the EU (4), we note that giving less lectures and more active teaching/learning activities are critical for competence-oriented curricula. Such activities require more time for preparation, and the latter may not be well reflected in the time either given or paid to lecturers. To allow for the effective implementation of credit-based, competence-oriented curricula, university leaders may need to either revisit the payment system or revise the task quantification systems.

The analysis of Pita *et al.* (4) and Mulkey (5) shows also that the curricula need to be responsive, for example, being flexible along with new knowledge, trends and changes, and being decisive along with the obsolete and no-longer applicable knowledge from the past. This requires an 'antenna' not from lecturers only, but also from the entire institutional system because the former could just modify their module. The ACCCU partners used their alumni network and the annual job fairs to collect information on the market needs.

However, "curriculum responsiveness" requires also a continuous (professional) development of the universities and their lecturers.

The requirements for changes may be quite local, and therefore the universities should be able to act independently, while their curricula still need to be submitted for approval or for certification.

Pita *et al.* (4) also mention that the students' drive or motivation to learn skills needs to be stimulated. The results of the above-mentioned evaluation indicate that students might experience some challenges with the shift from knowledge-based courses only to modules with activities aiming to learn skills and attitude. Other universities address this issue by stressing the learning goals for each module before or at the start of this module, and by relating these to the professional environment.

Evaluating courses and the lecturers is not yet the common practice, although this is a crucial step in achieving high quality teaching and learning. Such evaluations can very well be coupled with the proposed continuous training of the lecturers. Another improvement would be to involve students in (re)designing the curricula.

Conclusion

ACCCU has contributed to transforming the theory- into competence-oriented agriculture curricula of the Vietnamese Universities. At the same time, ACCCU has also made possible the integration of issues on gender and climate change. This transformation was done by training those lecturers and leaders of faculties who were involved with ACCCU. These activities improved the skills and raised the awareness of the involved persons. However, lecturers and leaders who were not involved in ACCCU and related NICHE activities either did not develop new skills or still resisted change. The main challenges, therefore, are the inclusion and assessment of real skills training, and the aggregation of closely related courses in modules. A fragmented curriculum with many courses increases the risk of repetitions and leaves too little time for didactical activities on training skills and attitude.

Many of the constraints for developing competence-based education were caused by insufficient knowledge on curricula, modules and competences, insufficient know–how on the design of curricula and modules, and lack of teaching skills.

For change to happen, all lecturers need to be trained in didactics for active learning, and the universities need to provide sufficient means to implement competence-oriented curricula. Well-trained lecturers will be able to develop by themselves appropriate content and activities; the ministries can then just set the overall mission and overall learning outcomes for the various agricultural faculties. They do not need to provide detailed course topics. Overall outcome then would be the curricula becoming responsive to the needs of society, i.e. the market for the graduates, or the World of Work.

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Implementing the Credit-Based Education Model in Vietnamese Universities

Bau V. Le*, Hien M. Le & Giang P.A.

Keywords: Credit model- Vietnamese Education- Vietnam

Summary

The Vietnamese ministry of education and training (MOET) has instructed universities to implement a credit-based education model that includes the training of skills. This paper discusses three issues in implementing the model; namely: (i) difficulty to provide skills training, (ii) lack of staff, quality lecturers and facilities such as library and laboratories and (iii) mismatched habits and skills of students with those required by the new model. To fully benefit from this model, the authors give five recommendations for MOET and concerned universities to consider: (i) strengthen the competence education of this new model; (ii) enact policies to improve lecturers' qualifications and practical experience; (iii) use facilities from outside groups or other universities; (iv) improve soft skills of students by assigning them appropriate tasks and encouraging them to finish their tasks; and (v) implement the model on a step by step approach based on the specific conditions of each university.

Résumé

Mise en place d'un système d'éducation basé sur les crédits dans les Universités Vietnamiennes

Au Vietnam, depuis près de dix ans, le Ministère d'Education et de l'Apprentissage (MOET) a donné des directives aux universités de mettre en place un système éducatif basé sur les crédits, incluant l'enseignement de compétences. Cet article discute trois contraintes majeures de l'introduction de ce modèle: (i) la complexité de la formation des aptitudes et des attitudes, (ii) la qualité insuffisante aussi bien des professeurs que des infrastructures telles que les bibliothèques et les laboratoires, et (iii) la non-compatibilité des attitudes et des aptitudes des étudiants avec celles nécessaires pour le nouveau système d'éducation. Afin de bénéficier pleinement de ce système, les auteurs recommandent au MOET et aux universités de considérer: (i) à renforcer les aspects de l'apprentissage des aptitudes et des attitudes liées à ce nouveau système; (ii) de mettre en œuvre de nouvelles politiques pour améliorer les qualifications et les expériences pratiques des professeurs; (iii) de partager des infrastructures avec d'autres instituts, départements ou universités; (iv) d'améliorer les aptitudes sociales des étudiants en les assignant à des tâches appropriées et en les encourageant à compléter ces tâches; et (v) de mettre en œuvre le système en étapes adapté aux conditions spécifiques de chaque université.

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Introduction

Education is one of the most important elements affecting the development of any nation. State government acknowledged this by making it as a top national policy in enhancing intellectual human resources and talents (40, p.13), and by primarily investing on this sector (38, p.1). In 2013, for example, the Vietnamese government invested 20 percent of its finance in the education sector (18, p.13).

Since 1993, some universities in Vietnam have already implemented the credit-based education model. This model was first applied in 1886 in Harvard and then spread all over the world. In this model, the curricula are flexible. Although students have to enroll in some compulsory courses, they can choose several elective courses that they are interested in.

Moreover, they could decide when to enroll in a course. The credit-based training system is applied to meet multiple objectives, including a change of the education concept. Traditionally, this concept is based on education authority under which students learn by obedience and unconditional acceptance of both program and content that universities and lecturers fix and communicate.

However, in recent years, from a more authoritarian system, education has gradually shifted to a more democratic system (2). Democratization is thus exhibited through two main ideas: (i) create and focus on the most appropriate learning environment for students and (ii) pay attention to the needs and interests of students in relation to the competencies required for their future professional career. Not only do they have the right to choose professions, but also to a certain extent, they have the right to design their own training schedule, to partly choose their own training content, and to participate in the construction of the curricula and course schedule. The concept of learner-centered education is the most concentrated expression of the democratic right to learn more and better (1).

Along this line, MOET had published the decision, No 43/2007/QĐ-BGDĐT, to promote the training of skills in credit-based training curricula. However, the conversion from the annual course model to a credit system faces some challenges. In particular, new and local universities are facing issues related to their resources, as well as to the quality and quantity of students (30). They are confused about the application of this model (30, 32); thus the decision of MOET may be not satisfactorily implemented.

This paper examines whether or not the conditions in Vietnamese universities meet the requirements for a credit-based training model, and whether the credit training model is appropriate or not for all types of universities: public, private and local. It compares the standard conditions that a university "ideally" needs in implementing this credit training model with the actual conditions of the respondent-universities. This paper discusses other relevant issues, such as education program, resources and students; the last section presents recommendations for an effective application of this model in Vietnamese universities.

Methodology

This study used mainly a quantitative method to examine whether goals of shifting from the old model to the new one reaches the main goal: to improve quality of training data on the core factors affecting the quality of training, curriculum, resources, syllabi and students.

The reality of these factors were collected by using reports from three universities and MOET. The reality was compared to MOET's decision, No 43/2007/QD-BGDĐT, from 15th August 2007 which ruled out the regular training in university and colleges under the Credit System to assess whether there was a mismatch between requirements and reality. The results of comparisons were analyzed and discussed in this paper.

Analysis and Discussion

Education program

Most of the curricula satisfied the requirements of MOET (24). However, some universities such as Vinh University, Engineering and Technology University of Danang and Hanoi National University of Education did not indicate the outcomes of the training.

This led to misinformation among students and difficulty for them to define their assignments, as well as to get oriented with their activities. Eight studied curricula satisfied the regulation in quantity of credits (Table 1). However, data show that students have to pass between 122 and 150 credits to gain a Bachelor's degree. These curricula required students to attend classes for about 1200 hours for listening (theory), leaving about 800 hours for discussion and self-study; students thus needed to spend approximately 2000 hours to get a Bachelor's degree (19). Although the number of credits is lesser than that of the University of New South Wales (144 and 192 credits for the 3-year and 4-year courses, respectively) (35), this is higher compared with the time that students studied theory in Australia. If Vietnamese universities would reduce time for theory, students would gain more time to acquire specific knowledge and skills, e.g., reading reference materials; visiting laboratory; and observing, experiencing and analyzing business processes (Table 1).

In contrast, the proportion of elective courses is about 25% higher in UNSW (35) than that in Vietnamese universities. This shows that Vietnamese students have limited possibilities to choose courses, which is not characteristic of the new model. Elective courses are very important for students to expand their knowledge beyond their own disciplines; these courses would enable them to do collaborative interdisciplinary research and to analyze problems in a broader context (3). As for flexibility, the difference between curricula in quantity of credits and courses across universities (Table 1) implies that it is difficult for students to transfer their credits between and among Vietnamese universities. Most of the curricula have already a fixed schedule of the program which prevents students from shortening their study time. Thus the flexibility of the new model, from choosing their elective courses to setting their own schedule, is not fully taken advantage of.

As for quality, the audit report of training programs and syllabi in the academic year 2013-2014 at Hong Duc University, a typical local university, states that 12.5% of the syllabi did not satisfy the requirements completely (Table 2). This self-assessment covered 100% of the training programs and shows that the new curricula and syllabi scored better compared with the old ones (Table 2).

A survey on former students of Hong Duc university (9) showed that the education program mainly focused on theory only, instead of professional skills. This is similar to findings contained in several recent speeches (26). Soft skills such as communication, working in groups, and foreign language are important, but students are not trained in these. This observation is also recognized in the Conference on the relation between universities and businesses which was organized on 19th September 2009 (25). Thus, changing the curricula to include training students to learn soft skills, for example, can create not only a positive image for universities, but it also can eliminate negative reports about them.

Human resources

According to MOET (22), the number of universities has increased in the last six years. The number of staff having a Bachelor's degree accounts for a high proportion (Figure 1). In universities, this number should be lower because these staff can only teach general disciplines in the first semesters. In order to teach specific knowledge, the lecturers have to own at least a specialized Master's degree (39, article 54). Though the number of PhDs has improved, this was mainly in alpha sciences, especially Literature. The low number of technical PhDs poses serious constraints (22) with regard to the increasing number of students (Figure 1). In general, the qualification of lecturers has shown much improvement in the last six years, but the number of BScs has increased along with those having PhDs and MScs. Although the number of staff has increased relatively fast, and the student/staff ratio has become lower than the maximum standard set by MOET (20), the ratio of student/lecturer should be lower than 25, 20, 15 or even 10 for some technical education programs (Figure 1).

At Hong Duc University, there are highly qualified staff for some courses, such as English, Information technology, Finance Banking, Sociology, Forestry and Civil construction.

Table 1

Number of credits in some typical universities (Adapted from 5, 6,13, 16, 34, 36, 41 & 42).

Universities	VNUH	LUHCM	EUHCM	EUVNUH	HNUE	UPVNUH	VNUH	UCCW
Subjects	Law	Law	Economics	Economics	Pedagogy of Math.	Pedagogy of Math.	Mechanic Electronic	Architecture
General knowledge	27	32	37	27	34	30	29	34
Inter-disc. Knowledge	6	21	12	10	16	25	4	49
Disciplinary knowledge	19		15	16		39	22	
General prof. knowledge	53	59	30	20	63	9	43	57
Professional knowledge	16	12	22	39		27	11	
Practice and graduate	9	7	10	11	17	7	13	10
Total	130	131	126	123	130	137	122	150
Compulsory credits	112	119	111	102	108	133	118	129
Elective credits	18	12	15	21	22	4	4	21

Table 2

Quality assessment of syllabi used in the academic year 2013-2014 at HDU (11).

	Total	Good		Accepted		Unsatisfactory*	
		n	%	n	%	n	%
New constructed syllabuses	135	51	37.8	74*	54.8	10	7.4
Old constructed syllabuses	99	17	17.5	73*	73.7	9	9.1

* These syllabi should be reviewed

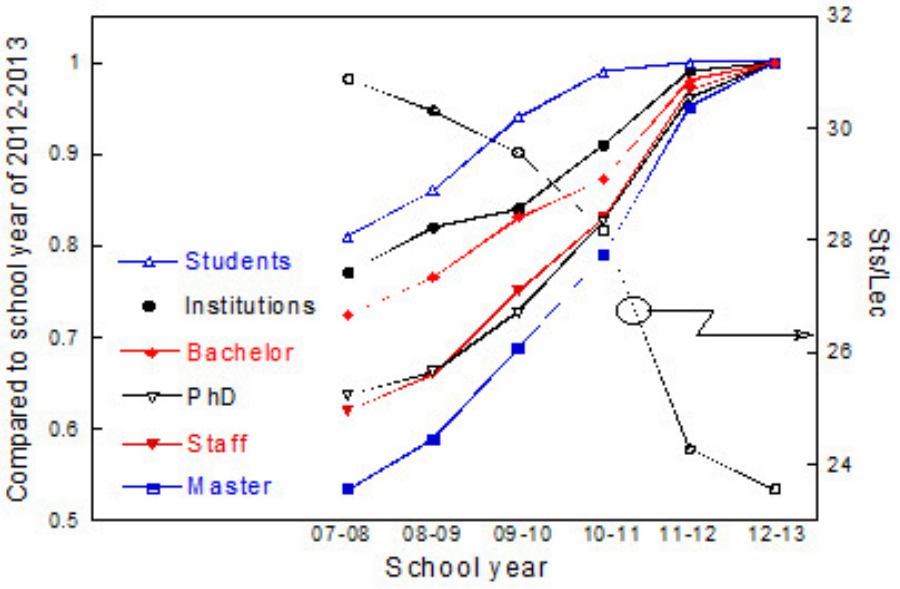

Figure 1: The trends in number of students and qualified lecturers (left panel) and the ratio of students and lecturers (right panel) at Vietnamese universities in last six years [Extracted from MOET (22)].

However, there are also other courses that are taught by teachers who only have a Bachelor's degree. This violates MOET's regulation (23). Moreover, 70% of the courses in forestry and civil construction could not be taught due to insufficient number and competency of available lecturers. The quality of lecturers was also assessed through their ability to do scientific research which is measured by the number of articles published in international journals. This criterion on scientific research is not included in the requirements of MOET. The number of articles published by Vietnamese scientists is lower than that of their counterparts in other countries. This may imply a more urgent need for Vietnamese lecturers to improve their skill and experience in conducting research (37), particularly at HDU. As a matter of strategy, HDU planners may need to look at how their lecturers can boost their capability on conducting research which may begin with learning the fundamentals of writing and speaking English that are at par with the standards of internationally refereed journals.

Facilities

MOET reports (21) that facilities of several universities have to be improved, in particular in the South of Vietnam. Most universities have acquired internet-connected computer rooms, and nearly two-thirds uses software in their training process, but on average, a computer serves 3.6 lecturers and 27.3 students (28). Some universities have built modern libraries comparable with those of developed countries; nevertheless, only 39% has an electronic library, 88% still operates with a traditional library, and 10 % does not have any library at all. This report also shows that most libraries have a narrow subject coverage, poor or outdated references, and/or insufficient materials (28). Modern facilities are therefore crucial for lecturers who are conducting research and for students who are pursuing competency-oriented studies.

Although many modern laboratories have been established, MOET states that only 22.5% is rated to have good quality equipment; 15.5% has met the needs of scientific research, while 0.8 is close to liquidation (21). This is based on a survey of 5572 laboratories and practical rooms and 442 workshops. Additionally, the laboratory equipment being used in the training process is insufficient both in quantity and quality, and most universities have not developed regulations on the organization and operation of their laboratory. On a positive note, some universities have begun investing in new facilities recently; however, for others, they have not enough area for expansion (24).

Overall, in terms of available facilities, top universities have only partially met the requirements for the new model. Equipment and facilities need upgrading as libraries, laboratories and workshops can directly affect the quality of both the education process in these universities.

Student's capacity

University students are clients in educational service and, at the same time, the object of the educational process. In this model, students play a role themselves. Their motivation to learn is one of the key factors in the quality of the educational process because the acquisition of their skills depends on their active participation (7, 8). Thus in the credit-based system, the training of competencies, does not only require changes for the institution and the lecturers, but also requires changes on the part of students, especially on their active participation (8). Using a ranking survey with five scales, Hieu (12) found that the student's learning of 14 skills was moderate in the three Vietnamese universities applying the credit-based system. The standard deviation of the rankings was high; it showed that on the one hand some of the students are able to learn skills in a credit-based training model, but on the other hand, a number of them face challenges (12). The skills relating to information technology are asserted to be the best. This could help them to enroll faster and search for materials quicker. Although all students have been guided to enroll online (24), the high standard deviation (0.93) shows that several students found it difficult to enroll online. Not owning or not having their own computers could be the reason for this result.

Group discussion is one of the most popular skills in this credit-based model, but more than 15% of the students recognized that they are very bad at this skill, and even close to 40% struggled with organizing their self study (12). For writing skill, like writing a report or an essay, students scored low on this; but 35% of them asserted that they are very good at listening and taking notes (12). Students developed the latter skill early in their primary school, and "teachers read, students write" approach is still popular in most Vietnamese schools (31).

Hieu (12) reports that 49.6% of the students mentioned that they are inferior in skills and methods. Besides, nearly 40% of students stated that they do not have any specific motivation to study. This may be one of the main explanations why students are not enthusiastic and active in studying. Self-study is, among others, a typical feature of the credit model. However, students still scored low for the skills they need to be equipped with under the credit-based training setting. They lack the essential skills mentioned earlier, and their competencies "deviate from employers' needs" (2, p. 583). A bigger challenge in applying the credit-based model (14, 17), therefore, is for implementers to find ways and means to undo the students' habits formed through years of being exposed to the "teachers read, students write" approach at the lower levels (15). This approach has milled out students that are so used to listening, but lacking in self-confidence to express their opinion and thoughts in higher education. Hieu's (12) results show that the higher the students' capacity, the better skilled they are. While credit-based training reduces the amount of class time, it does not, however, diminish the students' academic requirements. Currently, a large number of students do not understand this so they do not always use their free time for self-study (15). Although reducing class time is theoretically beneficial, it has some drawbacks because majority of students in the local universities have low capacity (29). On the other hand, to reach their targets regarding success rates and revenues, universities pressure their lecturers to reduce the quality of requirements that students need to meet (15).

The enrollment boom for some universities has resulted in reduced quality of students' inputs, especially in new and local universities.

This poor quality of students' inputs does not match with the new model's requirements which call for students to be more active and to own several skills. Given this situation, it implies that students will face more difficulty in meeting the requirements of the credit-based training model. On the other hand, a small number of students in some specific professions would also make it difficult for universities to organize classes that would meet student's demands.

Implementation issues

Small class sizes might favor interaction between lecturer and students. For a qualified university, a larger number of students are enrolled in each course (Adapted from 5, 6,13, 16, 34, 36, 41 & 42). These figures are between 33 and 219, and an average of 107 students in each course. Whether these figures are appropriate for a credit-based training model or not, depends on the number of assistants used by the lecturers. However, for other universities, the number of students is unbalanced. For Hoa Sen University, eleven of their courses attract less than 15 students, or even less than 10 students in each course of 8 professions. These courses could not generate profits (14). This situation is similar to that of Hong Duc University (10), but is worse than that in Dong Thap University (4).

In the new model, students can choose the subjects they prefer and decide their learning process (19). However, it will be very difficult for Vietnamese students to do so because if only a small number of them will choose the same subjects and/or process, they cannot enroll the courses they prefer due to the barrier of not meeting the imposed minimum number of 40 students before a class is officially permitted by the university (19). Consequently, they cannot take advantage of the new model.

Another challenge confronting universities implementing the credit-based training model is the need to enrich the training of skills of the lecturers by modifying the didactics suited for this model, i.e. train them on how to use methods that make students actively engage in learning events.

For example, lecturers need to use methods that would encourage students to express their opinion, instead of just letting them listen or write notes. They could implement this by assigning them tasks with detailed guidelines (33). Each student has to finish his/her task and present the output in the class. Simultaneously, other students can be encouraged to contribute to the presentation. The first tasks must be easy enough to encourage students, but not too difficult for the students to deal with so as not to discourage them. The extent of difficulty of tasks should be increased depending on the capacity of students. Doing these could be only in the short-term.

Conclusion

In the long-term, however, developing skills for students requires a change in the mindset of parents, schools, MOET and individual students on answering the question "What do students hope to learn." Studying to explore knowledge and develop individual capacities/skills should therefore be recognized, instead of sticking to the traditional opinion that students enter universities mainly to pass exams, get a high mark (33) and/or gain a prize.

The competency-oriented, credit-based training system has improved the quality of education in many universities all over the world. Applying the credit-based training system is compulsory in Vietnam since 2007. Several Vietnamese institutions have successfully applied this model and the quality of students graduating from these universities has improved. However, some issues remain in applying the credit-based training model, particularly in new private and local universities.

In appearance, most curricula have satisfied the requirements of the regulation, but some have resulted in overload of time. Students thus have less time for reading, self-study, and engaging in activities to improve their soft skills. Moreover, these curricula focus too much on theory and hardly include practicing of skills relevant for their future profession. Part of the syllabi requirement which is essential for self-study does not match the students' habits and skills. Except for listening and taking notes, the students rated very low their learning skills. Although the time for self-study was limited, some students struggled with doing this because they never learned how to do self-study and other skills needed to perform in the credit-based model. The new model requires students to be more active, while most Vietnamese students are generally passive. For this to change, the education methods at the primary and secondary schools need to change. In the meantime the universities may offer training or guidelines to the students. Moreover the lecturers need to include more and better skills training in their classes.

Students rated their motivation for skills training low. This may be due partly to three factors: (i) the limited proportion of elective objects, thus reducing the students' opportunity to take part in what they are interested in; (ii) for students' part, this may relate to their involuntary orientation and, perhaps, the most important factor inducing the students' low motivation is (iii) the didactical skill of the teachers.

As for curricula and number of credits, these differed from university to university. This difference generates difficulties for students to transfer their credits between universities. These limitations affect one of the advantages that the credit model should generate.

As for the number of staff serving these universities, although this has increased, the staff per student ratio was still lower than that required by the credit-based training model for technical universities. Likewise, the qualifications of some staff do not satisfy the requirements of the model. As a result, lecturers have to teach subjects that are not in line with their expertise, and for which they do not meet the specific requirements. Because they handle more subjects and a higher number of students, they have little time to conduct research. This situation implies that they are not updated with the advances of science.

Recommendations

All of the above factors affect the quality of the training process in the credit-based model in some Vietnamese universities. To take full advantage of the credit-based system, universities may opt to apply the following recommendations:

1. Restructure education based on this new model by:

a. Focusing more on professional skills training and less on lecturing theory;

b. Increasing the proportion of the forms of discussion, group presentation, and doing experiments in laboratories and workshops;

c. Involving employers and companies in defining these skills because they know exactly what skills students need to serve their businesses

d. Implementing surveys regularly to identify the needs of business and society. The results of these surveys could be the bases for adjusting the curriculum. In addition, seminars with the participation of enterprises could be inserted in the curricula to familiarize the students with the requirements from their future employers.

2. Enact policies that will:

a. Improve lecturers' qualifications and practical experience;

b. Facilitate flexibility of students to change their program across universities, and/or to continue with a second degree;

c. Enable recognition between and among universities. This could be done by setting basic outcomes that students need to reach under the guidance of MOET, educational experts and employers;

d. Enable universities to encourage, even compel their staff to enhance their didactical capacities. Lecturers should not only improve their knowledge, but they also should learn skills by themselves like searching information, critical thinking, and exploring and addressing problems through research;

e. Encourage universities to allow their lecturers to participate and practice in businesses and companies during sabbaticals. This could help them to learn and update the development of science and technology. This will enrich their knowledge, experience and their teaching activities; and then attract students and encourage the latter in studying. Moreover, approaching businesses and companies could help the lecturers to identify problems requiring research. The research addressing factual problems will enhance the capacities of lecturers, and, when reflected in their teaching activities, encourage students to conduct research.

3. Allow the use of facilities and related resources from outside groups or from other universities;

4. Improve soft skills of students by assigning them appropriate tasks and encouraging them to finish their tasks;

5. Implement the model on a step by step approach based on the specific conditions of each university. For new small and local universities, they can apply this model step by step or phase by phase, depending on the particular conditions of the university.

A step by step implementation of the credit-based training model would help universities do away with the too many constraints encountered in implementing this model in one single shot. The first steps would then begin with assessing the gaps; e.g., qualifications, knowledge and skills of lecturers who will be implementing this model correctly. This would then be followed by designing, implementing a training and evaluation program for leaders to address the gaps found in the assessment phase.

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Seven Steps in Identifying Local Climate Change Responses for Agriculture in Vietnam

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Summary

This study presents a seven-step approach to identify and support local climate change (CC) responses in agriculture. The following seven steps comprise this approach:

1. *Analyse past trends on the climatic factors and model the future trends.*
2. *Simulate the possible impacts of CC on the selected system(s) or product(s).*
3. *Present and discuss the predicted impacts with the local stakeholders.*
4. *Identify and rank CC responses together with the local stakeholders.*
5. *Elaborate plans to develop and test the highest ranked response(s).*
6. *Evaluate the results of the tests and recommend implementation or changes.*
7. *Report the results to the involved authorities and suggest ways to implement the responses and/or advise new tests if the first ones were not able to sufficiently deal with the impacts.*

Six pilot studies in Vietnam were funded through two projects led by Wageningen University & Research. The first addressed several production systems in one southern province, and the second in three more northern districts, each with different problems. This paper reflects and communicates the seven-step approach in order to make local CC responses accessible to the larger rural development communities. Most of the identified solutions can spread autonomously, while others will require specific planned interventions.

Résumé

Sept étapes pour identifier des réponses locales aux changements climatiques dans l'agriculture vietnamienne

Cette étude présente et discute une approche structurée en sept étapes pour identifier et développer des réponses locales aux changements climatiques (CC) affectant le secteur agricole. Ces étapes sont les suivantes:

1. *Analyser les tendances historiques du climat et simuler les futures tendances.*
2. *Simuler les impacts éventuels des CC sur le(s) systèmes/produits choisis.*
3. *Présenter et discuter les impacts identifiés avec les acteurs locaux.*
4. *Identifier et hiérarchiser les réponses aux CC ensemble avec les acteurs locaux.*
5. *Elaborer des plans pour développer et tester les réponses préférées.*
6. *Evaluer les résultats des tests et modifier les réponses ou bien recommander leur mise en œuvre.*
7. *Rapporter les résultats aux autorités impliquées et suggérer des voies de mise en œuvre des réponses et/ou conseiller de nouveaux tests, si les essais préliminaires n'ont pas suffisamment atténués les impacts des CC.*

Six études pilotes au Vietnam étaient financées par deux projets menés par l'Université de Wageningen. Le premier projet traitait de plusieurs systèmes de production dans une province au sud et le second dans trois districts plus au nord, chaque fois avec des problèmes différents. Cet article reflète l'approche en sept étapes afin de rendre les réponses locales aux CC accessibles aux institutions de développement rural. La plupart des solutions identifiées pourront être diffusées d'une manière autonome, tandis que d'autres demandent des interventions spécifiques planifiées.

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Introduction

Globally, Vietnam is among the five countries most threatened by sea level rise due to climate change (11). In response to climate change impact, Vietnam, like most countries, has assessed Climate Change (CC) impact and prepared its mitigation and adaptation plans at the national level. However, at the local level (region, province/district/commune), these adaptation plans for CC hardly exist. Adaptation can refer to natural or socio-economic systems; it can be reactive or anticipatory relating to their timing, and can be planned or spontaneous, depending on the degree of spontaneity (44). Frankhauser *et al.* (15) adopted the definition of autonomous adaptation from Carter *et al.* (3) as the "natural or spontaneous adjustments in the face of a changing climate," and consequently defined planned adaptation as "requiring conscious intervention" (e.g., large-scale flood protection works). The hypothesis of the present study is that conscious anticipatory actions can stimulate autonomous adaptations at community and/or farm household level, and reduce pressure on planned large-scale infrastructural interventions. Even though the national level authorities inform their local counterparts on adaptation and mitigation measures, if local authorities are not engaged in implementing measures that stimulate autonomous adaptations, related plans then become useless. Autonomous adaptations involve the local population and are done by institutes, companies and (farm) households; without these local partners, autonomous adaptations are impossible to do.

In Vietnam, the districts, the lowest administrative level of the agricultural extension services, serve as one of the sources of programs for communes, villages and hamlets. For autonomous responses to happen, for example, among farm households, they would need support from institutions/authorities, like the districts, to assist them to identify and test solutions. This study describes and analyses a seven-step method to stimulate autonomous adaptations through case-studies from six districts in four provinces of Vietnam. Before describing and discussing examples of the steps, we give the main characteristics of the sites. Before concluding we discuss the seven steps more broadly.

The study sites

In all six districts in four provinces, namely from south to north: three in Soc Trang, one in Quang Nam, one in Thanh Hoa and one in Nam Dinh, options on CC responses among farm households and rural communities were identified and tested. All pilot sites focused on agriculture, either for food or cash crops; but in some cases, the solutions went beyond the sector.

Soc Trang province

Soc Trang is one of the provinces in the Mekong Delta in the south of Vietnam where the monsoon season last from May to November (Figure 1). The Mekong delta faces four major threats: sea level rise (17, 43, 48), land subsidence (18, 14, 23), reduced fresh water flow (33) and salinity intrusion (5, 43, 48). Land subsidence is due to groundwater use and flood prevention dikes (14, 22). Taken all together, these threats impact on fresh water availability. The study in Soc Trang province was done on three different agricultural practice systems in three different agro-ecological zones: (i) applying alternate wetting–drying irrigation for rice in Nga Nam, a freshwater-dominated area, (ii) diversifying terrestrial crops on dikes by using rain water in rice-shrimp rotation system in My Xuyen, a brackish water area and (iii) applying mangrove-shrimp integrated system in Vinh Chau, a saline water-dominated area (9).

Dai Loc in Quang Nam

In the centre of Vietnam, Dai Loc district in Quang Nam province has, since 1977, experienced water shortage for rice cultivation in the summer-autumn season (May-September). Most rains normally fall between September and January. Here, drought has affected rice production in 11 of the 18 communes, or a total of 143 ha of land area. Thus, there are more frequent conflicts occurring around the water-sharing system between rice cultivation and other uses of water (e.g., for other crops, drinking water and hydro-power). This situation has forced some farmers to turn to crops requiring less water (21).

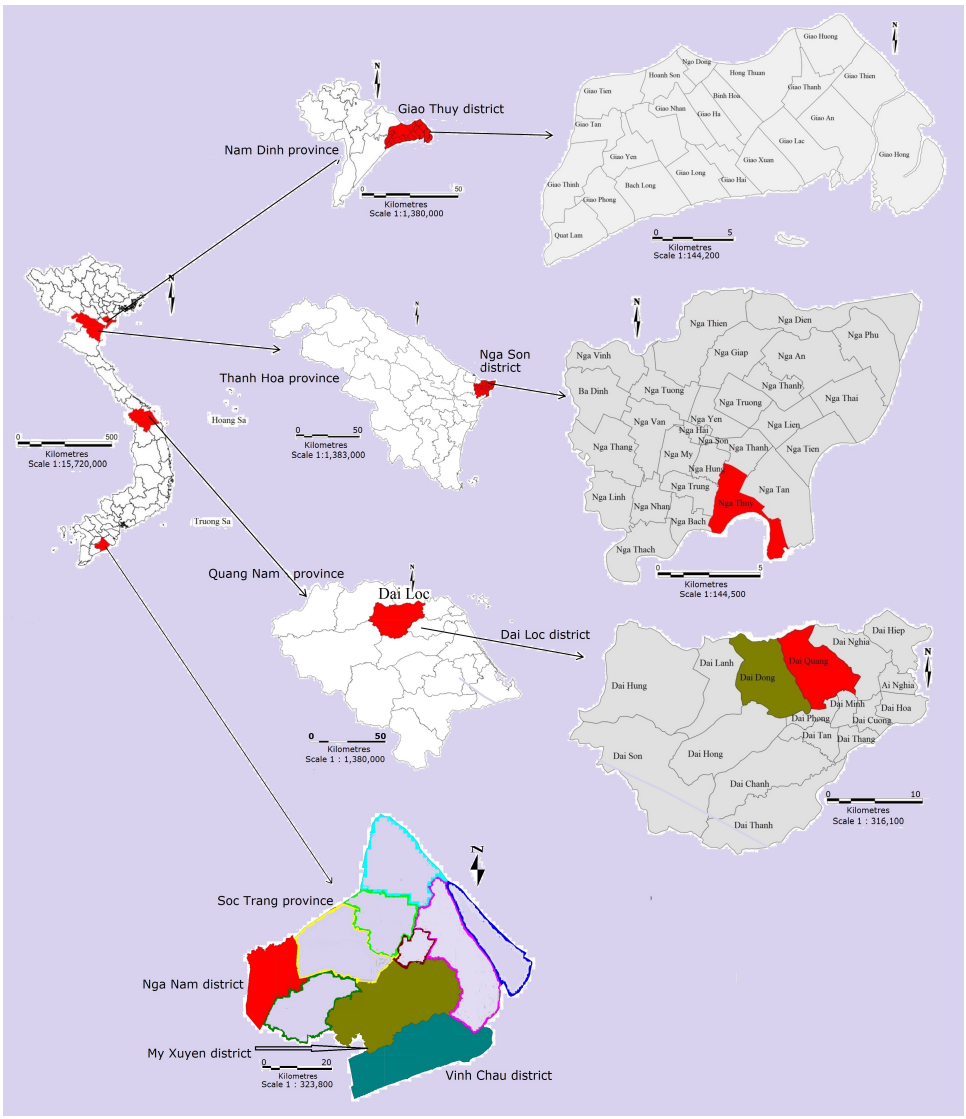


Figure 1: The geographical location of the six districts that were supported to develop Climate Change responses.

