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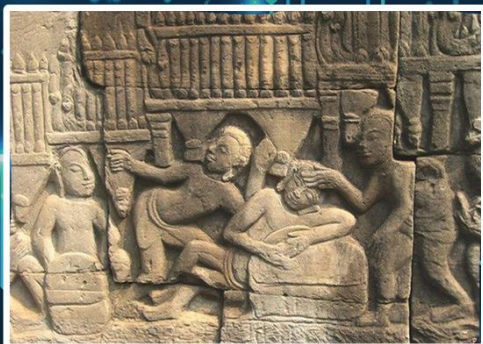
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Insight

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News

Keo Duong, a Lecturer at the Department of History has won a Young Researcher Prize

Keo Duong has been awarded the 2022 Voltaire Prize from the University of Potsdam in Germany. The members of the jury stated that *"Duong Keo's careful research, courageous communication, and committed interaction in Cambodia have contributed significantly to a more conscious approach to the past, as well as to more tolerance towards the socially marginalized Vietnamese minority."*

Figure 1. Keo Duong with Professor Oliver Günther, President of the University of Potsdam, and Professor Ottmar Ette.

The 5000 EUR prize is awarded to a young scholar who has campaigned for freedom in research and teaching or the right of free expression. It acknowledges those who have contributed toward "*social dialogue on peace, international understanding, tolerance, and respect for differences*", or those who "*promote diversity in society oppose racism and discrimination*". It is

organized by the University of Potsdam in Germany with financial support from the Friede Springer Foundation. Since 2017, the award has been received by young scholars from Turkey, Guatemala, Afghanistan, Hungary, and Rwanda. Keo Duong, of Cambodia, is the first person from Southeast Asia to be recognized by the award.

Figure 2. Keo Duong with his supervisor, Professor Timothy Williams and Professor Ottmar Ette © University of Potsdam/Sandra Scholz

Keo Duong's current PhD research at Bundeswehr University in Munich is supported by a scholarship from the Gerda Henkel Foundation. He was nominated by his doctoral supervisor; Professor Timothy Williams based on two aspects of his work over the past 15 years. The first is his work as a lecturer since 2014 at the Royal University of Phnom Penh, contributing to a more nuanced and comprehensive understanding of the history of the Khmer Rouge. He has taught several subjects regarding the modern history of Cambodia, and historical research. Additionally, he worked for many NGOs, most notably Youth for Peace, Kdei Karuna, and the Bophana Audiovisual Resource Center, where he has conducted research, written books, and

produced films and multi-media resources. He was also involved in revising of national history curriculum for the Ministry of Education, Youth and Sports seeking to improve education in Cambodia. He has also worked to promote tolerance and respect, and contributed to a deeper public understanding of ethnic Vietnamese minorities living in floating villages in Cambodia. He is one of a few Cambodian researchers brave enough to speak publicly about this politically sensitive topic, bringing academic and public attention to this issue.

Picture 3. Keo Duong holding the 2022 Voltaire Prize © Keo Duong

Keo Duong is committed to developing his academic career by continuing to contribute his knowledge, especially through his role at the Royal University of Phnom Penh. He plans to continue teaching and take part in research activities to contribute to strengthening the research culture in Cambodia. In his acceptance speech at the award ceremony in Potsdam, Keo Doung stated *"this acknowledgement of my work is very important to me and the prize motivates me to work harder in my research to contribute to the academic, as well as in my advocacy community in Cambodia and overseas."*

Editorial: The **use of** a tracer study to advance the undergraduate program at the Royal University of Phnom Penh

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It has been recognized that academic performance does not always help students to seek decent work. Tracer studies have become popular at Higher Education Institutions (HEIs) for tracking and evaluating student progress beyond graduation and are recommended to be conducted regularly on individuals, groups, or departments over time. For instance, a study may track a cohort of students with scholarships, as an experimental group, and another without a scholarship, as a control group (INTRAC, 2017).

Tracer studies use alumni surveys to evaluate the performance of HEIs by monitoring graduate outcomes (Millington, 2010) and are essential for reflection on how curricula may better meet the demands of the labour market (Harvey, 2000). They are used to identify skills mismatches and salary expectations, as well as monitor job satisfaction (Badillo-Amador & Vila, 2013), which have policy and equity implications (Rogan and Reynolds, 2016). Tracer studies collect data about the relationship between HEIs and

employment outcomes to explore deficiencies in teaching and learning processes, which is useful for policy and planning decisions within the higher education sector (Schomburg, 2003).

Tracer studies retrospectively analyze graduate outcomes using a standardized survey conducted six months to three years after completion of a program, which is systematically repeated either annually or biannually (ETF-Cedefop-ILO, 2016). The results from these studies are essential for educators and program evaluators to gather evidence to review and further develop curricula in line with workplace demands (Osei, 2010). For instance, the Department of Library and Information Studies at the University of Botswana conducted a tracer study to collect and analyze data from alumni about the training of librarians and their perception of the teaching content, quality of education, and career pathways (Latif and Bahroom, 2010). This kind of information enables HEIs to transform academic knowledge to better meet market requirements (Schomburg, 2003).

Since 2004, the Royal University of Phnom Penh (RUPP) has conducted biannual tracer studies. Based on this experience, the Department of Higher Education within the MoEYS instructed all HEIs in Cambodia to conduct annual studies. Since this time, the RUPP has contacted 1,562 alumni in 2020 and 1,076 alumni in 2021 to obtain a richer understanding of the employability of alumni and their satisfaction with the curriculum. This editorial paper outlines some of the findings of the tracer study conducted in 2021.

Knowledge and skills obtained at the RUPP

Tracer studies at the RUPP ask alumni about the knowledge and skills that have been used after graduation. It found that 58.5% of the alumni from the Faculty of Social Science and Humanities used the skills they had learned, compared with 88.9% of those from the Faculty of Development Studies. A chi-square test revealed no significant relationship between these percentages across the five faculties (P-*value*=0.211), suggesting that these results were similar (Figure 1).

Figure 1. Skill used after alumni by faculty after graduation
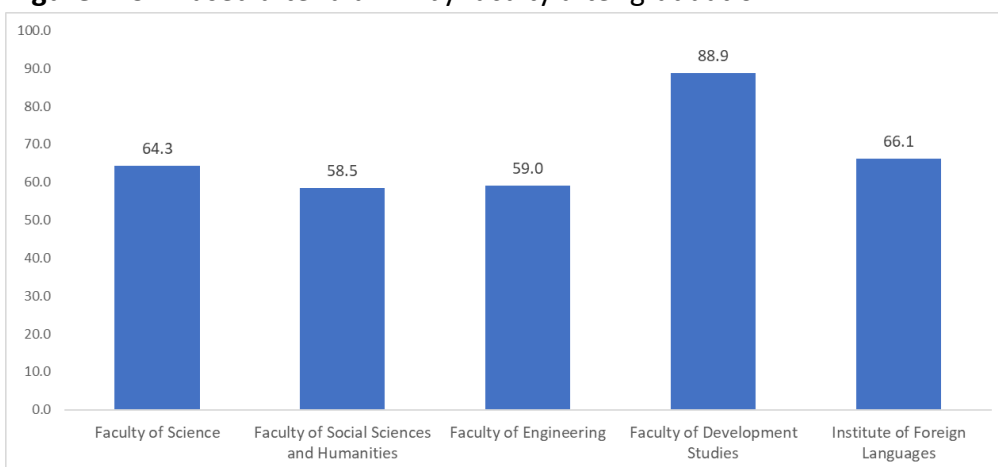
Note: Chi-square test (P-*value*=0.211).

Overall, alumni indicated a high degree of satisfaction with the knowledge, skills, and competencies acquired from the RUPP. This was especially the case for the ability to work in a team, critical thinking skills, obtaining experience in social work, communication skills, and the development of a gentle attitude (Figure 2).

Alumni also indicated a high degree of satisfaction with teachers, teacher attitudes and ethics, teacher skills and qualifications and matching the topic of study with the level of experience of teachers. They also ranked the research discoveries of teachers, their use of teaching tools and equipment, encouragement offered, timely lesson completion, lesson preparation, and teaching quality highly (Figure 3).

Figure 2. Satisfaction with knowledge, skill, and competencies
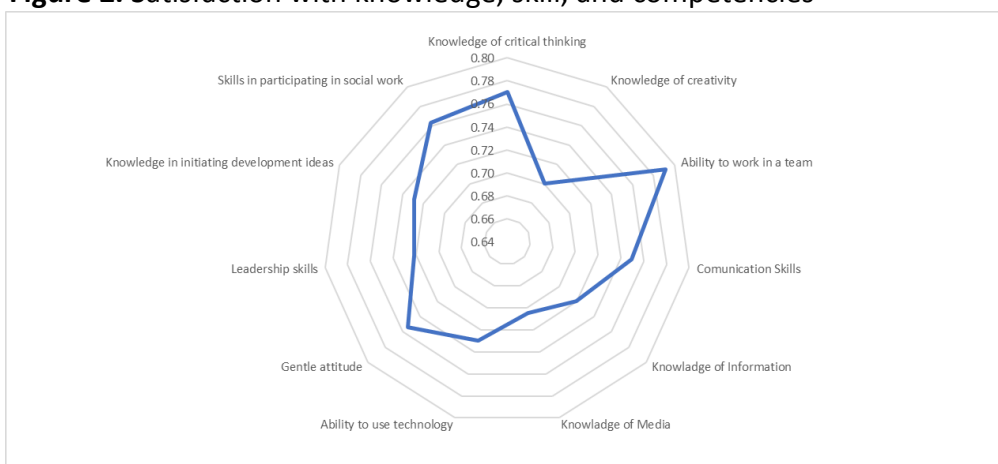
Notes: WAI = Weight Average Index measured on a five-point scale [Very low (VL) = 0.00-0.20, Low (L) = 0.21-0.40, Moderate (M) = 0.41-0.60, High (H) = 0.61-0.80, Very high (VH) = 0.81-1.00]; OA = Overall Assessment.

In Figure 4, the employability rate after graduation from the RUPP is presented. Overall, graduates from Science or STEM disciplines (61.6%) had greater access to employment opportunities than graduates from the Faculty of Social Sciences and Humanities (16.5%); Institute of Foreign Languages (IFL) (11.7%); Faculty of Engineering (FoE) 9.2%; and Faculty of Development Studies (FDS) (1.1%).

The percentage of students responding relative to the proportion of graduates, however, is so small from some facilities (i.e. FoE & FDS) that it may be assumed that graduates faced challenges accessing jobs. When tracing the job opportunities available to graduates, the data reveals that graduates had similar opportunities to access work. Remarkably, most graduates could find relevant jobs in their field of study in Phnom Penh. Another significant finding was that other provinces in Cambodia such as Kandal, Takeo, Kampot, Kampong Cham, and Prey Veng require similar skills to those required in Phnom Penh. In other words, these provinces also require graduates with 21st Century skills.

Figure 3. Satisfaction with teaching and learning at RUPP
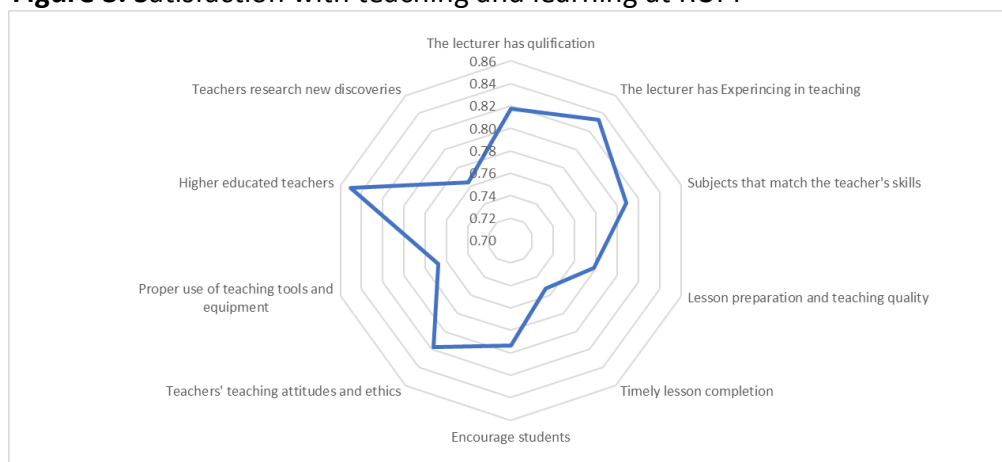
Notes: WAI = Weight Average Index measured on a five-point scale [Very low (VL) = 0.00-0.20, Low (L) = 0.21-0.40, Moderate (M) = 0.41-0.60, High (H) = 0.61-0.80, Very high (VH) = 0.81-1.00]; OA = Overall Assessment.

Figures 5, 6, and 7 describe the relationship between communication skills and (1) the ability to work in a team, (2) knowledge of information technology, and (3) leadership skills. This correlation analysis confirms that

communication skills are strong and positively associated with knowledge of information technology and leadership skills. Communication skills were found to be beneficial for students in their future employment. When students are equipped with good communication skills, they are also likely to be competent in information technology and leadership.

Figure 4. Employment rates by province
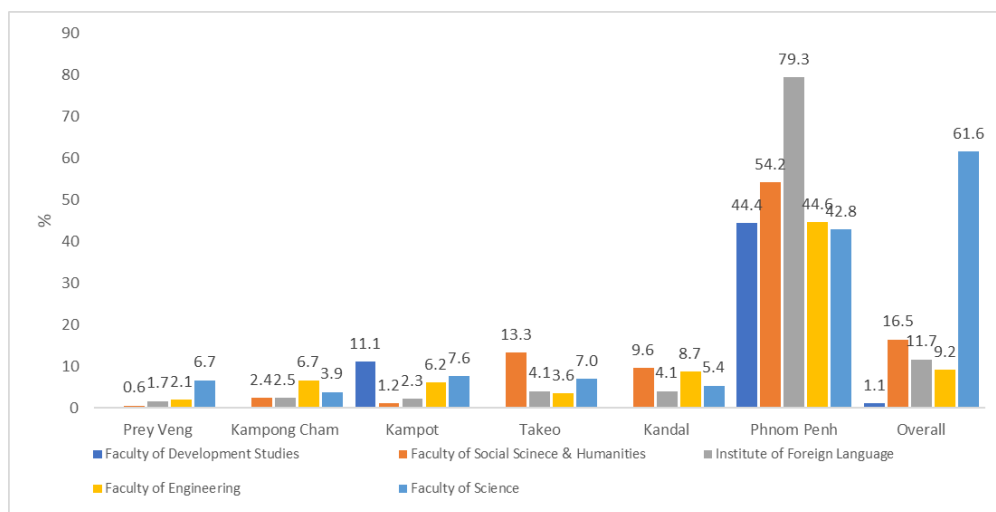
Note: Chi-square test (P-*value*=0.000).

Figure 8 and Figure 9 show a strong and positive association between leadership skills and level of initiative. The analysis also reveals a strong and positive association between initiative and social work capacity. Graduate students with good leadership skills tended to have a high competency in demonstrating initiative and social work capacity.

There were several reasons why alumni chose to study at the RUPP including its reputation (66.1%), quality of education (44.6%), courses (38.2%), and availability of scholarships (16.7%). In recent years, the RUPP has

gained national and international recognition and as a result, more students have enrolled in courses (Figure 10).