Nga Son in Thanh Hoa

Nga Son district in the northeast of Thanh Hoa province where the warm rainy season lasts usually from July to October/November, is well known for its fast-growing sedge or papyrus (*Cyperus* sp.). Sedge is a raw material for making handicraft products, such as sleeping mats to be gifted to wedding couples. The sedge cultivation area of Nga Son represents 20% of the country's total sedge cultivation area (about 13,800 ha).

However, since some years back, sedge production remarkably declined; e.g., in Nga Thuy commune in 2012, the total sedge yield was more than halved (1,470 tons) compared with that in 2002 (3,180 tons), thus reducing the handicraft employment (36).

Giao Thuy in Nam Dinh

The most northern site, Giao Thuy district is located in the coastal area of the Red River delta where most rains fall in the warm season between April and November. Its agricultural production focuses on aquaculture, rice, vegetables, melon and some animal husbandry. However, these livelihood options do not provide a decent income to many farm households and some options are impacted by CC (10).

Applying the seven steps to CCA

To increase the chances of broad adoption of feasible local CC responses, researchers used several participatory tools to embed the proposed seven-step approach. In a preliminary step, the team made an agreement with all relevant local authorities of each province and pilot district. The seven-step approach is summarized as follows:

1. Analyse the trends of selected climatic factors (rainfall and temperature min-max) in the past and present to model their future trends and effects on the patterns of flooding and salinity intrusion when relevant.
2. Model the predicted impacts of climate change on the selected issue(s), e.g., the present and future cropping calendar.
3. Present the predicted impacts and discuss in Focused Group Discussions (FGD) with the local stakeholders (local decision-makers and representatives of producers).
4. Hold separate FGDs with different types of stakeholders, e.g., considering position in society (i.e., farmers and leader-officers) and gender (i.e., women and men) to identify and rank solutions to respond to the CC impacts; use several criteria to assess each of the solutions on its feasibility to be implemented, either autonomously or with support from outside.
5. Elaborate plans to develop and test the highest ranked response(s).
6. Evaluate the responses and recommend implementation or changes in case the tested responses seem insufficient to deal with the predicted impacts.
7. Report the results to the local communities, the district and provincial authorities who approved the study in the pilot district, as well as in other provinces with the same agro-ecological conditions.

Step 1: Analyse and model climatic trends. The teams analysed trends on climatic factors, such as rainfall, minimum and maximum temperatures, and subsequent impacts on flooding periods and flood-depths and land-use by conducting a four steps approach:

(i) collect information on the past trends,
(ii) assess the trends in a GIS-based local climate change impact model (CCIM),
(iii) validate the outcomes of the model and
(iv) explore future trends by modelling.

This four-step-approach was applied by using three different methods and the choice of the methods depended on the availability of a CCIM. First of all, the teams checked whether a GIS-based local CCIM, including hydrological models of the water bodies, flooding levels and periods, was available. Such models may be available at the local or national institutions (universities, international projects, regional or non-governmental organizations).

In Dai Loc district, Quang Nam province, a local CCIM was not also available; thus, the Dai Loc team used an approximated method (Box 1).

A CCIM was not available for both Nga Son (Thanh Hoa province) and Giao Thuy district (Nam Dinh province), but digital maps and databases were. Both teams collected secondary data to make the local CCIM for the past, and then calibrated the model (Figure 2). The Giao Thuy team developed a local CCIM based on the GIS database available from previous projects of VNUA (37).

The teams collected data for DEM and the historical data from years with high and normal flooding and drought. Nga Son, for example, was hit by a storm with high amount of rainfall that caused severe floods in 2007; at Len river, the water level reached 6.95 m which was 0.15 m higher than that of the previous highest flood in 1973 (28). After calibrating the models, the teams modelled the impact of CC on the district's flooding (period, duration and height), drought and salinity intrusion by using Vietnam's B2 scenario.

For the entire Mekong delta, a CCIM was available but the local impacts for the three sites in Soc Trang province were lacking. The CCIM of the higher aggregation level was used as a starting point to make the local CCIM. The team then collected secondary data on climate change and extreme climate events and subsequent impacts on agriculture and aquaculture from provincial reports, and primary data on the digital elevation model (DEM) from the Mekong River Commission (48).

Box 1

The drought assessment method used in Dai Loc district.

Interpreting secondary data: Available reports and data were collected at Dai Loc district, Dai Quang and Dai Dong communes, Quang Nam province's Office of CCA, agricultural cooperatives, irrigation teams, hydrological and meteorological stations in the region, and statistical offices. These secondary data covered the issues mainly at provincial level. Then, water situation and its impacts on rice production were visualised on GIS-based water resource and irrigation network map; the team analysed rainfall and evaporation data and the discharge of rivers. In addition, other methods, such as "drought index - TPI" were used (31, 22).

Participatory mapping: The researchers, together with irrigation workers of the agricultural cooperative, commune staff and farmers (both male and female) mapped the water resources, irrigation systems and drought-prone areas in more detail at district and commune levels. Using these maps at 1:10,000 for the communes and 1:25,000 for the district showing streams, lakes, rivers and drought-prone rice production areas, stakeholders discussed the drought issues. Also the local hydro-power plant and drinking water companies were invited to join in the analysis. Then, the maps were checked by using a GPS device and were validated by the stakeholders. This participatory GIS mapping increased all the stakeholders' awareness on water management and drought-related issues.

Diagnosing rice effect on rice yield: To diagnose the overall situation of rice production, water resources, irrigation systems, water shortage and droughts, the project team interviewed 15 officials in charge of agriculture, irrigation, environmental resources at commune and district levels. Interview results disclosed the role of stakeholders in the management and the use of water resources. The collected information revealed that conflicts on water management and water use both at the communal and the district levels exist between two communes.

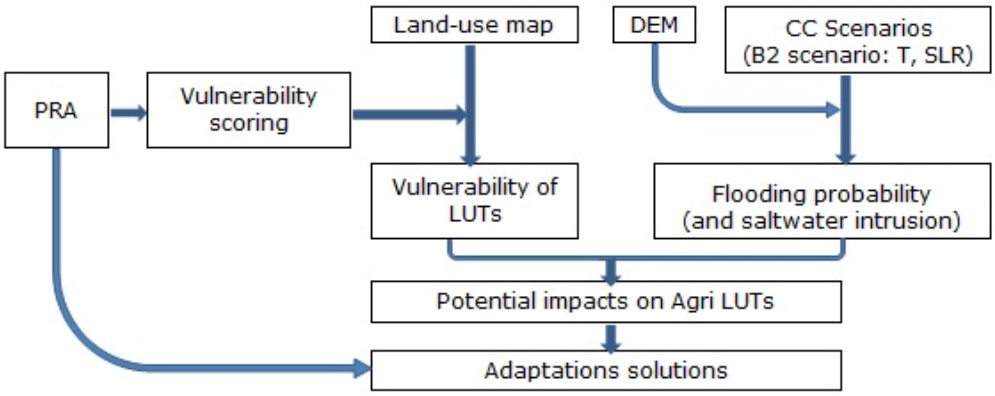


Figure 2: The framework for assessing the impact of flooding on agricultural land uses in Giao Thuy district (38).

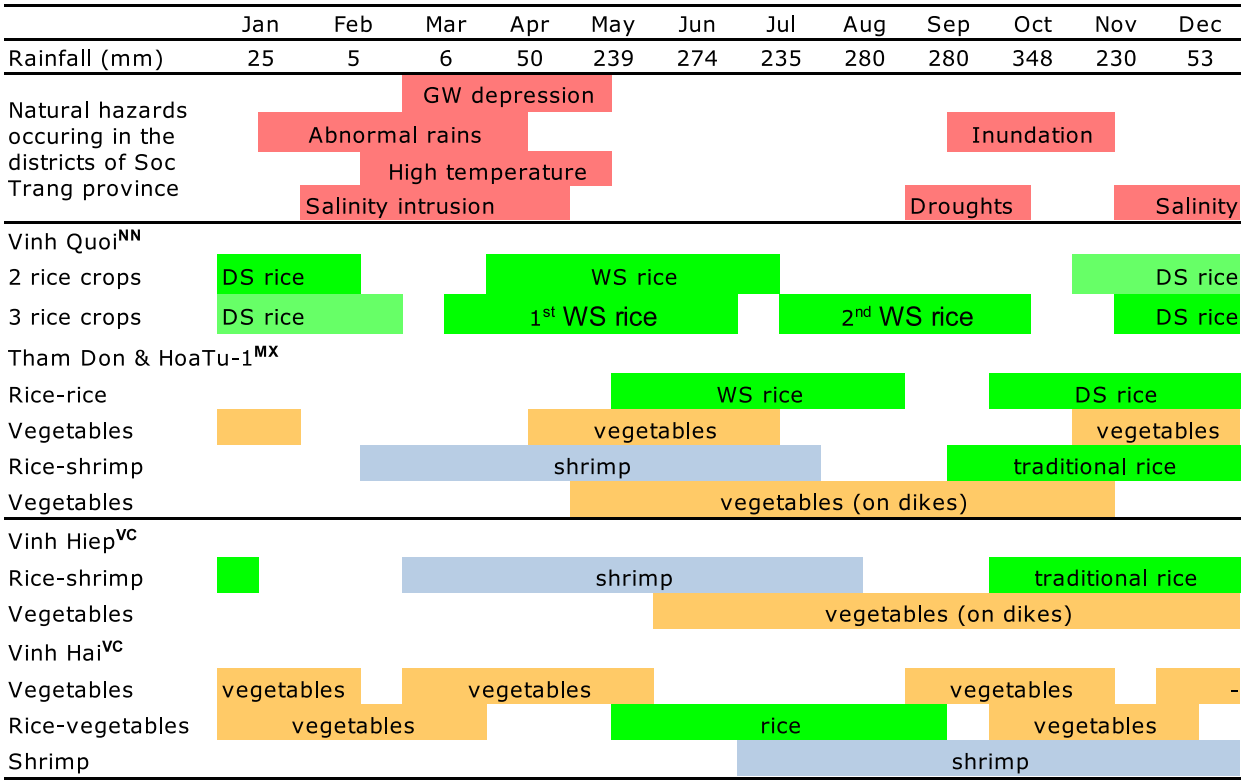
The next step was to validate the secondary data by collecting in-situ data focusing on climatic impacts on existing farming systems and trend of changes. Thereafter the past events were simulated in the CCIM by using a year with extreme flooding (2000) and a year with extreme salinity intrusion (1998) as references for impact of climate change. The CCIM produces maps based on the past trends. The model's simulation results on the impact of past climatic events were validated with the local stakeholders. After this ground truthing, the models were adjusted and fine-tuned as needed.

Step 2: Assess CC impact on land use

Using participatory tools (4, 20), such as calendars, maps, cause-effect trees, and FGDs, the stakeholders assessed CC impacts, for example, flooding characteristics and/or salinity intrusion on their crops. The cropping calendars were superimposed on the predictions of rain and flooding (Figure 3).

To ensure that gender concerns, among others, are included in the analysis of impact, all teams were given a complementary training on FGDs and on gender inclusion in research protocols and methods. Sampling of household was not random but based on representativeness of poor, well-off and rich households (4). Therefore, the work in the hamlets started with wealth ranking, and in the Mekong Delta, within three social groups: (i) old men, (ii) old women, and (iii) mixed young men and women. After the FGDs by wealth category and social group (gender), in-depth interviews were held.

The impact assessments on agriculture were either general, or related to a specific land-use activity in the districts, according to the agreement with the authorities. In Dai Loc and Nga Son, the assessments focused on rice and sedge, respectively. In Giao Thuy and Soc Trang, the assessments concerned all food production systems that were under threat.



Legend: GW= groundwater; DS= dry season; WS= wet season.

Figure 3: The monthly rainfall distribution (mean over 2005-2010) and major natural hazards in the study sites (13), and the cropping calendars of the principal farming system practiced in selected communes in Nga Nam (NN) and My Xuyen (MX) and Vinh Chau (VC) districts (9).

Nga Nam district is dominated by rice paddies that were planted twice or on a limited scale thrice a year. The rice paddies are already threatened by sea water intrusion in the dry season; thus, adaptations in this zone will need either shifting from triple to double rice-crop cultivation with crop diversification, or storing irrigation water in communal canal systems and applying good irrigation practices, in the dry season. In addition, the adaptation strategy aimed to spread the economic risk by diversifying freshwater-based ventures using rainwater, e.g., for growing prawn concurrently with rice, or growing dryland crops and grasses for cattle on the farm dikes.

In My Xuyen district, the main production systems were rice farming (two crops per year) and both freshwater and brackish water aquaculture. Based on the FGDs, however, the brackish water shrimp aquaculture is restrained by water quality issues and less than optimal fluctuating salinity concentrations leading frequently to disease outbreaks and yield losses. The adaptive strategy aims to introduce sediment settlement and "green water" filter basins through which the water is sourced before supplying to the shrimp pond for refreshment (47). To function well, this system requires a combined water ponding surface area (both settlement and green filter ponds) to shrimp pond area ratio of 1:4. If this is a considerable constraint for smallholder shrimp farms, the "green water" ponds to prepare the water might be jointly implemented and managed by a group of shrimp farmers. In addition, the adaptation strategy aimed to spread the economic risk by diversifying freshwater based ventures by using rainwater for e.g. growing prawn concurrently with rice, or growing dryland crops and grasses for cattle on the dikes of the farm.

Vinh Chau district has, next to the dominant intensive brackish shrimp aquaculture, zones with protected mangrove forest, mixed mangrove-shrimp production system and vegetable and fruit production systems, including salt production. Cultivation of vegetable (and to some extent, fruits) has been promoted, but is entirely dependent on the deep phreatic fresh groundwater, which is an unsustainable production stray, as over exploitation of the groundwater will lead to higher pumping costs, increased competition and eventual collapse of the water resources base. The latter is characteristic for those parts of the Vietnamese coasts having narrow elevated sandy strips (Giao Thuy is another example), which are not suitable for aquaculture and deprived of surface freshwater supplies, particularly during the dry season. Dai Loc district, the concern of authorities and farmers was the diminishing rice (*Oriza sativa*) production. This was due to drought, (temporary) abandonment of rice farming and changes in land-use.

In Nga Son district, the issue was on the reduced production of sedge (*Cyperus tegetiformis*). In 2010, sedge farms suffered drought and widespread pest infestation. In general, the yield and quality of the crop declined; thus, in several commune, farmers abandoned sedge farming (28). FGDs and in-depth interviews revealed that, next to the yield, the length of the sedge was also reduced, which consequently resulted in lower farm-gate prices.

In Giao Thuy district, various adaptation responses were tested, such as cultivating salt-tolerant rice varieties, fattening pigs, producing community-based clams, putting up community-based homestay tourism, culturing earthworm, growing fruit with microbial fertilizer and growing mixed fruits, such as new varieties of apple, dragon fruit and grapefruit. Part of these aimed at diversifying the rice-farming to improve farm household livelihoods. During their testing period, these models proved to be effective, but they had limited practical impact, probably due to lack of active participation by the stakeholders during the testing phase.

Step 3: Present the predicted impacts

The predicted impacts should be presented to and discussed with the local stakeholders. Three steps are recommended:

i. Prepare the local climate change impact maps for all or the selected production system(s) in a format which can be shared with local level people;

ii. Consult experts and literature to acquire background data on the local farming systems, their problems and a preliminary list of solutions;
iii. Present the impact maps to the local stakeholders by using FGDs. Participants of the FGDs are local farmers and the local agents in charge of the processes in the concerned hamlet. Hold separate FGDs for each of the following: staff of government, NGOs and private sector, local decision-makers and leaders and male and female producers.

Thus the team needs as many facilitators as the number of groups. When team members have no experience in facilitating FGDs, a short training is provided and after the workshop in a first commune, facilitators and trainers should review the process. FGDs of step 3 should confirm:
(i) description of the local farming systems,
(ii) past impacts and
(iii) expected impacts. When the causes of the impacts are not clear, a complementary study might be needed; this was the case for the sedge value chain in Nga Son (Table 1).

Step 4: Identifying and ranking solutions
After having reached an agreement on the problem analysis with the local stakeholders, the teams review related literature and consult experts to complete the list of solutions. This list was used as a background for the FGDs with the local stakeholders: farmers (women / men), leaders and officers. If no new problems are listed and the list of solutions is comprehensive, then the ranking can be done at the same meeting as the identification. FGDs are then used for stakeholders to complete the list, agree on the solutions and rank the solutions (Tables 2 & 3). The chosen solutions should focus on autonomous adaptation to the CC impacts, i.e., responses to CC that could be implemented at the local level with little or no external assistance.

Criteria to Assess and Rank Solutions
Each solution is assessed for its feasibility of whether or not the stakeholders can implement it autonomously among themselves, or with support from outside based on five to eight criteria. At least the following five criteria should be used: financial, technical, management and labour capacity of the stakeholders to implement the solution, and the expected effectiveness (benefit) of the solutions. These could also be summarized as efficiency, feasibility (3 or 4 issues), and effectiveness. The financial capacity can be assessed for the local (farmer) level, but the extent of support required from outside can be assessed as well (Table 2).
Next to these, the criteria, such as the solution's possible side effect, robustness and flexibility (i.e., ability to combine with other measures) were used by some teams, while neglecting the financial capacity and the need for support from outside (Table 3). The latter led to high ranking of solutions that could not be carried out autonomously. A report should not provide the final ranking only but include the scoring for all criteria, in order to be able to re-assess the ranking. The table which focused on their capacity (Table 2, and Table in (28)) , increased the stakeholders' insights and provided them with a comprehensive information for decision making on actions they can take without depending on external support mechanisms after the test period. The highest ranked solutions could be analysed further by listing the enabling and constraining factors, and suggestions to relieve these constraints.

The ranking of results
Districts which focused on a product (Dai Loc for rice and Nga Son for sedge) had a different way of ranking solutions from those with generic cases. The solutions for the products included both planned (water sharing) and autonomous (changing crop) measures to adapt; including both types of measures that allow stakeholders to plan options for short- and long-term adaptation. The solutions of the generic cases aimed more at the (re)design of production systems. In Soc Trang, improving the efficiency of using fresh water sources to increase farm benefits, was the main goal of all tests.

Table 1

Causes of the reduction of sedge yields based on FGD in Nga Thuy commune and Nga Son district, and percentage of the participants agreeing on the cause (Source: 29).

Causes	Agreement (%)
Market price decrease	98
Fresh water shortage	98
Salt intrusion	92
Extreme weather events (storms, drought, flood)	80
Changes in climate pattern	78
Pests and diseases	74

Table 2

Ranking of solutions based on six criteria of feasibility and financial support from outside (yes/no) for drought-affected rice culture in Dai Loc district (Source: 22).

Solutions	Finance		Technical	Management	Labor	Benefit
	Local	Outside				
Dredging of canals, streams						
- Large scale	Weak	Yes	Weak	Weak	Weak	Strong
- Small scale	Strong	No	Medium	Weak	Strong	Strong
Sheet pile along the river	Strong	No	Strong	Strong	Strong	Strong
Intensive plantation	Weak	Yes	Weak	Medium	Weak	Strong
Scattered plantations	Strong	No	Weak	Strong	Strong	Strong
Water-sharing mechanism	Strong	No	Strong	Strong	Strong	Strong
Changing crop patterns	Medium	Yes	Medium	Medium	Strong	Strong
Drought–tolerant rice	Weak	Yes	Weak	Medium	Strong	Strong

Table 3

Ranking solutions for responses to reducing sedge yield based on average scores for Effectiveness, Reducing the impact of CCA, Side effects, Economic efficiency, Feasibility, ability to combine, Conditions enforcement and Flexibility (Source: 29).

Solution	Average	Ranking
Improve irrigation system	8,6	1
Build and upgrade coastal dike system and fresh water dam	8,3	2
Improve sedge cultivation techniques for better yield & quality	8,1	3
Restructure crop and livestock patterns	7,8	4
Strengthen connection between producers, traders and users	7,6	5
Find a new market for sedge and its products	7,3	6

In Giao Thuy, from among a range of problems, the stakeholders decided to focus only on two solutions that can be realized at the household level. The first solution was for farmers to grow a new melon variety by using compost to recycle waste, while simultaneously linking them to the value chain for the inputs, techniques and marketing (37). The second solution was to test an ecological aquaculture pond management technique to produce white shrimp in polyculture with red tilapia (27).

Step 5: Testing prioritized solutions

For the highest ranked solution(s) the team elaborated experimental plans together with the local stakeholders. Testing these solutions on-farm can either be simple, but may also require training or assistance from specific experts, as in the case of Giao Thuy (value chain) and Dai Loc (participatory water management). To prepare the teams for the on-farm trials, researchers provided training on the conception of research embedded in sustainable rural development to some team members.

Farming in coastal Mekong Delta

The test to improve water productivity in irrigated rice farming systems through the Alternate Wet/Dry rice farming was very successful in Nga Nam and included in the package of the provincial extension agents (8). To improve the sustainability of rice-shrimp farming systems in the brackish area three options to increase the availability of fresh water were considered, of which two were evaluated theoretically. In theory, the option to store water in the canal system for rice irrigation during peaks of saline intrusion would provide enough water, but this could not be tested in the field given constraints, such as large area of rice field to be affected and high investment cost (48).

The option to store water in flood plains in provinces further upstream was also evaluated (Box 2). Instead of these communal adaptations, a household-scale model was tested (8, 9).

Box 2

Climate change adaptation in the Mekong Delta: giving room for water in upstream areas (12).

One of the strategies to increase the availability of fresh water of the coastal Mekong delta provinces in the dry season would be to extend/increase the water storage in the upstream floodplains in An Giang province, where the Mekong River first enters into Vietnam. This study explored this alternative through function analysis and a multi-criteria analysis (MCA) to evaluate the best adaptation option for water scarcity with data collected through desk studies, and structured interviews of stakeholders, including households and local experts. Using indicators for land-use, the researcher identified two study sites: 24 ha of crop land near Binh Thien Lake and 245 ha from the Tra Su forest.

Four alternatives for water storage were evaluated: expanded lakes, community ponds, natural wetlands and household ponds by using the following criteria: effectiveness, implementation cost, loss of annual yield, preserving biodiversity, benefits from aqua-products, capability for expansion, public access, and human health and safety. A function analysis was applied to both study sites to identify the current functions and services of ecosystem. The potential losses and gains of these functions and services for each measure were quantified. The interested participating stakeholders determined different weights for the criteria.

The MCA shows that expanding Binh Thien Lake is the best adaptation option for the first research area, and transforming in natural wetlands is the preferred option for Tra Su forest. In the Binh Thien area, the provincial government has policy instruments to support the implementation. However, in the forest area, the consequence of longer flooding for the biodiversity should be assessed.

The techniques to improve productivity and resilience of integrated mangrove-shrimp farming were successfully demonstrated. Cleaning and dredging the pond, post-larvae nursing and supplying additional shrimp seeds improved the yield of shrimp and other aquatic animals. Total production costs of the pilot farms were lower compared with both the control farms and before intervention in 2012, while gross and net incomes of pilot farms were higher (40).

tTo sustainably produce dryland crops in Soc Trang, local authorities and farmers need to design and use production systems that do not depend on the deep phreatic water. Though technically feasible, solutions, such as buying and/or constructing large storage tanks and installing drip irrigation systems are not economically feasible; thus, shifting to various other mixed systems was tested ((9) and (Box 3).

Water-sharing mechanism in Dai Loc

To elaborate the water-sharing mechanism, the Dai Loc team measured and mapped all waterways for two cases: hydropower vs. irrigation in the Suoi Mo basin (a conflict between Dai Quang and Dai Dong commune, and drinking vs. irrigation in Suoi Tho basin in Dai Quang commune. The team separately met with each stakeholder group of three communes, including the electricity and water companies. The team used PRA tools, such as power mapping matrix, Venn diagram, crop and irrigation calendars, and problem and solution trees ((22), and Table 4). During this process, the team was advised by a WUR expert on participatory water management. After several rounds of consultation, a water-sharing protocol was signed by leaders of the involved parties. The protocol included an autonomous funding mechanism for the monitoring.

Box 3

Improved fresh water storage at household level.

In My Xuyen district, three groups of farm households tested new techniques on water storage: (i) six piloted the storage of water in their pond area, (ii) eight were early adopters of storage ponds, and (iii) six continued their normal practice of shrimp farming without storage pond, but tested the culture of upland crops and grass for cattle on the dikes. Farmers stocked Nile tilapia with low density to improve the quality of the inlet water for the shrimp in the storage pond occupying 15 to 20% of the shrimp farming area. After harvesting the tiger shrimp, farmers raised white leg shrimp (*Litopenaeus vannamei*) in the storage pond.

The first group raised tiger shrimp (*Penaeus monodon*) with low stocking density. The second group tested the feasibility of raising freshwater prawn (*Macrobrachium rosenbergii*) in the rice field. Before the wet season, freshwater prawn juveniles were raised in a pond for 2 to 3 months, and when rice had reached an acceptable height, shrimps having 3-5 cm were released at low stocking density (0.5-1.0 shrimp/m^2 water surface).

The storage pond improved the water quality, shortened the shrimp farming cycle and reduced the feeding costs; the first two contributed to reducing the disease risk. Stocking white leg shrimp in the storage pond after harvest of the tiger shrimp gained high financial returns. Freshwater prawn farming in rice fields did not affect the rice yield. Stocking 1.0 shrimp/m^2 water surface had a higher yield than stocking at a density of 0.5 shrimp/m^2. Growing vegetables and grass for fodder on pond dikes made a high financial return (8, 9). Cultivating these 'upland' crops would provide a higher income if farmers would do two crops/year, or combine vegetables with sorghum to produce feed for livestock. Growing sorghum mulched with rice straw yielded about 30% more than that without mulch. Farmers integrating all three practices got higher economic returns than that from the traditional tiger shrimp-rice farming system.

Table 4

Overview of the data and methods used for the pilot in Dai Loc district (Source: 25).

Objective	Input data	Tools/Methodology	Expected Output
1. Analyse the trends of rainfall and temperature (min-max) from 1978 to 2013 and 2014 to 2050.	Rainfall, T (daily min-max) from 1978 to 2013 Rainfall, min-max T in future (period 2014-2050)	Primary data collection in Excel Analyse the outputs of the RCM model or MONRE 2012	The tendency of climatic factors from1978-2013 Explore the tendency of rain and T (2014-2050); Calculate SPI (Standardized Precipitation Index)
2. Assess drought index and identify future potential drought hazard areas.	Current land use map, soil map, topographical map. Satellite images: Landsat, NOAA/AVHRR Existing drought map (if available). Climate change scenarios of district. Information about drought hazard; including: frequency, intensity, time, area…	Secondary data collection. Interpret satellite images with ENVI and ArcGIS. Secondary data collection. Participatory Rapid Assessment (PRA).	+ Landsat to detect land use/cover change (1978 -2013) + NOAA/AVHRR to calculate Normalized Difference Vegetation Index (NDVI) from 1978 -2013 Scenarios of drought for Dai Loc at present and in future
3. Evaluating the predicted impacts of climate change (drought) on the present and future cropping calendar, focusing on rice production.	Land use planning map. Influence of climate change (drought) to rice production (seasonal yield, cultivated area, irrigated sources, gender…). Simulate the influences of climate change (drought) on rice production till 2050.	Secondary data collection. PRA and Stakeholder analysis. Observe and assess seasonal variations. GIS & SPI tool. GIS, SPI and PRA.	Assess the influence of climate change to rice production at present and in future
4. Inform stakeholders: local decision-makers & representatives of producers.	Presentations of the modelling results. Discussion guidelines.	Break-out group discussions. SWOT analysis.	Validation of the model results; Pilot sites for testing adaptation/mitigation measures.
5. Identify and design solutions to adapt with climate change.	Information of resource persons, literature and experts; Local people's experiences; A list of options for adaptation and mitigation in Dai Loc, Quang Nam.	Secondary data collection; Focus Group Discussions (FGDs) and expert/literature consultation.	A list of test to be carried out at farm / hamlet/ district level; list of hamlets were this can be done; planning.
6. Feedback to the district and decision on the adaptation tests to carry out.	District leaders (district people committee e.g. vice head of the district), DARD, DONRE, Irrigation company, Dyke protection unit. Representatives from communes where the agricultural land uses are vulnerable (commune leaders, farmers).	Presentations, round table and break-out groups to discuss and agree upon the suggested options.	

Recovering the sedge yields

In order to propose technologies to recover the sedge yield, the team carried out preliminary on-station trials near the stakeholder's residences. The first trial assessed the use of an organo-mineral fertiliser (46), and the second one demonstrated the effect of reducing urea and adding Silicium to correct the micro-nutrient balance (28).

The results were presented to and discussed with the stakeholders, agents of the extension services, interested local farmers and representatives of farmers from neighbouring communes. Discussions used open questions to analyse the results together, and were done in three FGDs: one group each for officers, female farmers and male farmers. Though the trials did not demonstrate a full recovery, these clearly showed that the farmers had been applying high dosage of N, low K and non or too little organic matter. Twelve farmers registered for an on-farm experiment with an adapted fertilizer regime.

Red River delta

In the Red River delta, two adaptation models were tested: the introduction of a technology package with a new Melon variety (37) and the polyculture of shrimp with red-tilapia (27). The design of an agronomic trial to test a new melon variety in Giao Thuy was simple for the responsible team. However, the farmers needed to be trained in composting and in culturing the new variety; this was done by the seed company. Moreover, to ensure that the participating farmers could avail of the correct inputs and a market for the new variety, the researchers embedded the value-chain concept in the minds of the farmers right at the start of the trial. The value-chain analysis allowed the farmers, who were willing to engage in the market, to benefit from the new melon variety (37).

Step 6: Evaluating the tests

In the Mekong Delta, the Alternate Wet/Dry rice farming and the options to improve water management for shrimp farming at household level were included in the package of the extension agents of Soc Trang province. Rules of the contracts for mixed mangrove–shrimp farming in the special use forests were adjusted. Although producing vegetables at large scale remains an option for the farmers, converting to growing sorghum for livestock farming seems the better one to consider.

After the trial period, the teams of Dai Loc and Giao Thuy evaluated the implementation. In Giao Thuy, this evaluation consisted of two straightforward steps: i) listing the constraints and advantages experienced by the participants, and ii) counting the number (%) of farmers who continued to use the new melon variety in the next season (37). The Dai Loc team surveyed the stakeholders and held two plenary meetings to assess the satisfaction on the two equitable water-sharing mechanisms. Overall the stakeholders were very satisfied as no conflict had occurred; all had reached their goals and funding for implementation in the next season was ensured (22). Both cases that had completed the cycle could recommend to the authorities a broader implementation of the solutions.

However, when responses are insufficient to deal with the predicted impacts, the team would need to further analyse the evaluation, and then redesign the solution or propose to implement one of the other solutions that has more constraints, according to the initial assessment of step 4, but which might be more effective.