Figure 5. Relationship between communication skills and ability to work in a team *r*=.728, P-*value* =0.000
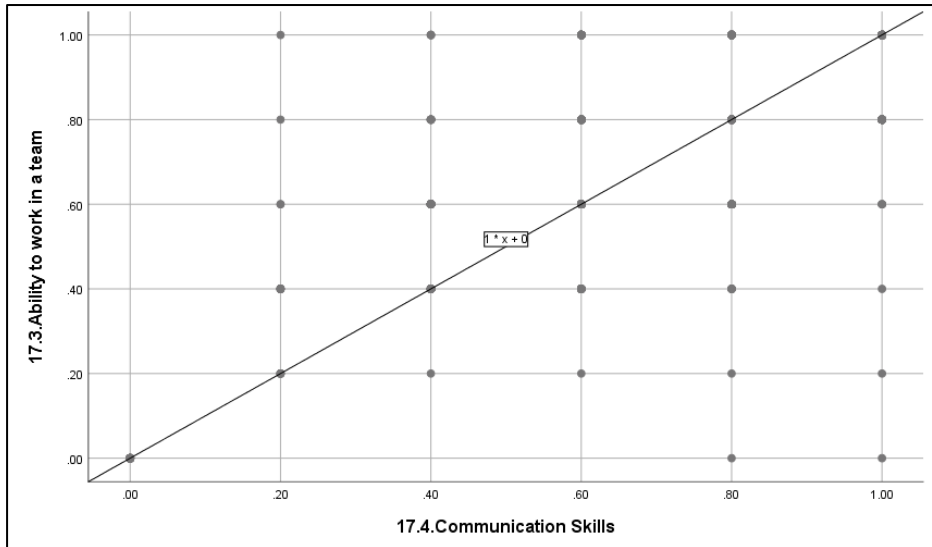
Figure 6. Relationship between communication skills and knowledge of information technology *r*=.714, P-*value* =0.000
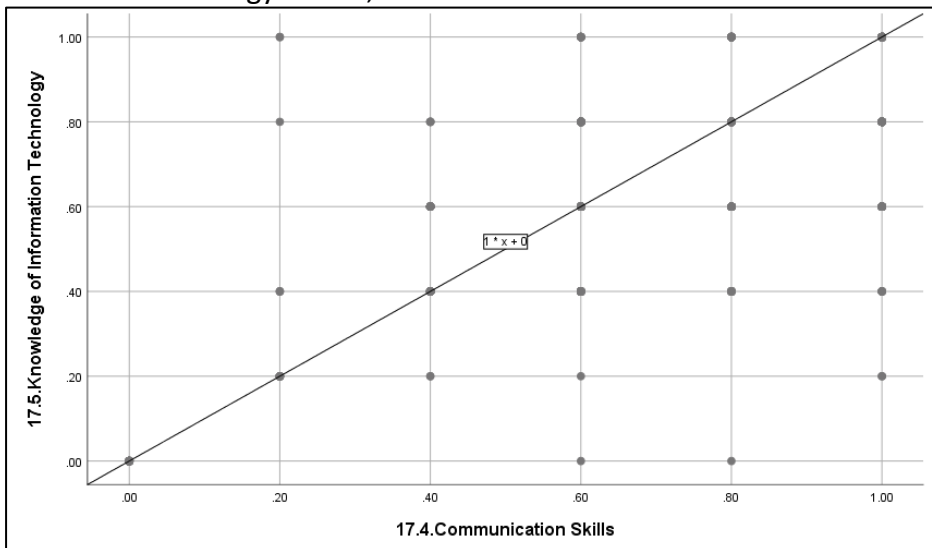
Figure 7. Relationship between communication and leadership skills *r*=.705, P-*value* =0.000
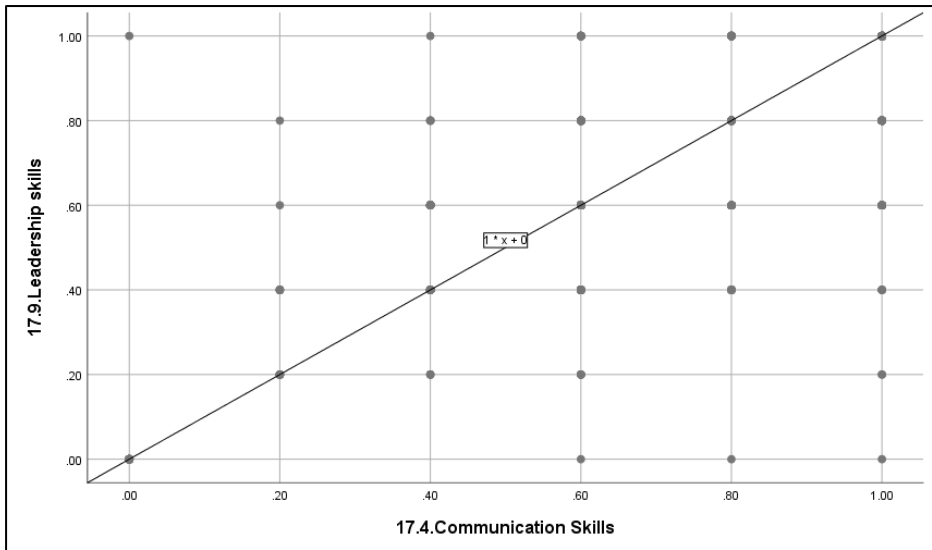
Figure 8. Relationship between leadership skills and level of initiative *r*=.745, P-*value* =0.000
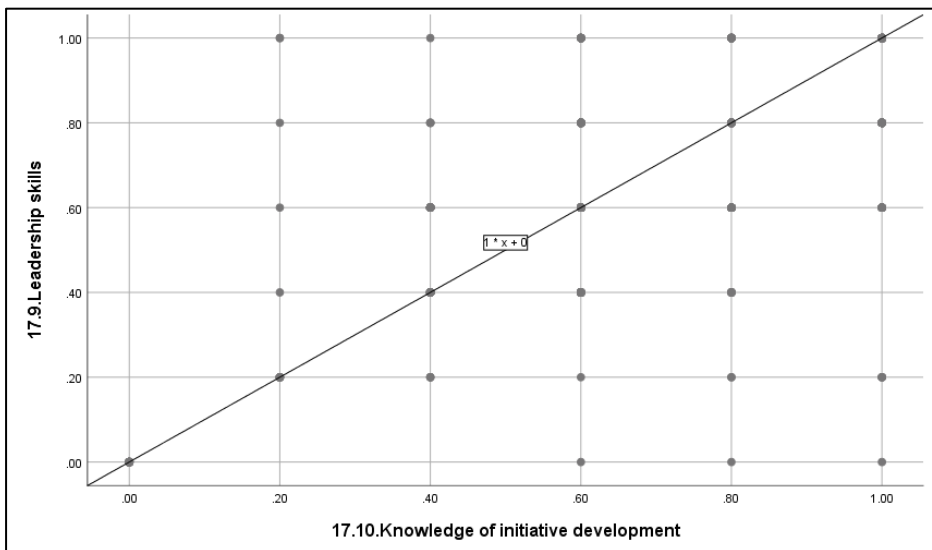
Figure 9. Relationship between level of initiative and social work capacity *r*=.745, P-*value* =0.000
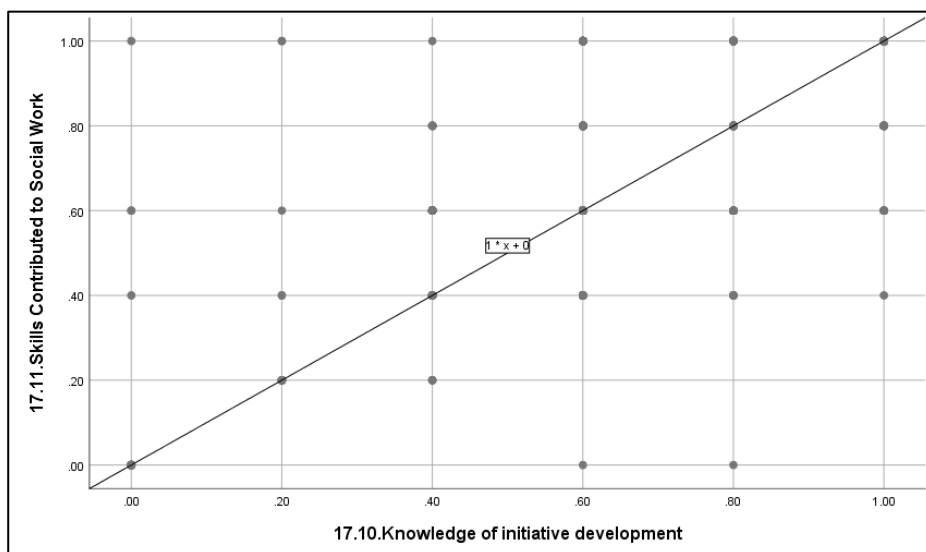
Figure 10. Reasons for enrolling in courses at RUPP
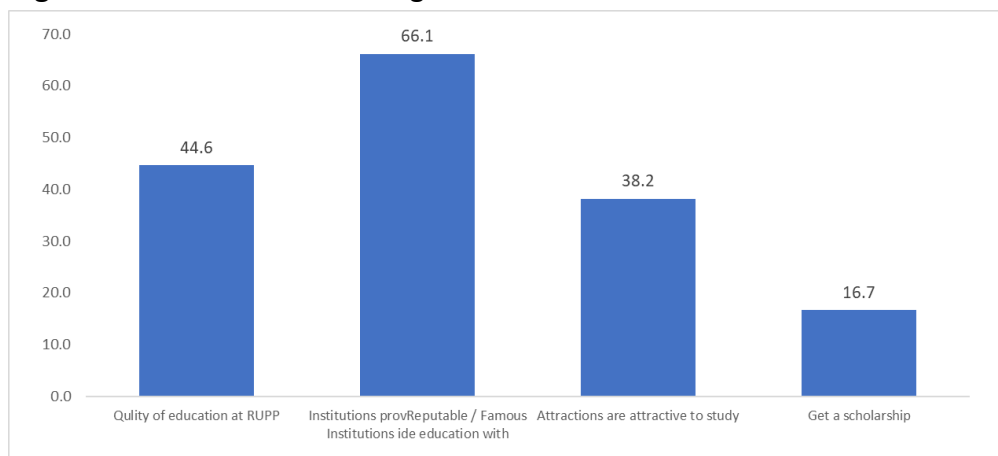
On average, alumni earned 293.07 USD per month following graduation, however, income inequality was high, especially for students from the Faculty of Social Science and Humanities (Figure 11). An ANOVA test reveals a significant difference in income across the five faculties (P-*value* = 0.015).

While alumni from the Institute of Foreign Languages earned as much as 317.11 USD per month, alumni from the Faculty of Development Studies earned as little as 277.78 USD per month. It is common for undergraduate students to hold either part-time or full-time jobs while studying to help cover school fees and living costs. On average, a student earned 193.80 USD per month while studying. A t-test analysis reveals that monthly income after graduation was significantly higher than monthly income earned while studying.

Figure 11. Monthly salary earned after graduation
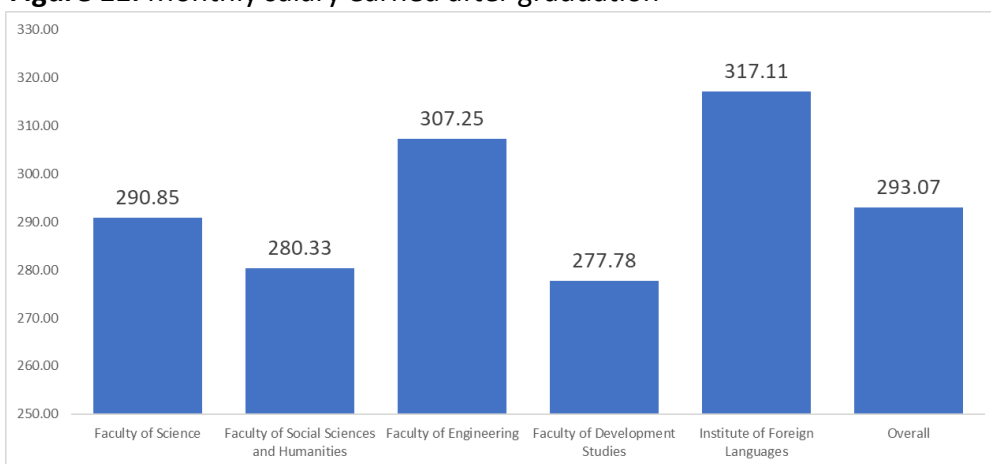
Note: ANOVA test (P-*value*=0.015).

Multiple linear regression was used to predict key influencing drivers of the salary of alumni after graduation from RUPP. The model indicated that higher salaries are more likely when (1) the curriculum responds to the labour market, (2) the curriculum adheres to national policy, (3) students present at conferences, (4) students publish a thesis or a journal article, (5) the

restaurant provides affordable meals for students, and (6) job finding services are provided to students

Figure 12. Monthly salary during and after study at the RUPP
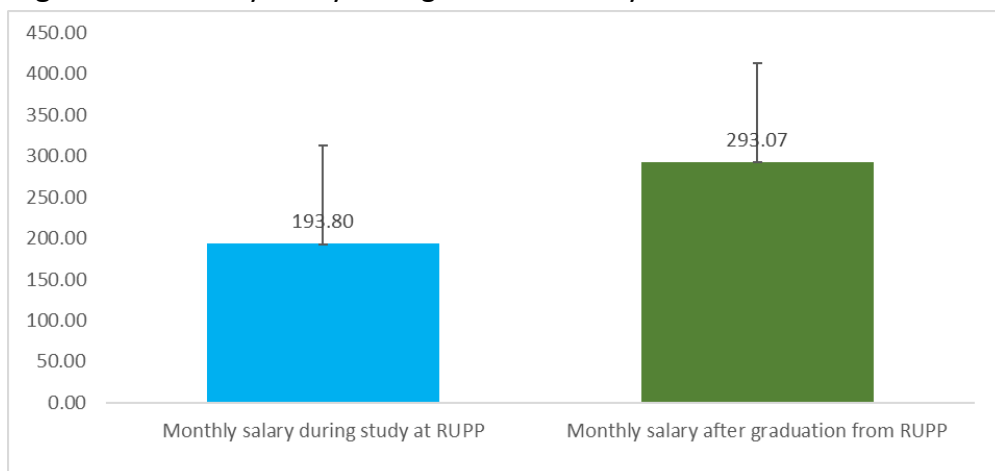
Note: t-test (P-value =0.000).

It was also found that alumni may gain higher salaries when RUPP (1) improves curriculum in response to the labour market, (2) improves national policy, (3) encourages participation and presentation at conferences by students, (4) published the work of students, (5) provides a better connection with employers during studies, and (6) improves the job services offered by the RUPP.

Multiple linear regression was also applied to predict factors influencing promotion opportunities obtained by alumni. These included the application of knowledge and technology, career and skills development, working environments, knowledge of creativity, and communication skills. Higher levels of access to the factors help to increase the chances of promotion.

Table 1. Key drivers influencing salary of students after graduation

Attributes	B	Standard error	P-*value*
(Constant)	0.850	0.138	***0.000***
Curriculum responds to labor market	0.142	0.052	***0.006***
Curriculum responds to societies needs	0.089	0.056	0.114
Curriculum adheres to national policy	0.100	0.048	***0.039***
Curriculum contribtues to global development	-0.042	0.056	0.453
Curriculum is linked to research	-0.089	0.050	0.073
Participation and presentation at conferences	0.156	0.051	***0.002***
Publication of a journal article and/or thesis	0.127	0.047	***0.007***
Classroom environment appropriate to the number of students	0.033	0.038	0.385
A good learning environment at the institution.	-0.088	0.046	0.056
There are sufficient vehicles for the number of students	-0.022	0.044	0.614
The restaurant has reasonable services for students	0.087	0.042	***0.036***
Provision of counseling services for students	-0.001	0.049	0.986
Provision of health services and health education programs	0.053	0.045	0.242
Students are able to express opinions and provide constructive criticism	-0.061	0.047	0.195
Provide job finding services for students	0.203	0.042	***0.000***

Table 2. Key drivers influencing promotion opportunity of students after graduation

Attributes	B	Standard error	P-*value*
(Constant)	-0.029	0.111	0.795
Application of knowledge	0.362	0.040	**0.000**
Career and skills development	0.274	0.045	**0.000**
Scope of work and responsibilities	-0.032	0.042	0.452
Working environment	0.246	0.040	**0.000**
Critical thinking	-0.013	0.046	0.786
Creativity	0.099	0.047	**0.036**
Ability to work in a team	-0.006	0.047	0.902
Communication skills	-0.121	0.050	**0.016**
Use information	0.092	0.052	0.075
Use of media	-0.040	0.047	0.399
Ability to use technology	-0.055	0.048	0.251
Gentle attitude	-0.060	0.046	0.196
Leadership skills	0.083	0.044	0.062
Level of initiative	0.035	0.049	0.475
Skills in social work	0.049	0.047	0.298

The regression model outlines the essential factors related to the ongoing career development of graduates. These included education-related theories and practices; applying the skills and knowledge learned while studying; skills being closely linked to future employment; knowledge obtained being

relevant to Cambodian society; the capacity to analyze and resolve career challenges; access to stable employment; the capacity to maintain good workplace relationships; the capacity to use information technology; satisfaction with the quality of education provided; and the influence the course you completed had on shaping your career.

Table 3. The aspects of education that are important to the careers of RUPP graduates

Attributes	B	Standard error	P-*value*
(Constant)	0.087	0.086	0.311
Education related theories and pracitces	0.090	0.032	*0.005*
Skills and knowledge accessed	0.107	0.031	*0.001*
Skills attained being closely linked to future employment	0.229	0.033	*0.000*
Knowledge being relevant to Cambodian society	0.111	0.031	*0.000*
The capacity to analyze and solve career challenges	0.098	0.036	*0.006*
Access to stable employment	0.077	0.038	*0.044*
The capacity to maintain good working relationships	0.094	0.039	*0.016*
Improved creativity	-0.022	0.037	0.556
Capacity to use information technology	0.067	0.030	*0.023*

Capacity to become an entrepreneur or establish a business	0.044	0.029	0.129
Sufficient English language skills	-0.050	0.029	0.085
The requirement to complete an internship before graduation	-0.029	0.026	0.265
The usefulness of an internship in accessing employment	0.014	0.028	0.617
The usefulness of the internship in building your capacity in your current job.	0.021	0.033	0.517
You would recommend your course to other students	-0.059	0.031	0.057
You are satisfied with the quality of education provided	0.090	0.032	***0.005***
The course completed helped you shape your current career	0.101	0.032	***0.001***

The regression model indicates that critical thinking, creativity, and the ability to use technology are key variables that influence whether the skills and knowledge accessed at RUPP may be applied in a future career.

The RUPP has paid attention to the quality of education and employment opportunities for its graduates via annual tracer studies. The findings of these studies have been used to revise, plan and design the curriculum. The vision of RUPP is to be the flagship university in Cambodia, with a national and regional standing in teaching and learning, research and innovation, and

social engagement. Thus, the findings of tracer studies as part of the monitoring and evaluation system at the RUPP are used to track the progress of the Strategic Plan (2019-2023) and for continuous quality improvement. Improvements in the quality of education through curriculum revision are applied to meet the demands of society and turn the unique vision of the RUPP into a reality.

Table 5. The skills and knowledge RUPP graduates apply to their current job

Attributes	B	Standard error	P-*value*
(Constant)	1.302	0.153	*0.000*
Knowledge of critical thinking	0.253	0.045	*0.000*
Knowledge of creativity	0.113	0.046	*0.014*
Ability to work in a team	-0.062	0.049	0.203
Communication Skills	0.023	0.054	0.667
Knowledge of Information	0.073	0.057	0.203
Knowledge of Media	-0.023	0.055	0.673
Ability to use technology	0.100	0.048	*0.037*
Gentle attitude	-0.069	0.048	0.148
Leadership skills	0.080	0.052	0.121
Knowledge in initiating development ideas	0.002	0.057	0.978
Skills in participating in social work	0.091	.052	0.078

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Spectral Analysis of Banach Spaces and their Application to Age-Structured Equations

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សង្ខិត្តន័យ

ក្នុងអត្ថបទនេះ យើងនឹងប្រើទ្រឹស្តីបទ Floquet សម្រាប់ការវិជ្ជមាននិងមានខួបលើ លំហ Banach ដើម្បីសិក្សាភាពមានចម្លើយនិងភាពមានចម្លើយតែមួយគត់នៃបញ្ហា តម្លៃផ្ទាល់ Floquet និងបញ្ហា adjoint របស់វា។ នៅផ្នែកចុងក្រោយ យើងនឹងប្រើ ទ្រឹស្តីបទនេះទៅលើសមីការសម្ព័ន្ធអាយុ ដែលមានមេគុណវិជ្ជមាននិងមានខួប ដើម្បី សិក្សាស្វ័យគុណ Floquet ដែលជារង្វាស់នៃអាត្រាកំណើន។ ស្របពេលជាមួយគ្នា នេះ យើងនឹងទទួលបាននូវការថយចុះបែបអិុចស្ប៉ូណង់ស្យែលនិងអាស៊ីមតូតរយៈពេល វែងតាមវិធីសាស្ត្រអង់ត្រូពី។

Abstract

In this paper, Floquet's theory will be applied to a positive periodic operator on a Banach space to show the existence and uniqueness of a solution to Floquet eigenvalue problems and their adjoints. Then, the theory will be applied to an age-structured equation with positive and periodic coefficients to study a Floquet exponent, which measures the growth rate of a population. At the same time, exponential and long-run asymptotic decay will be derived using the entropy method.

Keywords: Eigenvalue problem, age-structured equation, Floquet theory

Introduction

When modelling population dynamics, the first step is to identify significant variables that enable the division of a population into homogeneous subgroups. This is used to describe the dynamics of the interaction between these groups. Age is one of the most natural and significant parameters for structuring a population. Many internal variables are dependent on age. For example, age differences may be associated with different reproductive and survival abilities.

A model for age-structured populations (McKenDrick, 1926; von Foerster, 1959) was designed to study disease transmission in populations. Often diseases have different infection and mortality rates for different age groups (Anderson & May, 1991). For instance, chickenpox or measles are spread mainly via contact between two members of a population of a similar age. In models of disease transmission, an age-structured equation is useful as it allows the ages of different members of a population to be accounted for when determining variables such as contact rates.

Iannelli & Milner (2017) defined the evolution of a population over time using an age density function known as the McKendrick equation. There are several reasons for introducing time dependence between the coefficients of this equation. A common rationale is to represent seasonality. Another is related to modelling cell division in cancer treatments, such as resonance and chrono-therapy, which are based on modelling Circadian rhythms (Clairambault, Michel & Perthame, 2016).

In this paper, an age-structured model is analyzed for the periodic death and birth rate of a population over time. It uses a partial differential evolution equation (Iannelli & Milner, 2017) that models the dynamic nature of the population density $n(t,x)$ of individuals aged $x > 0$ at a time $t \in (0,\infty)$ with age-dependent birth and death rates. The age-structured equation has the following form

$$\begin{cases} \dfrac{\partial}{\partial t}n(t,x) + \dfrac{\partial}{\partial x}n(t,x) + d(t,x)n(t,x) = 0, \ \forall t \geq 0, x \geq 0 \\[2mm] n(t, x = 0) = \displaystyle\int_0^\infty B(t,x)n(t,x)dx \\[2mm] n(t = 0, x) = n^0(x), \end{cases}$$

where $d(t,x) \ and \ B(t,x)$ represent the death and birth rate of a population, respectively, as periodic functions with a period T.