Step 7: Reporting to the authorities

The last step is to inform the requesting authorities on the results of the tests on the assessment and the development of CC responses. This meeting is also an opportunity to inform or remind these authorities about other challenges and options for follow-up when responses were insufficient. When relevant, the authorities can call upon the university to assist them in identifying responses to CC threats to other sectors. This would make the CCA research a double-edged sword: cutting through both research &training for university staff &students, while simultaneously responding to CC concerns at the local level.

Discussion

As the impact of climate change and resources utilization gets more intense so that the natural resources base, both in quantity (inundation and flood hazards, droughts and water shortages) and quality (salinity intrusion, waste management, sedimentation and fertilization) within agricultural systems and production come under duress, the call to redress these effects on the resources base increases.

The usual response is a quest for planned adaptation. The six described cases using the seven-step approach show conscious anticipatory actions to stimulate autonomous CC adaptation and contain three interwoven restorative themes:

(i) Putting up multi-functional natural resources (water and land) management arrangements, not only to provide specific natural resource functions, but also to combine with direct agricultural production practices.

(ii) Designing climate-smart agricultural production systems that embed technical and social empowerment, good market/profit offer within CC adaptation responses, and

(iii) Enhancing autonomous adaptation that requires human resources and training, as well as creativity and flexibility.

Multiple functions of water

A central feature of the agriculture-based CC adaptation approaches described above, lies in the establishment of multifunctional agricultural systems that provide for the CC adaptation based on water availability. The functions of water for ecology and food production are optimised in an integrated production system that is specifically tailored and nested within its landscape and natural resources base. Safeguarding existing production systems tends to resort in calls for infrastructural measures such as flood protection dykes.

These planned adaptations increase the regulation capacity of the water resources base that depends on government funding and community external interventions. But the more the pressures and impacts on the resources base increase, the more the technical options and cost-effectiveness of such measures become delimiting (32), while at the long term, the production might decrease (24).

With the proposed agriculture-based CC adaptation approach, the CC impacts and adaptation measures are internalised, rather than externalised, becoming central features of a multifunctional production system. In these specific CC-adaptation functions – e.g., flood protection, water retention for drought spells, water purification etc. – are purposely shaped within the landscape and natural resources management arrangements to not only provide specific water (or natural resources) regulation functions to the agricultural production system, but also to combine with direct production functions. Thus, (i) retention of fresh water for rice cultivation in canals or lakes is combined with fresh aquaculture and forestry biodiversity, whilst safeguarding the water supply for biodiversity; or (ii) polyculture-based brackish aquaculture systems with retentions/settling basins to enable the storage of fresh brackish water with good water quality (sanitary, salinity & waste), the production of seafood and waste treatment; or (iii) the provision of drinking water and electricity to complement to food production. In essence, the multi-functionality is given shape by purposely combining and exploiting the inherent multiple ecosystem services (6, 30, 50) and aligning these for multiple uses and services – within a natural resources system (fish & water retention) and across systems (water retention & irrigated rice).

Smart design of production systems

The historical alignment of apparently successful trials in Giao Thuy district, followed by no or weak adoption of the tested technologies, shows that developing adaptations that are effectively taken-up require a participatory approach.

In our case, establishing the water-sharing mechanism required more complex negotiation skills that were not yet available in the community. Once these negotiation skills were embedded at local level through series of trainings, the adaptation by respective stakeholders became more autonomous; but would still require some level of planning in the future.

In their decision for autonomous adaptations, farmers do consider factors relating to the market and economic profitability (1, 17, 18, 25, 33). Therefore, farmers having a good profit margin tended to adapt various methods more autonomously to counteract drought (39), as shown also through the adoption by some other farmers of the new melon variety with a technology package and with good market opportunities after the trial (37). The market element confirms the findings of Fujisawa *et al.* (16) who stated that adaptation policies deployed through sale channels tend to be more successful.

The reluctance of farmers in Dai Loc to shift away from rice, an important commodity for their household's food security, is supported by findings from other authors (42, 2). The six cases demonstrated that the solutions are not outlined from the start, but gradually develop from scratch in consensus between and among the stakeholders.

Stimulating autonomous adaptation

Climate change adaptation includes planned or autonomous actions to enhance the resilience against increasing influences of climate change (35). The implementation of the two fair water-sharing arrangements required many rounds of consultations and signing of contracts, but were successfully implemented in the first year. The rice crop did not fail, and although the electricity company had to accept a lower turn-over, all stakeholders were satisfied with the results and agreed on permanent funding mechanisms for the control. Thus, the water-sharing mechanism should be classified as planned adaptation.

While enhancing household's capacity to adapt to impacts of climate change, the positively tested farming systems required management skills and family labour resources. Promoting farming practices demanding new skills might require support from the government and new services either from public or private partner, particularly for training, credit, input supply and marketing. However, most of the adjusted agricultural practices can spread autonomously from farm to farm (group to group) without government support, if input supply and marketing is not regulated. These adaptations included: alternate wet/dry rice farming, increased on-farm water storage, melon cultivation, polyculture of tilapia and shrimp. The autonomous response usually happens when farmers perceive the benefits or observe the good experiences from others (16, 41).

In some cases, these responses might require (i) first a participatory technology development (20) as done in the proposed step 4, 5 and 6, and (ii) the assistance of a training program by the regular extension services (1). Then, preferably these services organise innovation platforms where farmers exchange know-how (26).

In general, the pilots learned that supporting conscious anticipatory interventions that stimulate autonomous climate change adaptation requires creative and flexible institutions and their respective staff. Nevertheless, increased output from improved integrated farming would also create opportunities for rural employment and market development, which would pay for the complementary public investments.

In most cases, the implementation of the seven steps required training and expert's guidance of the teams on several technical and social tools (Figure 2 and Table 4). Using PRA tools, such as the FGDs to engage the farmers seems easy, but we learned that some trainings are required to obtain good results. Moreover scientist and policymakers tend to neglect the importance of separating farmers from officers and men from women in different FGDs. Giving each person the opportunity to talk is crucial for obtaining all relevant information and support from all groups (4).

Conclusion

The design and establishment of an agriculture-based CC adaptation, as described above, place specific requirements on an integrated and interdisciplinary resources management approach. The first requirement is a multi- (or inter-) disciplinary assessment together with an understanding of the biophysical system. This type of assessment considers the dynamic behaviour of the natural resources base across the realms of climate, water management & hydrology, soils and ecology. The second requires a holistic identification of agricultural production systems that cuts across the broad spectre of crops, aquaculture, fisheries, animal husbandry, (agro)forestry, and ecology. The third considers the social & institutional realms of rethinking on natural resources management arrangements in the context of community stewardship (either private or community enterprise form) of management and exploitation of multiple services. The fourth emphasises the spatial planning and congruent alignment of multiple systems and functions (or ecosystem services) – both at community and river or delta scale. Specific

demands in this case are on coordination and integration of plans, policies and regulations across institutional governance levels. These same elements were likewise highlighted in the recent established Mekong Delta Plan.

Using the seven-step approach, the two projects developed climate change responses for the most felt problems which all revolved around water in the districts of Nga Nam, My Xuyen and Vinh Chau in Soc Trang province, and in the districts Giao Thuy (Nam Dinh province) and Dai Loc (Quang Nam province). The experiment in Nga Son demonstrated that climate change can be a scapegoat for poor management and maintenance practices.

Most responses related to improving farming practices of one (rice, melon) or more crops (rice-shrimp, rice-grass or other dry-land crops, tilapia-shrimp), or to increasing on-farm water storage capacity combined with shrimp farming. Crucial for the adoption of a new variety (melon) was the integration of all value chain actors in the trial phase. The response regarding the mangrove-shrimp farming on land, with limited user rights, required changes in the contractual rules on dredging of canals; thus, the need to involve institutions in charge of forest management. Most of the autonomous adaptations were complex and could be developed only by multidisciplinary teams. To be successful even for the introduction of a single new crop variety, all interested value-chain actors needed to be associated to the trials. Except for the water-sharing mechanisms, these adaptations could be realized without engaging in political advocacy. Higher-scale planned adaptations, e.g., of increasing water storage in canals or in upstream flood-plains, are often cross-border issues, and even for district borders, these required negotiation at a higher hierarchical level by politicians or NGOs.

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Adapting the Melon Production Model to Climate Change in Giao Thuy District, Nam Dinh Province, Vietnam

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Keywords: Climate change- Melon- Salinity- South East Asia- Red River delta- Vietnam

Summary

Embedded in a package of climate change adaptation, researchers and farmers tested the melon hybrid variety, Kim Hoang Hau (KHH), for yield and disease resistance during the spring-summer season from March to June 2015 in Giao Thuy district, Nam Dinh province. The results were analysed and subsequently discussed with local farmers in focused groups. Analysis showed that the KHH was suitable to local soil conditions. The farmers preferred this new variety over the local melon, because not only did KHH give higher yield and pest resistance, it also showed less vulnerability to climatic stressors. Farmers decided to grow KHH based on the prevailing good market price at that time. However, farmers only shifted away from the old melon when they could anticipate the possibility of selling the new product. Those who did not continue with the KHH had difficulty in actively accessing the market for this new product. This study suggests that the market information does not solely drive the process of the adaptation itself, but it also provides relevant stimuli to farmers enabling them to successfully shift to new crop varieties. This study also implies that such process-based understanding is crucial in formulating strategies that increase the farmer's capacity to adapt to climate change.

Résumé

Adaptation de la production du melon aux changements climatiques dans le district de Giao Thuy dans la Province Nam Dinh, Vietnam

Impliqués dans une approche participative d'adaptation aux changements climatiques, des chercheurs ont évalués la productivité et la résistance aux maladies de la variété hybride du melon Kim Hoang Hau (KHH) avec la variété locale. L'étude a eu lieu entre mars et juin 2015. Les résultats obtenus ont été analysés et ensuite discutés avec les producteurs. L'analyse a montré que les conditions locales du sol étaient appropriées pour la culture du KHH. Les producteurs préféraient la variété KHH par rapport au melon local, car la KHH avait non seulement un rendement meilleur mais aussi une meilleure résistance aux maladies et était également tolérante au stress climatique. Les producteurs ont choisi de cultiver la variété KHH vu que le prix de marché était prometteur. Cependant, les agriculteurs n'ont abandonné la variété locale que lorsqu'ils pouvaient espérer avoir la possibilité de vendre le nouveau produit.. Ceux qui n'ont pas adopté la variété KHH étaient ceux qui avaient éprouvé des difficultés à écouler leur produit sur le marché. L'étude suggère que l'information sur la demande et l'offre sur le marché incite le processus d'adoption et stimule les agriculteurs à adopter la nouvelle variété de melon. Les résultats de cette étude montrent que la compréhension du processus de production est crucial pour la formulation des stratégies afin d'accroître la capacité des agriculteurs à s'adapter aux changements climatiques.

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Introduction

Giao Thuy district of Nam Dinh province is located in the coastal region of Red river delta where crop production is highly vulnerable to climate change. The major agricultural production types in the district include paddy rice and annual crop cultivation, animal husbandry, mangrove forest management and protection, aquaculture, and salt production. Every year, local farmers face high risks due to erratic weather which leads to the reduction of crop yield and farmers' income. Recent research shows a declining trend in quality of soil and water in Giao Thuy (3, 4, 6). The impact of extreme weather events such as erratic rainfall pattern, increased intensity of hot and cold spells and saltwater intrusion has brought major challenges for local agricultural producers (5).

Currently, a number of adaptation solutions to climate change have been tested in Giao Thuy district, such as the RVT salt-tolerant paddy rice variety cultivation, pig raising in organic litter, building community-based adaptation models, community tourism, earthworm farming, fruit plantation using organic fertilizers and renovated home gardening with new fruit trees, such as apple, red dragon and pomelo. These solutions have been implemented effectively at the beginning but could not be sustained, most probably due to the non-inclusion of market information in the research approach (6).

Local farmers, in fact, have demonstrated active adaptation to climate change by spontaneously applying new crop varieties or changing cropping pattern to adapt to impacts of climate change and unstable markets. These adaptation measures have also been identified and studied in previous research study (1). However, the driving force of the changes still has not been well understood. Whether or not shifting crops reflects the adaptation to Climate Change or to market stimuli remains a question.

This study analysed the driving forces of adaptation in annual crops cultivation and determined the adaptation process at individual household-scale for a new melon variety (KHH) known for its many good traits, including resistance to diseases, vigorous growth, high yield, good quality, attractiveness and high selling price.

The efficiency of the local farmer's adaptation process in cultivating this new melon variety and in selling its products parallel to climatic and environmental changes were probed. Other factors, such as agricultural policy, and labour and market demands were also analysed. Key research questions asked in this study were:

(i) Can the introduction of KHH be a suitable CC adaptive solution for Giao Thuy district?
(ii) What is the determinant driving force to make the adaptive solution applicable in the locality?

Materials and Methods

Experimental protocol

Six farm households categorised into 3 groups based on income and skills (2 better-off, 2 middle and two 2 low) were selected for the trial in Giao Thuy district.

Materials used for testing the new cultivation model included

(i) KHH-F1 melon seeds provided by the East-West Seed company (http://www.eastwestseed.com/);
(ii) Seeds of the local pear-shaped melon which is most popular among local growers (Gia Huy variety from Nong Huu company);
(iii) Plastic cover sheet and
(iv) Fertilizers: Song Gianh NPK <20-0-12>, super phosphorus, bio- fertilizer "super humate", manure and lime powder. The characteristics of these two varieties are in Table 1 (8, 9).

At each selected farm, 1440 m^2 of homogenous arable land was split into 2 equal plots: the KHH treatment and the control with local melon. The cultivation technique was applied based on the guideline of East-West Seed Company. The crop was cultivated in the spring-summer season, from March to June 2015. During the experiment, soil quality, plant growth, pest & disease damages, yield, cost, income and labour issues were monitored. The results were analysed and subsequently discussed with local farmers in focused groups.

Table 1

Characteristics of KHH-F1 (experiment) and local pear shaped melon (control).

Variety	Growth period (day)	Fruit weight (kg)	Brix (°)	Yield (ton/ha)
KHH	62 – 65	1.5 – 1.8	16 – 18	22 – 25
Pear shaped (local)	55 – 60	0.4 – 0.5	14 – 17	14 – 20

Table 2

Chemical soil parameters and the analytical methods.

Parameters	Method of analysis
pH-KCl	TCVN5979:2007
OC:	TCVN 4050:1985
P_2O_5 ts	TCVN 4052:1985
K_2O ts	TCVN 8660:2011
K_2O dt	TCVN 8569:2010
P_2O_5 dt	TCVN 5256:1990
Ndt	TCVN5255:2009
EC:	TCVN 6650:2000
SO_4^{2-}	TCVN 6656:2000
Cl^-	Soils & Fertilizer Institute (SFI)

Soil sampling and analysis

Soil samples from the top 20cm layer were taken at the experimental farms. At each farm, 5 samples were taken and mixed into 1 common sample, and analysed in the Soil-Water and Environment Laboratory of Vietnam National University of Agriculture (VNUA) in Hanoi. Table 2 lists the soil parameters and analysis methods. The soil parameters were evaluated by comparing these with the standards in the "Handbook of agricultural land use" (10).

Fruit characteristics

Fruit diameter, fruit height and flesh thickness were measured by using a vernier calliper (cm). The degree Brix was measured with a hand-held Brix degree refractometer. Infection by diseases was scored according to the guideline of the World Vegetable Centre, formerly the Asian Vegetable Research & Development Centre (htttp://avdrc.org) (see Table 9).

Household interview and Focus group discussion

To assess adaptive ability of local communities, three consecutive surveys/interviews were conducted: before melon plantation, immediately after melon harvesting and one year later. The last survey was followed by an in-depth interview to determine which factors influenced the continued cultivation of new high-yielding melon varieties and what reasons made them discontinue with the new melon variety.

To determine the adaptation of cultivation practices in the context of climate change and local market, researchers used semi-structured questionnaire in interviewing 6 selected households who participated in the model design. The questionnaire consisted of 3 components:

(i) general information of the households, crop cultivation, land, farming practices, labour and household income;

(ii) Changes in melon cultivation during the last 5 years (seedling, land cultivated area, harvesting, market and reasons for changes);

(iii) Local farmers' response to external impacts, including climate change, market and ranking the degree of impact, as well as the reaction of the local people.

Focused group discussions (FGD) were conducted to collect information about climate phenomena and market demands. The first FGD with representatives of the six households and the village authorities was held before planting melons. To analyse market accessibility, researchers conducted the second FGD before melon harvesting by engaging the same participants from the first FGD, but adding 5 melon buyers as respondents from the district.

Data analysis

To compare and assess the adaptive ability of local households, this study invited three local authorities and five farmers who had not participated in the experiment. These respondents were asked to score three variables: experimental farm's labour availability, market accessibility and its owner's skills. These three were scored within the range of 0 – 10, a higher mark representing better scores for the households. Farm households were categorized into classes by the K-mean method (2) that was run in SPSS® 16.0 software.

The percentage of fruit produced was calculated by counting the total flowers and the successful fruits from 10 random selected plants at each plot at flowering and before harvesting (%).

Results

The study area

The elevation of the study ranged from 2.3 m to 7.0 m above sea level (Figure 1). Soil of agricultural land in the study area was mostly sandy loam which is quite suitable for melon cultivation (Table 3). The soils were slightly alkaline (pH> 7), and most of the farms had rich total and available phosphorus contents (P_2O_5>0.1% and > 15mg/100g soil). The total and available potassium (K_2O) contents were poor, ranging of 1.0 to 2.0% and <10 mg/100g soil, respectively. Among 6 experimental farms, only one had a good cation exchange capacity (EC=1.07), while the other farms had an EC far below 1. One farm had a moderate saline soil (Cl^- = 0.2%).

The study area is characterised by typical coastal climate of the Red River delta, generally suitable for planting melons. FGDs with participants gathered five extreme weather-based reasons that caused damage on melon production, namely: typhoons, heavy rains, very cold and hot spells, drizzling rains and salty fog from the sea (Table 4).

Farmers in Giao Thuy raise five main crops: peanuts, watermelon, musk melon, kohlrabi and cabbage. A small number of households cultivate rice in summer season (late July to early November). The popular land-use patterns are

(i) spring-summer season with melon/summer-autumn melon or watermelon-winter vegetable, or

(ii) spring peanut/early-summer melon-winter vegetable and potato. The crop calendar is described in Table 5.

For melon crops, the problems causing the most impact were:

(i) salty fog from the sea during the dry season (January-March) which damaged leaves and

(ii) flooding due to excessive rain during summer-autumn melon season. In addition, the pests, thrips and aphids caused major damage to the melon plants. Farmers commonly used pesticides and planted new melon varieties as their adaptive measures.

Two major channels provided them with melon seeds: seed companies coming and introducing their seeds directly; and local dealers/agencies offering seeds to them. Melon fruits went through 3 market channels:

(i) local retailers collecting at the field gate;

(ii) traders collecting at the farm gate and transporting to the cities and

(iii) producers selling at the local market. Market demands and prices are often not stable. New melon varieties with large fruits are often difficult to sell in the local markets due to high price.

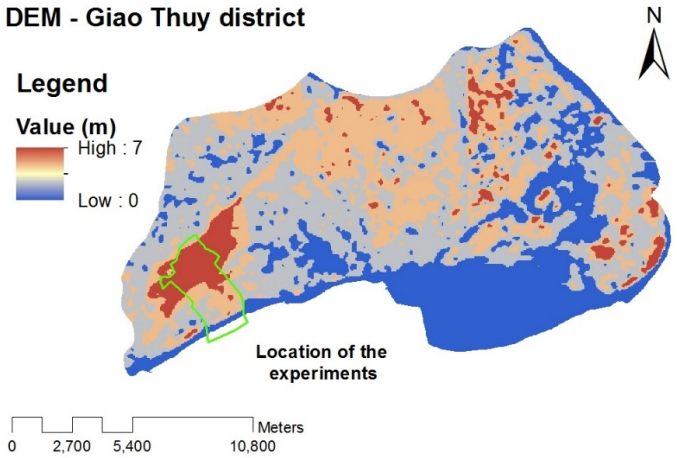

Figure 1: Digital Elevation Model (DEM) for Giao Thuy district.

Table 3

Soil characteristics at the experimental farms.

Farm code	pH_{KCl}	OC (%)	P_2O_5 (%)	K_2O (%)	P_2O_5 mg/100g	K_2O mg/100g	EC	SO_4^{2-} (%)	Cl^- (%)
1	7,45	0,26	0,13	1,68	65,4	5,4	1,07	0,01	0,207
2	7,38	0,21	0,13	1,66	95,1	5,7	0,14	0,004	0,037
3	7,39	0,27	0,14	1,48	60,7	5,7	0,08	0,006	0,028
4	7,32	0,21	0,08	1,66	32,8	16,9	0,13	0,006	0,038
5	7,26	0,44	0,16	1,67	103,4	7,1	0,13	0,006	0,04
6	7,43	0,23	0,18	1,72	98,5	6,6	0,14	0,005	0,035

Table 4

Weather extreme events effecting the melon production.

Phenomena	Period	Local definition
Typhoon	Aug-Oct, late typhoon in Nov	Strong typhoon > 12 Beaufort; destroys crops
Very cold spell	Feb – Mar 3	Very cold (<10°C)
Heavy rain, late rain	End of July – Sep, late rain in Oct	High Intensity, locally flooded
Very hot spell	End of May – July	> 40°C, causes crop' roots rottening
Drizzling rain	Feb – Mar	Mild drizzle, Humid, crop diseases
Salty fog from the sea	Jan – Mar	Fog in the morning and evening, Salt particles cover on the leaves -> withered leaves

Table 5

The crop calendar with pear-shaped melon (PSM), water melon (WM), and mixed PS/WM at Giao Thuy.

Crops	Season	Winter			Spring		Summer				Autumn		
	Month	12	1	2	3	4	5	6	7	8	9	10	11
Spring peanut													
Melon						PSM				WM or PSM/WM			
Winter potato Vegetables (Kohlrabi, cabbage etc)													

Table 6

Characteristics of participating households (HH).

HH code	Skill/ Experience	Labour availability	Market assess	HH group
1	9	8	7	I
2	10	10	10	I
3	9	1	7	II
4	6	3	5	II
5	5	6	3	II
6	-	-	-	-

The scores given by FGD: 10 is best; 1 is worst;

I: High capacity to adopt a new melon variety;

II: Low capacity to adopt a new melon variety.

Local melon growers often find traders selling melon products to big cities. Farmers reported that if they do not want to take risks, they would choose to plant the local pear-shaped melon varieties despite the lower price compared with that of the new melon varieties, because the local fruits were easier to sell at the local markets.

Household categorization

During the experiment, five of six participating households successfully completed the trial. The sixth household did not follow the cultivation technique provided, and all their melon plants suddenly died after about one month of cultivation. Thus, the analysis below includes only the remaining five experimenting farms.

The household classification based on K-mean clustering method provided two different household groups (Table 6). Group one consisted of two households having excellent cultivation skills, good labour availability for melon farming and better market access. The second group had overall lower scores, while one farm scored low only for labour availability.

Melon plant growth

The variation on fruiting rate in the experimental farms is large (Table 7). Therefore, the comparative analysis was conducted only between plots within the same household, but not for groups (see the last column). Both households belonging to group 1 had higher rates, while two of group II had a lower rate; the high fruit rate of one farmer in group II, household 5, can be explained by the high values in available phosphorus and potassium (Table 3). The results show that households with high capacity to adopt a new melon variety (group I) could perform farming techniques better than others.

Fruit characteristics

The fruit of the KHH variety is larger and has thicker flesh than that of the local melon. The degree of Brix measured for the flesh of the KHH was lower; thus, the taste is not as sweet as that of the local melon (Table 8). However, some farmers said that the KHH had better aroma and taste.

Table 7

Percentage of fruit produced in the model in comparison with control.

HH code	HH group	Fruit produced (%)		Ratio KHH/Local
		KHH	Local melon	
1	I	100	60	1,67
2	I	85	70	1,21
3	II	20	70	0,29
4	II	50	60	0,83
5	II	95	65	1,46
Mean ±SD		70 ±30.5	65 ±4.5	

Table 8

Fruit characteristics of KHH and local melons

Variety	Fruit diameter (cm)	Fruit height (cm)	Flesh thickness (cm)	Degree Brix (%)
KHH	15,7	17,3	4,1	13,8
Local melon	11,3	12,6	2,3	14,3

Table 9

Farmers' Scores on seriousness of damage caused by some pests on melon.

HH code	Aphids		Thrips		Downy mildew		Wilt **	
	KHH	Local	KHH	Local	KHH	Local	KHH	Local (%)
1	5	1	3	3	1	1	0	6,7
2	1	2	2	1	1	1	1	2
3	2	2	1	1	1	2	2	4
4	3	1	2	2	2	1	2	5,3
5	3	2	4	3	1	1	1	2

Note: a Scores of infection by diseases were determined according to the guideline of AVRDC as 0: no symptom of disease (no infection), 1: 19% of leaf area was infected (very slight infection), 2: 20-39% of leaf area was infected (slight infection), 3: 40-59% of leaf area was infected (medium infection), 4: 60-79% of leaf area was infected (severe infection), 5: >80% of leaf area was infected (very severe infection).

Diseases

Based on FGD results, KHH scored slightly higher on the incidence of pests and diseases than the local variety (Table 9). However the percentage of plants infected by bacterial wilt was lower for the new variety.

Melon productivity

The yield of KHH was significantly lower than that of the control local melon (Table 10). Average gross income from the control was also higher, but the income obtained from KHH by group I was as good or better than that in the control. This is also demonstrated by the high ratios for the group I farmers and the low ratio for farmers with lower capacity.

Soil environmental impact

The impact on the soil quality of the local melon and the new melon variety KHH together with the improved practice was not conclusive.

The impact on available P_2O_5 was positive at most farms, but for K_2O all, except one farm, had a negative balance for both treatment and control (Table 11). Before the experiment, available P_2O_5 in the soil was quite high, up to 103.4 mg/100g (Table 3). The rate of changes in this parameter (after and before trail) were only slightly positive, with an average of 5.4% and 5.2% in KHH and local melon plots, respectively. The average decline in available K_2O in KHH plots (18.6%) was slightly less than that of the local plots (24.3%).

Table 10

Yield and income from new KHH melon and local Gia Huy, with mean plus SD for five farms.

HH code	KHH (New)		Local melon (Control)		Rate of Income KHH/Local
	Yield (ton/ha)	Income (Mill. VND/ha)	Yield (ton/ha)	Income (Mill. VND/ha)	
1	20,8	208	27,8	139	1,5
2	20,8	153	27,8	167	0,9
3	20,8	96	27,8	139	0,7
4	12,5	46	27,8	150	0,3
5	18,1	97	23,6	181	0,5
Mean ±SD	18.6 ±3.6	132.0 ±49.5	27 ±2	175 ±46	

Table 11

Changes of available P_2O_5 and K_2O before and after experiment.

HH code	Change P_2O_5 (mg/100g)		Balance K_2O (mg/100g)	
	KHH	Local melon	KHH	Local melon
1	9,6	6,2	0,6	-2,6
2	-1,6	-2,0	-1,2	-0,8
3	5,3	3,7	-1,3	-1,0
4	2,4	3,5	-7,8	-5,9
5	-2,1	1,9	-1,0	-0,5

Table 12

Operational cost (OC), gross income and margin for melon production in five farms (million VND/ ha).

HH code	KHH (New)			Local melon (Control)		
	Total OC	Gross income	Gross margin	Total OC	Gross income	Gross margin
1	124,8	208,0	83,2	125,8	139,0	13,2
2	128,3	153,0	24,7	142,8	167,0	24,2
3	107,2	116,0	8,8	128,6	139,0	10,4
4	80,9	86,0	5,1	128,9	150,0	21,1
5	93,6	97,0	3,4	139,4	181,0	41,6
Mean ±SD			25.1 ±30.0			22.1 ±11.0

Table 13

The effect of the score for market access and type of market channel (trader collecting at the field gate) on the field gate price of KHH.

HH code	HH group	Market access score	Market group	Field gate price (VND/kg)
1	I	7	Wholesale trader	10 000
2	I	10	Wholesale trader	8 000
3	II	7	Local retailers	8 500
4	II	5	Local retailers	5 000
5	II	3	Local retailers	6 000

Economic impacts

Results of economic benefits from five participating households are presented in Table 12. The gross margin for the KHH melon of group 1 households who were advanced in cultivation skills, labour availability and market access was higher than that for the other group. Group 1 also had higher margins with KHH than that of the group 2 farmers with the local melon.

Market access

The market accessibility and price for melon products differed for the two groups of households (Table 13). Group I household (better-off and good skills), sold the product through the wholesale market channel. The middle men, with vehicles, purchased and collected the melon directly at the farm gate and sold melon at wholesale markets in Nam Dinh, Long Bien fruit market (Hanoi) and Gia Loc market (Hung Yen). The price received by farmers through the wholesale channel was higher than that received by the group selling their product to local retailers. The consumer markets for high quality melons are normally located in large cities, in this case through Long Bien and Gia Loc markets). The minimum quantity of products per vehicle is 3.5 tons, the volume that usually middle men prefer to collect directly at the farmer fields and discharge at the wholesale markets. The price for KHH melon is higher due to the larger size and weight, from 2.5 - 3.0 kg per fruit; usually, not preferred by local households who prefer to buy melon fruit at the price below 40,000 VND per kg. There is no contract for melon delivery between farmers and middle men or between regional retail dealers. They trade based on verbal agreement that the price for buying and selling will depend on the market price. None of the participating households sold directly at the local market.

The pre-processing of the fruits by the farmers is restricted to washing and cleaning the melons, before selling to local retailers, middle men or regional wholesale traders. If melons are bought for marketing in other provinces then the farmers need to pack around 10-15 kg of melons per bag for the middle men or traders.

Acceptability and driving forces of the changes in adopting new melon varieties

The survey conducted one year after the experiment showed that four households continued to grow the newly introduced KHH; two of these households belonged to group I, while two others did not participate in the experiment. These farmers preferred to replace the local melon with HHK because this new variety is less vulnerable to climatic stressors. Besides this, the decision to grow the new variety is due to its higher price and higher tolerance to specific diseases that often affect the local melon.

The in-depth interview after one year, revealed that two new households started to cultivate the new melon variety because they had sufficient capital and learned about the success from the two households who had continued growing KHH even after the trial. Farmers reported that they only shifted to a new crop when they could anticipate the possibility of selling this new product. Farmers who discontinued with the KHH had difficulty in actively accessing market for this new product.

Discussions

Both the new hybrid melon and the local melon varieties maintained soil P_2O_5 content.

The K_2O content was reduced in both practices, although somewhat less when propagating KHH together with the improved fertiliser practice. At short term these unbalances of soil chemical elements might not cause environmental problem because farmers always apply NPK fertilizers at the beginning of each cropping season. However, the one farmer who succeeded to improve both these soil parameters presents an interesting case for learning by research, extension services and other farmers.

The financial gain from KHH were either improved or remained the same compared with that of the local melon, while the disease risk decreased for KHH. The size and other characteristics of KHH were comparable to those of other melons that are cultivated in the Red River Delta in recent times (7). The lower Brix, indicating lower flesh firmness of the new variety compared with that of the local melon, was compensated for by thicker flesh, better aroma and taste making KHH attractive for the more selective consumers in the cities.

This study suggests that the market information did not drive the process of the adaptation itself, but rather provided relevant stimuli to skilled farmers enabling them to successfully shift to new crop varieties. This study also implies that such market process understanding is crucial in formulating strategies to increase farmer's capacity to adapt to Climate Change.

Conclusion

Skilled farmers producing the new KHH melon earned a higher income than those who produced the local variety. This newly introduced melon variety was well accepted by the more skilled farmers who actively accessed the wholesale market channel in cities. However, the market information did not drive the process of the adaptation, but rather provided relevant stimuli to these farmers enabling them to successfully shift to new crop varieties.

The introduction of a new melon variety and cultural practice in Giao Thuy, accompanied with suitable soil conditions for annual melon cultivation, contributed to climate change adaptation of these experienced and skilled farmers. The KHH melon variety was suitable for the summer-spring season of Giao Thuy. It had vigorous growth, good flowering and fruiting, high yield and good quality. The agro-chemical properties of the soil were more reduced by the local practice compared with that of the KHH produced according to the seed company's cultivation guideline, which is thus a first step to a more sustainable melon production model.