This work derives a solution for the age-structured equation and its long-run asymptotic exponential decay, as well as a proof of its uniqueness.

Methodology

An age-structured model based on a partial differential evolution equation has been used to predict population density dynamics. More specifically, this is an eigenvalue problem that poses some fundamental questions about the existence and uniqueness of these equations. To answer these questions, Floquet's theory is applied to a Banach space. This is an extension of applying Floquet's theory to a matrix (Brown, Easthem & Schmidt, 2013) to prove the existence of a Floquet exponent. Then, the long run asymptotic exponential decay of the solution of the age-structured

equation is proven via the entropy method (Perthame, 2007; Michel, Mischler & Perthame, 2004; 2005).

Results and Findings

This work comprises two parts. The first deals with the extension of Floquet's theory for any positive periodic matrix to any positive periodic operator on a Banach space. More specifically, a linear differential equation of the form

$$\frac{d}{dt}X(t) = A(t)X(t),$$

where $t \in R_+, X(t)$ is a vector on a Banach space E and $A(t)$ is a periodic continuous operator with period T on E.

The existence and uniqueness of the Floquet exponent λ_{per} and the positive and T -periodic $N(t), \phi(t)$ will be proven for the following equations

$$\frac{dN(t)}{dt} = A(t)N(t) - \lambda_{per}N(t) \text{ and } -\frac{d\phi(t)}{dt} = A^*(t)\phi(t) - \lambda_{per}\phi(t).$$

The second part of this paper applies these results to an age-structured equation. Partial differential evolution equations using coefficients that are periodic functions of time are used to model population density dynamics. The existence and uniqueness of $(\lambda_{\text{per}}, N, \phi)$ will be proven for the following age-structured equation:

$$\begin{cases} \frac{\partial}{\partial t}n(t,x) + \frac{\partial}{\partial x}n(t,x) + d(t,x)n(t,x) = 0, \ \forall t \geq 0, x \geq 0 \\ \qquad n(t, x = 0) = \int_0^\infty B(t,x)n(t,x)dx \\ \qquad\qquad n(t = 0, x) = n^0(x). \end{cases}$$

The associated Floquet eigenvalue problem of the age-structured equation above is given by:

$$
\begin{cases}
\dfrac{\partial}{\partial t} N(t,x) + \dfrac{\partial}{\partial x} N(t,x) + \Big(\lambda_{per} + d(t,x)\Big) N(t,x) = 0, \;\; \forall t \geq 0, x \geq 0 \\[2ex]
N(t, x=0) = \displaystyle\int_0^\infty B(t,x) N(t,x)\,dx \\[2ex]
N(t,x) > 0, T - periodic, \displaystyle\int_0^T \int_0^\infty N(t,x)\,dx\,dt = 1,
\end{cases}
$$

And it's adjoint eigenvalue problem is given by

$$
\begin{cases}
-\dfrac{\partial}{\partial t}\phi(t,x) - \dfrac{\partial}{\partial x}\phi(t,x) + \Big(\lambda_{per} + d(t,x)\Big)\phi(t,x) = B(t,x)\phi(t,0), \\[1ex]
\hspace{8cm} \forall t \geq 0, x \geq 0 \\[2ex]
\phi(t,x) > 0, T - periodic, \displaystyle\int_0^\infty N(t,x)\phi(t,x)\,dx = 1.
\end{cases}
$$

The long-run asymptotic exponential decay of this equation is derived as follows:

$$
\int_0^\infty \big| n(t,x) e^{-\lambda_{per} t} - \rho N(t,x) \big| \phi(t,x)\,dx
$$

$$
\leq e^{-\alpha t} \int_0^\infty \big| n^0(x) - \rho N(0,x) \big| \phi(0,x)\,dx.
$$

where $\rho = \int_0^\infty n^0(x)\phi(0,x)\,dx$ and its long-run asymptotic behaviour via the entropy method

$$
\int_0^\infty \big| n(t,x) e^{-\lambda_{per} t} - \rho N(t,x) \big| \phi(t,x)\,dx \to 0 \; as \; t \to \infty.
$$

Floquet's Theory

Floquet theory for matrix. The following homogeneous linear periodic system

$$
\frac{d}{dt} X(t) = A(t) X(t), \tag{1.1}
$$

where $X \in R^d$ and $A(t)$ is a continuous $d \times d$ real matrix-valued function in t, and $A(t + T) = A(t), for\ some\ T > 0$. A unique solution exists for Equation 1.1 for the initial condition $X(t_0) = x_0$. This solution satisfies $X(t) = \Phi(t, t_0)x_0$, where $\Phi(t, t_0)$, is known as a principal fundamental matrix solution and is a solution to the matrix initial value problem

$$\frac{d}{dt}\Phi(t, t_0) = A(t)\Phi(t, t_0),\ \Phi(t_0, t_0) = I.$$

1. As this solution is unique,

$$\Phi(t, r) = \Phi(t, s)\Phi(s, r),\ \forall r < s < t$$

2. $\Phi(t, t_0) = \Phi(t_0, t)^{-1}$.

Thus, it may be observed that

$$\begin{cases} \frac{d}{dt}\Phi(t + T, t_0 + T) = A(t + T)\Phi(t + T, t_0 + T) = A(t)\Phi(t + T, t_0 + T) \\ \Phi(t_0 + T, t_0 + T) = I. \end{cases}$$

Again, due to the uniqueness of the solution, $\Phi(t + T, t_0 + T) = \Phi(t, t_0)$. Now, it may be denoted that,

$$M(t_0) := \Phi(t_0 + T, t_0)\ \text{and}\ M := \Phi(T, 0).$$

Then, it follows that

$$M(t_1) = \Phi(t_1 + T, t_1) = \Phi(t_1 + T, t_0 + T)\Phi(t_0 + T, t_0)\Phi(t_0, t_1)$$
$$= \Phi(t_1, t_0)M(t_0)\Phi(t_1, t_0)^{-1}.$$

This means that $M(t_0)$ and $M(t_1)$ are similar for $t_0 < t_1$ and thus have the same eigenvalues. That is, the eigenvalues of $M(t_0)$ are independent of t_0. Thus, the eigenvalues of $M = \Phi(T, 0)$, also known as a monodromy matrix, are of interest to this study. As $det(M) \neq 0$, a constant matrix B exists, whereby $M = e^{TB}$.

Definition 1.1. The eigenvalues ρ_j of M are called Floquet multipliers. The complex eigenvalues λ_j of B are called Floquet exponents and are related by the equation $\rho_j = e^{\lambda_j T}$.

Theorem 1.2 (Floquet). If M is a monodromy matrix for a T-periodic linear system (Equation 1.1). Then, there is an invertible periodic matrix $P(t)$ and a constant matrix B such that

$\Phi(t, 0) = P(t)e^{tB} \ for \ any \ t > 0.$

Proof. If $\Psi(t) := \Phi(t + T, 0)$ then the following initial value problem is satisfied

$$\begin{cases} \dfrac{d}{dt}\Psi(t) = A(t + T)\Psi(t) = A(t)\Psi(t), \\ \qquad\qquad \Psi(0) = M \end{cases}$$

since $A(t)$ is T-periodic, a unique solution is given by $\Psi(t) = \Phi(t, 0)M$. Thus,

$$\Phi(t + T, 0) = \Phi(t, 0)M = \Phi(t, 0)e^{TB}.$$

By taking $P(t) := \Phi(t, 0)e^{-tB}$,

$$P(t + T) = \Phi(t + T, 0)e^{-(t+T)B} = \Phi(t, 0)e^{TB}e^{-(t+T)B} = P(t)$$

and $P(0) = I$.

Theorem 1.3. There exists a real $2T$-periodic matrix $Q(t)$ and a real matrix R such that

$\Phi(t, 0) = Q(t)e^{tR}.$

Proof. Since $det(M) \neq 0$, there exists a real matrix R such that $M^2 = e^{2TR}$. Thus, it may be defined that $(t) := \Phi(t, 0)e^{-tR}$.

Then, it follows that

$$Q(t + 2T) = \Phi(t + 2T, 0)e^{-2TR}e^{tR} = \Phi(t + T, 0)Me^{-2TR}e^{tR}$$
$$= \Phi(t, 0)M^2e^{-2TR}e^{tR} = \Phi(t, 0)M^2M^{-2}e^{tR} = Q(t).$$

Therefore, Q is $2T$-periodic.

Theorem 1.4. If ρ_j is a characteristic multiplier and λ_j is a corresponding characteristic exponent so that $\rho_j = e^{\lambda_j T}$; then a solution $X(t)$ exists for Equation 1.1, such that

1. $X(t + T) = \rho_j X(t)$

2. $X(t) = N(t)e^{\lambda_j t}$, where $N: R_+ \to R^d$ is a T-periodic function.

Proof. If ρ_j is an eigenvalue of M, then $v_j \neq 0$ and $Mv_j = \rho_j v_j$. Thus, if $X(t) = \Phi(t, t_0)v_j$, then $X(t)$ satisfies the initial value problem

$$\begin{cases} \dfrac{d}{dt}X(t) = A(t)X(t), \\ \quad X(t_0) = v_j \, . \end{cases}$$

It follows that

$$X(t + T) = \Phi(t + T, t_0)v_j = \Phi(t, t_0)Mv_j = \rho_j\Phi(t, t_0)v_j = \rho_j X(t).$$

Furthermore, by taking $N(t) = X(t)e^{-\lambda_j t}$ and using the fact that $\rho_j = e^{\lambda_j T}$, it may be stated that

$$N(t + T) = X(t + T)e^{-\lambda_j(t+T)} = \rho_j X(t)e^{-\lambda_j t}e^{-\lambda_j T} = X(t)e^{-\lambda_j t} = N(t).$$

So, when $A(t)$ is a positive T-periodic function, and if $\int_0^T A(t)dt$ is positive and irreducible, then matrix B in **Theorem 1.2** is also positive and irreducible, leading to the following corollary.

Corollary 1.5. There exists a Floquet exponent $\lambda_{\text{per}} > 0$ and a T-periodic $N(t) > 0$ satisfying

$$\frac{dN(t)}{dt} = A(t)N(t) - \lambda_{per}N(t).$$

Proof. Since B is positive and irreducible, so is M. Thus, by the Perron-Frobenius theorem, an eigenvalue $\lambda > 0$ of B exists and is associated with a positive eigenvector. If it is taken that $\lambda_{per} = \lambda > 0$. Then $e^{\lambda_{per}T}$ is a positive eigenvalue of M associated with a positive eigenvector v.

Then it may be defined that

$$N(t) = X(t)e^{-\lambda_{per}t},$$

where $X(t) = \Phi(t, t_0)v$ and the desired result follows from **Theorem 1.4.**

Next, the adjoint linear periodic system can be considered

$$\frac{d}{dt}Z(t) = -A^*(t)Z(t). \tag{1.2}$$

Given $Z(t_0) = z_0$, it has a unique solution $Z(t) = \Psi(t_0, t)z_0$, where $\Psi(t_0, t)$ is defined as the matrix solution to

$$\frac{d}{dt}\Psi(t_0, t) = -A^*(t)\Psi(t_0, t), \ \Psi(t_0, t_0) = I.$$

The monodromy matrix M^* then may be defined as follows:

$$M^* := \Psi(0, T) = \left(\Phi^*(0, T)\right)^{-1} = \left(\Phi(T, 0)\right)^{-1} = M^{-1}.$$

Theorem 1.6. If ρ_j be a characteristic multiplier and λ_j is a corresponding characteristic exponent so that $\rho_j = e^{\lambda_j T}$. Then there exists a solution $Z(t)$ to Equation 1.2 such that

1. $Z(t + T) = \dfrac{1}{\rho_j}Z(t).$

2. $Z(t) = \phi(t)e^{-\lambda_j t}$ for some T-periodic function $t \mapsto \phi(t) \in R^d$.

Proof. If ρ_j be an eigenvalue of M, then, $v_j \neq 0$ such that $Mv_j = \rho_j v_j$. Let $Z(t) = \Psi(t_0, t)v_j$. Thus $Z(t)$ satisfies the following initial value problem

$$\begin{cases} \dfrac{d}{dt}Z(t) = -A^*(t)Z(t), \\ \quad Z(t_0) = v_j \end{cases}$$

Then,

$$Z(t+T) = \Psi(t_0, t+T)v_j = \Psi(t_0, t)M^{-1}v_j = \rho_j^{-1}\Psi(t_0, t)v_j = \frac{1}{\rho_j}Z(t).$$

And it may be defined that $\phi(t) = Z(t)e^{\lambda_j t}$. Thus if $\rho_j = e^{\lambda_j T}$, it follows that

$$\phi(t+T) = Z(t+T)e^{\lambda_j(t+T)} = \rho_j^{-1}Z(t)e^{\lambda_j t}e^{\lambda_j T} = Z(t)e^{\lambda_j t} = \phi(t).$$

Corollary 1.7. Under the assumption that $A(t)$ is positive and T-periodic, a Floquet exponent $\lambda_{\text{per}} > 0$ and a T-periodic $\phi(t) > 0$ exists satisfying

$$-\frac{d\phi(t)}{dt} = A^*(t)\phi(t) - \lambda_{per}\phi(t).$$

Proof. Since B is positive and irreducible, so is M. Therefore, by the Perron-Frobenius theorem there exists an eigenvalue $\lambda > 0$ of B with an associated positive eigenvector. If it is taken that $\lambda_{\text{per}} = \lambda > 0$, then $e^{\lambda_{per}T}$ is a positive eigenvalue of M associated with a positive eigenvector v. Thus it may be defined that

$$\phi(t) = Z(t)e^{\lambda_{\text{per}}t},$$

where $Z(t) = \Psi(t_0, t)v$ and the desired result follows from **Theorem 1.6**.

 Floquet theory on Banach space

If a linear periodic system on a Banach space E is considered,

$$\frac{d}{dt}X(t) = A(t)X(t). \tag{1.3}$$

where $X \in E$ and $A(t)$ is a continuous operator-valued T-periodic.

Then is a unique solution to Equation 1.3 together with the initial value $X(t_0) = x_0 \in E$. This solution is given by $X(t) = U(t, t_0)x_0$, where $U(t, t_0)$ is a linear and bounded operator on E and satisfies the following properties:

1. $\frac{d}{dt} U(t, t_0) = A(t)U(t, t_0), \ U(t_0, t_0) = I$
2. $U(t, r) = U(t, s)U(s, r), \ for \ any \ r \le s \le t$
3. $U(t + T, t_0 + T) = U(t, t_0).$

If an operator-valued function is specified as $M(t_0) := U(t_0 + T, t_0)$ and a monodromy operator as $M := U(T, 0)$, then the following can be denoted:

Definition 1.8. μ is an eigenvalue of M if $\mu \in \sigma_p(M)$, thus, there is a non-zero vector v of E such that $Mv = \mu v$. This vector is an eigenvector corresponding to the eigenvalue μ of M.

Theorem 1.9. The following results hold:

1. $M(t_0 + T) = M(t_0)$
2. $\sigma_p(M(t_0)) = \sigma_p(M)$ where $\sigma_p(M) = \{\mu : \mu I - M$ is not one-to-one$\}$.

Proof.

1. By the definition of M, it follows that

   $$M(t_0 + T) = U(t_0 + T + T, t_0 + T) = U(t_0 + T, t_0) = M(t_0).$$

2. It can be proven that for $t_0 < t_1, \sigma_p(M(t_0)) = \sigma_p(M(t_1))$. For instance, if $\mu \in \sigma_p(M(t_0))$, then $0 \ne v \in E$ exists, such that $M(t_0)v = \mu v$. Then, if $w := U(t_1, t_0)v$, it follows that

   $$M(t_1)w = U(t_1 + T, t_1)w = U(t_1 + T, t_1)U(t_1, t_0)v$$
   $$= U(t_1 + T, t_0)v = U(t_1 + T, t_0 + T)U(t_0 + T, t_0)$$
   $$= U(t_1, t_0)M(t_0)v = \mu U(t_1, t_0)v = \mu w.$$

That is, $\mu \in \sigma_p\big(M(t_1)\big)$. This means that $\sigma_p\big(M(t_0)\big) \subseteq \sigma_p\big(M(t_1)\big)$.

Conversely, it may be said that if $n_0 \in N$ large enough, so that $n_0 T + t_0 > t_1$, then $\sigma_p\big(M(t_1)\big) \subseteq \sigma_p\big(M(n_0 T + t_0)\big)$. Finally, since $M(t_0)$ is T-periodic, then

$$\sigma_p\big(M(t_0)\big) \subseteq \sigma_p\big(M(t_1)\big) \subseteq \sigma_p\big(M(n_0 T + t_0)\big) = \sigma_p\big(M(t_0)\big).$$

Theorem 1.10. If $\mu = e^{\lambda T}$, then the following are equivalent.

1. μ is an eigenvalue of M

2. A T-periodic function $t \mapsto N(t) \in E$ exists, where

    $X(t) = N(t)e^{\lambda t}$ is a solution to Equation 1.3 with an initial value $X(t_0) = x_0$.

Proof. In the theorem above, (1) implies (2). Following the same process as the proof for this matrix, (2) also implies (1). Then, if $y_0 := U(0, t_0)x_0$, it follows that

$$
\begin{aligned}
N(t + T) &= X(t + T)e^{-\lambda(t+T)} \\
&= U(t + T, t_0)x_0 e^{-\lambda(t+T)} \\
&= U(t + T, T)U(T, 0)y_0 e^{-\lambda(t+T)} \\
&= U(t, 0)U(T, 0)y_0 e^{-\lambda(t+T)}.
\end{aligned}
$$

Or alternatively,

$$
\begin{aligned}
N(t + T) &= N(t) \\
&= X(t)e^{-\lambda t} \\
&= U(t, t_0)x_0 e^{-\lambda t} \\
&= U(t, 0)y_0 e^{-\lambda t}.
\end{aligned}
$$

Therefore,

$$U(t, 0)U(T, 0)y_0 = e^{\lambda T}U(t, 0)y_0.$$

By taking $t = 0$,

$$My_0 = U(T,0)y_0 = e^{\lambda T}y_0$$

It follows that $e^{\lambda T}$ is an eigenvalue of M.

Corollary 1.11. If additionally, an operator $U(t,0)$ is compact and strictly positive on a Banach lattice, then a Floquet exponent $\lambda_{\text{per}} > 0$ and a T-periodic $N(t) > 0$ exists, satisfying

$$\frac{dN(t)}{dt} = A(t)N(t) - \lambda_{per}N(t). \tag{1.4}$$

Proof. Since $M = U(T,0)$ is compact and strictly positive, the Krein-Rutman theorem demonstrates that there is a simple eigenvalue $\mu > 0$ with an associated eigenvector $N_0 > 0$. Taking $\lambda_{per} > 0$, such that $\mu = e^{\lambda_{per}T}$ and defining $N(t) = X(t)e^{-\lambda_{per}t} > 0$, such that $X(t)$ is defined as in **Theorem 1.10**, the desired result is yielded.

Corollary 1.12. (Uniqueness). There is a unique solution (up to a multiplicative constant) to the Floquet eigenvalue problem in Equation 1.4.