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Analyzing Drought Adaptation Practices of Sugarcane Growers in Thanh Cong, Thach Thanh District, Thanh Hoa, Vietnam

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Keywords: Drought adaptation practices- Sugarcane growers- Extreme climatic events- Vietnam

Summary

To understand drought adaptation practices, we compared two groups of sugarcane growers in Thanh Cong commune, Thach Thanh district, Thanh Hoa province in Vietnam. Results of this study point out that farmers, depending on their preferred type of market channels, reacted differently to the impacts of drought. Contractual farmers paid more attention to the impact on sugarcane tillering and sugar content, while market-oriented farmers paid more attention to sugarcane colour, as this trait directly determined the market price on the cane that is either consumed as cane or as juice. In responding to water stress in the growing season, the open market-oriented farmers showed more flexibility in changing their cropping calendar. They were also more willing to invest in enhancing the water management system and in providing organic fertilizer than the contractual farmers. On the other hand, the low cane price and the harvesting date set in contract by the processing company lessened the contractual farmers' flexibility in investing in water management technologies; thus, hampering their adaptation to drought.

Résumé

Analyse des pratiques d'adaptation à la sécheresse des cultivateurs de canne à sucre de Thanh Cong, District de Thach Thanh, Thanh Hoa, Vietnam

Afin de comprendre les pratiques d'adaptation à la sécheresse, nous avons comparé deux groupes de cultivateurs de canne à sucre dans la commune de Thanh Cong de la province de Thanh Hoa au Vietnam. Les résultats indiquent que la réaction à la sécheresse de ces producteurs variait en fonction du type de marché qu'ils visaient et dont ils dépendaient. Les producteurs ayant un contrat avec une usine portaient plus d'attention à l'impact de la sècheresse sur le nombre de pousses de canne à sucre et à sa teneur en sucre. Par contre, les producteurs orientés vers le marché libre portaient plus d'attention à la couleur de la canne à sucre. Ce trait détermine son prix de vente pour la consommation directe ou comme jus après extraction. En réponse au stress à la sécheresse pendant la période de production, les agriculteurs orientés vers le marché libre montraient plus de flexibilité à changer leur calendrier cultural. Ces agriculteurs étaient plus disposés à investir dans l'amélioration du système d'irrigation et à utiliser des engrais organiques que les fermiers contractuels. Pour ces derniers, le bas prix offert et la date de récolte fixée dans le contrat réduisaient la flexibilité à investir dans des technologies d'irrigation, ce qui a des effets sur leurs capacités à s'adapter à la sécheresse.

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Introduction

Climate change and several other causes, such as market sector, policy changes, cultural and personal perception drive adaptation practices of stakeholders. Thus, understanding the process of the stakeholders' autonomous adaptive responses is as important as studying the change of climate, its impacts and adaption solutions (2, 5).

Among other extreme climatic events, recently, drought has affected largely the agricultural areas in Viet Nam, especially, those in the Central and Mekong Delta. At the provincial level, Thanh Hoa Department of Agriculture and Rural Development (DARD 2010) reported that drought affected 13,500 ha of sugarcane and destroyed 1,290 ha (12). At the national level, the Ministry of Agriculture and Rural Development estimated the loss caused by drought at about 15 thousand million VND from the late of 2015 to the mid of 2016.

While farmers of most crops experienced difficulties and loss of productivity, many sugarcane growers, however, succeeded during this period. Sugarcane is a drought-tolerant plant, but it is still negatively affected by water shortage during its germination, tillering and ratooning stages.

In Thanh Cong commune, where sugarcane is the main agricultural crop of many households since about 20 years ago (10), drought adaptation practices among farmers are strikingly different. The complexity of farmer's perception on the impacts of drought and other climate-related changes has been investigated by others. The common conclusion of studies, for example, in rural Sahel (8), Semi-arid and Sub-humid Regions of Kenya (7), South Africa (13) and in Punjab Pakistan (1) showed that farmers considered, in particular, market and economic profitability for their autonomous adaptation to climate change. Fujisawa and Kobayashi (4, 5); likewise, found that the type of market mattered among farmers. In order to understand the causes of success and/or failure of growing sugarcane in Thanh Hoa, we studied the drought adaptation and farming practices of two groups of sugarcane growers: farmers who sold their product by annual contract to sugar companies (contractual type) and farmers who sold to markets or to retailers (market type). After describing the methods, we discuss the results and conclusions of our study.

Study area and methods

The study area and sugarcane production

The study was conducted in Thanh Cong commune, Thach Thanh district, Thanh Hoa province. Similar to other areas in Thanh Hoa, climate of Thanh Cong has two seasons, summer and winter. In the early summer, western foehn wind usually occurs and increases water stress in Thanh Cong Commune and in most of the areas in Than Hoa. The hydrothermal coefficient is relatively low from December to March and coincides with the dry season (Figure 1). Thanh Hoa province covers 11.3% of Vietnam's total national sugarcane area and contributes 10.4% to the national sugarcane production (11). There are three types of sugarcane in the province. The first type is named "purple sugarcane." It is also known as "the cane to King" or "Kim Tan," and is mostly eaten directly as cane. The 2nd type is the white sugarcane which is mostly extracted as raw juice for drinking. The last type is the cane for industrial sugar extraction introduced by the Viet-Dai Sugarcane Company since 1996.

DARD reports that for the three main types of sugarcane, the average productivity ranges from 47 ton ha^{-1} to 55 ton ha^{-1} in Thanh Cong. Thach Cong Commune has a total sugarcane production area of 242 hectares (DARD 2015) which is much larger than that for paddy rice (168 hectares) and permanent fruit trees (156 hectares) (10).

Primary data collection and analysis

Between February 2016 and April 2016 we interviewed 40 households. We started with collecting the general information on the household, and then proceeded with questions aimed at helping sugarcane growers to recall the years in which the productivity, the crop season or the profits of sugarcane were peculiar. We did not mention drought or other climate risks in order to avoid bias about the factors which affected sugarcane production. We also asked about their cultivation practices. In the last section of the questionnaire, we asked their experiences with drought and its impacts.

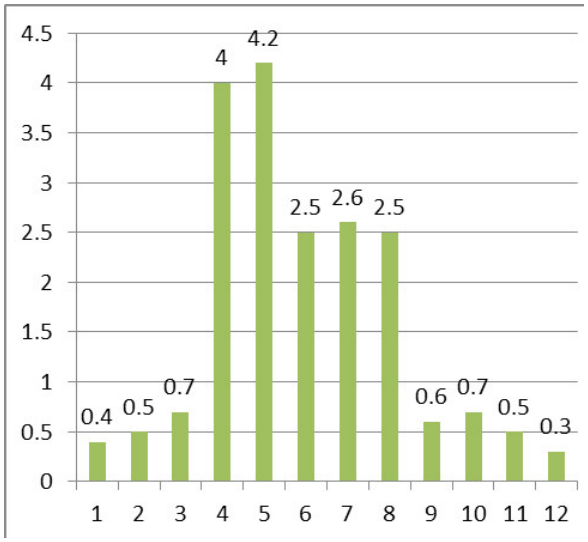

Figure 1: Hydrothermal coefficient in 2015 (6).

To understand sugarcane growers' perception on drought and its impacts, we analyzed their personal perception about the good and the bad years in sugarcane production history. Then, we compared this information with that on the years when they observed heavy impacts of drought on sugarcane production to find overlap of the good, the bad and the drought years when drought occurred. To understand better their circumstances during that time, we collected additional information. Finally, we asked the farmers to evaluate, based on their own perception, the impacts of drought by using a 5-point scale.

Results and Discussion

Characteristics of interviewed sugarcane growers
On the average, the income from sugarcane production contributed more than 60% to the total household income from the 40 interviewed farms. The average age of farmer was about the same for both groups: 47 years (Table 1). The households had been growing sugarcane for at least 6 years; some even had more than 20 years of experience. The farmers who planted sugarcane for sugar extraction had longer experience (over 18 years) than those who planted white or purple sugarcane (over 7 years).

The "purple sugarcane" and "white sugarcane" types that were sold in the market or bought by retailers were mostly used for juice extraction or raw consumption.

The price of these types depends on the quality (colour and size) of each stalk and the time of selling. In 2015, farmers sold these types of sugarcane for an average price of 4,000 to 6,000 VND per stalk. Normally, the cash revenue for one hectare of white or purple sugarcane varied from 200 to 250 billion VND ha^{-1} yr^{-1}, and some households even got much higher income. However, these types of sugarcane require higher investment, good soil quality and more labour days in order to meet the required quality. Thus, in Thanh Cong, only a few households can afford to cultivate "white" or "purple" sugarcane.

Farmers sold sugarcane by tons to the sugar company they were in contract with. In recent years, the sugar company uses the sugar rate as an indicator for pricing the sugarcane.

The average price in 2015 was 920,000 VND per ton of sugarcane, and farmer received an estimated 45 billion to 55 billion VND ha^{-1} yr^{-1} . The income from this type of cane is much lower than that coming from the white and purple sugarcane types; but this cane can grow on sloping lands with poor soil quality.

Cropping calendar

All types of sugarcane have approximately one year to complete the growth cycle. However, they have slightly different cropping calendars (Figure 2).

Table 1

Characteristics of interviewed sugarcane growers in Thanh Cong Commune.

Characteristics	Contractual	Non-contractual	
Type of planted sugarcane	Cane for sugar extraction by Sugar Company	Purple sugarcane for raw consumption	White sugarcane for juice extractiom
Sale channel	Annual contract with company; Price set per ton of sugarcane	Market or retailors Price was set per stalk of sugarcane	
Indicators to define the price	The rate of sugar in the canes	Quality of the stalks: colour, size. Time of demand	
Number of interviewed farmers	16	12	12
Average ages of farmers	48	47	47
Average number of years growing sugarcane	18,6	7,8	7,3

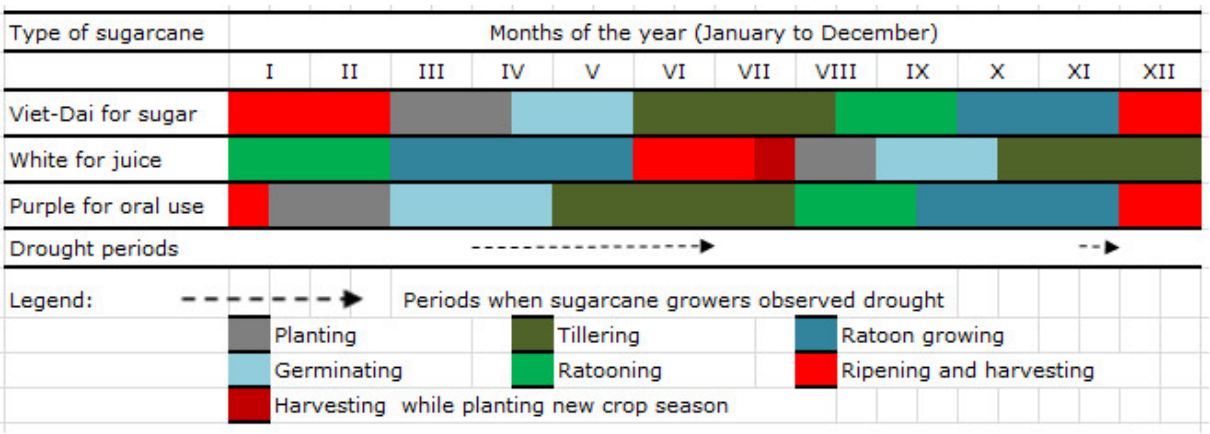

Figure 2: Crop calendar of sugarcane in Thanh Cong, Thach Thanh, Thanh Hoa.

Compared to the other types, the purple sugarcane is planted earliest, from January to the mid of February in order to be harvested around the time of next Lunar New Year, when it could be sold at the best price. The planting of sugarcane being supplied for sugar production always starts from mid-February to March and then collected by the sugar company from December to mid-February. The cropping calendar of the white sugarcane used for juice extraction is very different: planting is from mid-July to mid-August in order to be harvested next year in summer when the demand for sugarcane juice peaks. The planting time of the latter type coincides with the time of drought and when the foehn occurs seriously in the north central of Vietnam. The cropping calendar of this type is changeable depending on the market forecast.

Grower's perception on drought and its impact on sugarcane production

Most farmers observed that drought affected their sugarcane production in 2013 and 2014, but more in 2015. For each type of sugarcane, drought affected different phases of the sugarcane growth cycle. The contractual farmers observed that drought affected sugarcane during germination, ratooning and tillering. They said that during the drought years, sugarcane plants germinated and tillered slowly and weakly, shoots turned yellow and some cane cuttings died.

They also observed borers and congested tops. The farmers who cultivated purple sugarcane observed similar symptoms.

Table 2

Successful, difficult and drought years observed by three types of sugarcane growers (%).

Year of event	Types of farmer		
		Market or retailer	
	Contractual (n= 16)	Purple (n=12)	White (n=12)
Successful			
2012	19	8,3	0
2013	40	16,7	0
2014	44	66,7	33,3
2015	44	16,7	66,7
Difficult			
1996	13	0	0
2010	19	17	17
2011	19	0	33
2012	19	25	25
2013	13	33	25
2014	6	0	0
2015	25	8	0
Drought			
2012	6	25	0
2013	31	17	17
2014	19	17	50
2015	81	50	83

Drought additionally affected the ripening time; farmers saw a change in colour and the size of ratoons.

For those who planted white sugarcane, they observed that drought mostly affected the ratoon growth and ripening. With high temperature, ratoons cracked, colour became lighter; overall, plants germinated and grew slowly (table 2).

Surprisingly, only few farmers thought drought years were bad years of sugarcane production; these were, in particular, farmers who grew white and purple sugarcane. One third of the white sugarcane growers claimed that 2015 was their most successful year, while one third of the purple sugarcane growers mentioned that 2014 was their most successful year. On the other hand, 44% of the contractual farmers claimed that 2013, 2014 and 2015 were their most successful years. In these years, most of the sugarcane growers produced high yields with high selling price. The farmers who planted purple and white sugarcane also mentioned that the appropriate match of selling time, the high demand for market and the presence of a good irrigation system all contributed to their success.

Meanwhile, the percentage of farmers who claimed that the drought years were bad years for them comprised only a smaller proportion of the total number of respondents. One quarter of growers who supplied canes to the sugar company claimed the 2015 was a bad year for them. Only 8 % of the purple sugarcane growers had the same opinion and none of white sugarcane growers thought this was a bad year.

One third and one quarter of the purple and white sugarcane growers, respectively, mentioned 2013 as a bad year for them.

Most of these farmers mentioned that the lack of rain, lack of good irrigation source, low productivity, low quality, low price and inappropriate selling time all contributed to their failure during the dry years.

Table 3

Changes (%) in the sugarcane management practices for the three types of sugarcane growers in 2015.

Management practices	Type of farmers		
	Contractual	Market or retailer	
		Purple	White
Increase of growing area	13	0	0
Decrease of growing area	19	0	0
Increase of productivity	44	67	100
Decrease of productivity	31	8	0
Early planting	0	0	50
Late planting	13	25	8
Early harvest	6	0	67
Late harvest	31	0	8

To understand the responses of different sugarcane growers, we analyzed the changes in 2015, the year for which most of the farmers agreed that it was the worst drought year for them. We asked them to recall the changes in sugarcane production in terms of productivity, production area, and planting and harvesting time (Table 3).

In 2015, 19% of the contractual farmers reduced their sugarcane production area. The main reasons were water shortage, disease, low financial capital and low quality of sugarcane. One household stopped growing sugarcane due to water shortage; others reduced their production area by one third to a half due to poor irrigation and low financial capital. None of the farmers of the market type, however, reduced their production area in this year. In terms of productivity, in 2015, on the average, more than half of the farmers confirmed that their sugarcane production was higher in 2015 than that in other years: 44% of the contractual farmers, 67% of the market type farmers who sold purple sugarcane and 100% of those who sold white sugarcane.

Contractual farmers reported that the reasons for their increased productivity were good water source and strong sugarcane variety, while market farmers said that the presence of good irrigation source contributed the most to their increased sugarcane productivity. However, 31% of the contractual farmers reported a decrease in their productivity due to diseases, weak tillering and low drought tolerance of the variety. Only 8% of the market type farmers who cultivated white sugarcane observed a decrease in productivity, but none of them mentioned that water shortage was the reason behind it.

Regarding the change in cropping calendar, in particular, the time for planting and harvesting, market farmers who planted white sugarcane had more opportunities than those who planted purple sugarcane. They also had more opportunities than the contractual farmers. In 2015, 50% of the white sugarcane growers planted earlier than usual because of the early harvest and the early rain in the preceding year. Furthermore, in 2015, two thirds of the farmers harvested earlier than the usual date due to the early growing season and the prevailing high market price at the start of the harvest season. Both the contractual and market type farmers growing purple sugarcane did not plant early in 2015.

Only 13% of the contractual farmers planted late; 31% of them harvested late. The delay in planting and harvesting, however, was not caused by drought and water shortage, but by changes in the policy of the Sugar Company which affected the farmers' production plan.

All sugarcane growers gave a similar ranking on the impacts of drought on cropping calendar, cultivar, sugar rate, growth, disease, investment cost, productivity and profit (Table 4).

Both contractual farmers and market farmers confirmed that drought had little effects on the cropping calendar. They said that the most important factor for changing the cropping calendar was the purchasing demand of sugarcane. The contractual farmers depended more on the collection schedule of the sugar company, while the market farmers depended more on the demand from the free market. They said, they could have changed the cropping calendar, but their main objective was to achieve the best time of selling, and not to avoid the impact and timing of drought. Nevertheless, all farmers agreed that water shortage resulted in weak growing and tillering of sugarcane. Drought also slightly affected the choice of sugarcane cultivar because currently, only a few farmers were willing to change to the drought-tolerant cultivar for fear of losing income. This was especially true for purple sugarcane growers who used only the traditional cultivar, "Kim Tan." The farmers evaluated that drought had low impact on the sugar rate in the canes, although most of them agreed that this rate increased as drought progressed. Both types of sugarcane growers claimed that drought affected more highly on the growth, productivity, disease and investment cost of sugarcane; thus, the profit of sugarcane production. However, the market farmers paid more attention to the growth of the ratoons than the contractual type farmers (Table 4).

The different perceptions of farmers clearly present their opinions about the impacts of drought on sugarcane tillering and sugarcane colour. The average scores of contractual farmers were 4.6 and 1.2 for the impacts on tillering and colour of sugarcane, respectively. For market type farmers, these average were 0.8 and 3.7 for the impacts on tillering and colour of sugarcane, respectively. These results reflect the market preference of different types of sugarcane. The profit of contractual farmers highly depends on the rate of tillering because they sell their sugarcane in tons. For market type farmers, their profit depends on the quality of each cane that is sold. Thus, when the colour of the stalk becomes irregular or deviates from that preferred by the consumer, this may induce the retailers or buyers to lower the buying price.

Growers' actions against drought

To reduce the impacts of drought, sugarcane experts recommend that farmers adjust their cropping calendar, apply water-saving irrigation method, use organic fertilizers and intercrop legumes. During the drought period (2012-2015) the two types of farmers reacted differently as regards their cropping calendar, irrigation, intercropping and fertilizer application practices.

Table 4

Contractual and market-oriented sugarcane growers' ranking of the drought impacts on several crop characteristics.

Impacts	Contractual	Market or retailer	
		Purple	White
Crop season	1,6	1	1,4
Sugarcane cultivar	0,3	0	0,4
Sugar rate	0,9	0,9	1,5
Sugarcane growth	4,8	4,8	4,8
Sugarcane tillering	4,6	0,2	1,5
Sugarcane Disease	3,9	3,2	3,8
Sugarcane colour	1,2	3,9	3,4
Sugarcane yield	4,6	4,3	4,9
Investment cost	4,1	4,3	4,9
Profit	4,1	4,5	4,8

Note: Ranking was done by using a 5-point scale: 5= highest, 1= lowest and 0= no impacts.

Adjusting cropping calendar

Few contractual farmers adjusted their cropping calendar. Some households decided to start cropping season despite lack of water irrigation and accepted a low yield in order to meet the collection schedule of the sugar company. The market type farmers adjusted their cropping season more often in drought years, particularly those who planting white sugarcane. They were more independent in the deciding when to start their cropping calendar. They were able to delay the cropping season and wait for favorable weather, or start cropping earlier based on their market forecast so they could achieve a better selling price. All farmers in Thanh Cong, however, indicated that drought and drought impacts were not their main reason in adjusting their sugarcane cropping calendar . The market factor, in this study, played a more important role in farmers' decision making because it connected directly to their households' economic benefit (Table 5).

Water-saving irrigation methods

Besides rainwater, farmers in Thanh Cong may avail of two water sources (Table 6): wells and local water reservoirs (lake, river and canal). None of farmers used boreholes to irrigate their sugarcane field. Most of the contractual farmers totally relied on the natural water (rain and reservoirs), while 100% of the purple sugarcane growers and 58% of the white sugarcane growers invested in their own wells. In addition, most white sugarcane growers decided to crop the cane in a field nearby the local water sources. Having their own water sources enabled these farmers to actively control irrigation; thus contributing to their success during drought years.

The contractual farmers practiced run-off irrigation method only for all types of water sources (Table 7). In contrast, all market farmers practiced additional water-saving methods, like furrow irrigation. However, other water-saving irrigation methods, such as drip irrigation, sprinkler irrigation and border irrigation, were not practiced by farmers in Thanh Cong.

Intercropping

In Thanh Cong commune, none of the contractual farmers practiced intercropping as a win-win solution to control drought, improve soil quality and increase household income. But some market-oriented farmers intercropped legume, maize and vegetables in their sugarcane fields (Table 8). One quarter of the purple sugarcane growers and one-third of the white sugarcane growers intercropped with legume. Thirty percent of the purple sugarcane growers intercropped with maize and vegetable, while only 8% of the white sugarcane growers intercropped with maize.

Fertilizer application

The contractual farmers preferred chemical fertilizer to organic fertilizer (Table 9). They applied only the micro-organic fertilizer that was provided by the sugar company in the planting time. In the later phases of sugarcane growth, they applied chemical fertilizer thrice. However, all purple sugarcane growers applied manure before planting; 75% of them did the same during tillering and ratooning. A few white sugarcane growers (17%) applied manure at planting time only. Although only a small proportion of sugarcane growers applies organic fertilizer, this practice effectively mitigates the impact of drought, and simultaneously, improves soil quality.

Growers' actions against pests

Effective prevention of pests can contribute to reducing the negative impact of drought. At the time of drought, all farmers in Thanh Cong found borers in their fields, while half of the contractual farmers and a small portion of the market farmers observed aphids (Table 10).

Although facing similar pest problem, the farmers prevented pests quite differently (Table 11). Close to 90 % of the contractual farmers sprayed insecticide as soon as they discovered the borers, while close to 60% of the white cane growers and only 30% of the purple cane growers used this method. On the other hand, 13 % of the contractual farmers peeled the old leaves and weeded grass to prevent borers from growing. Although time consuming, all market farmers practiced this solution.

Table 5

The changes in cropping calendar practiced by the three types of sugercane growers from 2012 to 2015 (%).

Year observing drought	Early planting			Late planting		
	Contractual	Market or retailer		Contractual	Market or retailer	
		Purple	White		Purple	White
2012	6	8	8	6	0	0
2013	6	0	17	0	8	8
2014	6	8	25	6	17	8
2015	0	0	50	13	25	8

Table 6

The irrigation water sources available to the three types of sugarcane farmers (%).

Source of irrigation water	Contractual	Market or retailer	
		Purple	White
Rainwater	100	100	100
Open wells	6	100	58
Local water sources (lake, river, canal)	100	42	92
Others	0	0	0

Table 7

The irrigation methods applied by the three types of farmers (%).

Irrigation methods	Contrac-tual	Market or retailer	
		Purple	White
Runoff	100	0	0
Furrow	0	100	100

Table 8

Intercropping by the three types of sugarcane growers in Thanh Cong (%).

Types of crop	Contrac-tual	Market or retailer	
		Purple	White
Legume	0	25	33
Maize	0	8	8
Vegetable	0	25	0

Table 9

The fertilizer application by the three types of sugarcane growers (%).

Time of application	Type of fertilizer	Contrac-tual	Market or retailer	
			Purple	White
Planting	N-P-K	88	100	100
	Manure	25	100	17
	Micro-organic	75	42	0
	P	6	0	67
Tillering and ratooning	N-P-K	81	100	100
	Manure	0	75	0
	P	0	0	42
Ratoon growing	N-P-K	25	25	0
	N	75	83	100
	K	75	83	100

Table 10

The type of pests observed by the three types of growers in sugarcane fields during drought (%).

Type of pests	Contractual	Market or retailer	
		Purple	White
Borer	100	100	100
Aphid	50	8	17

Table 11

Borer-prevention practices of three types of sugarcane farmers (%).

Prevention methods	Contractual	Market or retailer	
		Purple	White
Peeling the old leaves and weeding grass	13	100	100
Spraying	88	33	58
Dipping cane cuttings in insecticide before planting.	0	58	33

They peeled the old leaves more frequently, once or twice a month, than the contractual farmers, once or twice a year.

Thirty percent of the white cane growers and 58% of the purple cane growers dipped the cane cuttings in an insecticide solution before planting; insecticide solution dipping kills pathogens and reduces the growth of borers and other pests. Although the contractual farmers knew about the effectiveness of the methods practiced by the white and purple sugarcane growers, they were not willing to practice these for fear of losing profit. Peeling the old leaves, cleaning the fields more regularly and dipping cane cuttings in insecticide solution before planting are time- and money-consuming methods. Their revenue which was around 50 to 55 billion VND yr^{-1} ha^{-1} only, was much lower than that of white and purple sugarcane, a factor that may have hindered them from practicing these environmental friendly methods. Market- oriented farmers, seeking more profits, invested more to increase the sugarcane quality to meet the consumers' and retailers' demand for quality, and premium price based on colour, size, softness and the length of stalks. The high revenue per hectare may have strongly affected the decision making of these farmers in practicing pest prevention methods, as well as other drought- mitigation activities.

Discussion

Surprisingly, some farmers said that drought is an opportunity for them. For some, drought increased their income as a result of higher sugar rate in the cane, and others experienced an increased demand and thus a high price. The latter is probably due to an increased direct consumption induced by the related hot weather. All sugarcane growers were well aware of the impacts of drought, and most of them agreed on the negative consequences of water stress and hot weather during drought periods in Thanh Cong.

They observed weak and stunted plants; experienced loss of productivity; encountered more pests, such as borers and aphids, and needed to invest more.

However, market type farmers were less constrained with drought than the contract type farmers. The former were able to sell their product at a good price provided they meet the quality demands of their consumers. They decided more independently in terms of their planting and harvesting schedules.

They actively controlled the irrigation system by digging their own wells and applying the furrow method; they planted inter-crops to improve soil quality, regularly peeled the old leaves and weeded to reduce pests. These are all autonomous responses of the growers, forecasting by themselves the market demand, deciding on the varieties in their fields and investing more willingly for higher yields and extra income.

Having the needed capital, they were more motivated to implement drought adaptation because they could earn around 200 billion VND ha^{-1} which is 4 to 5 times higher than that of the contractual farmers. Autonomous responses usually happen when farmers perceive the benefits or observe the good experiences from others (3; 9). Enhancing farmers' capacity for autonomous adaptation enables them to reduce the negative consequences of climate change. Our findings agree with those of Fujisawa and Kobayashi, (5) who investigated the climate change adaptation practices of apple growers in Nagano, Japan. Japanese free market type apple farmers focused more on meeting the different market requirements of their consumers for their goods, such as color and appearance. Being motivated by the premium price they get from meeting these requirements, they then practice and invest more on drought adaptation methods so that they could meet the consumers' demand.

Similar conclusions of earlier studies on other products show that even if agriculture is highly vulnerable to the impacts of climatic change, farmers generally consider market and economic profits as a major factor for their adaptation (1, 4, 5, 8).

On the other hand, contract farmers in this study who were tied to the stipulations of the contracting company paid less attention to the color of the cane, but more on the rate of tillering as this determined the volume of their production; more tillers meant more tons and more profit for them. In contrast to the market type sugarcane farmers who adjusted their cropping calendar to meet consumers' demand and invested more on drought adaptation methods, contract farmers adopted the planning calendar of the sugar company. The farmers who sold their products to Viet-Dai Company adapted less to drought than the market type farmers. This was due to their dependency on the purchase policies fixed in the annual contract. Due to the time schedule of collection, these growers changed their cropping calendar only if this was required by the Sugar Company (Table 3). Through incentives system the company also affected the varieties of the cane and the type of fertilizers that farmers used. Thus, compared with the market-oriented farmers' behaviour, contractual farmers tended to be more passive in their reaction to drought because they depended on the top-down policy of the collectors. Fujisawa *et al.* (3) suggested that in order to be successful, adaptation policies should be based on farmers' needs and deployed through sale channels. Although the established sale channel between farmers and Viet-Dai Company in Than Cong has positive merits, the solutions proposed by the company for coping with drought were rare (providing micro-organic fertilizers and introducing new drought-tolerant variety) and not effective. For instance, the new variety of cane introduced by the company was not widely accepted by farmers due to their fear of losing productivity, which explains the low impact of drought on the sugarcane cultivar used by these farmers (Table 4). In addition to this, the low profit gained by contractual cane farmers constrained them from applying adaptation solutions, as any additional investment might lead to further losses on their part. This could explain why these farmers had limited actions to reverse the impact of drought.

Whether market or contractual, both types of sugarcane farmers in Thanh Cong face the risks of fluctuating market demands. Since not all of them are investing in water-saving irrigation system and other improved farming techniques, they may, therefore, incur unexpected low yields and losses due to unseen extreme climatic events. To minimize these impacts and maximize their resilience, there is a need to increase their awareness on knowledge and skills on climate change adaptation methods. Abid *et al* (1), in their study of the Punjab farmers, suggested that greater investment in farmer education might be a solution, while Fujisawa et al (3) suggested to strengthen the link between farmers and their contractual partners.

Conclusion

Many factors contribute to farmers' reactions to the impact of climate change. Among others, the type of market proves to be a more significant one. In this study, we found all three types of sugarcane growers confirming the negative impacts of extreme drought, hot weather and water shortage; but reacting quite differently. The white and purple cane growers perceived hot weather as an opportunity because this increased the market price of and demand for cane for juice and direct consumption. With high market price and benefit per hectare of the white and purple sugarcane that are several times higher, market type farmers are able to invest more time and money in implementing adaptation methods than the farmers who are bound to a company with a contract to deliver sugarcane for industrial processing. Consequently, market-oriented farmers invest more in irrigation, spend more time to prevent pests and diseases and apply more organic manure than the contract type farmers. All these efforts reduce the vulnerability of the market-oriented farmers to drought, at the same time, assure them of increased profits. These farmers are also able to autonomously adjust their cropping calendar, not primarily to reduce the impact of drought on their product, but to adjust to the timing of harvest when the selling price of their product is at highest.

On the other hand, contractual farmers are constrained to apply drought mitigation methods because of the low profit and benefit that they get from the contracting company. This hindered them from investing in drought-adaptation methods; thus making them more vulnerable to drought. Even when they already foresaw the incoming negative impacts of drought, these farmers postponed solutions; they stuck to the planting and harvesting of sugarcane within the period set by the company. Understanding the complexity of farmers' coping behavior with regard to drought is important. To achieve a more effective drought adaptation strategy, policy makers and experts need to consider the factors mentioned in this study that have encouraged farmers to reach their economic goal, at the same time, strengthened their climate change adaptation resiliency.

Without a doubt, knowing first and foremost the type of market channel to which the farmers are engaging with would lend to a better understanding on the dynamics of climate change adaptation. In addition, when proposing adaptive solutions to extreme climatic events, this study recommends that planners consider other stakeholders and institutions/partners that are directly linked to the farmer-producers; e.g., contracting company, market outlet trader/retailer channels, agricultural extension service providers and local agencies, among others. Overall, individual farmers' capacity in coping with the negative impacts of climate change needs to be strengthened by increasing their knowledge and skills on adaptation technologies that make up for a stronger climate change resiliency in the future.

The policy makers and experts should consider these findings when proposing adaptive solution to extreme climatic events.

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Comparing the Effectiveness Between Payment for Environmental Services (PES) and a Local Compensation System on Conservation of Special-Use Forests, Son La Province, Vietnam

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Summary

Tà Xùa and Xuân Nha special-use-forests (SUF) are located in Son La, one of two provinces chosen to pilot test the PES in Vietnam. Since 2009, Tà Xùa has received PES from 119,970 to 263,785 VND/ha per year. On the other hand, Xuân Nha SUF received a 5-year-fixed payment of 100,000 VND/year per ha from the forest protection system that was launched in 2015 by the Vietnamese government. To assess the effectiveness of forest protection in Tà Xùa and Xuân Nha, 21 authorities and 190 local people were interviewed and 28 group discussions were conducted. The effect on forest protection was observed by using transect walks. In both SUFs, the Management Boards (MBs) signed contracts with local Village MBs who are responsible for managing, and enforcing forest regulations. In Tà Xùa, MBs had not developed a comprehensive forest protection plan with criteria for checks. Local people's awareness of SUF management regulations and PES requirements remained weak, illegal logging still prevailed and high-valued timber continued to dwindle. In contrast, the relative small support in Xuân Nha, a forest with less high value timber, resulted in a comprehensive plan for the SUF and local governments successfully promoting forest protection through the local communities.

Résumé

Comparaison de l'efficience du payement entre les services écologiques (PES) et un système de compensation locale pour la conservation des forêts spécialisés dans la province Son La au Vietnam

Les Forêts à Utilisation Spéciale (SUF) deTà Xùa et de Xuân Nha sont localisées dans la province de Son La, une des deux provinces choisies pour étudier le système PES (Services écologiques) au Vietnam. Pour assurer la protection de ces SUF, Tà Xùa a reçu des PES variant de 119,970 à 263,785 VND/ha/an depuis 2009, tandis que Xuân Nha a reçu un montant fixe de 100,000 VND/an/ha dans le cadre d'un système de protection lancé par le gouvernement Vietnamien en 2015. Afin de comparer l'efficience de la protection des SUF de Tà Xùa et de Xuân Nha, 21 fonctionnaires et 190 habitants ont été interviewés, et 28 interviews de groupes ont été conduits. L'effet sur la protection de la forêt a été quantifié en analysant des transects. Dans les deux SUF, les Conseils de Gestion (DGs) avaient signé des contrats avec les villages environnants. Les DGs sont responsables de la gestion de la forêt et du respect des règlements. Dans le cas de Tà Xùa, le DG n'avait pas développé un plan global de protection de la forêt avec ses critères de contrôle. La prise de conscience des habitants locaux par rapport aux règlements de gestion du SUF et aux demandes du PES est restée faible, les coupes illégales des arbres ont persisté et le nombre d'arbres de grande valeur commerciale a diminué. Par contre, avec un support financier plus faible, le DG du Xuân Nha disposant d'une forêt avec moins d'arbres de grande valeur, a établi un plan global pour le SUF et le gouvernement local a réussi à promouvoir la protection de la forêt au sein des communautés locales.

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Introduction

The Millennium Ecosystem Assessment defines "ecosystem services" as those benefits that people obtain from ecosystems (17), or more simply, "the good things nature does" for people. PES is a system that compensates or rewards local communities for maintaining and/or protecting the ecosystem. Through PES transactions, non-market values are supposed to be translated into real financial incentives that pay local actors who rely on natural resources to conserve landscapes and secure ongoing provisions of ecosystem services (14, 33, 27, 6 and 5). PES has been described as an innovative approach for improving natural resource management and offers a win–win solution for people and the environment (19, 23, 25, 30 and 31). Many scholars have promoted PES as an effective market-based mechanism to ensure efficient environmental conservation amongst local users. However, PES application has been considered incipient in some cases (30, 31, 23 and 32).

PES programs have been implemented in several countries of Latin America, Africa and in Southeast Asia. For these countries, PES plans currently rely on government or hybrid buyers.

The governments have incorporated PES as part of their natural resource management policies. These types of government-run PES programs, which in some places can be compulsory, are thus close to traditional "taxes" for environmental programs (4; 16, 18, 20, 23 and 32). For these types of PES, the payment procedure is considered not strict enough, and PES needs to be managed more effectively to contribute to better nature resources management. In implementing PES, buyers often do not want it, or in some cases, do not have rights to examine the work of the receiving parties.

Three quarters of Vietnam's total area is hilly or mountainous and thus forest plays a very important role in its development. Before the start of PES, considerable investment was made by Vietnamese government in forest management; for example, through the 661 Program with 31,650 billion VND (following the resolution No. 08/1997 / QH10. 2007) or the Forest Protection and Development Plan 2011-2020 with 49,317 billion VND (Decision 57/QD-TTg. 2012). In Vietnam, PES has officially become operational since 2008 when its Government established the "Vietnam Forest Protection and Development Fund" by Decree 05/2008/ND-CP and approved to pilot PES in Son La and Lam Dong by Decision No. 380/ QD-TTg/2008. Following the pilot period, Decree No. 99 provided guidance on the nationwide implementation of PES from 1 January 2011. PES is considered an outstanding achievement of MARD during the period 2011-2015 (13). PES revenue is over USD 45 million per year contributing 25% of the total forestry budget. Up to June 2016, budget from PES was more than USD 261 million and Forest Protection and Development Fund was established in 41 provinces (28).

Special-use-forests (SUFs) are being protected most strictly in three types of forest in Vietnam and are defined as "SUFs, which are used mainly for conservation of nature, specimens of the national forest ecosystems and forest biological gene sources; for scientific research…. " (Law No. 29/2004/QH11, Law No. 20/2008 / QH12, Decree 117/2010/NĐ-CP).Vietnam has 164 SUFs covering 2,198,744 ha. SUF MBs are assigned "to manage the SUF and they are state organizations which have the tasks and functions of forest owners and the State-assured conditions for managing, protecting and developing SUF".

SUF management faces many difficulties, including the high pressure from local people; overexploitation of forest resources, habitat fragmentation, low public awareness of biodiversity conservation and insufficient budget. Under-funding of the SUF system constrains SUF management (11, 12, 8 and 9), particularly at the provincial level. Research on 53 SUFs indicated that they used up to 90% of the total budget for the operation of MB (7). Under this circumstance, PES may provide a sustainable budget for the conservation of SUF in Vietnam.

In the North of Vietnam, PES was piloted in Tà Xùa SUF, with PES payment covering 13,912 out of 17,650 ha. As a pilot, Tà Xùa SUF aimed to provide critical experience for PES implementation in the SUF system. Tà Xùa is a high biodiversity area of 17,650 ha with 671 flora and 282 animal species. Tà Xùa is home to the most important conifer populations of North-Vietnam.

Xuân Nha is also a high biodiversity area of 18 789 ha with 1,074 species of vascular plants and 278 species of animals. The forest protection contract (FPC) was financially supported by the KFW7 project and was officially launched in March 2015. The Xuân Nha SUF-MB established contracts with 8 villages to provide protection for a total area of 2000ha during 5 years from 2015 to 2019, against a payment of 100,000VND/per year.

After large-scale implementation of PES for 6 years, many experiences learned from PES have been documented. To contribute some lesson learned on PES for SUF management, this research (1) assessed the implementation of PES in Tà Xùa and FPC in Xuân Nha, (2) evaluated the effectiveness of PES and FPC for forest protection, and (3) proposed solutions for effectively using payment from PES or other sources for SUF.

Methodology

This research was conducted from April 2014 to June 2016. We collected initial data from April to June 2014 (in Tà Xùa) and from July to September 2014 (in Xuân Nha), and conducted complementary fieldwork in June 2016. We interviewed 211 people, held 28 group discussions and walked in total 41.5 km of forest appraisal transects (Table 1). The appraisal questionnaire had a general part and a section focusing on local people's perspective on forest protection. The transect walk followed the appraisal acceptance check standards.

Forest protection effectiveness

Forest protection effectiveness was assessed by: (1) Perspective of SUF and PES funds, represented by the forest owner, in charge of approval for payment;

(2) Perspective of villagers and VPFGs, contracted parties responsible for protection; and (3) The fact-finding field survey: (i) 24 km and 17.5 km transect walk following forest appraisal acceptance check process; (ii) in-depth interviews with four groups of villagers and 10 villagers.

Results

The Tà Xùa SUF-MB signed a contract with 8 villages to protect a total of 13, 912 ha of forest since 2009. The payment varied from 119,790 VND/ha per year (in 2009) to 263,785 VND/ha per year (in 2015). For Xuân Nha, 8 villages were paid, promised payment of 100,000 VND/ha/year for the protection of 2000 ha during 5 years from 2014 to 2019 (Table 2).

PES provided a considerable budget for forest management and a good income for local people. In 2015, Son La revenue from PES was 105 billion, almost equal to the budget of the 661 programs (110 billion) for 12 years (24). Having a three-fold larger contracted forest area than that of Xuân Nha and a higher cost norm, each village in Tà Xùa was paid fourteen times higher than that in Xuân Nha. Moreover, Tà Xùa villages have benefited from forest protection since 2009 with long-term payment, while Xuân Nha will only benefit for five years.

For forest protection, village MBs take overall responsibility and play a critical role in success of forest protection as these boards (1) collaborate with the SUF-MBs, and local communities to identify the forest areas for each village; (2) sign the contracts with the SUF-MBs and (in Xuân Nha) open bank accounts to receive payment; (3) develop forest protection plans for village such as proposing regulations on forest protection for village's members, and managing VFPGs; (5) use the payments from PES and FPC (Figure 1).

Forest protection plans

In Tà Xùa, the forest protection was mainly based on VFPGs and patrolling. The number of VFPG members ranged from 12 to 17 and was divided into groups of 2-5 members to patrol with rangers from the SUF-MB. Normally, they spend about 3-5 days in the forest for one patrolling.

VFPG members are provided with clothes and equipment and received an allowance of 80,000 VND per day in 2010 and 150,000 VND per day in 2015.

Table 1

Main methods and number of participants.

Methods	Tà Xùa SUF	Xuân Nha SUF
Interview	01 staff from Phù Yên and 01 staff from Bắc Yên PES funds	01 province staff, 01 district staff
	5 people from SUF-MB	4 people from SUF-MB
	01 staff from commune	03 staff from communes
Group interview	6 village management boards (VMB)	6 VMBs
24 group interviews	6 village Forest protection groups (VFPG)	6 VFPGs
Household interview 180 people	90 people in Hang Dong C, Lang Sang Hang Dong B villages	90 people in Ban Lay, Chieng Hin, Kho Hong Village

Table 2

Summary of areas and revenue from PES and FPC.

Tà Xùa SUF				Xuân Nha SUF			
Village	PES forest area (ha)	Population (persons)	PES (in million VND)	Village	FPC forest area (ha)	Population (persons)	FPC (million VND)
Làng Sáng	2,221	532	585.9	Láy	257	661	25.7
Háng Đồng B	473	239	124.8	Chiềng Hin	275	334	27.5
Háng Đồng C	2,099	592	553.7	Khò Hồng	347	630	34.7
Total	4 793	1,363	1,264.5	Total	879	1,625	87.9

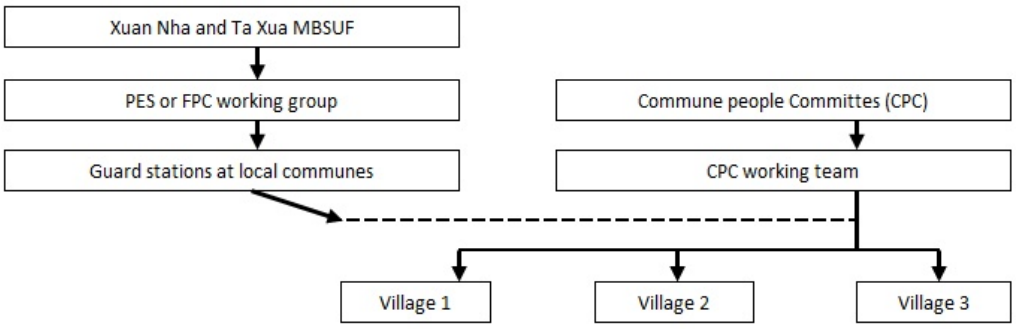

Figure 1: Structure of PES and FPC implementation.

Table 3

The patrolling schedule of the VFPG of Hang Dong C, Hang Dong B and Lang Sang.

Month (Lunar calendar)	Times/ month	Reasons
The first	2-3 times	Dry season; Traditional Hmong New Year, villagers are busy.
The second	3-4 times for Làng Sáng, 5 times for Háng Đồng C	Dry season; illegal logging peak because villagers are not busy with farming; destroying poppy
The third	3-5 times	Dry season, slash and burn season, high risk of forest fires. Rangers and staff from commune stationed in villages
Fourth to ninth	1-2 times	The rainy season, No risk of forest fires
Tenth to twelfth	3-4 times	Dry season, high risks of forest fire

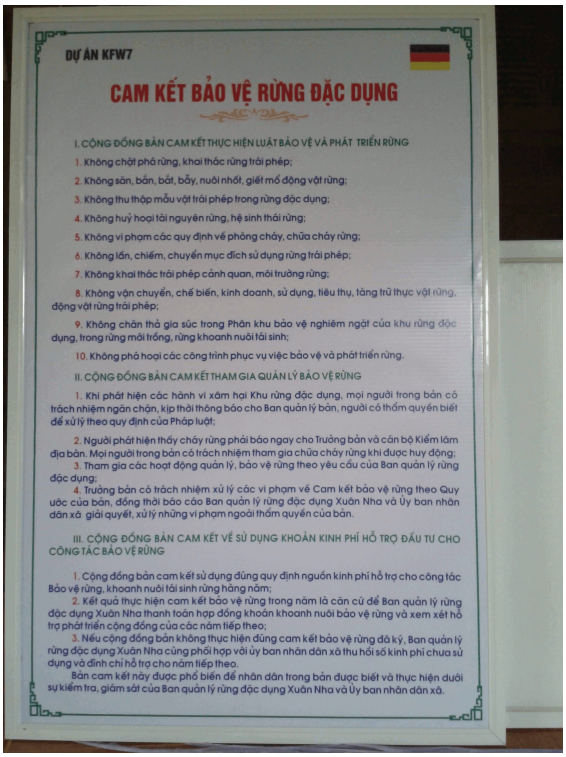

Figure 2: Forest protection regulations in Kho Hong village.

Figure 3: The village leader in Chieng Hin village announcing to villagers about their contracted forest and regulations.

The VFPGs spent more time in patrolling when forests were supposed to be under threat (Table 3). They focused on fire prevention but not on prevention of logging or poaching which cause the main conservation and biodiversity issues. After receiving PES, VFPGs patrolled more actively and more frequently, however, the amount of high value timber reduced which was widely reported in newspapers (3, 10 and 21) (Figure 2 & 3).

In Xuân Nha, VMBs worked effectively because they developed a comprehensive forest management plan for each village with strong support from the SUF-MB and local communes. They were fully involved in the whole process from identifying the contracted forest area for each village to developing the criteria for the annual forest check. All surveyed villages had very clear forest protection regulations and villagers were strongly committed. The protection in Xuân Nha was jointly worked out by both villagers and VFPGs to put more priority on community protection and on an informant network. This is a suitable strategy as they receive a very small budget only (from 25.7 to 34.7 million VND/year). Despite this limited budget, the forest resources are still well protected and VFPGs do not need to patrol often.

People's appraisal on the protection

In both Xuân Nha and Tà Xùa, the SUF-MB and WMB reported that forest areas were well protected, and that they earned the full payment. According to the reports, the forests were better protected; illegal cases, reduced; and violations, promptly reported. These acceptance checks were done by following instructions and requirements of PES and FPC. The villages providing the best forest protection were Háng Đồng A and Háng Đồng B in Tà Xùa, and Suối Quanh in Xuân Nha. According to the people, in Tà Xùa, the rate of illegal logging and wildlife hunting fell considerably, but there was no significant reduction in five other activities (Table 4).

Interviewees explained that these five activities were essential for local livelihoods and did not cause too much damage to forests. The representatives of the SUF-MB and communes also agreed that these activities should not be banned. In Xuân Nha, the FPC had positive impact on forest protection and reduced five exploitative activities, while free grazing by cattle and firewood collection by people continued. The SUF-MBs want to limit cattle grazing inside SUF so they allocated some grazing areas for local communities. However, this solution did not entirely solve the problem.

Table 4

Local people's rating (%) on forest protection.

Activities	Tà Xùa Special-Use Forest				Xuân Nha Special-Use Forest			
	Mean	Làng Sáng	Háng Đồng C	Hang Đồng B	Mean	Kho Hong	Chieng Hin	Ban Lay
Illegal logging reduced	80	60	80	100	100	100	100	100
Wild animal poaching reduced	80	70	70	100	87	90	90	80
Forest was better protected	90	100	70	100	98	90	100	100
Cattle grazing in the SUF reduced	10	0	0	30	23	30	20	20
Honey bee harvesting reduced	10	10	10	10	80	100	90	50
Shoots harvesting reduced	10	10	10	10	60	100	50	30
Firewood harvesting reduced	10	0	0	30	13	20	10	10
Mice trapping and hunting reduced	20	20	10	30	53	70	60	30
Shifting cultivation in non-permitted ares was reduced	13	20	20	0	100	100	100	100

Figure 4: Timbers gathered near Lang Sang before being floated (route No 2).

Figure 5: Remainings of *Fokienia hodginsii* logging near the road.

Effectiveness of forest protection

In Tà Xùa, the transect walk found evidences of logging, such as piles of timber ready for transport over the water stream (Figure 4) and 8 felled trunks (along a 6 km transect). In the area with high population of Fokienia hodginsii (Pơmu), almost all big trunks were felled (Figure 5).

In Xuân Nha, the research team walked for 17.5 km and found that the forests were well protected and no signs of forest damage were recorded. However, the forest quality in Xuân Nha is poorer than that in Tà Xùa.

Market channels for illegal logging.

The in-depth interviews with villagers in Tà Xùa revealed that commercial Pơmu logging had occurred since long time ago. Since 1990s a professional network of Pơ mu traffickers and their assistants paid villagers in advance to log and transport timbers. Timbers were sawn into bars (12cm x 22cm x 220 cm) or boxes (12 cm x 80-90 cm x 260 / 280cm). Payments for logging and shipping are estimated to be approximately 200-300 thousand VND/ bar; 1000 - 1500 thousand VND / box. On average, a person can earn 500 thousand VND / day. This is a very high income as the average income of people in Hang Dong C and Lang Sang is lower than 700 thousand VND/month per person.

The timbers from the Tà Xùa SUF were transported via two main routes:

Route No.1 follows this pathway :

(i) from SUF, 2-3 km to the A1 (near milestone 364),
(ii) then 3-4 km to Tàng Ghênh village,
(iii) then 6-10 km by motorcycle to Bản Mù commune and
(iv) then to A4 where timbers are transported by trucks.

Through this route, illegal timbers are exploited from the areas close to Ban Mu Commune (in Yên Bái Province), more than 10 km away from Lang Sang and Hang Dong C villages, and about 40 km away from the Hang Dong guard station. Timbers that are exploited from Tà Xùa are transferred to Yen Bai Province, out of the SUF-MB control area. Up till October 2016, illegal logging along this route was reported to occurr widely and to have recently increased (3, 22) as well. A leader of Tram Tau district confirmed that the timbers came from Son La.

Route No.2 follows this pathway: (i) from SUF, near Lang Sang village, timbers are floated 5 km downstream; (ii) then these are taken to either Bắc Bệ A or Bắc Bệ B, or Suối Sập in Suối Tọ Commune, about 5-7km then (iii) to a gathering station in Phu Yen. Loggers mostly come from Lang Sang and Hang Dong C. Logging occurs only in the rainy season (from months 4 to 7 of the lunar calendar) when the water level is high enough for timber transport. Meanwhile the VFPGs and rangers patrol little from months 4 to 9 because there is no threat of fire during rainy season and forests are not at risk. (Table 3).

About 60% of the total timber illegally exploited in the Ta Xua SUF were transported through the route 1, but this volume is expected to decrease with the recently improved law enforcement in Son La. Local people estimated that for route No.2, traffickers need 5-7 days to collect enough timber for one shipping (30-40 boxes or 100 bars). They rest and wait for about 1-3 weeks and collect another set of timber and transport these if they feel they can escape from the rangers. After PES implementation, illegal logging was reduced a little, but fell sharply in 2013 due to strong law enforcement and confiscations by new reporters and provincial rangers.

Some locals know when timbers are logged and also who are the timber traffickers. However, they do not want to report to assigned authorities because they do not feel comfortable, they lack trust, have no motivation and try to avoid conflicts. These are some of the reasons why the informant network, which had effectively contributed to a successful forest protection in Xuan Nha, is not formed yet in Ta Xua. The village leaders and the people in the commune still have low awareness on the link between forest protection and PES. Responsibility in protecting the forests by both stakeholders remains weak. This was showcased in 2010, when two illegal loggers were imprisoned for 2 years, their families continued to receive full PES money, which

contrasts with the regulations of both PES and SUF management. However village and commune leaders did not agree with this rule for violators. The PES representatives were ignored, and those of SUF-MB could not give alternative solutions. In Tà Xùa, no offences had been reported since 2009, but in Xuân Nha, several violations were reported and criticized. In April 2016 an illegal transport of 1.5m3 was reported by people in Kho Hong, and in June 2016, the SUF-MB arrested an illegal transport of 8m3 Pomu (Fokienia hodginsii). In 2013, at the first two village meetings on the Xuan Nha FPC, local people in Ban Lay village did not agree to report violations to responsible authorities. However, after negotiations with the SUF-MB, communes and villagers agreed that local people would report all violations to SUF-MB, but did not need to report the names of violators; all information about the informants would be kept confidential also. Although the FPC had been implemented for one year at a small scale only, the program was evaluated as a successful model to fund community- based forest management. Thus, Son La province has proposed to replicate the FPC model of Xuan Nha in other SUFs (29).

Discussion and conclusion

Next to the length of operation, Tà Xùa and Xuân Nha have at least two basic differences: rich forest versus already over-exploited forest, and not having a comprehensive plan versus having such a plan, respectively, Moreover, the Tà Xùa SUF-MB did not succeed in gaining the commitment and support of local communities, while Xuân Nha SUF-MB was able to get support and commitment to implement requirements, comply with criteria and set a clear disbursement mechanism from the start. All local communities around Tà Xùa are Hmong people and are famous for strong relationships and commitment towards their communities.

On the other hand, the Tà Xùa SUF-MB did not succeed well in promoting participatory forest protection because of the insufficient capacity of the SUF-MB staff, as well as the common interest of both communities and the SUF-MB to have access to the same sources of livelihood. The latter is supported by the non-penalization of the household when one member has been imprisoned after committing an infraction; socially, this attitude of the SUF-MB is understandable, especially when the imprisoned person is the main income provider of the household. Not providing the household with the money might force them in (other) illegal activities. Not paying the dues, in agreement with the SUF management regulations and PES requirements, might reduce the people's commitment to forest protection. Consequently, although the VFPGs spend a lot of time in patrolling forests, illegal logging is still widely done which results in a significant reduction of high-valued timber. The case studies of Tà Xùa and Xuân Nha concur with findings of other authors (1, 26 and 2) that support of local communities plays a critical role in successful forest protection, but gaining communities' support and achieving conservation at the same time remain a challenge.

It is therefore timely for SUF-MB to elaborate the clear mechanism and requirement for forest protection. SUF-MB should also collaborate with the Hang Dong commune to elaborate requirements for forest protection for all villages.

Communities need to come to an agreement that violators should be fined or at least their families, not rewarded by PES. The informant network, a very effective tool, should be established and promoted. At the beginning, the staff should give their phone numbers or the way that the local people can contact them. To avoid conflicts and reduce the risks for informants, all information about informants are kept confidential, the informants do not need to provide the name of violators. Perhaps, it would help if informants are given incentives or rewarded for their efforts, but this contrasts with the proposed confidentiality. At the community level, SUFs should propose clear penalties in case those villages do not fulfill their duties to make examples for other villages. It is difficult and complicated to keep and return PES in case those local communities did not protect forest as requirements because of budget disbursement pressure. Similarly, shifting or canceling the contracts is also complicated. However, if the SUF-MBs are not able to apply some penalties for violations and they lose their control, they may not protect the forest properly.

PES provides a great opportunity for SUF-MB to achieve forest protection and gain commitment from local communities by compensating them for the lost livelihood options from the forest. Several authors claim that the PES has not achieved the desired outcomes regarding forest conservation because the procedures are not strict enough, and government has provided no clear directions on monitoring and evaluation (22 and 15).

These limitations can be addressed by integrating PES into SUF management regulations as these regulations were clearly defined on legal documents; this opportunity was demonstrated by the Xuân Nha SUF, although the resources of this forest were not so attractive for illegal loggers. Representing the SUF owner, assigned to manage the SUF, a SUF-MB is responsible for the strict protection of the forest, which means that when the SUF-MB fulfills its tasks properly, the SUF would be protected much better than according to the PES requirements. The PES provides them with a complementary tool to achieve these tasks to protect the forest.

PES provides a great chance for effective forest conservation. However, to achieve the expected outcomes, the capacity of SUF-MB needs to be improved. Capacity development in the areas of engaging local communities in putting up the PES, establishing rules that are acceptable for the local communities accompanied with sufficient compensation from PES for the lost livelihood options need to be put in place.

More study, however, is needed to effectively utilize the budget from PES to improve the livelihood for local people to be compensated by PES. In addition, SUF-MBs need to also learn skills and approaches on effectively raising the awareness of people on the forest protection, and knowledge on related SUF management regulations and PES requirements. This awareness raising should also address the consumers who buy products that are made from the forest resources; the latter could be supported by Sustainable Forest Certification.

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Screening Three Finfish Species for their Potential in Removing Organic Matter from the Effluent of White Leg Shrimps (*Litopenaeus vannamei*) Farming

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Keywords: Organic matter- Finfish- White leg shrimp- Shrimp wastewater- Vietnam

Summary

*White leg shrimp (*Litopenaeus vannamei*) farming effluent contains pollutants that include high levels of organic matter (OM) nutrients and growth-promoting substances. This study investigated the effects of varied concentrations of white leg shrimp (*Litopenaeus vannamei*) farm wastewater 0, 50, 75 and 100%, on the survival rate (SR) of three finfish species: tilapia (*Oreochromis niloticus*), grey mullet (*Mugil cephalus*) and rabbit fish (*Siganus guttatus*) as part of screening their potential in removing organic matter from the effluent of white leg shrimp farming. The different initial levels of shrimp wastewater from 50% to 100% had no significant effect on the survival rate of tilapia and mullet; but the survival rate of S. guttatus significantly decreased with increasing shrimp wastewater ($P<0.05$). The results showed that the removal of BOD, COD and TSS occurred in the range of 66-83, 68-81 and 30-54%; respectively and the removal efficiency of OM by mullet was higher than Tilapia in all treatments. The study also indicated that the reduction highest removal of BOD, COD and TSS was achieved being 83.1%, 80.7and 53,7% respectively, at the medium stocking density (25 fish/m^2) of mullet.*

Résumé

Comparaison de trois espèces de poisson pour leur potentiel à réduire la matière organique des effluents de l'aquaculture des crevettes blanches (*Litopenaeus vannamei*)

*Les effluents des bassins de production de crevettes (*L. vannamei*) contiennent des éléments polluants tels que la matière organique (OM), des nutriments et des substances stimulant la croissance. Cette étude analyse les effets de trois concentrations (0, 50, 75 et 100%) d'effluents de bassins de production de crevettes, sur la survie (SR) de trois espèces de poisson: le tilapia (*Oreochromis niloticus*), le mulet gris (*Mugil cephalus*) et le poisson-lapin-doré (*Siganus guttatus*) afin de connaître leur potentialité à réduire le taux de matière organique de cet effluent. Les différents niveaux initiaux de ces effluents (50, 75 et 100%) n'ont pas d'effets significatifs sur la survie des tilapias et du mulet, alors que la mortalité de S. guttatus augmente significativement avec la concentration d'effluent ($P<0,05$). Les taux de réduction de BOD, COD et TSS étaient entre 66-83, 68-81 and 30-54%, respectivement. Le taux de réduction d'OM par mulet était plus élevé que pour le tilapia dans tous les traitements. Les taux de réduction les plus élevés, avec une densité moyenne de 25 mullet/m^2, sont observés pour des BOD, COD et TSS de 83%, 81% et 54% respectivement.*

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Introduction

Organic matter (OM) is the main pollutant from the effluent of intensive shrimp farming. In wastewater, OM includes both dissolved and suspended particles comprising mainly carbon chains. OM is readily available to microbes and algae; an increase in OM concentration will affect the structure of the phytoplankton community, thereby leading to eutrophication in the pond (9).

Without proper treatment, the shrimp wastewater discharge containing high OM unfavourably affects aquatic life, water quality and the environmental system.

In the last few decades, several methods have been applied to control OM in aquaculture wastewater. These methods include wetland treatment, polyculture systems, trickling filters, biofilms, membrane filtration, electro-coagulation and chemical treatment (4). Boopathy (2) suggested that most of these methods may be used to reduce OM from wastewater, but biological methods are the most advantageous. Nowadays, alternative systems for removing OM involve aquatic animals and/or plants from aquaculture wastewater have been studied. Troell *et al.* (7) used a polyculture system which combined seaweed, fish and shrimp to treat shrimp farming effluent. Their study suggested that the polyculture system could be used to remove OM, as well as produce an aquatic organism as a food source. Tian *et al.* (6) investigated a closed-polyculture system including Chinese shrimp (*Penaeus chinensis*), Taiwanese tilapia (*O. mossabicus* x *O. Niloticus*) and constricted tagelus (*Sinonovacula constricta*). The study indicated that chemical oxygen demand (COD) in a polyculture system was lower than that in shrimp monoculture, while other parameters such as pH, dissolved oxygen (DO) and nutrient concentrations were not significantly different. Erler *et al.* (3) used two finfish species (*Mugil cephalus* and *Siganid nebulosus*) and vertical artificial substrates (VAS) to treat shrimp farm effluent.

The study concluded that VAS significantly improved the settlement of particulates, while *Mugil cephalus* potentially reduced the production of nitrate (NO_3-N) when VAS was absent.

However, when *Siganid nebulosus* was added, the total finfish nitrogen (N) retention increased. Limited information is available on the applicability of tilapia, grey mullet and siganid in removing organic matter from shrimp farm effluent.

Fish can filter feed on things such as phytoplankton, organic particles and bacterial films in the upper water column (8).

This study investigated the potential of finfish species for assimilating OM and their optimal stocking density for maximizing the removal of OM from intensive shrimp farm effluent through two subsequent experiments, the the first assessed survival rates and second the removal rates.

Materials and methods

Wastewater was collected at the shrimp farm effluent canal in the third month of the shrimp production cycle and diluted with seawater to obtain 75% and 50% wastewater concentrations. Three water quality parameters of the diluted treatments: (i) DO (±0.5), (ii) T (±0.5) and (iii) pH (±0.5) were adjusted to levels similar to the 100% treatment. All experiments were conducted at the Dien Mon Enterprise Shrimp Farming, Truong Son Company, Thua Thien Hue province, Vietnam. The water quality parameters including pH, temperature (T), salinity (S) and dissolved oxygen (DO) parameters were measured once in every two days at 8:00AM in the field. Water samples were taken at 25 - 40 cm in depth at 5 positions inside the tank, including the 4 corners and the centre, and then mixed together for analysis.

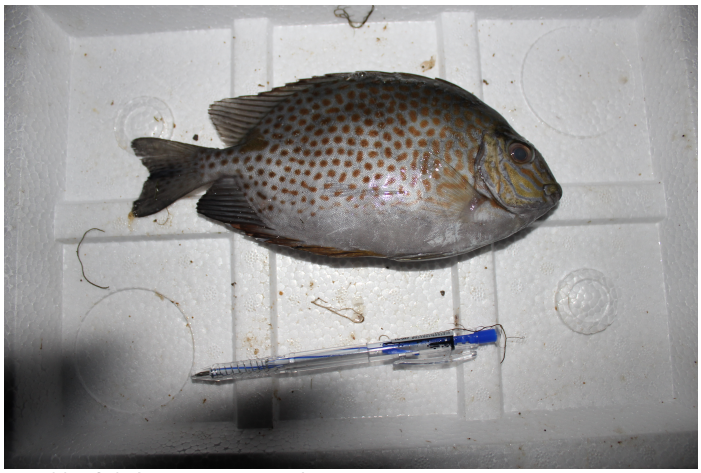
The concentration of TAN was measured by the Phenate method. TSS, BOD, COD, NO_3-N and PO_4-P were performed according to the standard method (1) in the laboratory.