Proof. If another positive T-periodic solution $M(t)$ exists for Equation 1.4, it can be proven that $N(t) = cM(t)$ as follows

$$\frac{d}{dt}\left(e^{\lambda_{per}t}M(t)\right) = A(t)e^{\lambda_{per}t}M(t).$$

The uniqueness of the solution to Equation 1.3 with the initial value gives

$$M(t) = e^{-\lambda_{per}t}U(t,t_0)x_0.$$

Taking $t = T$,

$$M(0) = M(T) = e^{-\lambda_{per}T}U(T,t_0)x_0 = e^{-\lambda_{per}T}U(T,0)U(0,t_0)x_0$$
$$= e^{-\lambda_{per}T}U(T,0)M(0).$$

Since $M(0) > 0$, $e^{\lambda_{\text{per}}T}$ is an eigenvalue of $M = U(T, 0)$ with an associated eigenvector $M(0)$, then $e^{\lambda_{\text{per}}T}$ is a simple eigenvalue of $U(T, 0)$ with an associated eigenvector N_0. Hence $M(0) = cN_0$. Thus,

$$M(t) = e^{-\lambda_{\text{per}}t}U(t, t_0)x_0$$
$$= e^{-\lambda_{\text{per}}t}U(t, 0)M(0)$$
$$= e^{-\lambda_{\text{per}}t}U(t, 0)cN_0$$
$$= cN(t).$$

For the adjoint linear periodic system

$$\frac{d}{dt}Z(t) = -A^*(t)Z(t), \tag{1.5}$$

where $A(t)$ is a continuous T-periodic linear operator-valued function, the following can be denoted.

Theorem 1.13. If $\mu = e^{\lambda T}$, then the following are equivalent.

1. μ is an eigenvalue of M

2. A T-periodic function $t \mapsto \phi(t) \in E$ such that $Z(t) = \phi(t)e^{-\lambda t}$ where $Z(t)$ is the solution of (2.5) with an initial value $Z(t_0) = z_0$ exists.

Proof. In the theorem above, (1) implies (2). Following the same process as the proof for this matrix, (2) also implies (1). Thus

$$\phi(t + T) = Z(t + T)e^{\lambda(t+T)}$$
$$= \Psi(t_0, t + T)z_0\, e^{\lambda(t+T)}$$
$$= \Psi(t_0, t)\Psi(0, T)z_0\, e^{\lambda(t+T)}.$$

Or alternatively,

$$\phi(t + T) = \phi(t)$$
$$= Z(t)e^{\lambda t}$$
$$= \Psi(t_0, t)z_0\, e^{\lambda t}.$$

Thus

$$\Psi(t_0, t)\Psi(0, T)z_0 = \Psi(t_0, t)z_0\, e^{-\lambda T}.$$

Taking $t = t_0$,

$$M^{-1}z_0 = \Psi(0, T)z_0 = e^{-\lambda T}z_0.$$

That is, $e^{\lambda T}$ is an eigenvalue of M.

Corollary 1.14. In addition, if the operator $U(t, 0)$ is compact and strictly positive on a Banach lattice, a Floquet exponent $\lambda_{per} > 0$ and a T-periodic $\phi(t) > 0$ exists satisfying

$$-\frac{d\phi(t)}{dt} = A^*(t)\phi(t) - \lambda_{per}\phi(t).$$

Proof. Since $M = U(T, 0)$ is compact and strictly positive, the Krein-Rutman theorem demonstrates that there is a simple eigenvalue $\mu > 0$ and associated eigenvector $\phi_0 > 0$. If it is taken that $\lambda_{per} > 0$, such that $\mu = e^{\lambda_{per}T}$ and $\phi(t) = Z(t)e^{\lambda_{per}t} > 0$, where $Z(t)$ is defined as in **Theorem 1.13**, the desired result is obtained.

General relative entropy

Definition 2.1. (Perthame, 2007, p. 165) If H is a real-valued convex function, then the general relative entropy (GRE) may be defined as

$$\sum_{i=1}^{d} H\left(\frac{X_i(t)}{N_i(t)}\right) N_i(t)\phi_i(t),$$

where $X_i(t), N_i(t)$ *and* $\phi_i(t)$ satisfy Equations 2.1, 2.2 and 2.3, respectively.

The uniqueness of the solution to the Floquet eigenvalue problem

If $A(t) = \left(a_{ij}(t)\right) \geq 0$ for $1 \leq i, j \leq d$, then $X_i(t) > 0, N_i(t) > 0, \phi_i(t) > 0$ and it can also be proven that a unique λ_{per} exists with a maximal real part such that

$$\frac{dX_i(t)}{dt} = \sum_j a_{ij}(t)X_j(t) - \lambda_{per}X_i(t) \tag{2.1}$$

$$\frac{dN_i(t)}{dt} = \sum_j a_{ij}(t)N_j(t) - \lambda_{per}N_i(t) \tag{2.2}$$

$$-\frac{d\phi_i(t)}{dt} = \sum_j a_{ji}(t)\phi_j(t) - \lambda_{per}\phi_i(t). \tag{2.3}$$

Theorem 2.2. If $A(t)$ be a T-periodic matrix with $\left(\lambda_{per}, N, \phi\right)$ defined as above, then for any positive initial conditions, for any solution of Equation 2.1, and any positive convex function H, then

$$\forall t \geq 0, \quad \frac{d}{dt}\sum_{i=1}^{d} H\left(\frac{X_i(t)}{N_i(t)}\right) N_i(t)\phi_i(t) = -D_H(X)(t),$$

where

$$D_H(X)(t) = \sum_{i,j} a_{ij}(t)N_j(t)\phi_i(t)\left[H'\left(\frac{X_i(t)}{N_i(t)}\right)\left(\frac{X_i(t)}{N_i(t)} - \frac{X_j(t)}{N_j(t)}\right) + H\left(\frac{X_j(t)}{N_j(t)}\right)\right.$$

$$\left. - H\left(\frac{X_i(t)}{N_i(t)}\right)\right] \geq 0.$$

Proof.

$$N_i(t)\phi_i(t)\frac{d}{dt}H\left(\frac{X_i(t)}{N_i(t)}\right) = N_i(t)\phi_i(t)H'\left(\frac{X_i(t)}{N_i(t)}\right)\frac{d}{dt}\left(\frac{X_i(t)}{N_i(t)}\right)$$

$$= \phi_i(t)H'\left(\frac{X_i(t)}{N_i(t)}\right)\left[\frac{d}{dt}X_i(t) - \frac{X_i(t)\frac{d}{dt}N_i(t)}{N_i(t)}\right]$$

$$= \phi_i(t)H'\left(\frac{X_i(t)}{N_i(t)}\right)\left[\sum_j a_{ij}(t)X_j(t) - \lambda_{per}X_i(t)\right.$$

$$\left. - \frac{X_i(t)\left(\sum_j a_{ij}(t)N_j(t) - \lambda_{per}N_i(t)\right)}{N_i(t)}\right]$$

$$= \phi_i(t)H'\left(\frac{X_i(t)}{N_i(t)}\right)a_{ij}(t)N_j(t)\phi_i(t)\sum_j\left(\frac{X_j(t)}{N_j(t)} - \frac{X_i(t)}{N_i(t)}\right)$$

and

$$\phi_i(t)H\left(\frac{X_i(t)}{N_i(t)}\right)\frac{d}{dt}N_i(t) + N_i(t)H\left(\frac{X_i(t)}{N_i(t)}\right)\frac{d}{dt}\phi_i(t)$$

$$= \phi_i(t)H\left(\frac{X_i(t)}{N_i(t)}\right)\left(\sum_j a_{ij}(t)N_j(t) - \lambda_{per}N_i(t)\right)$$

$$+ N_i(t)H\left(\frac{X_i(t)}{N_i(t)}\right)\left(-\sum_j a_{ji}(t)\phi_j(t) + \lambda_{per}\phi_i(t)\right)$$

$$= \phi_i(t)H\left(\frac{X_i(t)}{N_i(t)}\right)\sum_j a_{ij}(t)N_j(t) - N_i(t)H\left(\frac{X_i(t)}{N_i(t)}\right)\sum_j a_{ji}(t)\phi_j(t).$$

Thus,

$$\frac{d}{dt}\sum_{i=1}^{d}H\left(\frac{X_i(t)}{N_i(t)}\right)N_i(t)\phi_i(t) = -D_H(X)(t).$$

Corollary 2.3. A unique solution (up to a multiplicative constant) exists for the Floquet eigenvalue problem denoted by Equations 2.1, 2.2 and 2.3.

Proof. Using the general relative entropy property with the convex function $H(s) = (s-1)^2$,

$$\frac{d}{dt}\sum_{i=1}^{d} N_i(t)\phi_i(t)\left(\frac{X_i(t)}{N_i(t)} - 1\right)^2 = -\sum_{i,j} a_{ij}(t)N_j(t)\phi_i(t)\left(\frac{X_j(t)}{N_j(t)} - \frac{X_i(t)}{N_i(t)}\right)^2 \leq 0$$

Thus $\sum_{i=1}^{d} N_i(t)\phi_i(t)\left(\frac{X_i(t)}{N_i(t)} - 1\right)^2$ is a positive, periodic and decreasing function, hence, it is constant and

$$\sum_{i,j} a_{ij}(t)N_j(t)\phi_i(t)\left(\frac{X_j(t)}{N_j(t)} - \frac{X_i(t)}{N_i(t)}\right)^2 = 0.$$

This is only possible when for all $i, j = 1, \ldots, d$,

$$\frac{X_j(t)}{N_j(t)} = \frac{X_i(t)}{N_i(t)} = c(t).$$

It can now be proven that in the case where $X_i(t) = c(t)N_i(t)$, $c(t)$ must be constant. Using Equations 2.1 and 2.2

$$\frac{d}{dt}X_i(t) = N_i(t)\frac{d}{dt}c(t) + c(t)\frac{d}{dt}N_i(t)$$

$$= N_i(t)\frac{d}{dt}c(t) + c(t)\left(\sum_j a_{ij} N_j(t) - \lambda_{per}N_i(t)\right)$$

$$= N_i(t)\frac{d}{dt}c(t) + \left(\sum_j a_{ij} X_j(t) - \lambda_{per}X_i(t)\right)$$

$$= N_i(t)\frac{d}{dt}c(t) + \frac{d}{dt}X_i(t).$$

Then $N_i(t)\frac{d}{dt}c(t) = 0$. Since $N_i(t) > 0$, $\frac{d}{dt}c(t) = 0$. So $c(t)$ is constant as required.

Asymptotic behaviour

Here, the maximum entropy principle is used to prove exponential decay.

Proposition 2.4. If c and C are constants, such that $cN_i(0) \leq X_i(0) \leq CN_i(0)$, then it holds that

$$cN_i(t) \leq X_i(t) \leq CN_i(t) \; for \; any \; t > 0.$$

Furthermore, a constant $\alpha > 0$ such that

$$\sum_{i=1}^{d} N_i(t)\phi_i(t)\left(\frac{X_i(t)}{N_i(t)} - 1\right)^2 \leq \sum_{i=1}^{d} N_i(0)\phi_i(0)\left(\frac{X_i(0)}{N_i(0)} - 1\right)^2 e^{-\alpha t}.$$

Proof. By applying the entropy principle to the convex function $H(s) = max(0, s - C)$, it may be shown that $\sum_{i=1}^{d} N_i(0)\phi_i(0)H\left(\frac{X_i(0)}{N_i(0)}\right) = 0$. However, as general relative entropy is nonnegative and decaying, it remains zero at all times.

$$\sum_{i=1}^{d} N_i(t)\phi_i(t)H\left(\frac{X_i(t)}{N_i(t)}\right) = 0 \; for \; any \; t > 0.$$

Since $N_i(t), \phi_i(t) > 0$, $H\left(\frac{X_i(t)}{N_i(t)}\right) = 0$; that is $X_i(t) \leq CN_i(t)$. Similarly, for the convex function $H(s) = max(0, c - s)$, it can be shown that $cN_i(t) \leq X_i(t)$.

To prove the second claim, the entropy property may be applied to the convex function $H(s) = (s - 1)^2$ to obtain

$$\frac{d}{dt}\sum_{i=1}^{d} N_i(t)\phi_i(t)\left(\frac{X_i(t)}{N_i(t)} - 1\right)^2 = -\sum_{i,j} a_{ij}(t)N_j(t)\phi_i(t)\left(\frac{X_j(t)}{N_j(t)} - \frac{X_i(t)}{N_i(t)}\right)^2$$

$$\leq -\alpha \sum_i \phi_i(t) N_i(t) \left(\frac{X_i(t)}{N_i(t)} - 1 \right)^2,$$

where **Lemma 2.5 (**below) and the Gronwall's inequality (see Appendix) are used.

Lemma 2.5. If $\phi(t), N(t) > 0, a_{ij}(t) > 0$ for all $i, j = 1, \dots, d, i \neq j$, then there is a constant $\alpha > 0$ such that the following inequality holds

$$\sum_{i,j=1}^d \phi_i(t) a_{ij}(t) N_j(t) \left(\frac{m_j(t)}{N_j(t)} - \frac{m_i(t)}{N_i(t)} \right)^2 \geq \alpha \sum_{i=1}^d \phi_i(t) N_i(t) \left(\frac{m_i(t)}{N_i(t)} \right)^2$$

for all m such that $\sum_{i=1}^d \phi_i(t) m_i(t) = 0$.

Proof. For the case $m(t) = 0$, the proof is trivial. So a case where case $m(t) \neq 0$ and is considered and normalized so that $\sum_{i=1}^d \phi_i(t) N_i(t) \left(\frac{m_i(t)}{N_i(t)} \right)^2 = 1$. This case is proven by contradiction. If no such α exists, a sequence $\left(m^k(t) \right)_{k \geq 1}$ can be constructed, with

$$\sum_{i,j=1}^d \phi_i(t) a_{ij}(t) N_j(t) \left(\frac{m_j^k(t)}{N_j(t)} - \frac{m_i^k(t)}{N_i(t)} \right)^2 \leq \frac{1}{k}$$

and

$$\sum_{i=1}^d \phi_i(t) N_i(t) \left(\frac{m_i^k(t)}{N_i(t)} \right)^2 = 1.$$

The compactness of $\left(m^k(t) \right)_{k \geq 1}$ follows from the Arzela-Ascoli theorem, so a convergent subsequence can be extracted still denoted by $\left(m^k(t) \right)_{k \geq 1}$ with

$\lim\limits_{k\to\infty} m^k(t) = \bar{m}(t).$ Then   passing   to   the   limit   gives

$\sum_{i=1}^{d} \phi_i(t)N_i(t)\left(\dfrac{\overline{m_i}(t)}{N_i(t)}\right)^2 = 1$ and

$$\sum_{i,j=1}^{d} \phi_i(t)a_{ij}(t)N_j(t)\left(\dfrac{\overline{m_j}(t)}{N_j(t)} - \dfrac{\overline{m_i}(t)}{N_i(t)}\right)^2 = 0.$$

By the positivity of $\phi_i(t), N_i(t), a_{ij}(t)$, $\dfrac{\overline{m_i}(t)}{N_i(t)} = \dfrac{\overline{m_j}(t)}{N_j(t)} = v(t)$, for all $i, j =$

$1, \dots, d$. However since $0 = \sum_{i=1}^{d} \phi_i(t)N_i(t)\dfrac{\overline{m_i}(t)}{N_i(t)} = v(t)\sum_{i=1}^{d} \phi_i(t)N_i(t)$, it

follows that $v(t) = 0$, which contradicts to $\sum_{i=1}^{d} \phi_i(t)N_i(t)\left(\dfrac{\overline{m}(t)}{N_i(t)}\right)^2 = 1$.

Application to an age-structured equation

Now a model of dynamics of population age-structured can be considered in which the coefficients are a periodic function of time. This is described by the following Von Forester-McKendrick partial differential equation

$$\begin{cases} \dfrac{\partial}{\partial t}n(t,x) + \dfrac{\partial}{\partial x}n(t,x) + d(t,x)n(t,x) = 0, \ \forall t \geq 0, x \geq 0 \\ \qquad n(t, x = 0) = \int_0^{\infty} B(t,x)n(t,x)dx \\ \qquad\quad n(t = 0, x) = n^0(x), \end{cases} \qquad (3.1)$$

where $n(t,x)$ is a population density of individuals of age $x > 0$ at a time $t \in (0, \infty)$ with $d(t,x)$ and $B(t,x)$ representing the death and birth rate of a population and being T-periodic, respectively. The boundary condition at $x = 0$ represents the number of newborns at time t and $n^0(x)$ is the initial age distribution of the population at time $t = 0$. It is assumed that $d \geq 0, B > 0, d, B \in W^{1,\infty}$ and

$$1 < \inf_{t\in(0,T)} \int_0^{\infty} B(.,x)e^{-\int_0^x d(.-x+y,y)dy}\,dx,$$

$$\sup_{t\in(0,T)} \int_0^\infty B(.,x)e^{-\int_0^x d(.-x+y,y)dy}\, dx < \infty.$$

Then Equation 3.1 can be written as an evolution equation

$$\begin{cases} \dfrac{\partial}{\partial t}n = An \\ n(0,x) = n^0(x) \end{cases}$$

with the operator $An = -\dfrac{\partial}{\partial x}n - dn$ is defined on the space

$$E = \left\{ n(t,x) \in \mathcal{D}'\big((0,\infty)\times(0,\infty)\big) \big| n(t,0) = \int_0^\infty B(t,x)n(t,x)dx \right\}.$$

The long-run asymptotic behaviour of the population density, with a growth rate measured by the Floquet exponent λ_{per} using the Floquet eigenvalue problem can now be studied

$$\begin{cases} \dfrac{\partial}{\partial t}N(t,x) + \dfrac{\partial}{\partial x}N(t,x) + \big(\lambda_{per} + d(t,x)\big)N(t,x) = 0, \ \forall t \ge 0, x \ge 0 \\ \qquad N(t,x=0) = \int_0^\infty B(t,x)N(t,x)dx \qquad\qquad (3.2) \\ \qquad N(t,x) > 0, T - periodic, \int_0^T\int_0^\infty N(t,x)dxdt = 1 \end{cases}$$

together with its adjoint eigenvalue problem

$$\begin{cases} -\dfrac{\partial}{\partial t}\phi(t,x) - \dfrac{\partial}{\partial x}\phi(t,x) + \big(\lambda_{per} + d(t,x)\big)\phi(t,x) = B(t,x)\phi(t,0), \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \forall t \ge 0, x \ge 0 \quad (3.3) \\ \qquad \phi(t,x) > 0, T - periodic, \int_0^\infty N(t,x)\phi(t,x)dx = 1 \end{cases}$$

First, the existence and uniqueness of the following partial differential equation are considered

Theorem 3.1. If $\mu > 0$, then a unique solution $n \in C\big(R_+, L^1(R_+; \phi(.,x)dx)\big)$ to the below equation exists

$$\begin{cases} \frac{\partial}{\partial t} n(t,x) + \frac{\partial}{\partial x} n(t,x) + \big(\mu + d(t,x)\big)n(t,x) = 0, \ \forall t \geq 0, x \geq 0 \\ n(t,x=0) = \int_0^\infty B(t,x)n(t,x)dx \\ n(t=0,x) = n^0(x) \in L^1(R_+; \phi(0,x)dx). \end{cases}$$

Proof. The Banach-Fixed point theorem in the Banach space $X = C\big([0,T], L^1(R_+; dx)\big)$ endowed with the norm $\|n\|_X = sup_{t\in[0,T]}\|n(t,.)\|_{L^1(R_+)}$ and for a given $n^0 \in L^1(R_+; dx)$ is used to show that $n(t,x)$ is a fixed point of a contraction operator. The operator is defined as follows.

$$U: X \rightarrow X$$
$$m \mapsto n = U(m),$$

where n is a solution of

$$\begin{cases} \frac{\partial}{\partial t} n(t,x) + \frac{\partial}{\partial x} n(t,x) + \big(\mu + d(t,x)\big)n(t,x) = 0, \\ n(t,x=0) = \int_0^\infty B(t,x)m(t,x)dx \\ n(t=0,x) = n^0(x). \end{cases}$$

If $m_1, m_2 \in X$ and $n_i = U(m_i), i = 1,2,$ then the difference $n = n_1 - n_2$ satisfies

$$\begin{cases} \frac{\partial}{\partial t} n(t,x) + \frac{\partial}{\partial x} n(t,x) + \big(\mu + d(t,x)\big)n(t,x) = 0, \\ n(t,x=0) = \int_0^\infty B(t,x)m(t,x)dx \\ n(t=0,x) = 0, \end{cases}$$

where $= m_1 - m_2$. It also holds that

$$\begin{cases} \dfrac{\partial}{\partial t}|n(t,x)| + \dfrac{\partial}{\partial x}|n(t,x)| + (\mu + d(t,x))|n(t,x)| = 0, \\[2mm] |n(t,x=0)| = \left|\displaystyle\int_0^\infty B(t,x)m(t,x)dx\right| \\[2mm] |n(t=0,x)| = 0. \end{cases}$$

By the characteristics method,

$$n(t,x) = \begin{cases} 0,, x \ge t \\ n(t-x,0)e^{-\int_0^x (\mu+d)(t-x+y,y)dy}, x < t \end{cases}$$

Since d, B are positive and bounded, then there is a constant $M > 0$ such that

$$\left| B(t,x)e^{-\int_0^x d(t-x+y,y)dy} \right| \le M.$$

Thus,

$$\|n(t,.)\|_{L^1(R_+)} = \int_0^t |n(t,x)|dx = \int_0^t |n(t-x,0)|e^{-\int_0^x (\mu+d)(t-x+y,y)dy}\,dx$$

$$= \int_0^t \left| \int_0^\infty B(t-x,z)m(t-x,z)dz \right| e^{-\int_0^x (\mu+d)(t-x+y,y)dy}\,dx$$

$$\le M \int_0^t \|m(t,.)\|_{L^1(R_+)}\,dx = tM\|m(t,.)\|_{L^1(R_+)}.$$

Hence,

$$\|n\|_X = sup_{t\in[0,T]}\|n(t,.)\|_{L^1(R_+)} \le sup_{t\in[0,T]}tM\|m(t,.)\|_{L^1(R_+)}$$

$$= TM\|m\|_X.$$

And it is proven that $U: X \rightarrow X$. By selecting T so that $M \le \dfrac{1}{2}$, it follows that

$$\|U(m_1) - U(m_2)\|_X \le \frac{1}{2}\|m_1 - m_2\|_X.$$

This means that U is a contraction in the Banach space X, which proves the existence of the fixed point. This process can be iterated on the intervals $[T, 2T], [2T, 3T],...$ to build a solution in $C\big(R_+, L^1(R_+; dx)\big)$. Next, the density

argument is used to complete the proof: Let $n^0 \in L^1(R_+; \phi(0,x)dx), \exists n_k^0 \in L^1(R_+; dx)$ such that $n_k^0 \to n^0$ in $L^1(R_+; \phi(.,x)dx)$, and $\widetilde{n_k}(t,x)$ be solution of

$$
\begin{cases}
\dfrac{\partial}{\partial t}\widetilde{n_k}(t,x) + \dfrac{\partial}{\partial x}\widetilde{n_k}(t,x) + \big(\mu + d(t,x)\big)\widetilde{n_k}(t,x) = 0 \\[2mm]
\widetilde{n_k}(t, x = 0) = \displaystyle\int_0^\infty B(t,x)\widetilde{n_k}(t,x)dx.
\end{cases}
$$

If $\tilde{n} = \widetilde{n_k} - \widetilde{n_p}$, then

$$
\dfrac{\partial}{\partial t}\big(\tilde{n}(t,x)\phi(t,x)\big) + \dfrac{\partial}{\partial x}\big(\tilde{n}(t,x)\phi(t,x)\big) = -\phi(t,0)B(t,x)\tilde{n}(t,x)
$$

$$
\phi(t,0)\tilde{n}(t,0) = \phi(t,0)\int_0^\infty B(t,x)\tilde{n}(t,x)dx
$$

And it also holds that

$$
\dfrac{\partial}{\partial t}\big(|\tilde{n}(t,x)|\phi(t,x)\big) + \dfrac{\partial}{\partial x}\big(|\tilde{n}(t,x)|\phi(t,x)\big) = -\phi(t,0)B(t,x)|\tilde{n}(t,x)|
$$

$$
\phi(t,0)|\tilde{n}(t,0)| = \phi(t,0)\left|\int_0^\infty B(t,x)\tilde{n}(t,x)dx\right|.
$$

Integrating with x gives

$$
\dfrac{d}{dt}\int_0^\infty \big(|\tilde{n}(t,x)|\phi(t,x)\big)dx \le 0.
$$

And finally,

$$
\int_0^\infty \big|\widetilde{n_k} - \widetilde{n_p}\big|\phi(t,x)dx \le \int_0^\infty \big|n_k^0 - n_p^0\big|\phi(0,x)dx.
$$

Thus, $\tilde{n}$ is a Cauchy sequence in a Banach space $C\big(R_+, L^1(R_+; \phi(.,x)dx)\big)$. So $\tilde{n}$ converges in the space to a solution in the distribution sense.

Corollary 3.2. With the assumptions on d and B as above, there is a unique $\lambda_{per} > 0$ and $N, \phi \in C\big(R_+, L^1(R_+; \phi(.,x)dx)\big)$ of the Floquet eigenvalue problem in Equation 3.2 and its adjoint eigenvalue problem in Equation 3.3.

Proof. If $\lambda_{per} = \mu > 0$, then $N(t,x) \in C\big(R_+, L^1(R_+; \phi(.,x)dx)\big)$ exists by **Theorem 3.1.** It satisfies

$$\frac{\partial}{\partial t} N(t,x) + \frac{\partial}{\partial x} N(t,x) + \big(\lambda_{per} + d(t,x)\big) N(t,x) = 0.$$

Similarly, its adjoint is given by

$$-\frac{\partial}{\partial t} \phi(t,x) - \frac{\partial}{\partial x} \phi(t,x) + \big(\lambda_{per} + d(t,x)\big) \phi(t,x) = B(t,x)\phi(t,0),$$

where $\phi(t,x) \in C\big(R_+, L^1(R_+; \phi(.,x)dx)\big)$. Moreover, the operator U is strictly positive in $C\big(R_+, L^1(R_+; dx)\big)$ and T-periodic as soon as d, B are. It is also compact since $sup\ \{\|U(n)\|_X; \|n\|_X \leq 1\}$ is uniformly bounded hence equicontinuous and compactness follow from the Arzela-Ascoli theorem.

Then by **Corollary 1.11** and **Corollary 1.14** with $\lambda_{per} = \mu$ such that $r(\mu) = 1$, the spectral radius of U and up to renormalization N, ϕ is unique. To end the proof, μ needs to be found such that $r(\mu) = 1$. Since r is decreasing function and vanishes at infinity and

$$r(0) \geq inf \int_0^{\infty} B(.,x)e^{-\int_0^x d(.-x+y,y)dy}\, dx > 1.$$

It follows that a unique λ_{per} exists such that $r\big(\lambda_{per}\big) = 1$.

Long run asymptotic: exponential decay

In this section, long-run asymptotic exponential decay will be proven.

Theorem 3.3. Under the assumptions for d and B above and an additional assumption that $\exists \alpha > 0$ such that $B(t,x) \geq \alpha \frac{\phi(t,x)}{\phi(t,0)}$, it follows that

$$\int_0^\infty \big| n(t,x)e^{-\lambda_{per}t}$$

$$- \rho N(t,x) \big| \phi(t,x) dx$$

$$\leq e^{-\alpha t} \int_0^\infty |n^0(x) - \rho N(0,x)| \phi(0,x) dx,$$

where $\rho = \int_0^\infty n^0(x)\phi(0,x)dx$.

Proof. By taking $h(t,x) = n(t,x)e^{-\lambda_{per}t} - \rho N(t,x)$ and using Equations 3.1, 3.2 and 3.3

$$\frac{\partial}{\partial t}\big(h(t,x)\phi(t,x)\big) + \frac{\partial}{\partial x}\big(h(t,x)\phi(t,x)\big) = -\phi(t,0)B(t,x)h(t,x)$$

$$\phi(t,0)h(t,0) = \phi(t,0)\int_0^\infty B(t,x)h(t,x)dx.$$

By integrating with respect to x, it follows that

$$\frac{d}{dt}\int_0^\infty h(t,x)\phi(t,x)dx = -\phi(t,0)\int_0^\infty B(t,x)h(t,x)dx + h(t,0)\phi(t,0)$$

$$= 0.$$

Then,

$$\int_0^\infty h(t,x)\phi(t,x)dx = \int_0^\infty h(0,x)\phi(0,x)dx$$

$$= \int_0^\infty \big(n^0(x) - \rho N(0,x)\big)\phi(0,x)dx$$

$$= \int_0^\infty n^0(x)\phi(0,x)dx - \rho\int_0^\infty N(0,x)\phi(0,x)dx$$

$$= \int_0^\infty n^0(x)\phi(0,x)dx - \rho = 0.$$

And it also holds that,

$$\frac{\partial}{\partial t}\left(|h(t,x)|\phi(t,x)\right) + \frac{\partial}{\partial x}\left(|h(t,x)|\phi(t,x)\right) = -\phi(t,0)B(t,x)|h(t,x)|$$

$$\phi(t,0)|h(t,0)| = \phi(t,0)\left|\int_0^\infty B(t,x)h(t,x)dx\right|.$$

Now integrating with respect to x,

$$\frac{\partial}{\partial t}\int_0^\infty |h(t,x)|\phi(t,x)\,dx = -\phi(t,0)\int_0^\infty B(t,x)|h(t,x)|dx +$$

$$|h(t,0)|\phi(t,0)$$

$$\leq -\phi(t,0)\int_0^\infty B(t,x)|h(t,x)|dx$$

$$+ \left|\int_0^\infty [\phi(t,0)B(t,x)h(t,x) - \alpha\phi(t,x)h(t,x)]dx\right|$$

$$\leq -\phi(t,0)\int_0^\infty B(t,x)|h(t,x)|dx$$

$$+ \int_0^\infty (\phi(t,0)B(t,x) - \alpha\phi(t,x))|h(t,x)|dx$$

$$\leq -\alpha\int_0^\infty \phi(t,x)|h(t,x)|dx.$$

The proof is completed with Gronwall's inequality.

Long run asymptotic by the entropy method

Now long run asymptotic behaviour is proven by the entropy method.

Theorem 3.4.

1. For all convex function H and all $t > 0$; it holds that

$$\frac{d}{dt}\int_0^\infty \phi(t,x)N(t,x)H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)dx = -D_H(n)(t) \leq 0$$

where

$$D_H(n)(t) = \phi(t,0)N(t,0)\left[\int_0^\infty H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)d\mu_t\right.$$

$$\left. - H\left(\int_0^\infty \frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}d\mu_t(x)\right)\right].$$

2. For the probability measure $d\mu_t(x) = [B(t,x)N(t,x)/N(t,0)]dx$ and for all convex functions $H: R_+ \rightarrow R_+$; it holds that

$$\int_0^\infty \left[\int_0^\infty H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)d\mu_t(x) - H\left(\int_0^\infty \frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}d\mu_t(x)\right)\right]dt$$

$$\leq K\int_0^\infty \phi(0,x)N(0,x)H\left(\frac{n^0(x)}{N(0,x)}\right)dx.$$

Proof. Using Equations 3.1 and 3.2,

$$\frac{\partial}{\partial t}\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right) + \frac{\partial}{\partial x}\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right) = 0.$$

Hence,

$$\frac{\partial}{\partial t}H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right) + \frac{\partial}{\partial x}H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right) = 0.$$

And finally, it holds that

$$\frac{\partial}{\partial t}\left[\phi(t,x)N(t,x)H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)\right]$$

$$+ \frac{\partial}{\partial x}\left[\phi(t,x)N(t,x)H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)\right]$$

$$= N(t,x)H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)\left(\frac{\partial}{\partial t}\phi(t,x) + \frac{\partial}{\partial x}\phi(t,x)\right)$$

$$+\phi(t,x)H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)\left(\frac{\partial}{\partial t}N(t,x)+\frac{\partial}{\partial x}N(t,x)\right)$$

$$+\phi(t,x)N(t,x)\left[\frac{\partial}{\partial t}H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)+\frac{\partial}{\partial x}H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)\right]$$

$$=-B(t,x)\phi(t,0)N(t,x)H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right).$$

Integrating with x and using the notation $d\mu_t(x) = [B(t,x)N(t,x)/N(t,0)]dx$, which is a probability measure

$$\frac{d}{dt}\int_0^\infty \phi(t,x)N(t,x)H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)dx$$

$$=-\int_0^\infty \frac{\partial}{\partial x}\left[\phi(t,x)N(t,x)H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)\right]dx$$

$$-\int_0^\infty B(t,x)\phi(t,0)N(t,x)H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)dx$$

$$=\phi(t,0)N(t,0)H\left(\frac{n(t,0)e^{-\lambda_{per}t}}{N(t,0)}\right)$$

$$-\phi(t,0)N(t,0)\int_0^\infty H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)d\mu_t(x)$$

$$=\phi(t,0)N(t,0)\left[H\left(\int_0^\infty \frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}d\mu_t(x)\right)\right.$$

$$\left.-\int_0^\infty H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)d\mu_t(x)\right].$$

The last quantity is negative because of Jensen's inequality. This shows that

$\int_0^\infty \phi(t,x)N(t,x)H\left(\frac{n(t,x)e^{-\lambda_{per}t}}{N(t,x)}\right)dx$ is decaying and so the first inequality is

found. By integrating again in t, the second inequality is obtained.

Theorem 3.5. Under the assumptions for d and B above and $n^0 \in$ $L^1(R_+, \phi(0,x)dx)$, it holds that

$$\int_0^\infty \left|n(t,x)e^{-\lambda_{per}t} - \rho N(t,x)\right|\phi(t,x)dx \to 0 \ as \ t \to \infty,$$

where $\rho = \int_0^\infty n^0(x)\phi(0,x)dx$.

Proof. By setting $h(t,x) = n(t,x)e^{-\lambda_{per}t} - \rho N(t,x)$, h satisfies the equation

$$\begin{cases} \frac{\partial}{\partial t}h(t,x) + \frac{\partial}{\partial x}h(t,x) + \left(\lambda_{per} + d(t,x)\right)h(t,x) = 0, \ \forall t \geq 0, x \geq 0 \\ \qquad\qquad h(t,x=0) = \int_0^\infty B(t,x)h(t,x)dx \end{cases}$$

(3.4)

It also holds

$$\frac{\partial}{\partial t}\big(|h(t,x)|\phi(t,x)\big) + \frac{\partial}{\partial x}\big(|h(t,x)|\phi(t,x)\big) = -\phi(t,0)B(t,x)|h(t,x)|$$

$$\phi(t,0)|h(t,0)| = \phi(t,0)\left|\int_0^\infty B(t,x)h(t,x)dx\right|.$$

Now integrating with respect to x,

$$\frac{\partial}{\partial t}\int_0^\infty |h(t,x)|\phi(t,x)\,dx$$

$$= -\phi(t,0)\int_0^\infty B(t,x)|h(t,x)|dx + |h(t,0)|\phi(t,0) \ \leq 0.$$

This yields that $\int_0^\infty |h(t,x)|\phi(t,x)dx$ is decaying and it is positive, so it converges to some value $L \geq 0$. It remains to prove that $L = 0$.

Now the solutions $h_k(t,x) = h(t+k,x) \in C(R_+, L^1(R_+; \phi(.,x)dx))$ to Equation 3.4 are defined. If H is positive convex, then **Theorem 3.4** shows that a quantity I_k defined by

$$I_k = \int_0^\infty \left[\int_0^\infty H\left(\frac{h_k(t,x)}{N(t,x)}\right) d\mu_t(x) - H\left(\int_0^\infty \frac{h_k(t,x)}{N(t,x)} d\mu_t(x)\right) \right] dt$$

$$= \int_k^\infty \left[\int_0^\infty H\left(\frac{h(t,x)}{N(t,x)}\right) d\mu_t(x) - H\left(\int_0^\infty \frac{h(t,x)}{N(t,x)} d\mu_t(x)\right) \right] dt$$

is bounded. As the integrand is positive and integrable, it can be deduced that $\lim_{k\to\infty} I_k = 0$. Moreover, $h_k(t,x)$ satisfies the equation

$$\begin{cases} \dfrac{\partial}{\partial t} h_k(t,x) + \dfrac{\partial}{\partial x} h_k(t,x) + \left(\lambda_{per} + d(t,x)\right) h_k(t,x) = 0, \ \forall t \geq 0, x \geq 0 \\ h_k(t, x = 0) = \displaystyle\int_0^\infty B(t,x) h_k(t,x) dx \\ \displaystyle\int_0^\infty h_k(t,x) \phi(t,x) dx = 0. \end{cases}$$

Then $h_k(t,x) \in L^1(R_+; \phi(.,x)dx)$ is bounded up to a subsequence, $h_k \rightharpoonup g$ weakly. Passing to the limit in the definition of I_k and using the convexity in weak limits,

$$\int_0^\infty \int_0^\infty H\left(\frac{g(t,x)}{N(t,x)}\right) d\mu_t(x) dt \leq \lim_{k\to\infty} \int_0^\infty \int_0^\infty H\left(\frac{h_k(t,x)}{N(t,x)}\right) d\mu_t(x) dt$$

$$= \int_0^\infty H\left(\int_0^\infty \frac{g(t,x)}{N(t,x)} d\mu_t(x)\right) dt.$$

The last equality is valid since $\lim_{k\to\infty} I_k = 0$. But from Jensen's inequality, the reverse inequality is also found. Hence,

$$\int_0^\infty \int_0^\infty H\left(\frac{g(t,x)}{N(t,x)}\right) d\mu_t(x)dt = \int_0^\infty H\left(\int_0^\infty \frac{g(t,x)}{N(t,x)} d\mu_t(x)\right) dt.$$

This strictly convex equality for H shows that for almost all $t > 0$ on the support of μ_t,

$$\frac{g(t,x)}{N(t,x)} = C(t).$$

The limit in the weak sense gives

$$\begin{cases} \frac{\partial}{\partial t}g(t,x) + \frac{\partial}{\partial x}g(t,x) + \left(\lambda_{per} + d(t,x)\right)g(t,x) = 0, \ \forall t \geq 0, x \geq 0 \\ \\ g(t, x = 0) = \int_0^\infty B(t,x)g(t,x)dx \end{cases}$$

and

$$\frac{\partial}{\partial t}\frac{g(t,x)}{N(t,x)} + \frac{\partial}{\partial x}\frac{g(t,x)}{N(t,x)} = 0$$

Hence $\frac{g(t,x)}{N(t,x)} = C(t)$ and as a result

$$0 = \int_0^\infty g(t,x)\phi(t,x)dx = C(t)\int_0^\infty N(t,x)\phi(t,x)dx = C(t).$$

It can be concluded that $L = 0$ since $L = \int_0^\infty |g(t,x)|\phi(t,x)dx$.