Experiment 1

The survival rates of three local finfish species: tiliapia (*Oreochromis niloticus*) (Figure 1a), grey mullet (*Mugil cephalus*) (Figure 1b) and rabbit fish (*Siganus guttatus*) (Figure 1c), were tested at three different shrimp wastewater levels: 50%, 75% and 100% during 12 days of experiment period. At the beginning of the experiment, each tank contained 500 L of water composed of 100, 75 or 50% shrimp wastewater; the supplement was seawater.

a. Grey mullet (*Mugil cephalus).*

b. Tilapia (*Oreochromis niloticus*).



c. Rabbit fish (*Siganus guttatus*).

Figure 1: Three finish species were used in the experiments.

At days 4 and 8 of the experimental period, 250 L water of each tank was replaced with an identical mixture of seawater and shrimp wastewater collected from the water channel. Oxygen was supplied from the aerator system to maintain the DO level of the water above 4.0 mg/L during the experiment.

The experimental set-up had three parallel replicates at the same time. The average wet weight of the fish at the start of the experiment was 20.2 ±2.1 g for *O. niloticus*, 20.4 ±2.2 for *M. cephalus* and 20.5±3.1 for *S. guttatus*. Each tank contained 15 fish.

Experiment 2

Experiment 2 assessed the optimal stocking density for maximum biodegradation of the OM from shrimp wastewater by the fish species selected from experiment 1. The two species were tiliapia (*Oreochromis niloticus*) and grey mullet (*Mugil cephalus*). The mean wet weight of *M. cephalus*, 21.4 ±2.1g, was tested at three densities: 20 (M-20), 25 (M-25) and 30 (M-30) mullets/m^3, which approximated 400, 500 and 600 g/m^3, respectively. The mean wet weight of tilapia, 21.1 ±1.4g, was tested at the same densities; the treatments, referred to here, are: T-20, T-25 and T-30. Both species had a control of 0 fish/m^3 referred to here as CT and CM, respectively. The experiment was conducted over 8 days with three parallel replications at the same time.

Data analysis

The survival rate of the animals was calculated by Equation I.

$$SR = \frac{N_{en}}{N_{in}} \times 100 \qquad (I)$$

where: *SR* is the survival rate (%), N_{en} is the number of animals at the end of experiment (individuals) and N_{in} is the number of animals at the initiation of experiment (individuals).

The mean and the standard deviation (SD) values of the effluent water quality indicators of the three finfish species in three different shrimp wastewater levels were calculated by using descriptive statistics. The treatment efficiency was calculated by using the mean difference between initial and final values. The two experiments were analysed by using a one-way ANOVA followed by Tukey post hoc test and Tamhane's test (when equal variances were not assumed). SPSS® software Version 21 was used for the mentioned analysis.

The differences were considered significant at $P<0.05$. The time series was interpreted by using a straightforward analysis of the plotted graphs prepared in MS-Excel®.

Results and discussion

Screening the potential of finfish

Water quality

During the experiment, the mean values of Salinity (S), Temperature (T) and DO fluctuated ranging from 21.7 – 22.7%, 30.4 – 31.5 °C and 5.7 – 6.3 mg/L, respectively in the treatments.

At 100% shrimp wastewater level, the pH was slightly higher than that in the 75% and 50% levels for all the three fish species treatments, while the concentration of DO was usually lower than that in other two treatments of wastewater levels (50% and 75%) (Table 1).

At the initial stocking, the concentrations of both TAN and NO_2-N were not different among the three finfish species (Table 2).

Total ammonia Nitrogen (TAN) concentrations slightly increased with the increased concentration of shrimp wastewater (Figure 2).

The TAN increased from an initial level of 4.7 mg/L to 5.4, 5.1 and 5.5 mg/L for treatments T-100, M-110 and S-100, respectively. At treatments of 75% and 50% wastewater levels, TAN increased from 3.2 mg/L to 3.7 mg/L, and from 1.9 mg/L to 2.5 mg/L, respectively after 12 days of experimental period. At three different shrimp wastewater levels, the NO_2-N concentration increased in *O. niloticus* and *S. guttatus* treatments, while that in *M. cephalus* treatments slightly decreased (Figure 3). At the end of the experiment, the concentration of NO_2-N for each of the three treatments: M-100, M-75 and M-50 was reduced by 23%, 23.7% and 7.5%, respectively.

Table 1

The means ± SD, of salinity, T, pH, and DO in the different treatments for the 12 days experimental period.

Treatments	Salinity (‰)	Temperature (°C)	pH (logH⁺)	DO (mg/L)
T-100	21.8 ±11.0	31.5 ±3.8	7.8 ±0.15	5.8 ±0.2
T-75	21.9 ±10.7	31.3 ±4.0	7.6 ±0.18	6.0 ±0.1
T-50	22.2 ±10.2	31.3 ±4.0	7.7 ±0.15	6.1 ±0.1
M-100	21.9 ±11.8	31.3 ±3.8	7.7 ±0.19	5.9 ±0.1
M-75	22.6 ±11.1	30.4 ±3.2	7.5 ±0.05	5.9 ±0.2
M-50	22.6 ±11.3	30.3 ±2.9	7.5 ±0.11	6.3 ±0.2
S-100	21.8 ±11.7	31.3 ±3.7	7.7 ±0.11	5.9 ±0.2
S-75	22.5 ±11.1	30.5 ±3.3	7.6 ±0.15	6.0 ±0.2
S-50	22.7 ±11.0	30.5 ±3.3	7.6 ±0.17	6.3 ±0.2

Note: T-100, T-75 and T-50, M-100, M-75 and M-50, and S-100, S-75 and S-50: *O. niloticus*, *M. cephalus* and *S. guttatus*, respectively, stocked in 100, 75 and 50% shrimp wastewater.

Table 2

The initial and average values for days 2, 4, 6, 8 and 12 of TAN and NO_2-N in the three different finfish species for the 12-day experiment (means ± SD).

	O. niloticus		*M. cephalus*		*S. guttatus*	
	Initial	Final	Initial	Final	Initial	Final
TAN (mg/L)	3.2 ±1.4	3.8 ±1.4^{a}	3.2 ±1.4	3.5 ±1.4^{a}	3.2 ±1.4	3.7 ±1.3^{a}
NO_2-N (mg/L)	2.8 ±1.2	3.1 ±1.0^{a}	2.8 ±1.2	2.6 ±0.8^{b}	2.8 ±1.2	3.2±1.0^{a}

Different superscripts for the final values in the same row indicate that the values are significantly different at $p<0.05$.

Table 3

The survival rate of three finfish species at different shrimp wastewater levels at day 12.

Fish species	Shrimp wastewater level (%)			Mean survival rate
	100	75	50	
O. niloticus	91 ±1.9^{a,i}	92 ±1.9^{a,i}	94 ±1.9^{a,i}	93 ±2.2^{a}
M. cephalus	82 ±1.9^{a,i}	84 ±1.9^{a,ij}	91 ±1.9^{a,j}	86 ±4.3^{b}
S. guttatus	37 ±6.7^{b}	49 ±5.1$^{b\,ij}$	54 ±3.8^{b,j}	47 ±9.1^{c}

a,b,c Different superscripts in the same column indicate that the values are different ($p<0.05$).

i,j,k Different superscripts in the same row indicate that the values are different ($p<0.05$).

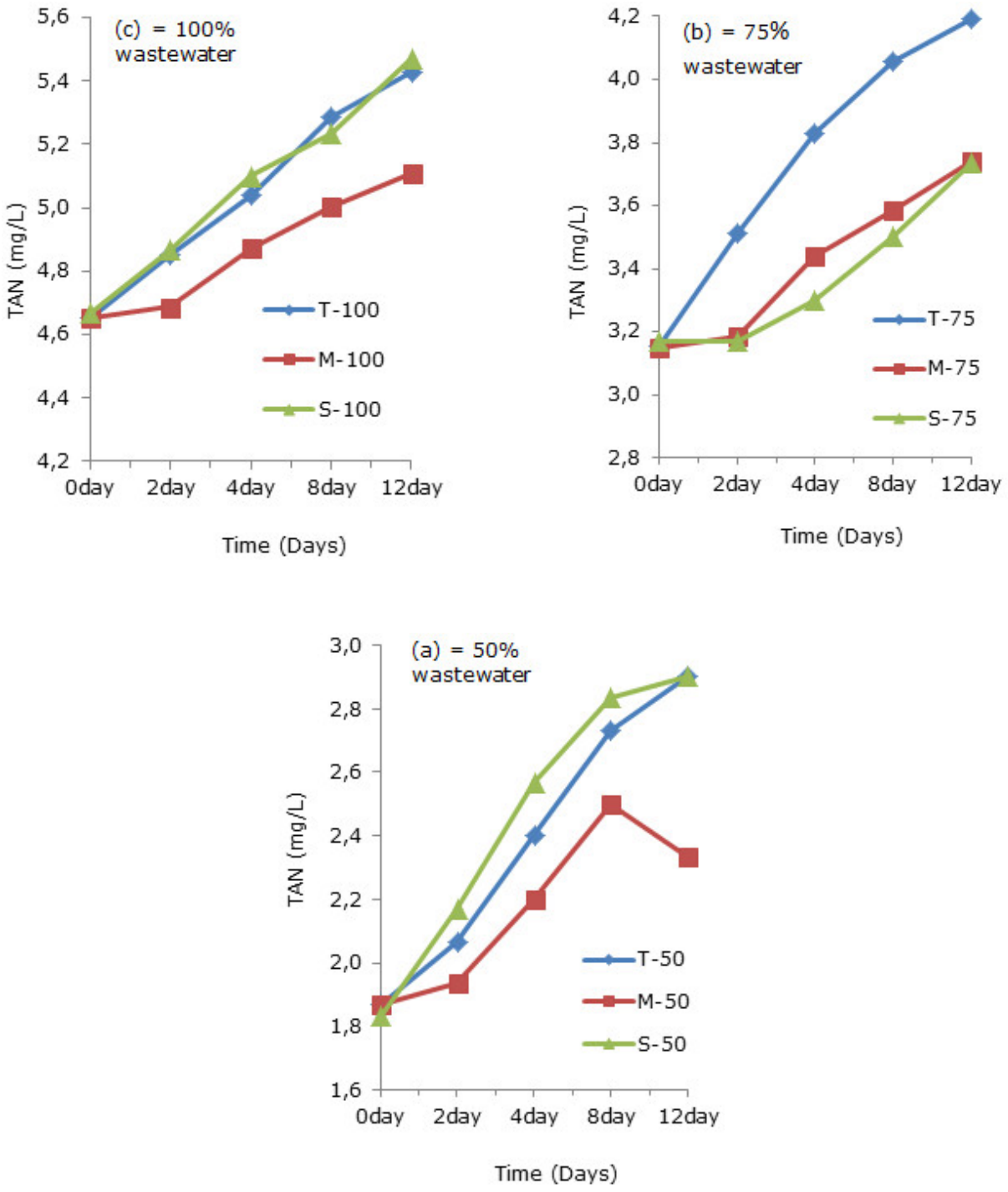


Figure 2: Effects of three selected finfish species (T= Tilipia ; M= Mullet ; S= Siganus) on TAN at three different shrimp wastewater levels.

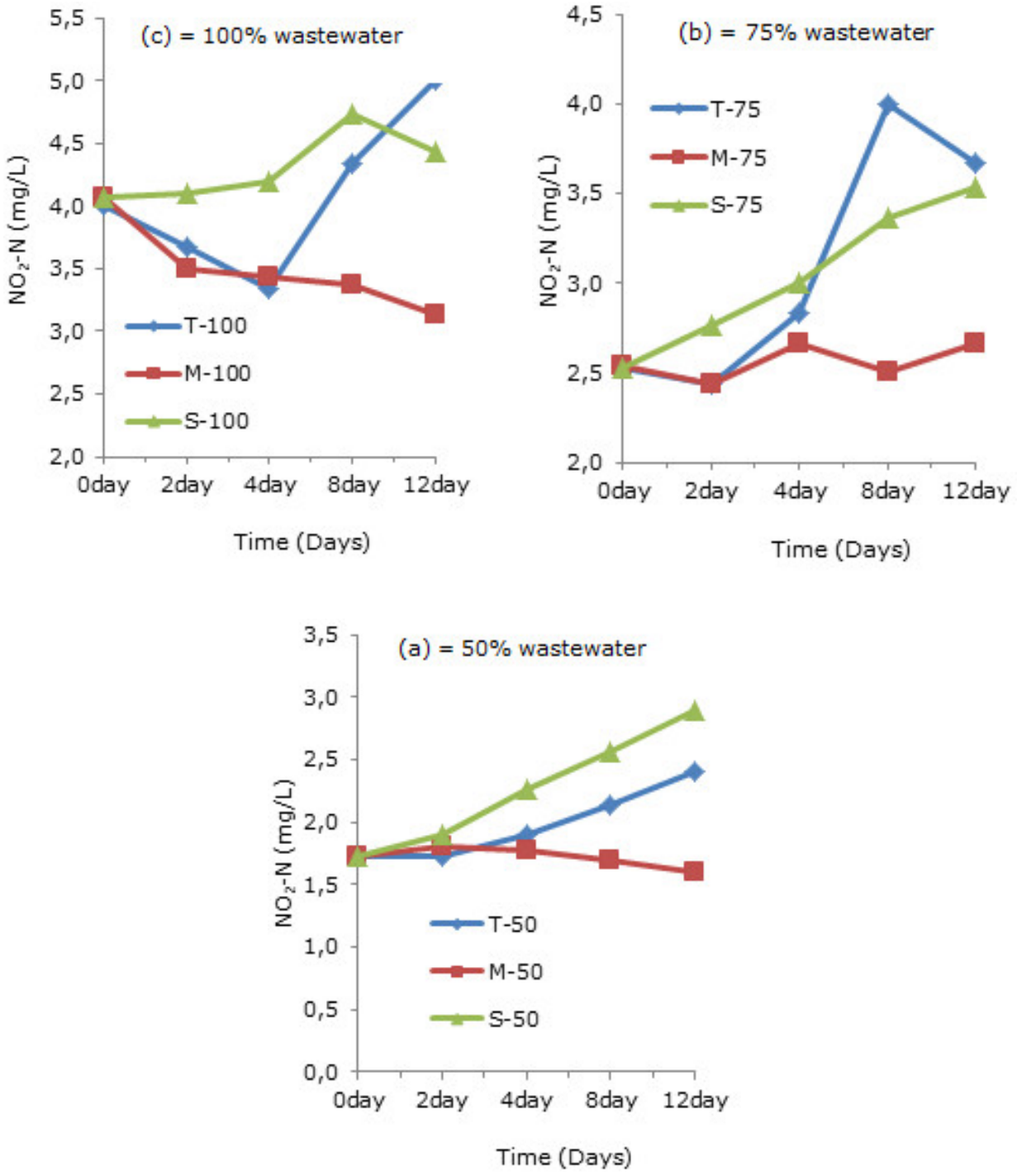


Figure 3: Effects of three finfish species on NO_2-N at three different shrimp wastewater levels.

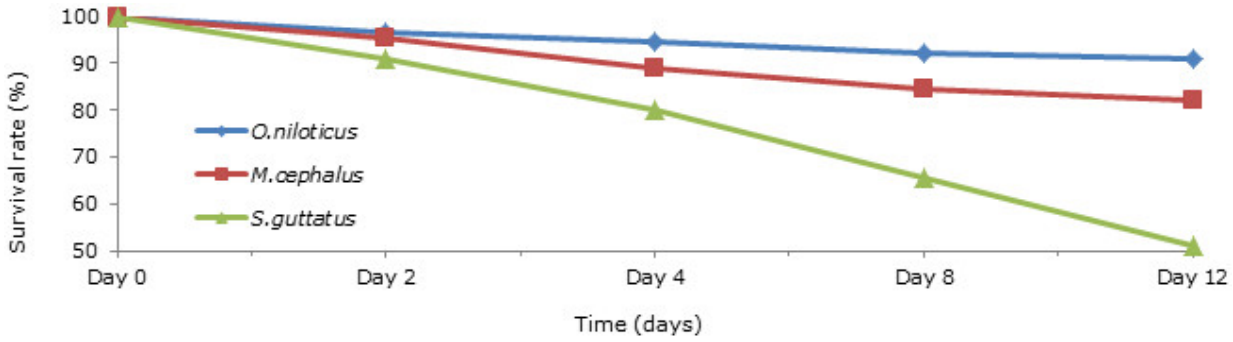


Figure 4: Comparison of the survival rate of the three selected finfish species.

The mean level of NO_2-N in *M. cephalus* treatment was significantly lower (P<0.05) compared with that of the other two species (Table 2). The survival rate (SR) of two species *O. Niloticus* and *M. cephalus* for the three shrimp wastewater levels was not different after the 12-day-experimental period (Table 3). However, the SR of *S. guttatus* decreased from 54% to 37% when shrimp wastewater level was increased from 50% to 100%. The mean SR of the three species was significantly different (P<0.05). At the end of the experiment, the mean SRs were 93%, 86% and 47% for *O. Niloticus*, *M. cephalus* and *S. Guttatus*, respectively (Table 3). Over the 12 day-period, the mortality rate of *O. Niloticus* and *M. cephalus* was steady, while the mortality among the *S. Guttatus* accelerated (Figure 4).

However, all three finfish species showed stress at 100% treatment which had 5 mg/L TAN. At the lower level of 0.1 mg/L NH3, the SRs of *O. niloticus* and *M. cephalus* were around 94 and 91%, but when the level of NH3 increased to 0.2 mg/L and 0.3 mg/L, the SRs decreased to about 92% and 91% for *O. niloticus* and 84% and 82% for *M. cephalus*, respectively. The survival rate of *S. guttatus* also significantly decreased from 54 to 37% when NH3 concentrations increased from 0.1 to 0.3 mg/L (P<0,05). The NH_3 and the NO_2-N toxicity levels in the water significantly influenced the fish biomass. Increasing the fish stocking density, likewise increased the concentrations of NH_3 and NO_2-N. This may be caused by different DO levels in the tanks due to different ecological niches these fish species were feeding on. Morris and North (5) reported that the oxygen consumption not only depended on the animal species, but also on their ecological niches, morphological changes at different life stages and biomass stocking densities. These may be the main reasons for the limited nitrification process in the tanks which increased NH_3 and NO_2-N concentrations in the water.

The results indicated that *S. guttatus* was less tolerant and had little capacity in removing OM from shrimp farm effluent compared with *O. niloticus* and *M. cephalus* which showed more capacity in biodegrading OM; these two species also had wider toxicity and salinity tolerance. The SR of *O. niloticus* and *M. cephalus* was not significantly affected with shrimp wastewater at 50% and 100%, but that of *S. guttatus* was reduced correspondingly with increased shrimp wastewater concentration.

Impact of fish stocking density

O. niloticus *densities and water quality*

The water quality parameters were similar among the treatments (P>0.05), except for DO (Table 4). The mean DO concentration decreased with increasing fish stocking density. The concentration of TAN, NO_3-N and PO_4-P increased with increasing *O. niloticus* stocking density from 20 to 30 tilapia/m^3, and these reached the highest level in the highest stocking density (T-30). The levels of TAN, NO_3-N and PO_4-P nearly doubled during the experiment, but the mean values did not differ between the treatments, except for DO. In the control, the mean value of NO_3-N was significantly lower than that in the three treatments, while the DO level was significantly higher (Table 4).

Table 4

Mean (± SD) values of T, pH, DO, TAN, NO_3-N and PO_4-P at three different *O. niloticus* densities.

	T (^{0}C)	pH ($logH^+$)	DO (mg/L)	TAN (mg/L)	NO_3-N (mg/L)	PO_4-P (mg/L)
T-20	33.0±0.4^a	7.9±0.12^a	5.9±0.22^a	2.5±0.80^a	4.6±0.60^a	1.4±0.42^a
T-25	32.9±0.3^a	8.0±0.13^a	5.6±0.19^a	2.6±0.73^a	4.8±0.64^a	1.4±0.47^a
T-30	33.0±0.3^a	7.9±0.12^a	5.2±0.36^b	2.8±0.71^a	4.8±0.69^a	1.5±0.51^a
CT	33.3±0.1^a	8.2±0.22^a	6.4±0.43^c	2.5±0.52^a	3.7±0.36^b	1.5±0.42^a

Different superscripts in the same column indicate that the values are different ($p<0.05$). T-20: 20 *O. niloticus* (400 g/m^3); T-25: 25 *O. niloticus* (500 g/m^3); T-30: 30 *O. niloticus* (600 g/m^3); CT: is control (no fish).

Table 5

Initial, final and reduction values of BOD, COD and TSS by O. niloticus in three treatments (T-20, T-25 and T-30) and the control (CT)

	BOD			COD			TSS		
	Initial (mg/L)	Final (mg/L)	Removal (%)	Initial (mg/L)	Final (mg/L)	Removal (%)	Initial (mg/L)	Final (mg/L)	Removal (%)
T-20	58,6	20.1±0.8	66 ±1.3^a	92,7	28.4±0.8	69 ±0.9^a	342	204±10.6	40 ±3.1^a
T-25	58,6	12.6±0.2	78 ±0.4^b	92,7	21.8±0.7	77 ±0.8^a	342	233±1.44	32 ±0.4^b
T-30	58,6	16.4±1.4	72 ±2.3^{ab}	92,7	21.2±0.6	77 ±0.6^a	342	240±2.12	30 ±0.6^b
CT	58,6	42.5±0.4	28 ±0.6^c	92,7	64.6±1.1	30 ±1.3^b	342	240±2.1	30 ±0.6^b

Different superscripts in the same column indicate that the values are different ($p< 0.05$). T-20: 20 *O. niloticus* (400 g/m^3); T-25: 25 *O. niloticus* (500 g/m^3); T-30: 30 *O. niloticus* (600 g/m^3); CT: is control (no fish).

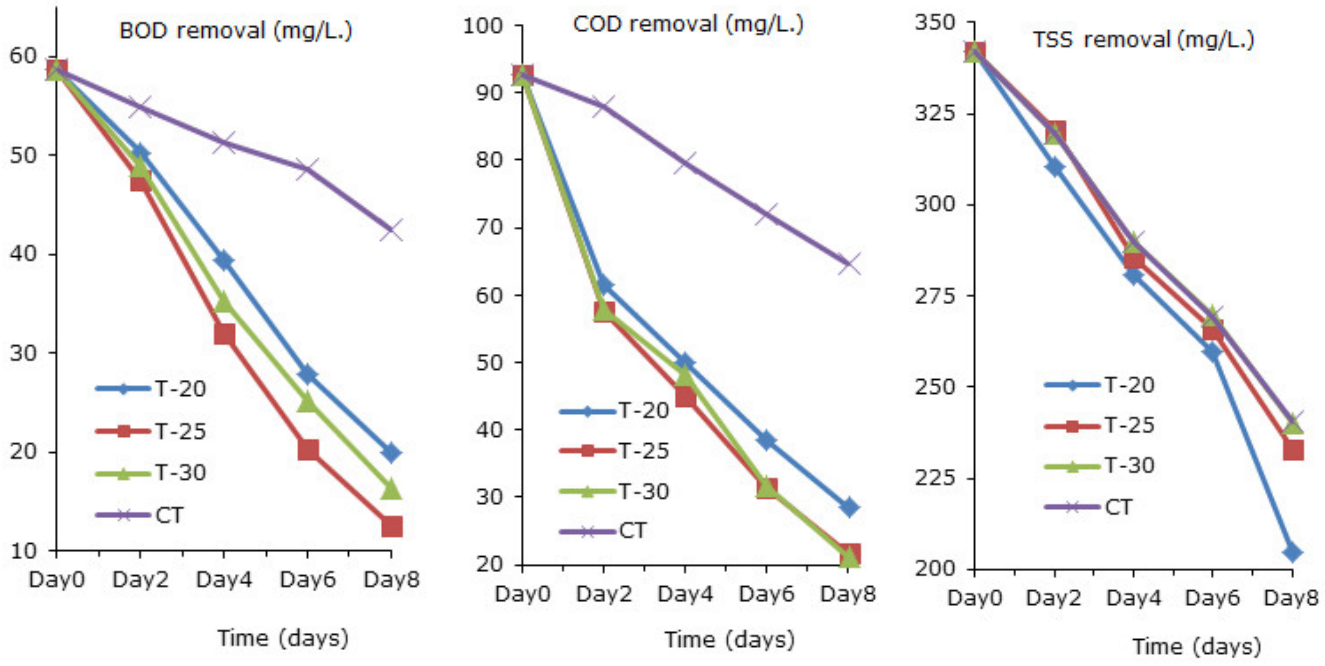


Figure 5: Reduction of BOD, COD and TSS by *O. niloticus* in three treatments (T-20, T-25 and T-30) and the control (CT).

Table 6

Mean (± SD) values of T, pH, DO, TAN, NO_3-N and PO_4-P at three different M. cephalus densities and the control.

	T (°C)	pH ($logH^+$)	DO (mg/L)	TAN (mg/L)	NO_3-N (mg/L)	PO_4-P (mg/L)
M-20	31.8 ±0.7[a]	7.7 ±0.1[a]	5.5 ±0.24[a]	2.2 ±0.05[a]	5.4 ±0.04[a]	1.3 ±0.05[a]
M-25	31.8 ±0.7[a]	7.7 ±0.1[a]	5.4 ±0.22[a]	2.2 ±0.06[a]	5.1 ±0.03[a]	1.3 ±0.01[a]
M-30	31.8 ±0.7[a]	7.7 ±0.1[a]	5.4 ±0.15[a]	2.3 ±0.04[a]	4.8 ±0.03[a]	1.4 ±0.01[a]
CM	32.0 ±0.7[a]	7.8 ±0.1[a]	6.2 ±0.32[b]	3.3 ±0.18[b]	4.0 ±0.28[b]	1.3 ±0.02[a]

Different superscripts in the same column indicate that the values are different ($p<0.05$). M-20: 20 *M. cephalus* (400 g/m³); M-25: 25 *M. cephalus* (500 g/m³); M-30: 30 *M. cephalus* (600 g/m³); CM: is control (no fish).

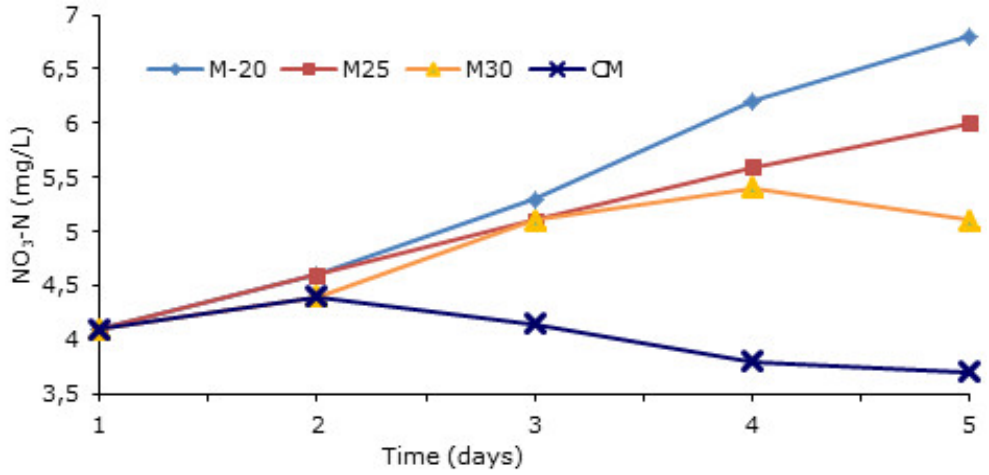


Figure 6: The NO_3-N level in three *M. Cephalus* treatment densities (M-20, M-25 and M-30) and the control (CM).

The BOD and COD concentrations were reduced during the experiment in all three treatments (Table 5). The reduction of BOD and COD was significantly stronger in all treatments compared with that in the control ($P<0.05$). In the three treatments, the removal rates were around 66 – 78% for BOD, 69 – 77% for COD, while in the control these rates were 28 and 30%, respectively (Figure 5). The removal rate of BOD was slightly better for the medium stocking density of *O. niloticus*; however, the difference between medium and high densities was not statistically significant. The latter might be related to the increased TAN concentration and the reduced DO level in the highest *O. niloticus* stocking density, which affected the survival and growth rate.

The reduction of TSS was significant at the low density (T-20), but not for the other densities and that of the control. At the end of the experiment, TSS was reduced by 40%, 32% and 30% in low, medium and high stocking densities; respectively, and that in the control, by 30% (from 342 mg/L to 240 mg/L). The low removal of TSS at higher stocking density may be explained by the higher production of waste compared to the low and medium stocking densities which resulted in increasing the internal TSS concentration.

M. cephalus *densities and water quality*

The T, pH, DO, TAN, NO_3-N and PO_4-P did not differ between the three stocking densities of *M. cephalus* (Table 6). The mean values of DO and TAN in the control were significantly higher than that in the treatments ($p<0.05$), while NO_3-N was lower in the control.

The concentration of NO_3-N significantly ($P<0.05$) increased during the experiment in all treatments, while it decreased slowly in the control (Figure 6).

Table 7

Initial, final and reduction values of BOD, COD and TSS in three treatments (M-20, M-25 and M-30) and the control (CM).

	BOD			COD			TSS		
	Initial (mg/L)	Final (mg/L)	Removal (%)	Initial (mg/L)	Final (mg/L)	Removal (%)	Initial (mg/L)	Final (mg/L)	Removal (%)
M-20	45,6	12.6±0.8	72±1.8^{a}	78,9	25.3±2.1	68±2.5^{a}	312	166.0±1.0	47±0.3^{a}
M-25	45,6	7.7±0.1	83±0.3^{b}	78,9	15.2±0.5	81±0.6^{b}	312	144.5±0.5	54±0.2^{b}
M-30	45,6	8.8±0.7	72±2.3^{a}	78,9	18.4±0.8	77±1.0^{b}	312	169.5±4.5	46±1.4^{a}
CM	45,6	33.1±0.3	28±0.7^{c}	78,9	53.9±0.7	32±0.8^{c}	312	281.5±3.5	10±1.1^{c}

Different superscripts in the same column indicate that the values are different ($p<0.05$).

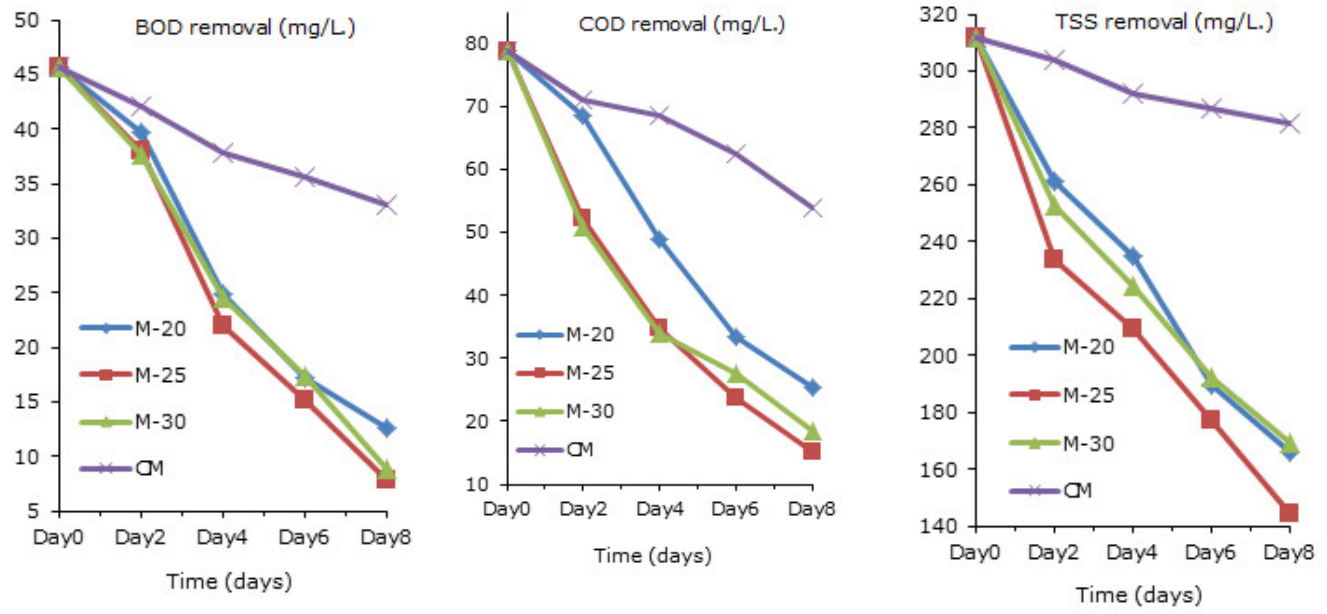


Figure 7: Reduction of BOD, COD and TSS by *M. cephalus* in three treatments (M-20, M-25 and M-30) and the control (CM).