Here, the following **Lemma 3.6** (Perthame, 2007, p. 100) was used.

Lemma 3.6. Any function $u = g/N$ satisfies

$$\frac{g}{N}(t, \Gamma(x)) = \frac{g}{N}(t, x) \ \forall t > 0, x \geq 0$$

and the fact that

$$\frac{\partial}{\partial t}\left(\frac{g(t,x)}{N(t,x)}\right) + \frac{\partial}{\partial x}\left(\frac{g(t,x)}{N(t,x)}\right) = 0$$

is constant.

Discussion and Conclusion

An age-structured model with both death and birth rates depending only on age (not varying in time) was analyzed for the existence of long-run behaviour. This model was based on the general relative entropy method in Perthame (2007).

In this work, an age-structured model with both death and birth rates of a population that depend on age and time, and that is periodic over time has been analyzed. Floquet theory was applied to Banach space to prove the existence and uniqueness of the solution of this age-structured equation. In addition, the general relative entropy method (Perthame, 2007) has been used to derive the asymptotic exponential decay of the solution for this setting.

The exponential rate of convergence guarantees that the solution reaches the steady-state fast enough to be observed in practice. The exponential decay rate is known in the case of non-constant coefficients (Gwiazda & Perthame, 2006). While in our case, the exponential decay holds for a wider class of data.

The existence and uniqueness of the solution for the Floquet eigenvalue problem for the periodic operator on Banach space have been proven, so as long as the models can be written as a partial differential evolution equation. It is now tempting to apply the Floquet theory on Banach space to more advanced models such as age-structured models with migration, growth-fragmentation equations or cell division equations (Mischler & Scher, 2016).

The aim of this work was twofold. On one hand, the existence and uniqueness of the solution of the Floquet eigenvalue problem on Banach space have been proven. On the other hand, the existence and uniqueness of the solution of the age-structured equation with positive and periodic coefficients have been proven. Moreover, long-run asymptotic exponential decay of the solution of the age-structured equation has been derived.

Appendix

Lemma (Gronwall's inequality). If $u \in C^1([0,T])$ satisfying $\frac{d}{dt}u(t) \leq \alpha u(t), for\ all\ t \in [0,T]$ where α is constant, then $u(t) \leq u(0)e^{\alpha t}$.

Definition. If T be an operator on a Banach space, the spectrum of T is $\sigma(T) = \{\lambda \in C : (\lambda I - T)^{-1}$ does not exist$\}$. Thus, the spectral radius of T is $r(T) = sup\{|\lambda| : \lambda \in \sigma(T)\}$.

Theorem. The spectrum of a bounded linear operator coincides with the spectrum of its adjoint; that is, $\sigma(T) = \sigma(T^*)$. In particular, $r(T) = r(T^*)$.

Theorem (Perron-Frobenius) (Perthame, 2007, p 160). If A is a positive, irreducible matrix, $d \times d$; then the spectral radius $r(A)$ of A is a positive simple eigenvalue of A associated with a positive eigenvector.

Definition. A cone K in a real Banach space $(X, \|.\|)$ is a closed set of X if it satisfies

1. $0 \in K$

2. $x, y \in K,$ then $\lambda x + \mu y \in K, \forall \lambda, \mu \geq 0$

3. $x \in K$ and $-x \in K,$ then $x = 0$

On a real Banach space $(X, \|.\|)$ the order on a cone K is defined by

$$(x \geq y \Leftrightarrow x - y \in K) \text{ and } (x > y \Leftrightarrow x - y \in Int(K))$$

A cone K is reproducible if $\forall x \in X, \exists y, z \in K, x = y - z$.

A cone K is normal if $0 \leq x \leq y \Rightarrow \|x\| \leq \|y\|$.

A dual cone of K is $K^* = \{y \in X^*, \forall x \in K, \langle y, x \rangle \geq 0\}$.

Theorem (Krein-Rutman) (Perthame, 2007, p. 175). If $(X, \|.\|)$ is a real Banach space, $K \subset X$ a reproducible and normal and T linear, compact and strictly positive (on K) operator. Then the spectral radius $r(T)$ of T is a positive simple eigenvalue of T associated with a positive eigenvector. In addition, if $Int(K^*)$ is non-empty, then $r(T)$ is also a positive simple eigenvalue of the adjoint operator T^* associated with a positive eigenvector.

Theorem (Banach-Fixed Point). If (X, d) is a complete metric space and $f: X \to X$ is a contraction; that is, $k \in [0,1)$ exists such that $for\ any\ x, y \in X$,

$$d\big(f(x), f(y)\big) \leq kd(x, y).$$

Then there exists a unique fixed point for f.

Theorem (Arzela-Ascoli). If (X, d) is a compact metric space. A subset $\mathcal{F}$ of $C(X)$ is relatively compact if and only if $\mathcal{F}$ is bounded and equicontinuous.

Corollary. If (X, d) is a compact metric space and $(f_n) \subset C(X)$ is a bounded sequence and equicontinuous in $C(X)$, then (f_n) has a uniformly convergent subsequence.

Acknowledgements

Author Biography

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Public perceptions about the management of plastic consumption in Kang Meas District, Kampong Cham Province

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សង្ខិត្តន័យ

ការស្រាវនេះមានគោលបំណងវិភាគយ៉ាងស៊ីជម្រៅទៅលើចំណេះដឹង ឥរិយាបទ និងការអនុវត្ត របស់ប្រជាជនក្នុងសហគមន៍ទន្លេអំពីការប្រើប្រាស់និងការគ្រប់គ្រងផ្លាស្ទិកនៅស្រុកកងមាស ខេត្តកំពង់ចាមនៃប្រទេសកម្ពុជា។ ការស្រាវជ្រាវនេះក៏មានគោលបំណងពន្យល់ផងដែរអំពី ស្ថានភាពបច្ចុប្បន្ននៃអនុវត្តជាក់ស្តែងរបស់ប្រជាជនក្នុងតំបន់នោះ ដើម្បីទាញយកចំណេះដឹង និងឥរិយាបទរបស់ពួកគាត់ស្តីពីការប្រើប្រាស់ថង់ផ្លាស្ទិក និងសិក្សាអំពីផលប៉ះពាល់ជាអវិជ្ជមាន មកលើបរិស្ថាន ព្រមទាំងគាំទ្រឱ្យមានការកែលម្អការគ្រប់គ្រងកាកសំណល់ផ្លាស្ទិកនៅតាមទី ជនបទនៃប្រទេសកម្ពុជាឱ្យបានប្រសើរឡើង។ ក្នុងការស្រាវជ្រាវនេះ គំរូសរុបចំនួន ២៣៥ គ្រួសារនៅយុំកងតាណីងនិងយុំរោអារត្រូវបានសម្ភាស។ ការសិក្សានេះបានរកឃើញទំនាក់ ទំនងរវាងការប្រើប្រាស់ផ្លាស្ទិក និងសូចនាកម្មួយចំនួនដូចជាប្រាក់ចំណូលជាដើម។ ឧទាហរណ៍ ប្រាក់ចំណូលគ្រួសារកាន់តែខ្ពស់ មានការប្រើប្រាស់ផ្លាស្ទិកកាន់តែច្រើន។ ដើម្បីកាត់បន្ថយ ការប្រើប្រាស់ផ្លាស្ទិកឱ្យមានប្រសិទ្ធភាព គប្បីមានការសិក្សាកំណត់តម្លៃថង់ផ្លាស្ទិកឱ្យបាន ត្រឹមត្រូវ ដើម្បីប្រជាជនអាចសម្របខ្លួនទៅនឹងការបង់ថ្លៃថង់ផ្លាស្ទិកដែលអាជីវករបានខ្ចប់ ទំនិញជូន។ ការចោលសំរាមផ្លាស្ទិកតាមផ្ទូវ ឬតាមទីសាធារណៈ ឬតាមដងស្ទឹង ដងទន្លេ ឬ តាមដងព្រែកបានបង្ហាញអំពីឥរិយាបទមិនល្អរបស់ជនខ្លះចំពោះចំណេះដឹង។ គ្រួសារទាំងនោះត្រូវ

ការការជួយជ្រោមជ្រែងកាន់តែខ្លាំងដើម្បីរួមគ្នាអនុវត្តគោលនយោបាយជាតិចំពោះការគ្រប់គ្រង ការប្រមូល និងការយកកាកសំណល់ទៅចោល។ តាមរយៈការស្រាវជ្រាវនេះ ការគ្រប់គ្រង កាកសំណល់ប្លាស្ទិកអាចត្រូវបានកែលម្អដោយ៖ (១) លើកកម្ពស់យល់ដឹងអំពីការប្រើប្រាស់ ប្លាស្ទិកដើម្បីឱ្យប្រជាជនទាំងនោះមានឥរិយាបថ និងទម្លាប់ល្អក្នុងការអនុវត្ត (២) អាជ្ញាធរ មូលដ្ឋានគួរផ្តល់កន្លែងចោលសំរាម និងធ្វើយុទ្ធនាការតាមសហគមន៍ ដើម្បីកំចាត់កាក សំណល់ប្លាស្ទិកក្នុងភូមិឬឃុំ (៣) គាំទ្រគោលនយោបាយស្តីពីការគិតថ្លៃថង់ប្លាស្ទិក ដើម្បី កាត់បន្ថយការប្រើប្រាស់ថង់ប្លាស្ទិកទូទាំងប្រទេស (៤) ផ្តល់បរិក្ខារជូនអាជ្ញាធរមូលដ្ឋានសម្រាប់ ប្រមូលនិងបែងចែកសំរាមប្លាស្ទិកឱ្យបានត្រឹមត្រូវសម្រាប់ការរៃកែថ្លៃឡើងវិញ និង (៥) បញ្ចូល ចំណេះដឹងស្តីពីការគ្រប់គ្រងកាកសំណល់ប្លាស្ទិកក្នុងកម្មវិធីសិក្សាតាមសាលារៀនដើម្បីលើក កម្ពស់ការយល់ដឹងតាំងពីក្មេង។

Abstract

This paper analyzes the knowledge, attitudes, and practices associated with the management of plastic consumption in *Kang Meas* District, *Kampong Cham* Province. It describes the negative environmental impacts of plastic consumption and advocates for improved plastic waste management in rural areas of Cambodia. A cohort of 235 households in *Kang Ta Noeng* and *Roka Ar* communes was selected to participate in this research. A significant correlation between plastic consumption and indicators such as household income was found. For instance, the higher the household income, the more plastic that each household consumed. To reduce plastic consumption, an adaptation study is required to set an appropriate price for plastic bags that may be enforced by small businesses. Littering on the road or in other public places such as rivers or canals was found to be driven by *people's behaviour and lack of knowledge*. Households demand better support to meet national policies for waste management, collection and disposal. It is recommended that the management of plastic waste is improved by 1) awareness-raising about issues linked to plastic consumption to improve the attitudes, behaviours and practices of local people 2) the designation and provision of waste disposal sites by local authorities, including community campaigns to manage plastic waste on a commune or village basis, 3) supporting a policy to discourage the use of plastic bags nationwide by charging a fee for their use,

4) providing sufficient budgets for local authorities properly collect and separate plastic for recycling, and 5) include knowledge about the management of plastic consumption in the school curriculum to raise awareness and plastic consumption from an early age.

Keywords: plastic, consumption, behaviours, knowledge, attitudes, waste management.

Background

Human life is impacted by environmental changes (Younan & Jenkins, 2020). Plastic waste has become a significant concern for humans, yet, it is vital to support daily activities. Dumping (Joyner & Frew, 2009) plastic trash into oceans has caused marine pollution at a scale that may never have been imagined before plastic packaging became widely used. Used plastic bags, bottles, and other packaging pollute shorelines as a result of disposing of waste in rivers and the ocean (Scott, 2007). This issue is one of the most serious environmental problems in Cambodia. In Phnom Penh alone, around 10 million plastic bags are consumed daily. They are used due to their convenience and low cost by food vendors, grocery stores, and clothing retailers for wrapping and packaging.

Plastic waste has a significant impact on more than 1,200 species of sea mammals and fish as it accumulates in their digestive tracts over time (Carey, 2010). Plastic, in the form of user end products, accounts for 60-80% of all marine litter (plastic bags, bottles, and packaging) (Chou, 2019), with the remainder linked to industrial raw materials (resin, granules, and pellets). In 2015, it was estimated that globally 55%, of plastic waste was discarded, 25% was incinerated, and 20% was recycled. The United Nations Development

Program suggests that *"500 billion plastic bags are disposed of and 13 million tons of plastic is washed into the oceans each year. Every minute one million plastic bottles are bought, and every year 100,000 marine creatures are killed by plastic waste. Plastic takes hundreds of years to degrade in the environment. Up to 90% of bottled water and 83% of tap water were found to contain plastic particles, with plastics comprising 10% of all human waste."* (Taylor, 2018).

Plastic consumption is a behavioural issue. Environmentally-friendly behaviours are a function of social norms, attitudes, and perceived behavioural control. These behaviours, such as public littering can be further influenced by a lack of public infrastructure, coupled with the infrequent collection of waste from low-income households and rural areas where services are not readily provided (Fang, 2017). Thus, transforming the existing knowledge, attitudes and practices of people is central to addressing this problem.

Currently, plastic waste in rural riverine communities is disposed of in pits or large open spaces, from where it accesses rivers and streams, which are also used as illegal sites for dumping plastic and other solid waste. Common alternatives, such as the open burning of plastic waste cause air pollution and the release of carbon, which is the driver of climate change. Changing public behaviour to improve public hygiene and sanitation is not straightforward. Although there are regulations promulgated by the Royal Government of Cambodia to manage the effective management of plastic waste, law

enforcement is weak in rural areas, and it is difficult to prevent haphazard disposal practices (Kumar et al., 2018).

In April 2018, the Ministry of Environment (MoE) introduced a new system, where people would be charged 10 cents per plastic bag at major supermarkets in Phnom Penh, such as Aeon, Bayon, and Lucky (UNDP, 2018). However, local markets, small grocery stores, and restaurants still provide plastic bags without charge and their consumption has not been significantly reduced. Plastic that is disposed of in the natural environment causes ongoing damage. Single-use plastics are easily carried long distances to oceans (Slavikova, 2018). They block stormwater drains, leading to flooding problems during the rainy season. Even the proper disposal of plastic wastes in landfills can take 400 years to completely degrade.

A study conducted across the 24 provinces, including 26 towns under provincial supervision has identified that Cambodia's waste collection services tend to be provided by private companies that operate in central urban areas only. In some towns, trash is collected from markets and residences (UNCRD, 2017). While reliable data on solid waste generation in urban areas is not available, it is evident that waste collection and disposal at provincial dumpsites is variable. Plastic waste generation has been recognized as one of the most significant environmental issues by a growing world alliance of more than 1,000 organizations and businesses (Testa, 2020). Thought leaders in 60 countries are working toward a world free of plastic pollution and its toxic impact on humans, animals, waterways, the ocean, and the environment.

There is a need for trash to be disposed of properly and for people to reduce the number of plastic products their use.

In rural areas of Cambodia plastic waste tends to be burnt, buried, or illegally dumped (Denney, 2016) resulting in negative impacts. Promoting Individual awareness to think about *one's behaviour* is key to responding to this problem. It is important to understand the key determinants of the knowledge and attitudes of the community to lead these thought processes (Seng et al., 2018). A particular focus should be the creating awareness among local communities about the need for reduced plastic consumption and recycling among children who may share this knowledge of plastic with their families. This is a most critical issue in the riverine communities of Cambodia. As such, this research has three main objectives: 1) to examine the current situation of the plastic consumption in the riverine communities in Cambodia, 2) to assess the knowledge, attitudes, and practices of local people related to regarding plastic consumption and its negative environmental impacts, and 3) to advocate for necessary changes to how plastic waste is managed in these communities.

Cognitive-behavioural therapy for reducing plastic consumption

This research adopts a framework that employs the concept of cognitive-behavioural therapy (see Figure 1) to analyze the behaviour, awareness and capacity of local people regarding plastic management (Beck, 2011). This analysis of the behaviours, knowledge and practices related to how local people consume, collect, and reduce the use of, and dispose of plastic is important. It is key to building the capacity of the local people via awareness-

raising, campaigns, and public advocacy about the problem. Additionally, community-led interventions in the collection and disposal of plastic bags and law enforcement may also help improve plastic management behaviours.

Figure 1. Cognitive-behavioural therapy conceptual framework adapted from Beck (2011)
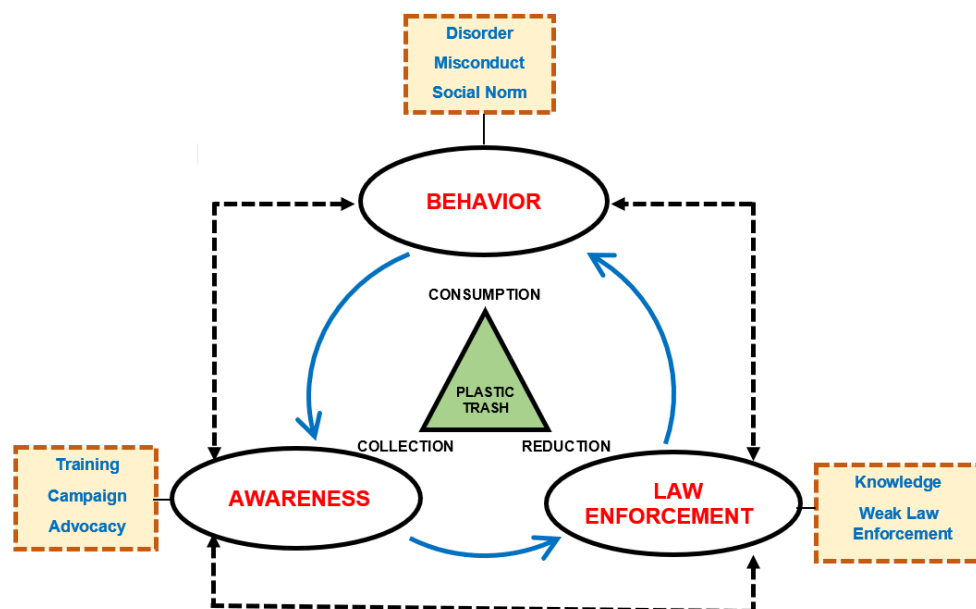
Research Methodology

The study adopted both exploratory and descriptive approaches to responding to the research questions. Data was collected using a survey and participatory field interviews about plastic consumption, waste disposal, public awareness, and the behaviours of local people related to the consumption and disposal of plastic waste. The face-to-face interviews interview questions were prepared in advance. In addition, a case study on one village was developed, highlighting the efforts made to improve levels of

participation in more effective waste management practices with a focus on plastic waste.

Kampong Cham is one of the most populous provinces in Cambodia, located 40 km to the northeast of the capital city, *Phnom Penh*. It is situated at the mouth of the *Tonle Sap* near the Mekong River, which flows along the eastern border shared with *Tboung Khmum* province. Two communes in *Kang Meas* District of Kampong Cham were selected for the study, *Kang Ta Noeung* and *Roka Ar*. These communes are located along the bank of the Mekong River and are seasonally inundated each year during the rainy season. During these events, solid waste that has been littered on the roadside and low lying locations in each commune is washed into the river by the floodwaters.