Within the treatments, the highest achieved NO_3-N level was at the lowest stocking density and the lowest achieved NO_3-N level was at the highest stocking density. The concentration of PO_4-P greatly increased from 0.61 mg/L to >1.5 mg/L (increase about 154-160%) in all treatments and in the control during the 8-day-treatment process, but no significant differences were found among different *M. cephalus* stocking densities.

The BOD and COD concentrations were reduced in all treatments with various densities of *M. Cephalus* (Table 7). The BOD and COD removal efficiency was highest at medium stocking density of *M. cephalus*. This removal rate met the required wastewater standard (BOD≤30 mg/L; COD≤50 mg/L) after 4 days of treatment at all three stocking densities (Figure 7).

The reduction of TSS in effluent from intensive shrimp farms varied with *M. cephalus* stocking densities; the highest reduction of TSS was achieved at medium stocking density of 25 fish/m^3. However, the final level of TSS at these three mullet densities was higher than the threshold (50 mg/L) of the wastewater standard.

Conclusion

This study indicated that *O. niloticus* and *M. cephalus* showed more capacity than *S. guttatus* to remove OM and reduce COD and BOD from shrimp farm effluent; both also exhibited wider toxicity tolerance. The different initial levels of shrimp wastewater from 50% to 100% did not significantly affect the survival rate of tilapia and mullet. However, increasing shrimp wastewater ($P<0.05$) significantly decreased the survival rate of *S. guttatus*.

The removal rates of BOD, COD and TSS were significantly different when the stocking densities of tilapia and mullet were changed in the range of 20-30 fish/m^3. BOD, COD and TSS contents were removed at 66–83%, 68–81% and 30–54%, respectively.

The highest removal was achieved at the medium stocking density (25 fish/m^3 equivalently 500 g of fish) ($P>0.05$). Although the TSS level remained above the threshold for wastewater, the medium stocking density of *M. cephalus* (25 fish/m^3) was the most effective for maximizing the removal of organic matter from intensive shrimp farm effluent.

Acknowledgments

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Impact of Salinity on the Incubation Rate and the Performance of Square Head Climbing Perch During the Nursery Phase (*Anabas testudineus* Bloch, 1792)

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Keywords: Square head- Climbing perch- Salinity- Incubation- Nursery- Vietnam

Summary

Square head climbing perch (Anabas testudineus Bloch, 1792*) is a high quality fish without small bones. It grows in a wide range of temperatures (10-42 °C), pH (3.5-9.5) and salinity (up to 16%). As regards climate change, this species may become important for aquaculture in the Tam Giang-Cau Hai lagoon near Hue city. To optimise the quality of fingerlings, we analyzed the effect of salinity levels on hatching and nursing in three subsequent experiments. Fertilization, hatching, survival and growth rates for 30 days were determined at salinity levels 0%, 5%, 7%, 13% and 15%. Water temperature and pH varied between 22-29.5 °C and 7.3-7.8, respectively. Between 0-5%, fertilization ratio was 77% to 83% and highest at 5%, but this dropped to 0% when salinity increased; hatching ratio was larger than 90%, but decreased to 0% at 13-15%. Between 0-11%, hatching time of fertilized eggs was not affected by salinity levels. The ratio of deformation gradually increased above 5%. After hatching at either 0 or 5%, survival ratios for square head climbing perch were above 13% up to 5%, but dropped to 0% at 9%. The growth after 30 days of nursing was higher at 5 and 7% compared with that of 0 and 3%.*

Résumé

Impact de la salinité sur l'éclosion et sur les performances de survie pendant l'élevage de la perche rampante à tête carré (*Anabas testudineus* Bloch, 1792)

La perche rampante à tête carré (Anabas testudineus Bloch, 1792*) est un poisson de haute qualité sans petites arêtes. Cette perche évolue dans un vaste éventail de températures (10-42 °C), pH (3,5-9,5) et de salinité (au-delà de 16‰). Au regard des futurs changements climatiques, cette espèce pourrait s'avérer importante pour le secteur aquacole dans la lagune de Tam Giang-Cau Hai près de Hue city au Vietnam. Afin d'optimiser la qualité des alevins, nous avons analysé l'effet du degré de salinité de l'eau sur l'incubation et l'élevage des alevins en trois expérimentations successives. La fécondation, l'éclosion, la survie et la croissance pendant les 30 premiers jours ont été suivis. Les taux de salinité étudiés étaient de 0‰, 5‰, 7‰, 13‰ et 15‰. La température et le pH de l'eau variaient respectivement entre 22-29,5 °C et 7,3-7,8. Entre 0 à 5‰, la fécondation variait entre 77% à 83% mais était la plus élevée à 5‰. Entre 0 à 5‰, l'éclosion dépassait 90%. Avec l'augmentation du taux de salinité, la fécondation et l'éclosion ont été réduites à 0% pour des taux en sel entre 13 et 15‰. Entre 0 et 11‰, la durée d'éclosion des œufs fécondés n'était pas affectée. Néanmoins, le pourcentage de déformation augmentait progressivement pour des taux de salinités supérieures à 5‰. Après éclosion à des taux de salinité de 0 ou 5‰, le pourcentage de survie des perches était de près de 13%. Ce pourcentage était nul lorsque le taux de salinité était de 9‰. La croissance pendant les 30 premiers jours d'élevage était meilleure à un taux de salinité de 5 et 7‰ comparativement au taux de salinité de de 0 et 3‰.*

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Introduction

Located in Thua Thien Hue province, Tam Giang Cau Hai is the biggest lagoon in Vietnam with an area of 22,000ha. The lagoon has a high value in terms of biodiversity and ecosystem services, and supports the livelihoods of thousands of households in the coastal areas. In recent years, global warming has strongly impacted on aquatic resources as well as aquaculture in this region. High temperature, saline intrusion and mud accretion are factors that impact the local aquaculture and the life of poor farmers (2, 6, 12, 13). In this context, the identification of fish species that deals with the influences of climate change is desirable (6).

Climbing perch is a popular fish and already farmed in aquaculture systems. Recent studies have discovered a climbing perch with slightly different morphology (14). This native species is identified with the local name square head climbing perch. This fish has high flesh quality and has no small bones (10,15,16). It grows fast, it is easy to culture and is well adapted to low oxygen content because of its auxiliary respiration organ. Previous research has determined their environmental comfort zone which ranges from 10-42oC and a pH of 3.5-9.5 (12, 13). These wide temperature and pH ranges allow the square head climbing perch to adapt well in brackish and marine water up to salinity levels of 16% (16). From the perspective of global warming and saline intrusion, the square head climbing perch is expected to become an effective and valuable species for both freshwater and brackishwater aquaculture in Thua Thien Hue province. Currently, there is no published research on the impact of salinity levels on the incubation and nursery phases of square head climbing perch in Vietnam. The identification of appropriate salinity and temperature for seed production may improve the quality of fingerlings, and therefore, enhance the local aquaculture and improve the farmers' livelihoods.

This study identified the optimal salinity level for square head climbing perch at incubation and nursery phases in order to optimise the quality of fingerlings for different environmental conditions. Thereto a three-staged experiment was carried out.

Materials and methods

Materials

The experiments were conducted at the Fish Breeding and Nursing Center, Thua Thien Hue province, Vietnam. After breeding, incubated eggs were taken and released into 6 L tanks with eight (8) different salinity levels: 0%, 3%, 5%, 7%, 9%, 11%, 13% and 15% designed by using the Pearson Square method. The different salinity levels were composed by mixing freshwater taken from a fish pond at the center with saltwater transferred from Thuan An beach near Hue city. During the experiments, all other factors were maintained at a similar level. The tanks were syphoned and water was changed daily.

Feed was added to the tanks four times per day. In both the hatchery and nursery phases, the feeds were: water-dissolved cooked chicken egg yolk, and industrial feed (protein>42%, lipid:6-8%, cellulose:<3%, maximum moister:11%).

Length was measured by using a panme ruler with a precision of 0.01 mm. For all three experiments, the water environmental parameters, such as temperature, DO and pH were checked daily at 8am and 2pm, and maintained within the optimal range for square head climbing perch. Temperature was measured by thermometer, while DO and pH were measured with a Serra test kit. Salinity was checked in a water sample taken from each tank with a refractometer.

Methods

Three experiments were carried out: Impacts of salinity levels on three phases; namely: incubation, nursery and after hatching at 0% of square head climbing perch. The nursery was monitored for a period of 30 days.

Impact of salinity on the incubation

The experiment involved 8 treatments with salinity levels of 0%, 3%, 5%, 7%, 9%, 11%, 13% and 15% in three replications withour air-blower. The treatments were distributed in the tanks (Table 1.1).

Impact of salinity on nursery after hatching at 0% The experiment involved 5 treatments with salinity levels of 0%, 3%, 5%, 7% and 9% in three replications and withour air-blower.. The treatments were distributed in the tanks (Table 1.2).

Table 1.1

Design of experimental treatments.

T1	T3	T2	T5	T7	T4
T8	T6	T3	T1	T5	T6
T2	T4	T7	T8	T1	T3
T7	T6	T5	T2	T4	T8

Remark: T: treatment; T1: 0%; T2: 3% ; T3: 5%; T4: 7%; T5: 9%; T6: 11%; T7: 13%; T8: 15%

Table 1.2

Design of experimental treatments.

T1	T3	T4	T5	T2
T4	T5	T2	T1	T3
T2	T4	T3	T5	T1

Remark: T: treatment; T1: 0%; T2: 3%; T3: 5%; T4: 7%; T5: 9%

Impact of salinity on nursery, after hatching at optimal salinity level

The experiment involved 5 treatments with salinity levels at 0%, 3%, 5%, 7% and 9% at three replications and withour air-blower. The optimal salinity level was determined from the experiment in nursery phase after fry was hatched at 0%. The treatments were distributed in the tanks (Table 1.3).

Data analysis

Fertilization, hatching and heteromorphic rates are calculated by using the following formulas: Daily growth in length (DGL) was calculated by dividing the increase in length during a period of 15 days by this number of days.

Means of treatments for the three experiments were compared by using an ANOVA followed by a Tukey test with Minitab 16.0 software. Treatments were declared significant for the level $p<0.05$.

Table 1.3

Design of experimental treatments.

T2	T1	T3	T5	T4
T3	T4	T2	T1	T5
T5	T3	T1	T4	T2

Remark: T: treatment; T1: 0%; T2: 3%; T3: 5%; T4: 7%; T5: 9%

Results and discussion

During the experiments, temperature, pH and DO remained in the optimal ranges for the growth of square head climbing perch (Table 2). Temperatures varied from 22-29 °C with means ranging between 26.4 and 26.6°C; all experiments lasted one month and therefore the temperatures varied within a wide range. DO varied between 4 and 5 mg l^{-1}. The pH varied among the treatments (7.4 in 0% and 7.7 in 15%) due to mixing freshwater and brackishwater, but the pH of the tanks was adjusted to remain within a range smaller than 0.5. In the experiment conditions, this level of variation in these parameters was deemed appropriate for the incubation and hatching phases of square head climbing perch.

Impact of salinity on the incubation

Fertilization ratio

The fertilization ratio was different ($p<0.05$) among the 5%, 7%, 9%, 11%, 13% and 15% treatments (Table 3). However, between 0% and 3%, these ratios were not significantly different. Fertilization and hatching ratios, 83% and 96%; respectively, were highest at 5%. Although the incubation of square head climbing perch eggs can be conducted up to a salinity of 11%, the resulting fertilization and hatching ratios were low: 8.4% and 5.8%, respectively. At these salinity levels, the embryo was damaged due to osmotic pressure.

Hatching time and heteromorphic ratio

Salinity levels did not affect hatching time (Table 4). After 15.4 to 15.6 hours, all fertilized eggs were hatched. However, at 13% and 15%, the eggs were not fertilized, and therefore, hatching time and heteromorphic ratios were unavailable.

In contrast to hatching time, the salinity levels considerably affected the heteromorphic ratio (Table 4). The number of deformed larvae tended to increase at higher salinity; the ratio was 2.4 at 0% and to 4.8 at 11%. There were no statistical differences among the treatments of 0%, 3%, 5% and 7%, as well as among 5%, 7%, 9% and 11%. At 0% and 3%, the heteromorphic ratio was significantly lower than that at 9% and 11% ($p<0.05$).

Table 2

Variation of Environmental parameters during the experiments.

Salinity (‰)	Temperature (0C)			pH			DO (mg/l)		
	Min	Max	Mean ± SE	Min	Max	Mean ± SE	Min	Max	Mean ± SE
0	22	29.5	26.5 ± 0.7	7.3	7.5	7.4 ± 0.02	4	5	4.7 ± 0.1
3	22.5	29.5	26.5 ± 0.6	7.4	7.6	7.5 ± 0.02	4.5	5.5	4.7 ± 0.1
5	22	29.5	26.5 ± 0.7	7.4	7.7	7.5 ± 0.02	4.5	5.5	4.9 ± 0.1
7	22	29.5	26.5 ± 0.7	7.5	7.7	7.6 ± 0.02	4	5	4.7 ± 0.1
9	22	29	26.5 ± 0.6	7.5	7.8	7.6 ± 0.02	4	5.5	4.8 ± 0.1
11	22	29.5	26.6 ± 0.7	7.6	7.8	7.7 ± 0.02	4.5	5	4.7 ± 0.1
13	22.5	29	26.5 ± 0.6	7.6	7.8	7.7 ± 0.02	4	5	4.8 ± 0.1
15	22	29	26.4 ± 0.7	7.6	7.8	7.7 ± 0.03	4.5	5.5	4.9 ± 0.1

Table 3

The mean and standard errors of fertilization and hatching ratios (%) of square head climbing perch at different salinity levels.

Salinity (‰)	Fertilization ratio	Hatching ratio
0	77.4 ± 0.9^{a}	90.8 ± 1.2^{a}
3	78.2 ± 1.14^{a}	91.3 ± 1.1^{a}
5	83.11 ± 0.6^{b}	96.0 ± 0.5^{b}
7	60.6 ± 1.3^{c}	72.1 ± 1.3^{c}
9	22.9 ± 1.3^{d}	10.1 ± 0.8^{d}
11	8.4 ± 0.7^{e}	5.8 ± 0.5^{e}
13	0	0
15	0	0

Remark: Different superscripts in the same column indicate that the values are different ($p< 0.05$).

Table 4

The mean and standard errors of hatching time and heteromorphic ratio of square head climbing perch at different salinity levels.

Salinity (‰)	Hatching time	Heteromorphic ratio
0	15.4 ± 0.2^{a}	2.4 ± 0.3^{a}
3	15.5 ± 0.2^{a}	2.8 ± 0.4^{a}
5	15.5 ± 0.2^{a}	3.3 ± 0.4^{ab}
7	15.6 ± 0.2^{a}	3.9 ± 0.4^{ab}
9	15.4 ± 0.2^{a}	4.4 ± 0.3^{b}
11	15.4 ± 0.2^{a}	4.8 ± 0.3^{b}
13	-	-
15	-	-

Remark: Different superscripts in the same column indicate that the values are different ($p< 0.05$).

Table 5

The mean and standard errors of the length of square head climbing perch at different salinity levels and time after 15 and 30 days of nursery, after hatching in 0%.

Salinity (‰)	Length (mm/individual)		
	Initially	15 days	30 days
0	3.5	10.39 ± 0.08^{a}	25.44 ± 0.32^{a}
3	3.5	10.36 ± 0.07^{a}	26.06 ± 0.29^{a}
5	3.5	10.38 ± 0.07^{a}	27.53 ± 0.3^{b}
7	3.5	10.43 ± 0.07^{a}	27.17 ± 0.23^{b}
9	3.5	10.26 ± 0.09^{a}	-
11	3.5		

Remark: Different superscripts in the same column indicate that the values are different ($p< 0.05$).

Table 6

The mean and standard errors of the daily growth (DGL) of square head climbing perch at different salinity levels and time after 15 and 30 days of nursery, after hatching in 0%.

Salinity (‰)	DGRL (mm/individual/day)		
	15 first days	15 last days	Average
0	0.46 ± 0.01^{a}	1.00 ± 0.02^{a}	0.73 ± 0.01^{a}
3	0.46 ± 0.01^{a}	1.05 ± 0.022^{ab}	0.75 ± 0.01^{a}
5	0.46 ± 0.01^{a}	1.14 ± 0.02^{c}	0.80 ± 0.01^{b}
7	0.46 ± 0.01^{a}	1.12 ± 0.02^{bc}	0.79 ± 0.01^{b}
9	0.45 ± 0.01^{a}	-	-

Remark: Different superscripts in the same column indicate that the values are different ($p< 0.05$).

Table 7

The mean and standard errors of the length of square head climbing perch at different salinity levels and time after 15 and 30 days of nursery, after hatching in 5%.

Salinity (‰)	Length (mm/con)		
	Initially	15 days	30 days
0	3.5	10.21 ± 0.12[a]	25.05 ± 0.29[a]
3	3.5	10.32 ± 0.10[a]	26.43 ± 0.27[b]
5	3.5	10.48 ± 0.09[a]	28.06 ± 0.24[c]
7	3.5	10.46 ± 0.08[a]	27.67 ± 0.25[c]
9	3.5	10.37 ± 0.09[a]	-

Remark: Different superscripts in the same column indicate that the values are different ($p < 0.05$).

Table 8

The mean and standard errors of the daily growth rate (DGL) of square head climbing perch at different salinity and time after 15 and 30 days of nursery, after hatching in 5%.

Salinity (‰)	DGRL (mm/individual/day)		
	Day: 1-15	Day: 16-30	Average
0	0.45 ± 0.01[a]	0.99 ± 0.02[a]	0.72 ± 0.01[a]
3	0.46 ± 0.01[a]	1.07 ± 0.02[b]	0.76 ± 0.01[b]
5	0.47 ± 0.01[a]	1.17 ± 0.02[c]	0.82 ± 0.01[c]
7	0.46 ± 0.01[a]	1.15 ± 0.02[c]	0.81 ± 0.01[c]
9	0.46 ± 0.01[a]	-	-

Remark: Different superscripts in the same column indicate that the values are different ($p < 0.05$).

Impact of salinity during nursery after hatching at 0% and 5%

The results during hatching for square head climbing perch were best at 5%. Therefore the performance of the fish hatched in this salinity level was comparable with that hatched at 0%. Impact of salinity on length and growth after hatching at 0%

At 15 days after nursery, the fish of the treatments was the same (Table 5). The average maximum length reached 27.5 mm per individual after 30 days of nursery at 5%; the value was statistically the same as that at 7%, but higher than that at 0% and 3%. However, the p value indicated a statistical difference between 0% and 3%, and on the other hand, between 5% and 7% ($p<0.05$). At higher salinity levels, the survival was close to zero and the length could not be measured.

In the first 15 days the DGLs among the treatments were equal (Table 6). During the last 15 days, the DGL was different between the salinity levels and was highest at 5%: 1.1 mm/individual/day. The DGL at 5% was significantly different from that of the 0% and 3% treatments, but not significantly different from that of the 7% treatment Impact of salinity on length and growth after hatching at 5%.

After 15 days of nursery, the length was the same for all treatments (Table 7). After 30 days, the measured lengths of fish raised at 5% and 7% were longer (28 mm/individual) than those raised at 0% and 3 %.

During the last 15 days, the DGL at 5% and 7% salinity was higher than that at 0% and 3 %; about 0.8 and 0.7 mm/individual/day, respectively (Table 8).

Impact of salinity on survival and growth

After hatching at 5%, the square head climbing perch reached a maximum length and DGL of 28 mm/individual and 1.2 mm/individual per day, respectively; while after hatching at 0%, these values were about 27 mm/individual and 1.1 mm/individual per day, respectively.

For the two levels of salinity (0% and 5%) at hatchery, the survival rates of square head climbing perch nursed at four different salinity levels were not different (Table 9). At 9%, no fish survived, and at 7%, the survival rate was only half (<7%) of those which reached at 0%, 3% and 5%. In the range of 0% - 5%, survival rate of the fish (>13%) was not significantly affected by salinity level at $p>0.05$.

Table 9

The mean and standard errors of survival rate (%) of square head climbing perch in the nursery phase at different salinity levels, after hatching at 0% and 5%.

Salinity (‰)	(0‰)	(5‰)
	Survival rate	Survival rate
0	13.7 ± 0.4[a]	12.9 ± 0.4[a]
3	13.2 ± 0.4[a]	13.3 ± 0.6[a]
5	13.4 ± 0.5[a]	14.0 ± 0.7[a]
7	6.1 ± 0.4[b]	7.0 ± 0.5[b]
9	0	0

Remark: Different superscripts in the same column indicate that the values are different ($p<0.05$).

Discussion

The fertilization ratio of square head climbing perch was significantly higher in brackish water with 5% salinity than that in freshwater with other salinity levels. The fertilization ratios at 5% were slightly higher (83%) than those found by Dan (2) when testing the effects of LH-RHa on Anabas testudineus in freshwater (70 – 81%). In another study, Oanh (8) tested the effect of salinity levels at 0%, 3%, 5%, 7%, 9% and 11% for snakeskin gouramy (Trichogaster pectoralis Regan) with the highest fertilization rate at 5% (68.3%) and lowest at 11% (34.2%). The data show a better adaptation of square head climbing perch to salinity in the early stage at low salinity (from 0% to below 7%). At higher or lower salinity, fish loses energy to adjust to the osmotic pressure (9,18); fish also consumes more oxygen (17), which impacts on both hatching and growth of the fry. At 5%, osmotic pressure of the fry is equal to the pressure of external environment, whilst it is higher at 0% and lower at 7% or 9%. When salinity was higher than 9%, hatching rate dropped to 5.78% due to low function of osmoregulation (4). Energy was consumed considerably in this case; therefore, fish has no ability to grow (5).

Survival rate, as a result, is considerably lower at the higher salinity levels. Consequently, 5% is advised as an optimal salinity to retrieve a higher ratio of fertilization and hatching. In spite of being an euryhaline species, square head climbing perch is sensitive to salinity in the early stage in comparison with other fish. Sarma (15) studied the effect of salinity on the fingerling stage of *Clarias batrachus*.

In the first 30 days, there was no difference in survival rate among the treatments of 0%, 4% and 8%. Enayati (3) indicated 8% as the point of death for *Ctenopharyngodon idella* (fish was up to 120 g in body weight), while *Channa striata* tolerated salinity up to 10% (7). Similar result was obtained with *Pseudophoxinus stymphalicus* in the ranges of 6 – 13.5% (1).

Additionally, maintaining salinity levels at 5% and lower reduced the heteromorphic ratio and improved survival ratio of the fry. For best results, fry should be nursed in the brackishwater (3 to 5%).

For salinity intrusion, square head climbing perch is a good choice for aquaculture in the Tam Giang Cau Hai lagoon.

Conclusion

The optimal salinity level for hatching square head climbing perch is at 5% when fertilisation rate is highest. The fertilization ratios of 78 to 83% in the range of 0% - 5% dropped to 0% when salinity levels increased to 13% - 15%. In the range of 0% - 5%, the hatching ratio was larger than 90%, but decreased to 0% at 13% - 15% salinity. The ratio of deformation increased gradually from 2.4% at 0% to 4.8% at 11% salinity.

Salinity levels affected the growth and survival of square head climbing perch fry between day 15 and 30 of the nursery phase. After hatching at either 0 or 5%, survival ratios for square head climbing perch were above 13% up to 5% salinity, but dropped to 0% at 9% salinity. The growth after 30 days of nursery was higher in salinity levels of 5 and 7%, compared to that at 0 and 3%.

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A Decision Tree Analysis to Support Potential Climate Change Adaptations of Striped Catfish (*Pangasianodon hypophthalmus* Sauvage) Farming in the Mekong Delta, Vietnam

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Summary

*This study uses the decision tree framework to analyse possible climate change impact adaptation options for pangasius (*Pangasianodon hypopthalmus *Sauvage) farming in the Mekong Delta. Here we present the risks for impacts and the farmers' autonomous and planned public adaptation by using primary and secondary data. The latter studies showed that a proportion of the pangasius farms located in the coastal provinces will be affected by salinity intrusion in the dry season. Options to adapt to this are: modify pangasius farming practice, stock other species or stock saline-tolerant pangasius. With research and extension support, farmers can further improve their already adapted practice to deal with salinity or use water recirculation systems for prolonged nursery rearing. A breeding program for saline-tolerant striped catfish requires a medium-to long-term investment (0.4 % of the production cost) from government and/or private company. Pangasius farms in up- and mid-stream regions and in coastal areas, which are not located within upgraded government dyke-protected areas, will be affected by flooding at the end of each rainy season. This implies an increased cost for dykes to about 0.34% and 0.25% of the total variable costs for one harvest per ha in the up- and mid-stream regions, and in the downstream region, respectively.*

Résumé

Une analyse en arbre de décision pour soutenir l'adaptation aux changements climatiques de l'aquaculture de poisson chat au Mekong Delta, Vietnam

*Cette étude a analysé les options d'daptation aux impacts des changements climatiques de l'aquaculture du poisson-chat (*Pangasianodon hypopthalmus *Sauvage) dans le Delta du Mekong à l'aide d'un arbre de décision. Basé sur des données originales et des données issues de la littérature et de bases de données, l'article présente les risques et les options d'adaptation aux changements climatiques en distinguant les adaptations autonomes par les pisciculteurs et celles planifiées par le secteur public. Les données originales montrent qu'une partie des étangs de pangasius situés dans les provinces côtières sera affectée par les intrusions salines pendant la saison sèche. Les options d'adaptation à cette contrainte sont: modifier les pratiques d'élevage, changer les espèces, ou élever des pangasius tolérants à la salinité. Soutenus par la recherche et les services de vulgarisation, les pisciculteurs pourront améliorer davantage leur pratique actuelle d'adaptation, en rallongeant la période d'alevinage, en utilisant des systèmes de recyclage de l'eau. Un programme de sélection d'une race de pangasius tolérante à la salinité demande un investissement à moyen terme, de 0,4 % des coûts de production de la part du gouvernement et/ou d'entreprises privées. Les pisciculteurs de pangasius dans les régions en amont et en zones côtières et qui ne se trouvent pas à l'intérieur des zones protégées contre les inondations par des digues, seront affectés par des inondations à la fin de chaque saison des pluies. Ceci implique un accroissement du coût pour rehausser les digues des bassins de production, représentant 0,34% et 0,25% du total des coûts variables pour une récolte et par hectare, respectivement dans des régions en amont et pour les régions côtières.*

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Introduction

Originating in the Mekong Delta, striped catfish (*Pangasianodon hypophthalmus* Sauvage) farming is acknowledged to be one of the most successful aquaculture developments in the world (8). The industry started on fattening of river catfish (*Pangasius bocourti*) in the upstream part of the two main branches of the Mekong River flowing through the provinces of An Giang, Dong Thap, and Can Tho (Figure 1).

However, land-based farmers gradually overtook the sector by culturing striped catfish in ponds after the artificial propagation of this fish was developed and successfully disseminated (5, 29, 34).

Thereafter, the industry expanded more downstream to Vinh Long, Tra Vinh, Soc Trang and Ben Tre provinces (Figure 1). At present the farming sector includes independent small-scale farmers and enterprises, both delivering their fish to processing companies, as well as vertically integrated holdings having their own feed-mills, ponds, and processing facilities. In 2012 and 2013, the sector produced 1.19 million tons of fish in a pond area of 5600 ha and exported the processed Pangasius mainly in the form of fillet valued at 1.7 billion USD to over 142 countries (41).

Vietnam, particularly the Mekong Delta, is likely to encounter adverse impacts of climate change (7), for example, Vietnam ranked as one among the top five countries that is mostly affected by rising sea levels. Studies used sea level rise scenarios to explore impacts on the infrastructure of the Mekong Delta (17), rice cropping areas (21, 42) and current Pangasius farming locations in the Delta (Figure 1). These studies show that Pangasius farms in upstream and middle-stream regions will encounter longer flood periods; thus, higher risks of flooding, while downstream farms will be affected by higher salinity levels and a longer period of salinity intrusion (1). Projecting the impact of climate change on the profitability of Pangasius farmers, Kam *et al.* (20) found that the short-term benefits of the inland Pangasius farms remain positive when climate change is ignored but benefits soon disappear when climate change impacts are considered.

Coastal Pangasius farms will even be more affected by climate change when projected benefits are predicted to be halved (20). Therefore, making decisions on adaptation strategies is urgent in order to counteract the negative impacts of climate change in this important Vietnamese aquaculture sector that sustains over 170,000 employment opportunities among the rural poor (8). While reviewing the impacts of and possible adaptation to climate change in developed and developing economies, Nath and Behera (28) indicated that adaptation also could enhance the resilience against increasing influences of climate change. Adaptation can refer to natural or socio-economic systems, can be reactive or anticipatory based on timing, and can be autonomous or planned depending on the degree of spontaneity (38). Frankhauser *et al.* (14) adopted the definition of autonomous adaptation first defined by Carter et al. (6) as "natural or spontaneous adjustments in the face of a changing climate" and consequently defined planned adaptation as "requires conscious intervention".

The Ministry of Agriculture and Rural Development (MARD) of Vietnam has established the action plan for adaptation of agriculture and rural development for the period 2008-2020. The action plan focuses on ensuring the safety of residents, stability of agriculture production and food security, and safety of dykes, levees and infrastructure.

In order to achieve these objectives, five main tasks were implemented:

(1) Conduct a communication and information program;
(2) Develop human resources and conduct adaptation studies;
(3) Develop a policy system;
(4) Promote international cooperation;
(5) Establish priority adaptation activities (26).

The implementation addressed the impacts of climate change on fisheries and aquaculture nationally (16), but did not yet result in regional adaptation plans for this sector.

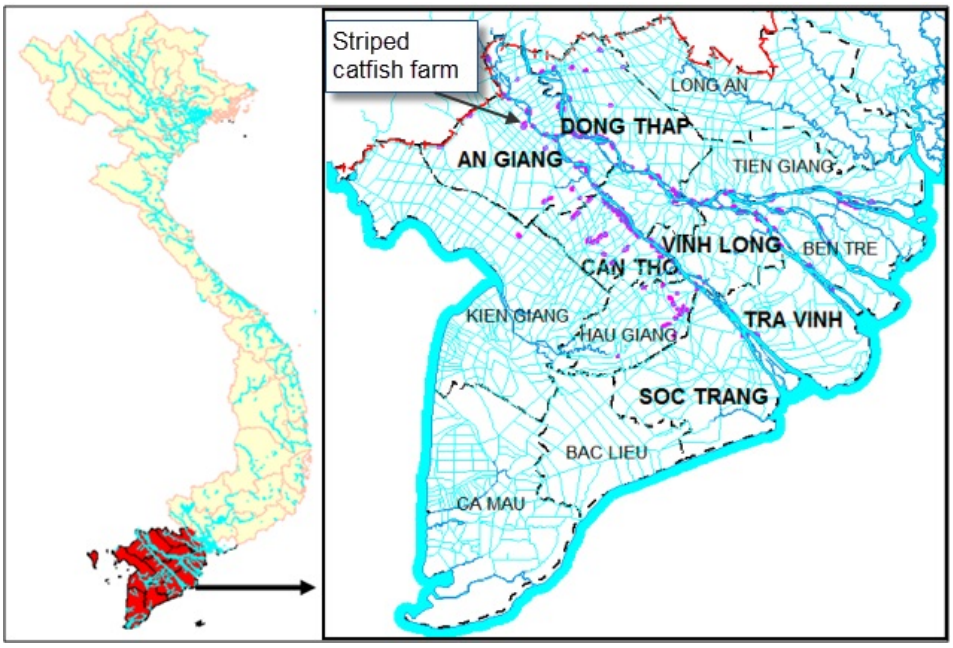

Figure 1: The administrative map of the Mekong Delta with locations of the Pangasius farms [Adapted from Ai (1)].

Anh *et al.* (2) observed that adaptation measures by Pangasius farmers focused on changing their farming practices or their cultured species, in some cases with financial and technical support from private, government and research agencies. Nath and Behera (28) noted that government and civil society play a crucial role in enabling efficient adaptation methods. The adaptation strategies for Pangasius farming, therefore, should combine both autonomous and planned adaptation at private and public levels. According to Smit *et al.* (38), the cost and benefit estimation is an important aspect in the evaluation of adaptation and provides support to recommendations of the most appropriate adaptation. Kam *et al.* (20) analysed the cost of autonomous farmers' adaptation; their analysis showed that the cost can be reduced by planned public adaptation measures.