The two communes were purposively selected to provide a comparison of waste management behaviours. *Roka Ar* commune is a moderately populated agricultural area, while *Kang Ta Noeng* commune is more densely populated with a local market and commercial activities, which consume a greater volume of plastic bags and produce more plastic waste. The two communes are similarly affected by seasonal flooding. The location of the two communes within Kampong Thom is outlined in Figure 2.

The sample size of the interview cohort was selected using a formula proposed by Yamane (1967) employed for identifying a statistically significant cohort. An acceptable sampling error of +/- 9 % was deemed appropriate. In 2017, there were 2,512 households in *Kang Ta Noeng* Commune and 2,199 Households in *Roka Ar* Commune (MoP, 2017). Thus 235 households were

selected to participate in the interviews in the two study communes based on

the formula below:

$$n = \frac{N}{1+N*(e)^2}$$

n = Sample Size

N=Total number of households

e =Level of precision (9%)

Figure 2. Location map of Kang Ta Noeng commune and Roka Ar commune
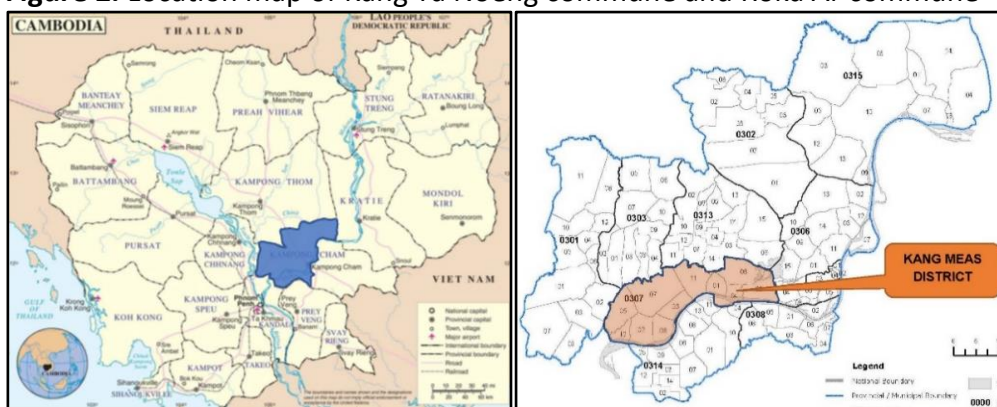
Both qualitative and quantitative data were analysed. The quantitative

data was accessed through household interviews and a questionnaire.

Qualitative data from the key informant interviews and focus group

discussions were also analysed.

Results and Findings
Household plastic consumption in riverine communities

Respondents from each commune frequently go to the market to

purchase goods for daily consumption. The frequency of these visits was not

consistent but dependent on the needs of each household, income levels, and

interests. Approximately 57.0% of respondents visited the market daily,

11.1% visited the market 3-5 times a week, 14.5% visited the market 1-2 times a week, 4.7% visited the once every two weeks, 8.1% visited the market monthly, while 4.7% visited the market less frequently than this. These results are shown in Figure 2.

Figure 2. Frequency of visits to the market
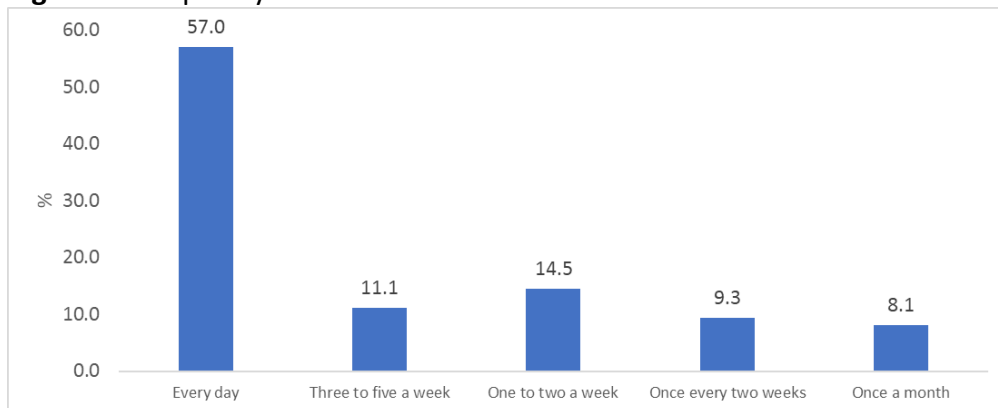
Interviewees were also asked about their purpose for using plastic bags. Respondents indicated that they are used to carry various items from the markets including water bottles or other drinks (20.4%), ready-to-eat food from vendors (15.3%), meat and fish (45.1%), fruit and vegetables (13.2%), bread or other bakery items (1.7%), clothes and/or shoes (0.4%), and other goods (3.8%). These results are shown in Figure 3.

In response to the question *"Where do you use plastic most frequently?"*, 48,9% of respondents indicated the grocery store, 21.7% indicated fish and meat shops, 15,70% indicated the supermarket, 13.2% indicated vegetable and fruit shops, while 0.4% indicated that they use plastic most frequently for garbage disposal. As the study area is not a large urban area, there is an absence of supermarkets, thus grocery stores have a larger share of retail

business. In rural communities, people tend to purchase meat and fish from local markets. Many people grow vegetables and fruits in their house, thus purchases of vegetables and fruit are less frequent than in urban areas. Water and drinks are other items commonly purchased from vendors in rural riverine communities. The results for the question are shown in Figure 4.

Figure 3. The purpose of using plastic bags
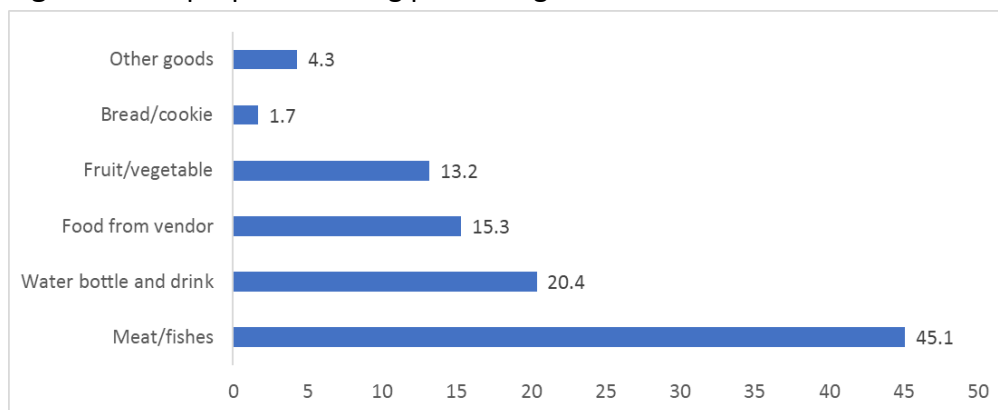
Data about the weekly consumption of plastic bags per household were also collected. There was not a large difference between the two communes in the study. Overall, 23.4% of respondents consumed ten, or less than ten bags per week; 47,2% consumed 11 to 30 plastic bags per week, 17.0 % consumed 31 to 50 bags per week, and 12.3% consumed more than 50 plastic bags per week. The average weekly consumption of plastic for all households was 27.6 bags with a standard deviation of 21.1 bags. Table 1 displays the disaggregated results for the weekly consumption of plastic bags in *Kang Ta Noeng* and *Roka Ar* communes.

Several variables were tested to determine whether there was a significant correlation between levels of correlation between plastic bag

consumption and factors such as age, level of education, number of household members, and net income.

Figure 4. Sources of plastic consumption
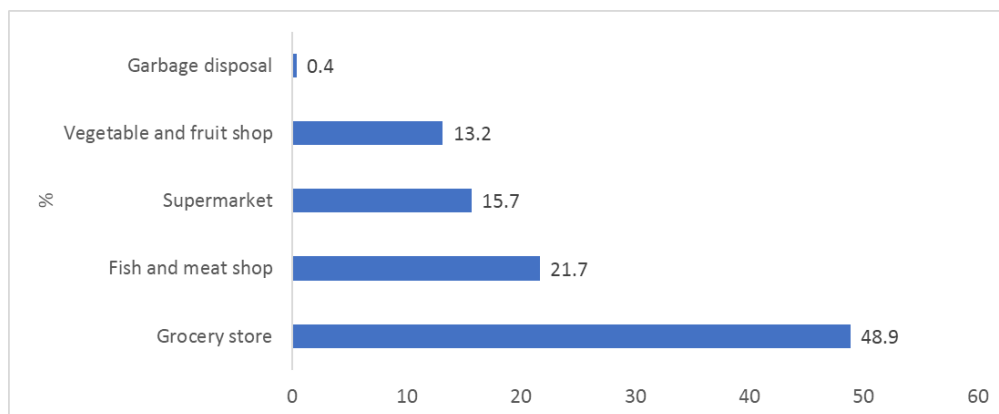
Household income was found to be the most significant indicator of plastic bag usage (P-*value*=0.010). Households with higher incomes were found to tend to use plastic bags more frequently, while factors such as age, level of education and number of household members were much less significant. These results indicate that respondents lacked knowledge of the impacts of plastic bag usage and consume as many as their income allows. The correlation between weekly plastic bag consumption and various indicators is shown in Table 2.

Figure 5 goes into more detail about the correlation between household income and the number of plastic bags consumed per week. The relationship is strongest for levels of weekly plastic bag consumption of up to 20 plastic bags. The majority of people using less than 20 plastic bags were found to have a meagre household income of less than 1,000 USD per month, whereas

levels of income were more evenly distributed for higher rates of consumption.

Table 1. Number of plastic bags consumed per week

Attributes (%)	Kang Ta Noeng	Roka Ar	Overall
0-10 Bags	21.2	25.6	23.4
11-30 Bags	50.8	43.6	47.2
31-50 bags	16.1	17.9	17.0
51 Bags and above	11.9	12.8	12.3

Table 2. Correlation between weekly plastic consumption and various indicators

Attributes	Pearson Correlation	P-value
Age	-0.032	0.620
Education	-0.005	0.945
Household Members	-0.031	0.639
Household Income	0.167	**0.010****

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

Knowledge regarding plastic consumption

Data about the knowledge of participants regarding plastic consumption was collected. A weighted average index was used to rate the degree of knowledge the household had obtained about plastic consumption on a five-point scale: (1) highly agree; (2) agree, (3) moderately agree; (4) disagree; (5) strongly disagree. Further, a t-test was also conducted using these five indicators. The results indicate that there was a moderate level of knowledge about the bio-degradability of plastic bags in *Kang Ta Noeng* (0.45) and a low level of knowledge in *Roka Ar* (0.37). There was a moderate level of the fact that single-use plastic bags take between 20 and 450 years to decompose

(WWF, 2021) (0.46 for both communes). These results are summarised in Table 3.

Figure 5. Correlation between household income and weekly plastic bag consumption
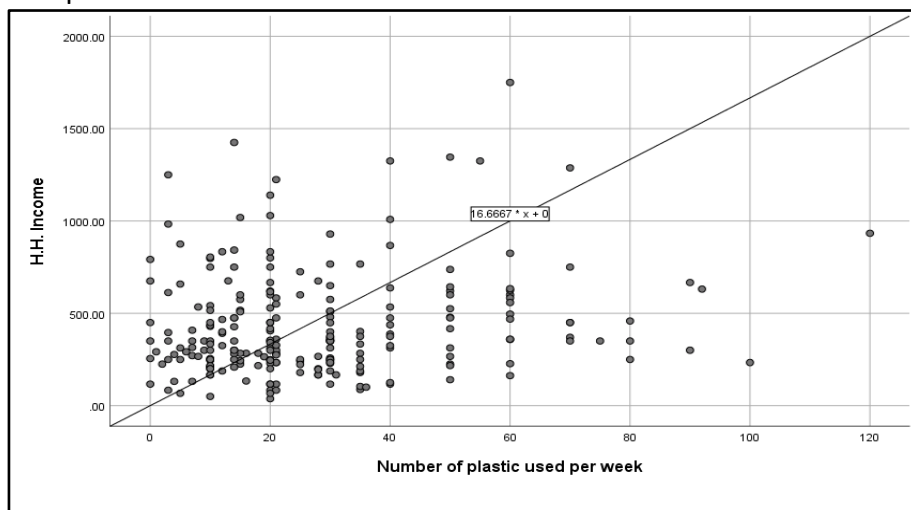
Table 3 Level of knowledge about plastic bag consumption among respondents

Indicators	Kang Ta Noeng (n=118)		Roka Ar (n=117)		Overall (n=235)		P-*value*
	WAI	OA	WAI	OA	WAI	OA	
Degradable	0.45	M	0.37	D	0.41	M	*0.000****
Decomposed in 20-450 years	0.46	M	0.46	M	0.46	M	*0.000****
Global issue	0.36	D	0.38	D	0.37	D	*0.000****
Burning plastic bags pollutes the air	0.43	M	0.46	M	0.44	M	*0.000****
Fish poisoning	0.63	A	0.64	A	0.63	A	*0.000****
Burning in public area	0.68	A	0.78	A	0.73	A	*0.000****
Policy to charge 20 cents per plastic bag	0.74	A	0.70	A	0.72	A	*0.000****

Notes: WAI = Weight Average Index measured on a five-point scale [Strongly disagree (SD) = 0.00-0.20, Disagree (D) = 0.21-0.40, Moderate (M) = 0.41-0.60, Agree (A) =

0.61-0.80, Strongly Agree (SA) = 0.81-1.00]; OA= Overall Assessment; *Significance at the 0.05 level; **Significance at the 0.01 level.

Households in *Kang Ta Noeng* and *Roka Ar* were found to have poor levels of knowledge about the adverse environmental impacts of plastic bad consumption and plastic waste. For instance, it was known that plastic waste may cause fish poisoning, which may eventually impact humans. They also believed that because of this knowledge, it is necessary to improve the current situation and leave a clean environment for the next generation. Thus, a policy of charging 20 cents for each plastic bag taken from a shop was generally agreed with. However, out of 235 respondents, only 89 had sufficient knowledge of plastic management to be driven to make further changes to their behaviour. Up to 146 research participants have insufficient levels of knowledge to influence them to change.

Table 4. Comparison of sufficient knowledge and previous awareness raising

Attributes	Have you ever received any form of awareness-raising regarding plastic management?			X^2	P-*value*
	Yes	No	Overall		
Do you have sufficient knowledge of plastic waste management? Yes	25	64	89	21.480	*0.000****
No	9	137	146		
Overall	34	201	235		

***P-*value*=0.000 is perfectly significant between awareness-raising and knowledge of plastic even though the respondents were not known enough.

To further analyse this result, three tables were created and analyzed to compare the cohort with sufficient knowledge and the cohort without sufficient knowledge. Each cohort was asked to answer questions about whether they 1) had engaged in previous awareness-raising training activities

2) would accept if a seller did not provide them with a plastic bag 3) would be willing to pay for a plastic bag when making a purchase. The responses to these questions from the different groups are analyzed below.

In response to the first question, *have you ever engaged in previous awareness-raising training activities*? Of the 89 respondents who had sufficient knowledge of plastic waste management, only 25 indicated that had previously engaged in awareness-raising training activities. Meanwhile, among the cohort of 146 who had insufficient knowledge of plastic waste management, only 9 of them had engaged in these activities. The chi-square value of 21.48 and the asymptotic significance value of 0.000 are summarised in Table 4 above. These results indicate that accessing awareness-raising training is significant in improving knowledge. Thus, to reduce plastic consumption and to improve attitudes to the disposal of plastic waste, it is recommended that these activities are provided to households at regular intervals until there is a sustainable improvement.

In response to the second question *Would you be accepting if a seller did not provide a plastic bag?* Of the 89 respondents who had sufficient knowledge of plastic waste management, 38 would not be accepting if a seller did not provide a plastic bag to them. For the cohort of 146 respondents, who did not have sufficient knowledge of plastic waste management, 94 would not be accepting of this practice. Table 5 demonstrates that the chi-square value calculated was 10.563, with an asymptotic significance of 0.000. This suggests that having sufficient knowledge of plastic waste management is essential for reducing the demand for plastic consumption.

Table 5. Comparison between sufficient knowledge and acceptance of not giving the plastic bag

Attributes	When you buy something, If the seller does not give you a plastic bag, do you accept this?			X^2	P-value
	Yes	No	Overall		
Do you have sufficient knowledge of plastic consumption?	Yes				
	Yes 51	38	89	10.563	*0.000****
	No 52	94	146		
	Overall 103	132	235		

***P-*value*=0.000 is perfectly significant.

In response to the question *Would you be willing to pay for a plastic bag when buying something?* Of the 89 respondents who had sufficient knowledge of plastic waste management, 43 would be willing to pay for plastic bags when buying something. This was higher than 26 respondents from the cohort of 146 respondents who did not have sufficient knowledge of plastic waste management.

Table 6. Comparison of sufficient knowledge on plastic consumption and willingness to pay for plastic bag

Attributes (%)	Are you willing to pay for plastic bags when you buy something?			X^2	P-value
	Yes	No	Overall		
Do you have sufficient knowledge to manage plastic bags?	Yes 43	46	89	24.810	*0.000****
	No 26	120	146		
	Overall 69	166	235		

***P-*value*=0.000 is perfectly significant.

Table 6 demonstrates a calculated chi-square value for this test of 24.810 and an asymptotic significance of 0.000. This comparison demonstrated that knowledge of plastic waste management did not have a significant impact on whether a respondent would be willing to pay for a plastic bag. This indicates that willingness to make these payments is dependent on the attitude, rather

than the knowledge of respondents. Many of the respondents with knowledge of plastic waste management still refused to pay the fee.

A further analysis was conducted to assess the correlation between the price paid for plastic bags and the maximum price desired. Some respondents had experience paying between 100 riels (2.5 cents) and 500 riels (12.5cents) for one plastic bag. These respondents indicated that they were willing to pay the maximum price for one plastic bag. These prices are shown in Table 7.

Table 7: Maximum price willing to pay for a plastic

Attribute (%)	Kang Ta Noeng (n=118)	Roka Ar (n=117)	Overall (n=235)
Nothing	31.4	29.1	30.2
100-500 (12.5 Cents-)	67.8	66.7	67.2
600-1000 (25 Cents)	0.0	2.6	1.3
1100-above	0.8	1.7	1.3

The pricing of plastic bags should be selected carefully. If the price is too low, it will be easily afforded and will be unlikely to reduce the consumption of plastic bags. This will lead to the fee eventually becoming ineffective. To effectively reduce plastic consumption, there is a need for a study on a realistic adaptive pricing strategy for plastic bags to enable feasible law enforcement for all sellers in small businesses in the future.

Attitude towards plastic waste management

In response to the question, *Why do you use plastic bags?* 40.4% of respondents indicated that they did because everybody does; 33.6% of respondents suggested it was because they were light and durable; 17.4% suggested that there were no other materials to replace plastic bags, 5.1%

said that they did not know; while 3.4% responded that plastic bags were cheaper than alternative materials. These results are summarised in Figure 6.