This paper aims to analyse the adaptation measures that may diminish the climate change impacts for the Pangasius farming sector in the Mekong Delta by using the decision tree framework. After describing the analytical framework, the paper summarises the climate change impacts requiring responses before analysing the options for adaptation. Subsequently the options for both autonomous and planned adaptations were inputted into a decision tree framework in order to facilitate adequate policy making.

The cost of the adaptation for the sector and the impact on the cost-efficiency at the level of the Pangasius farmers will be considered before concluding.

Analytical framework

Suitable adaptation strategies are best decided through a decision-making process. Such a process is defined as the systematic analysis of a problem (i.e. cause-effect-response chain) using appropriate data and the final choice of effective solutions (24).

Data

This study used both primary and secondary data. Primary data were collected from our previous studies on climate change impacts on Pangasius farming (1, 2, 3). Primary data on the cost of a Pangasius breeding program were acquired from an expert and complemented with secondary data. Secondary data were collected from the scientific and professional literature and statistical reports from the Vietnamese government and aquaculture organisations. The cost of autonomous adaptation was collected from several studies (20), and included measures, such as dyke enforcement.

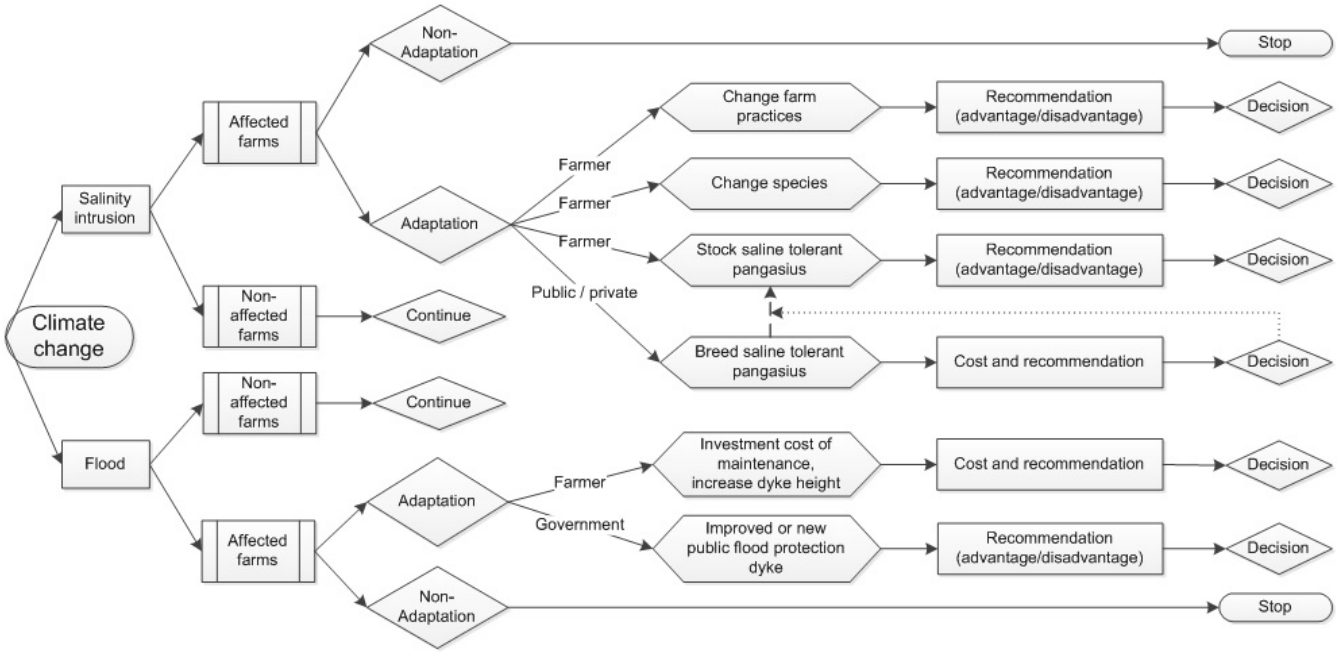

Figure 2: The decision tree framework used for the decision-making process of adaptation choices with events.

Decision tree framework

Decision-making is a process of problem analysis and solution design, implementation and monitoring. All steps involve decisions which can alter the systems and thus require visiting earlier steps; the inherent feedback loops make the process recursive (15). To support policy-making, the present study developed a simple rule-based decision support tree (Fig. 2). A decision tree is a decision support tool that uses a tree-like schematic representation or a model of the possible consequences of specific decisions, and the plausible interactions thereof.

To develop the decision tree, we elucidated the reasons and the recommendations for decision-making at the various nodes of the decision tree following the three steps below:

- Identify the problems (event nodes) and the specific decisions to be made (decision nodes).
- Build the structure of the decisions and its consequences, like a tree with the roots and the branches.
- Clarify the cost (disadvantages / trade-offs) and benefit (advantages / synergies) of each alternative decision in order to determine the most favourable decision.

In the present case, the event nodes represent a problem (e.g. salinity intrusion) requiring an assessment (will it affect my farm or not?), and then a decision (adapt or not?); upon the choice to adapt follows an analysis of options for adaptation. Each option (e.g. change of species) requires an analysis of the cost (disadvantage / trade-off) and benefits (advantage/ synergy) before a decision to apply could follow. If the decision is negative then the decision-maker may analyse another option making the process recursive (feedback loop), and finally enabling a decision to adapt or not to adapt.

Climate change impacts

Climate change may affect the Pangasius farming sector in the Mekong Delta mainly through flooding and salinity intrusion. However the impact varies according to the locations.

Flooding

Induced by sea level rise, flooding in the Mekong Delta of Vietnam is likely to worsen in the long term (17) as floods will arrive earlier and persist longer (42). According to Anh *et al.* (1), sea level rise (SLR) scenarios of +50 to +75 cm will cause an additional expansion of flooding in the upstream provinces of An Giang, Dong Thap and Can Tho, and

increase the inundated areas in the coastal provinces of Soc Trang, TraVinh and Ben Tre (see Figure 1).

Under a SLR +50cm scenario, Kam *et al.* (20) predicted the greatest increments in flooding depth will occur in An Giang, Dong Thap and Can Tho provinces, where the largest concentration of Pangasius farms is found. Anh *et al.* (1) calculated that Pangasius farms in all provinces have to deal with a 2-m-flood level in case of the SLR +50 cm scenario. Fifty-five percent of the interviewed Pangasius farmers in upstream provinces was concerned about flooding caused by climate change, and estimated their economic losses at 10% to 100% of their current income. According to these farmers, their cost for disease treatment of the stock would increase up to 300% due to such hazardous flooding (2).

The Pangasius farmers in the affected areas have to choose between either stopping the farming operations, or increasing the height of pond dykes as an autonomous adaptive measure. Pangasius farms located in areas protected from flooding by flood protection dykes constructed by the government can benefit from the planned adaptation.

Salinity intrusion

All Pangasius farms located in the south western area of the TraVinh province and most farms in the Ben Tre and Soc Trang provinces in the Mekong Delta are already subjected to diurnal fluctuations of up to 4% salinity level. The periods of this salinity threat, however, are likely to become longer; the majority of the interviewed farmers (93%) in the downstream region were concerned about salinity intrusion induced by sea level rise (1, 2).

The yield of Pangasius farms located in the downstream region was significantly lower than that in the other regions. Farmers could not stock Pangasius fingerling in months with high salinity, thereby reducing cropping period of Pangasius culture in these provinces (34).

To deal with this problem, the Pangasius farming sector has to either adapt or discontinue farming of Pangasius. Adaptation may be autonomous at farm level through, for instance, changing pond practice or shifting to farming other species that have high salinity tolerance (i.e. an euryhaline species). Planned adaptation, on the other hand, such as shifting to a salinity-resistant strain of Pangasius requires the involvement of other stakeholders.

Options for adaptation

There are five adaptation options that we discuss here for Pangasius farmers. These are:

(i) Changing Pangasius farming practice (e.g., extending the nursing period of Pangasius fingerlings);
(ii) Shifting to other species that have high salinity tolerance;
(iii) Breeding salinity-tolerant Pangasius;
(iv) Increasing the height of farmers' pond dykes
(v) Increasing the height of the public flood protection dykes.

Changing Pangasius farming practice

Some Pangasius farmers in the coastal area can extend the nursing period of Pangasius fingerlings to reduce the grow-out period in ponds during the months of high salinity (2). An extended nursery period, however, will result in slightly higher cost for transport, as juveniles will be heavier, and perhaps with increased risk (8).

In Vietnam, Pangasius farms have started experimenting with recirculating aquaculture system (RAS) during the nursery and grow-out phases. This can also be regarded as an autonomous adaptation. Results seem promising but the full cost and benefit is not known yet (31, 32, 33). The water intake for RAS system is very restricted, except for the last weeks of the grow-out period. The RAS system would simultaneously reduce water pollution, a mitigation benefit in favour of reducing the pollutants coming from Pangasius sector (4). This system may also contribute to the mitigation of climate change impact; a bone of contention of many environmental lobby groups (9).

Shifting to other species

To deal with saltwater intrusion, Pangasius farmers in the coastal provinces of the Mekong Delta might also choose to grow other species. Anh *et al.* (1) reviewed several experimental studies on the salinity tolerance of several freshwater fish species, including Pangasius in the Mekong Delta.

Table 1

The generic cost (USD) of a fish breeding program in Vietnam, respecting the principles of an effective population size as established by Ponzoni *et al.* (35).

	Year 1	Year 2	Year 3	Year 4
Fixed cost of infrastructure for renting 1.5 ha with 1.1 ha of ponds*	7.200	7.200	7.200	7.200
Salary cost	4.700	6.400	6.000	4.250
Materials: broodstock and feed	4.000	6.800	16.100	16.000
Accessories, disposable tools	480	2.850	950	950
Electricity, gasoline, diesel	320	1.700	320	320
Equipment	1.400	200	12.700	0
Maintenance cost	700	2.100	1.600	1.400
Total	18.800	27.300	44.770	30.120

Cost of land USD 30,000 and of infrastructure USD 23,0000; accounted for an interest rate of 8% and a depreciation of infrastructures over 20 years; exchange rate 21000 VND for 1 USD (Source of primary data: Dr. Trinh Quoc Trong, Director of National Breeding Centre for Southern Freshwater Aquaculture, Vietnam, personal communication).

The embryos of striped catfish can develop and hatch in brackish water at 11% (11); 25g individuals can grow in salinity of up to 9 % (30). Choosing to grow other species, farmers need to develop new adaptive capacity, like changing infrastructure, in particular that of ponds.

A pond with water depth of 3 to 4 m is preferred for Pangasius grow-out, but such deep ponds are unsuitable for most other commonly farmed salinity-tolerant species, like the Asian seabass or shrimp. Pond restructuring is required especially for those located on the river banks or main canals, and is likely to be very costly as lowering the water level in these deep ponds will increase; for example, the pressure on the dykes by the river water at high tides. For other ponds, lowering pond depth may be realised by just using a lower water level. Both technical and economic aspects on the feasibility of shifting to another species need further study.

Breeding salinity-tolerant Pangasius

Many farmers, who face the risk of salinity intrusion, prefer to continue producing Pangasius rather than shifting to other species. They believe that with Pangasius, they can maintain their revenues at a sufficiently high level and recover their investments (2).

Along this line, researchers suggest that breeding of a salinity-tolerant strain of Pangasius would be a good option as well.

A tolerant strain would require only a minimal change to farming practices and the related infrastructure, and also would avoid the need to develop new market chains (8, 9).

Though there is a potential for developing a salinity-resistant strain of Pangasius, one should consider that Pangasius matures for more than 3 years (40) which implies a longer generation interval, thus slowing the progress of a breeding program. The use of modern molecular genetic techniques in selective breeding can reduce the time period required to develop a strain with a desired trait, for example, in the case of tolerance to salinity, breeding time can be shortened significantly, unlike that of the traditional selective breeding programs used in the past. However, this would be a costly option.

According to Trong (personal communication), the generic cost of a Pangasius breeding program is about USD 120,000 (Table 1). Due to the long generation interval, the actual cost will be fourfold (USD 484,000) for a program starting from 150 individuals of wild broodstock of various origins in the Mekong river. This program will serve only the farmers in the coastal provinces who produce about 10% of the 1.2 million tonnes produced annually by Vietnam, i.e. 120 million kg. The cost per kg of Pangasius produced in the coastal provinces would be USD 0.004 kg^{-1}.

This is slightly less than 0.4% of the present production cost (USD 1.1 kg^{-1}) and seems a feasible investment. Whether or not such a program can successfully breed a salinity-tolerant Pangasius, however, remains to be seen.

The relatively long time frame and large costs of such a program require the continuous and persistent involvement of public agencies or a private company.

Reinforcing the pond dykes

The dykes of Pangasius farms and ponds have been threatened by flooding due to the increased water levels in the rainy season. This risk will worsen in the context of sea level rise caused by climate change (1). To deal with flooding, Pangasius farmers need to increase the height of their dykes. This would increase investment and operation costs for both dyke and water exchange. According to Sinh (37), the cost for dyke maintenance of Pangasius farms in up- and mid-stream regions accounted for 0.23% of the total variable costs (per ha and per crop), while in the downstream region cost was 0.12% depending on flooding intensity and farm location.

While investigating autonomous adaptation measures of Pangasius farmers, Kam *et al.* (20) estimated the costs for individual dyke upgrading in the period of 2010-2020 to be about USD 14.6 million in the up- and mid-stream regions and USD 3.0 million in the downstream region.

The costs for dyke upgrading of the entire Pangasius farming sector will be approximately 1% of the total annual Pangasius export value in 2013 (41). Sinh (2008) projected that for this decade, the operation cost for dyke upgrading (per ha) of the Pangasius farms in up- and mid-stream is expected to increase by six times and those located downstream, by fifteen times. The extra cost of autonomous adaptation for dyke upgrading per ha and per crop would be USD 222 in the up- and mid-stream region, and USD 223 in the downstream region. These figures were obtained by dividing USD 14.6 million and USD 3.0 million by the number of ha (4380 and 896 respectively) and by the number of crops over ten years (15 for both regions). This would imply an increase of the cost for dykes to about 0.34% and 0.25% of the total variable costs (per ha and per crop) in the up- and mid-stream regions and in the downstream region, respectively.

Improving public flood protection dykes

The action plan of MARD (26) foresees improvements of the government dyke system as an appropriate adaptation measure to protect agricultural activities against flooding. The Pangasius farms located within these dykes, therefore, will have lower autonomous adaptation cost for dyke upgrading at farm level.

The cost of this adaptation measure will be higher because of its large coverage area. However, the benefits accruing to the entire economy goes beyond the protected area covering the Pangasius farming sector. Since these adaptations take time, sea level rise may impact the Pangasius producers before these dykes are finalised.

Discussion

According to Kabari and Nwachukwu (19), decision trees are specifically used in decision analysis to support identification of strategies. This study analysed the plausible adaptive measures of both autonomous and planned adaptation to deal with impacts of climate change by using a decision tree framework. Decision support tools are often built through modelling (15, 19, 27). Modelling is appropriate to support decision makers choosing suitable adaptation option when referring to data from statistics or from observational studies such as household surveys. However, without time series of sea level rise impacts and adaptation processes, the statistical uncertainty of modelling is high. We chose for a rule-based decision support tree, also because the preliminary analysis summarized above (1, 2) showed that in most cases the problems are well circumscribed, and consequently the number of choices is limited.

This study used results from Kam *et al.* (20) for the analysis of the autonomous adaptation.

Just like all economic studies on climate change adaptations, their study was subjected to uncertainty surrounding the impacts of climate change projection, as well as to changes in input and output of commodity prices, in production technologies among others (20).

The future changes, both in the market and in international trade policies may affect the Pangasius sector without linear adjustment of the farm gate prices. Thus predictions on the financial capacity of farmers to adapt may not be valid. At present, the profit margins of Pangasius farming are lower than in the past (22, 8). The estimated increase of cost due to the climate change adaptations will further reduce profits. Thus if the margins do not improve, the risk of not recovering investments is high. If a farmer decides not to adapt to the impacts of climate change, the investment cost will be less than the cost for the farmers who adapt, but the former will face the risks induced by sea level rise. Some farmers may terminate farming operation either because they do not want to compromise the benefits they have accumulated already from Pangasius culture, or because they think that they will not be able to recover investment costs. The economic efficiency of farmers' autonomous adaptations by replacing species or changing aquaculture practice needs to be considered.

The preparation of these measures needs long-term (public) investments, first for the studies and later for support to the transfer of technology. The autonomous adaptation thus becomes planned adaptation involving more, such as institutes and local government (38).

Both options, reinforcing a pond dyke and improving the public dyke system, are appropriate measures to protect Pangasius farming against increased flooding risks. Increasing public dyke heights will not only benefit Pangasius farmers, but also most other agricultural activities, as well as rural and urban infrastructures. Hence this option is attractive to the government in general, though trade-offs on bio-diversity and on deposition of fertile sediments in e.g, rice-fields need to be considered (23, 25).

In the downstream region, the breeding of a salinity-tolerant strain of Pangasius might be the most efficient option for about 10% of the sector to adapt to the salinity intrusion due to the least disruption to livelihoods, the minimal change requirement in infrastructure and the maintenance of existing and reputedly highly established market channels. The use of modern molecular genetic techniques has shortened the time period required to develop strains with specific traits significantly (18). Perhaps Pangasius offers a good opportunity to develop a selected trait of salinity-tolerant strain relatively fast. On the other hand, breeding and selection need to be a continuous process otherwise the acquired characteristics will be diluted and might be lost (39, 35). The case of tilapia shows very well what happens if selection is not continuous (12), and special breeding programs have been designed to maintain stock quality when institutional capacity is low (13).

Conclusion

The options for Pangasius to respond to climate change depend on their location. The farms located in the coastal provinces affected by salinity intrusion in the dry season may either modify their Pangasius farming practice, or stock other species or stock saline-tolerant Pangasius. The modification would imply further prolonged nursery in fresh water basins or in water recirculation systems. A breeding program for saline-tolerant striped catfish will cost 0.4 % of the present production costs for the coastal provinces, and can be cost–efficient.

The Pangasius farms, which are not located within upgraded government dyke-protected areas, will be affected by flooding at the end of each rainy season. This would imply an increase of the cost for dykes to about 0.34% and 0.25% of the total variable cost for one harvest per ha in the up- and mid-stream regions, and in the downstream region, respectively.

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RESUMES
ABSTRACTS

SAMENVATTINGEN
RESÚMENES

Establishing a Local Water-Sharing Mechanism in Vietnam

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Keywords: Drought - Climate change - Irrigated rice - Water conflict - Vietnam

The agriculture sector in Vietnam faces shortage of water resources. This water shortage is expected to be more pronounced under the influence of climate change and the accompanying drought episodes. Sustainable solutions such as the equitable distribution of resources for both ecology and human needs, and their livelihoods now and in the future, are thus required. In the Dai Loc district of Quang Nam province, farmers are experiencing water shortage in the cultivation of paddy during the summer-autumn season. Because of this, some farmers have turned to other crops, while others have encountered conflicts regarding the sharing of water among various users. Although there is an existing water resource management policy, this was not fully implemented. But after an inventory of the problem, farmers ranked an equitable water-sharing mechanism as the most feasible solution. The question then was whether a local mechanism could be developed for farmers and other stakeholders to be able to equitably share water among themselves.

Thus, the participatory action research approach (Whyte, 1991) and the co-management approach developed by Ostrom (1990; 2009), and Schlager and Ostrom (1992), were employed. Under the participatory action research approach, stakeholders were identified and a co-management model of water resources was established for equitable and sustainable water sharing among various water users.

The participatory GIS was used to locally map and visualise water resources, irrigation system, and drought issues and make these clear at commune level. In this process, local knowledge, maps showing streams, lakes, rivers, and drought-prone rice production areas were used as inputs to make the GIS map. A series of meetings was organized to discuss the situation, identify and prioritize solutions; this then resulted in the implementation of a water-sharing mechanism as the selected equitable solution for all stakeholders.

The water-sharing mechanism became operational during the summer/autumn rice season of 2015 at the commune level in Tho stream and at the district level in Mo stream. Within a short time, stakeholders reached consensus in using the mechanism; they achieved good results during the implementation. Although the stakeholders still experienced water shortage, its severity was reduced because of the water-sharing scheme. Generally, they felt a more positive attitude towards sharing water among themselves. At the end of the season, a participatory monitoring and evaluation meeting was held where stakeholders decided to continue the mechanism and identify financial resources to sustain future implementation when more droughts are expected both due to water shortage and climate change. A study to understand further the magnitude of the drought and the impacts of climate change on water shortage is thus recommended.

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Climate Change as a Scapegoat: Assessing and Identifying Responses to Declining Yield of Sedge (*Cyperus Tegetiformis*) in Nga Son District, Thanh Hoa province, North Central Vietnam

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Keywords: Papyrus - Yield decline - Climate change - Soil - Fertilizer - Vietnam

The productivity of sedge in the coastal communes of Nga Son district is declining. Though climate change (CC) is an easy scapegoat in the present context, after an initial inventory this study did a broad assessment of the causes before identifying responses. The study team:

(1) Assessed the inter-annual variation of the weather
(2) The sedge yields by using secondary data;
(3) Mapped the predicted changes in flooded areas following the B2 CC scenario for Vietnam using GIS tools;
(4) Identified constraints of sedge production through a survey and Focus Group Discussions (FGDs) and other Participatory Rural Appraisal (PRA) tools. After an inventory, the proposed solutions were ranked on feasibility for five criteria (see Table 1).

The weather assessment showed that from 1970 to 2013 the average temperature had risen to about 0.3°C, and the amount of rainfall decreased approximately by 20%. At present, about 114 ha is flooded annually between July and November. The flooded area is expected to increase to 4,072 ha by 2050 and 10,316 ha by 2100, accounting for 26% and 65%, respectively of the district's total land area.

Over the past years, the yield and length of sedge had declined; likewise, the market price has declined partly because of the reduced length. The constraints of sedge production include:

(1) salt intrusion and fresh water shortage,
(2) extreme climate events,
(3) the applied dose of N (400 – 500 kg ha^{-1}) is far more than the crop demand and
(4) pests outbreak.

Three solutions to improve sedge yield and length were proposed. The top-ranking feasible solution was to improve the application techniques of fertilizer to increase N-use efficiency, as well as sedge yield and height. Other solutions which include improving irrigation system and finding new sedge varieties are less feasible due to financial and technical issues.

An on-station fertilizer experiment with lower N-application than that of the farmer's practice, but adding manure / organic matter (OM) improved the yield and quality of sedge. Amending Si might further enhance yields (Hanh et al 2016). Though climate change increases the problem of salinity intrusion, the main cause of reduced yield seemed to be related to excess N and low OM application.

Table 1

Feasibility ranking of the solutions to improve the yield and length of sedge.

Solution	Financial capacity	Technical capacity	Management capacity	Labour capacity	Expected efficiency
Improve application techniques of fertilizer	1	1	1	2	2
Introduce new sedge varieties	2	3	3	1	1
Improve irrigation system	3	2	2	3	1

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Integrated Nutrient Management for Papyrus (*Cyperus malacensis.* Lam) Production in Nga Son district, Thanh Hoa province, Vietnam

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Keywords: Sedge - Yield decline - Soil quality - Organic matter - Fertilizer - Vietnam

Papyrus is a major crop and a source of income for farmers in 23 communes of Nga Son, a coastal district in Thanh Hoa province. Farmers in these communes make a living by processing this crop into mats and other traditional products. In recent years, however, the papyrus cultivation area, as well as yield, quality and production efficiency have declined due to increasing salinity levels brought about by climate change. As a result, over 30% of the district's arable land has been affected. Moreover, drought, fresh water shortage, new pests and costly inputs, such as fertiliser and labor have contributed to the decreasing production efficiency of papyrus. Thus this study, first assessed through a survey on the main production constraints in 3 communes (Nga Thai, Nga Tien, Nga Thuy) of Nga Son. Thereafter the team tested fertiliser application rates in two treatments, and compared the soil quality and the papyrus nutrient demand. The 300 farmers represented 3 yield levels (high, average and low yields). The existing constraints in fertiliser application included:

(1) the very low or zero use of organic fertilisers and lime;
(2) the type of liming with CaO which is not suitable for saline soils;
(3) the applied dose of N (400 – 500 kg ha^{-1}) which exceeds the crop demand;
(4) the N-fertiliser is applied 3 to 4 times and the timing depends on the climate (rainy);
(5) the soil content of available P and K was insufficient to balance the N application and the crop demand, because farmers did not apply P and K.

The field trial compared the farmer's practice (control) with the application of (1) lime as $CaSO_4$ and (2) mineral-organic fertiliser (treatment). For the control, 500 kgN/ha was applied 4 times. The quantity of $CaSO_4$ applied was calculated to raise the soil pH to nearly neutral (pH = 6,5). A total of 2000 kg ha^{-1} mineral-organic fertilizer composed of 10%N, 5%P_2O_5, 3%K_2O and 9.5%C, was applied at tillering and elongation stages. Compared to farmers' practice, results showed that with application of fertilizer, the yield of papyrus increased by 19%, the ratio of papyrus longer than 1,75m increased by 7%. Without considering a variable interest rate for buying fertilizer on loan, the net profit increased by 32% in comparison with the current farmer's practice. Marginal benefit-cost ratio was more than doubled. This indicates that the treatment is economically viable for farmers producing papyrus.

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White Shrimp-red Tilapia Polyculture: a Response to Climate Change in Giao Thuy District, Nam Dinh Province

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Keywords: Aquaculture - Shrimp - Tilapia- Polyculture - North Vietnam

Giao Thuy, a coastal district, repetitively experiences direct impacts of climate change (CC), such as typhoons, heavy rains, very cold and hot spells. In addition, water pollution exposes the aquaculture industry to higher risk of damage. As a consequence, white shrimp farms, the most popular aquatic production in the district, are often confronted with mass mortality due to the limited capacity of shrimps to adjust to quick environmental changes and to higher incidence of diseases. Shrimp polyculture is a type of integrated model that shows beneficial effects to potential adopters. Several studies have demonstrated that culturing shrimp with other aquatic species, such as red tilapia in some coastal areas reduces the amounts of dissolved nutrients, filters suspended solids, utilises excess organic matter as feed (thus sometimes producing food for other species), improves water quality and enhances disease resistance against pathogens. Polyculture is still new to Giao Thuy district, and has not yet been tested as an adaptive solution to CC in the area. This study examines the results of the white shrimp-red tilapia polyculture to demonstrate that this can be a good adaptation strategy to CC for the local farmers. The experiments were carried out in six ponds with an area between 2000 to 2500 m^2 each in Giao Phong commune, Giao Thuy district, Nam Dinh province in 2014 and 2015.

The trials consisted of 6 models designed in six ponds: two integrated farms in brackish water and two integrated farms in freshwater, and for control, two monoculture shrimp farms, one in brackish water and one in freshwater. For the freshwater polyculture, the white shrimp had been gradually acclimatized to fresh water. In the integrated culture models, red tilapia was added at a density of 2 fish m^{-2} to a stocking density of 100 white shrimp m^{-2}; the shrimp was stocked twice per year but red tilapia was stocked only once. In the monoculture models, white shrimp was stocked at the same time and density as that of the integrated models.

In both brackish and fresh water, the polyculture of shrimp with red tilapia resulted in lower disease impact, lower cost of drugs and chemicals by about 70% and doubled economic benefits compared with the monoculture of shrimps. Farmers and the local authorities in the district highly appreciated the results of the integrated culture model. This model can be considered as a strategy to increase the adaptive capacity of aquatic production in the study area.

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Climate Change Adaptation Strategies for Freshwater Agriculture in the Coastal Mekong Delta: Farm-scale Opportunities and Water Management Challenges

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Keywords: Climate change - Water productivity - Rice - Aquaculture - Southern Vietnam

In the coastal zone of the Mekong Delta, farmers suffer heavy crop losses and fresh water shortage due to droughts and salt water intrusion in the dry season. These hazards will continue to increase in the future because of climate change.

Thus, we implemented a participatory action research in 2013-2014 in Soc Trang province. We developed adaptive farming technologies that would enable farmers to deal with climatic threats. After an impact assessment, we identified adaptive technologies that were tested on-farm, and monitored and evaluated with the active participation of local stakeholders.

For the irrigated agro-ecological zone, both the alternate wetting and drying (AWD) irrigation improved rice water productivity by 31% - 45%. The freshwater retained in communal irrigation canals significantly contributed to the irrigation requirement for rice crop from drought or salinity intrusion threats.

For the rain-fed and brackish rice-shrimp agro-ecological zones, a package of technological measures, including pond capacity improvement, crop water-saving irrigation and farming diversification improved rain water harvest for irrigation by 63% in the dry season. Farming diversification consisted of integrating vegetables, aquaculture and livestock within the farm. Application of these adaptive technologies increased the overall farm productivity. Farm income increased from 25% to 77% (Figure 1). Local stakeholders found these technologies feasible at farm level considering their technological, socio-economical and environmental context.

However, there are still barriers for scaling out the technologies. Fostering the adaptive capacity of farmers to climate change requires not only farming technologies at household level, but also changes in infrastructure (irrigation canal and field) and institutional arrangements supporting the adaptive and innovative capacity and appropriate technology transfer mechanisms like participatory extension method.

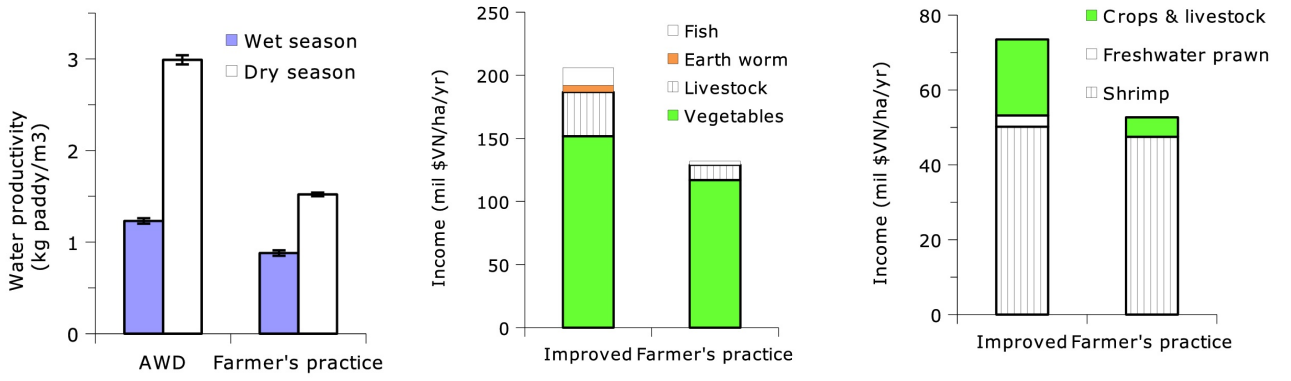

Figure 1: The effects (mean ±SE) of improved practices on (a) water productivity for rice in the irrigated sub-agroecology, and farm income in (b) the rain-fed and (c) the rice-shrimp sub agroecology. AWD = alternate wetting and drying irrigation.

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Presentation

Tropicultura is a multi-disciplinary journal, which publishes original articles, research and summary notes, overviews of books and essays, announcements and reports on films / audio-visual resources concerning all fields linked to rural development, as well as sustainable management of the environment in overseas countries.

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Tropicultura is published by the non-profit organisation AGRI-OVERSEAS and benefits from the scientific patronage of the Belgian Royal Academy of Overseas Sciences (RAOS: www.kaowarsom.be).
Tropicultura serves the purpose fulfilled by the "Bulletin Agricole du Congo Belge et du Ruanda-Urundi" (Agricultural Bulletin of the Belgian Congo and Ruanda-Urundi) until 1963. The first volume of Tropicultura was published on paper in 1983 (ISSN 0771-3312). It was replaced by an electronic version from 2013 (eISSN 2295-8010).

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Tropicultura is published every quarter in March, June, September and December.

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Application for Tropicultura to be indexed on the SCOPUS database has been submitted.

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32% of articles submitted to Tropicultura between 2010 and 2015 were accepted.

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Texte français dans le n°1 *Nederlandse tekst in Nr.3* *Texto Español en el N°4*

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