Figure 6. Reason for using plastic
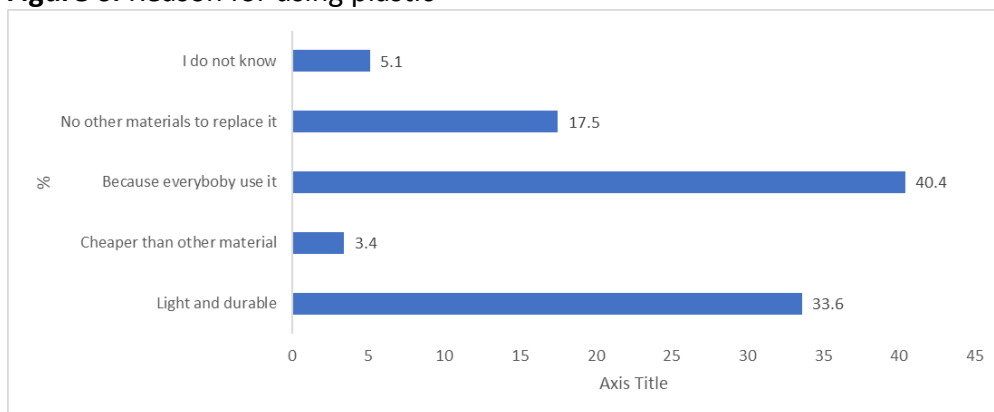
The above results suggest that plastic bags are popular and have the advantage of being lightweight and strong. There are no readily available materials for replacing plastic bags at a comparable price, which makes it difficult to replace them. This makes it harder to change plastic consumption behaviours. The attitudes and behaviours of those who littered with plastic after use were then analyzed. Of this cohort, 47.2% did not believe that this behaviour mattered; 34.9% thought that someone in the community would eventually collect plastic waste; 13.6% expected somebody else would collect it, and 1.3% believed that the waste would biodegrade naturally. A further 3% did not understand the question.

Others suggested that plastic waste was rarely seen after seasonal flood events. This is a serious environmental issue as plastic bags dispose of near the Mekong River are often washed down the river towards the ocean during

the wet season. Table 8 presents a summary of the attitudes held towards littering with plastic in the study area.

Table 8. Attitudes towards littering with plastic waste

Attributes (%)	Kang Ta Noeng (n=118)	Roka Ar (n=117)	Overall (n=235)
Disappear natural	0.0	2.6	1.3
Somebody will collect	17.0	10.3	13.6
Community will collect	37.3	32.5	34.9
No mater	45.8	48.7	47.2
I don't know	0.0	6.0	3.0

Table 9. Feeling of regret when littering with plastic bags

Attributes (%)	Kang Ta Noeng (n=118)	Roka Ar (n=117)	Overall (n=235)
I feel very sorry as I did a terrible thing	56.8	59.0	57.9
I feel a little sorry, but I have no other solution	31.4	31.6	31.5
It is my habit to throw outside	10.2	6.8	8.5
I feel I did the right thing	1.7	0.0	0.9
Cleaning is a government responsibility	0.0	2.6	1.3

Even though many people litter with plastic waste in public places, many indicate that they do not feel they have done the right thing. After throwing out used plastic in a public place, 57.9% suggested that they had done a terrible thing; 31.5% suggested that they felt a little sorry as there was no other solution; 8.5 % suggested that this was a usual or regular habit; 1.3% suggested that this was a job for the government or community to control;

while 0.9% mentioned that they felt no sorrow. Table 9 summarises these results.

Most people (89.4%) who littered public places with plastic waste felt sorry in their minds but continued with this behaviour as no collection service was available. Thus, if these behaviours are to change, it is necessary to provide proper waste collection and disposal systems, with community involvement, initiated by representatives at the commune and village level.

Practices following plastic consumption

Practices after plastic consumption depend on the respondent and their environment. Overall, 47.2% of respondents indicated that they throw plastic waste into a river or stream; 34.9% bring used plastic waste home to home to reuse or dispose of using a waste collection service; only 13.6% use a public garbage bin; while 1.3% throw away public waste immediately after it has been used. Along the Mekong River, many respondents find it easy to throw plastic bags into the river or stream as it is washed away during the rainy season. This practice is readily observed in the study area, with large quantities of plastic bags thrown into canals and under bridges. These results are summarised in Table 10.

As there is no garbage collection system in either commune, participants were asked how they manage plastic waste. Overall, 48.5% of respondents indicated that they burn their plastic bags and other waste in their house or open public space; 6.0% dump garbage on low-lying land or roadsides near their house; 13.2% of them throw the garbage into the nearby waterways or rivers; 3.4% bring their garbage to the public collection point, while a further

28.9% did not provide a specific answer to this question. These results are summarised in Figure 7.

Table 10. Disposal practices after using single-use plastics

Indicator (%)	Kang Ta Noeng (n=118)	Roka Ar (n=117)	Overall (n=235)
Throw immediately on the road or open space	0.9	1.7	1.3
Throw in the public dustbin	12.7	14.5	13.6
Bring back to my house and reuse or throw away	38.1	31.6	34.9
Throw into the river/lake	46.6	47.9	47.2
Others, specify	1.7	4.3	3.0

Figure 7. Disposal practices after plastic consumption
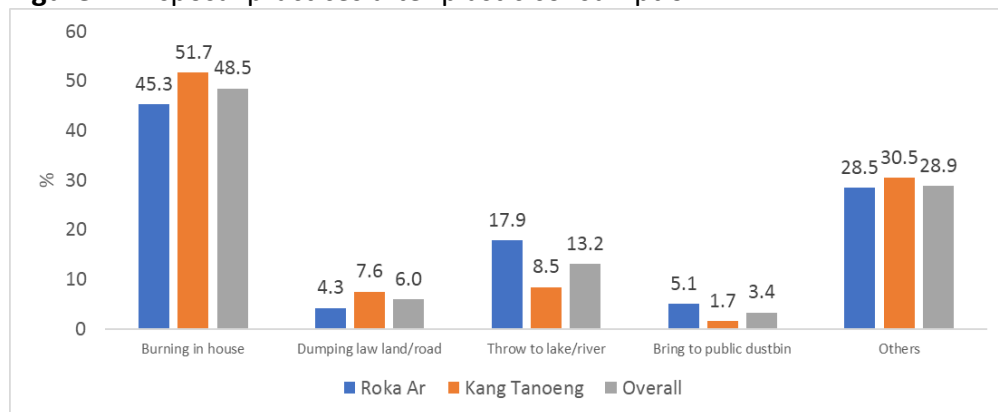
Management of plastic consumption

Many respondents expressed concern about future environmental problems if the current situation of disposing of plastic waste is continued without any government intervention. Overall, 62.1 % of respondents thought the community would become increasingly unclean; 16.2% worried about health problems associated with burning plastic; 12.8% were concerned

about the river becoming more polluted; 5.1% were primarily concerned about soil contamination; while 3.8% had a different response. These results are summarised in Figure 8.

Figure 8. Future problems without improved plastic waste management
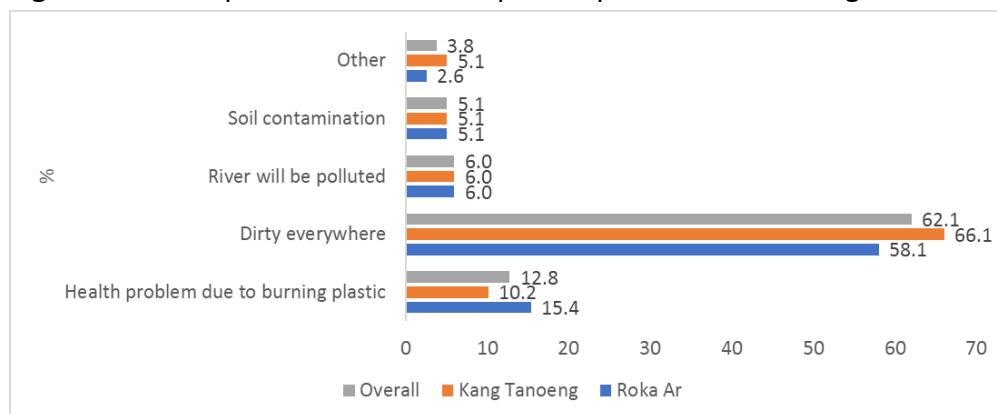
In response to the question *What is the most urgent need for improving waste management,* 55.3% of respondents suggested regular collection of waste was required; 25.5% suggested that community waste disposal sites were necessary; 9.4% referred to the need for proper education and training provided by the government; 7.2% suggested that the community needs to be active in initiating community movement to clean the environment; 0.9% suggested that new policies were required from the RgoC; while 1.7% provided a different response. These results are summarised in Table 11.

In response to the question *If a recycling program was set up, would you be willing to separate your plastic waste into separate bags for collection purposes?* 86.8% of respondents agreed to participate in the separation collection program; 10.2 % suggested that they were unsure, as they did not know precisely what the program would involve; while 3.4% suggested they

would not agree to participate in the program. Most people would welcome RGoC policy and campaigns for the improvement of the current waste management system within the local government. Table 12 summarises these results.

Table 11. Most urgent need for improving waste management in the commune.

Attributes (%)	Kang Ta Noeng (n=118)	Roka Ar (n=117)	Overall (n=235)
Regular collection of waste	54.2	56.4	55.3
Public dumping site	29.7	21.4	25.5
Education and training	6.8	12.0	9.4
Community campaign	6.8	7.7	7.2
Government Policy	0.0	1.7	0.9
Other	2.5	0.9	1.7

Table 12. Intended participation in a recycling program

Attributes (%)	Kang Ta Noeng (n=118)	Roka Ar (n=117)	Overall (n=235)
Yes, I will do	86.4	87.2	86.8
No, I don't want to do	3.4	4.3	3.8
Not sure	10.2	8.6	9.4

Respondents indicated that they would be willing to participate in a program that separated plastic waste for recycling. If adequately recycled, plastic bags can be repurposed to produce composite lumber as a base material for decks, benches, and playgrounds. Plastic bags can also be reprocessed into small pellets, which can be made into new plastic bags, containers, crates, and pipes. Recycling may help to conserve natural resources, keep roads, streets, streams, and rivers clean, and protect wildlife

by properly separating and collecting plastic bags instead of burning or burying them in a landfill.

Interviews with the two commune chiefs revealed that plastic bags were commonly used by shops and food stalls. They mentioned they often communicated with villagers advising them not to throw plastic bags in public places but it was difficult to prevent this behaviour as the commune was too large to manage. They also suggested that they had not considered using information about the knowledge, attitudes, and behaviours of villagers to plan their activities in the past.

Beyond the household interviews, two focus group discussions were also conducted to further clarify the situation regarding plastic bag consumption and waste management. Three men and three women from each commune were selected for the group discussion. In *Kang Ta Noeng*, households had advised every shop in the commune that they expected them to provide plastic bags free of charge when they made purchases. This advice was consistent with habits and existing practices for both sellers and customers. Nobody is required to bring shopping bags to the market. After using plastic bags, the participants advised that they did not have a pre-determined place in which to dispose of the plastic bags. Thus, households tend to throw them in open public spaces or on the Mekong River.

The commune officer mentioned that he often advised people not to dispose of plastic bags in public places, yet the households suggested that they had little choice to do this, beyond burning them or throwing them into the river. In *Roka Ar*, householders mentioned that people commune throw

plastic bags into public spaces or burn garbage without thought. Most used a strategy of collecting plastic waste and throwing it into the river. There is a branch of the Mekong River in the centre of the commune, which is deep. Households tend to use this branch as a disposal place. A local NGO was also consulted about institutional activities used to reduce plastic bag consumption. During this discussion, it was suggested that the current situation may be improved by classifying types of recyclable waste into three groups, then transferring the national budget to allocate local authorities to manage waste in the commune. Training may be provided on plastic waste management, funded by charging an additional cost for using plastic bags in the marketplace.

Discussion

The results presented in the previous section are of practical importance in understanding the attitudes and behaviour of respondents from two riverine communities in Cambodia towards plastic consumption and plastic waste management. This has been used to answer the following research questions.

What is the current situation regarding plastic consumption and plastic waste management in rural riverine communities in Cambodia?

People living in the two communes go to the market frequently to access goods for their daily consumption. As the study area is not an urban area, there are no supermarkets. Thus small grocery stores supply the majority of the retail products in the two communes. The overall average weekly consumption of plastic bags per household in the two communes is 27.6 bags, with a standard deviation of 21.1. There was no remarkable difference in

plastic consumption between each commune. Household income was found to be the most significant indicator of plastic bag consumption, whereas other factors such as age, education, and the number of household members had less influence on the consumption rate. Villagers tend to consume more plastic if they have the financial resources to do so. These indicate a lack of knowledge among villagers and a need for training activities that raise awareness of plastic waste management, community-led efforts, and enhanced law enforcement to reduce plastic bag consumption.

To what extent are local people be aware of the significance of plastic management in riverine communities?

Plastic bags and other waste are regularly burned by households, with no law enforcement implemented to discourage such actions. Only 89 out of 235 respondents, were found to have sufficient knowledge about the need for plastic waste management. When there is low awareness of the impacts of poor plastic waste management, it is difficult to improve the situation. The research found that awareness-raising activities targeted at local people would provide sufficient knowledge on plastic waste management to reduce the consumption of plastic bags and improve the attitudes towards the disposal of plastic waste. These activities would be required to be provided at regular intervals to be sustainable. It was found that when households disposed of plastic waste in public spaces, 89.4% of respondents felt sorry in their minds, but continued to do so as there was no alternative garbage collection service. Overall, 46.6% of households in the rural riverine communities studied admitted to throwing single-use plastic waste into rivers or lakes, while 48.50% of respondents burned plastic waste at home.

What role does the RGoC play a role in promoting plastic waste management?

Overall 62.1% of households surveyed indicated that they were concerned that their communities might become more unclean in the future if there is no improvement in the collection and disposal of plastic and other solid waste. However, several constraints prevented this from occurring. These factors were closely examined to inform the research about possible interventions that may be utilised in this context. As the study was conducted in riverine communities, villagers tended to throw plastic waste into the rivers or streams as this waste would be washed away during the rainy season.

Householders indicated that an appropriate alternative would be for local authorities to provide public dumping sites near the village to improve plastic waste management. This was described as an urgent need that would enable waste to be collected more regularly in a convenient location. Moreover, 86.4% of householders indicated that they would be willing to participate in a trial program designed to separate plastic waste for recycling. Recycling is a strategy that may help to conserve natural resources, keeping roads, streams, and rivers clean. Thus, it is recommended that the RGoC trial this type of program.

It was found that plastic bags are popular because they are lightweight, strong and easy to carry. Currently, it is perceived that there are no alternative materials capable of replacing these resources. Thus, an effective way to mitigate their negative impacts is to reduce their consumption. Currently, only people who shop in supermarkets in larger urban areas pay for plastic bags. The RGoC should expand this policy nationally to include smaller retailers to trigger a more effective reduction in plastic bag consumption. The

strategy used to implement this policy needs to be carefully considered as the effect of paying more for plastic bags is known the diminish over time (Haoran, 2010). Policies on charging fees for plastic bag consumption need to be coupled with long term efforts to enforce laws regarding plastic waste disposal to be effective.

Policy implications for promoting plastic waste management in Cambodia

The following recommendations are presented to the RGoC ad other supporting institutions to effectively reduce plastic consumption and improve plastic waste management practices in rural riverine communities in Cambodia.

- The *Ministry of Environment* should conduct research into the effectiveness of the current practices of charging for plastic bags in supermarket chains to guide the further expansion of this initiative to other small business activities to enhance the reduction of plastic bag consumption nationwide. Additionally, the Ministry should plan and provide awareness-raising training on plastic consumption and plastic waste management for rural riverine communities.

- The *Ministry of Interior* should develop a policy on plastic waste management and waste collection services that enables local authorities to effectively implement waste management systems at the commune level and seek to arrange access to necessary budgets to establish and operate these services.

- The *Ministry of Education, Youth and Sports* should include reducing plastic consumption, separation of plastic waste, and behaviours and

practices related to effective plastic waste management in the school curriculum for elementary and secondary schools to raise awareness from an early age.

- *Provincial Governments* should provide a practical training program for community-based plastic waste management.

- *Local (Commune) Authorities* should prepare a guide on reducing plastic consumption and plastic waste management via public dumping sites located close to villages. Awareness-raising activities among local villagers should be conducted to reduce plastic consumption and change plastic waste management practices.

- *NGOs* should provide awareness-raising activities focused on the reduction of plastic consumption and plastic waste management. At the same time, NGOs should help to facilitate and support communities to conduct campaigns to clean plastic waste from areas along rivers.

The effectiveness of the current policies that charge fees for the use of plastic bags in supermarket chains should be reviewed and assessed for their efficacy in reducing plastic consumption. The price of various sizes of plastic bags should be considered carefully to avoid excessive consumption of plastic bags when customers purchase goods. If the fee is too low, it will not be effective in reducing consumption. Thus, it is necessary to conduct more detailed research to provide a logical framework by which the RGoC may implement effective policies to further reduce plastic consumption in the future.

Conclusion

The research analyzed the knowledge, attitudes, and behaviours of people in the riverine communes in Cambodia related to plastic consumption and plastic waste management. Plastic waste in rural communities tends to be found illegally dumped in pits, rivers, and large open public spaces areas. A field survey found that burning plastic waste is a common practice in riverine communities, even though people knew it pollutes the air causing climate and human health impacts. But the evolution of behaviour is not easy, although there are regulations and laws in force by the RGoC.

A sample of 235 households from two communes in *Kang Meas* District in *Kampong Cham* was selected to participate in interviews to collect primary data. It was found that respondents used plastic to carry various items from the markets in each commune. The average weekly consumption of plastic bags was found to be 27.6, with a standard deviation of 21.1. Most respondents (40.4%) indicated that they used plastic bags because everybody else does. Moreover, 33.6 % said they were used because they were light and durable. After disposing of plastic waste in a public place, 57.9% of respondents felt that they had done something terrible, while 31.5% felt a little sorrow as there were no viable alternatives. When disposing of plastic waste, 47.3% of respondents admitted throwing it into rivers or lakes, while 34.9% brought the waste home to later dispose of or reuse it. There was no existing waste management system in either commune.

Regarding the management of plastic waste, 48.5% of respondents indicated that they either burn it at their house or in open public spaces, while

13.2% of respondents throw plastic waste into the nearby canals or rivers. A greater number of households throw plastic waste into rivers in *Roka Ar* Commune than in *Kang Ta Noeng* Commune. Overall 6.0% of respondents reported that they dump plastic waste on low lying land near their houses. Only 3.4% of respondents bring plastic waste to public collection points.

Most respondents expressed concern about future environmental problems if the current waste management situation continues without any government intervention. Many (55.3%) suggested the more regular collection of waste; 25.5% suggested that public dumping sites need to be provided close to the village; while 9.4% suggested a need for public education and training. The research activities found that people will continue to use plastic, and then burn it or dispose of waste in the river or low lying areas if no alternative waste management system is provided.

People tended to pay less than 500 riels (12.5 cents) for one plastic bag and considered this to be the maximum price they would be willing to pay. This price needs to be set carefully. If it is too low, it will be ineffective in reducing plastic bag consumption. Respondents indicated that they would be willing to participate in a program to separate plastic waste for recycling. Recycling may help to conserve natural resources and protect wildlife by properly reducing consumption, separating and collecting plastic waste instead of burning or burying it in the dumping site in the village.

The consumption of plastic bags will not be reduced if current knowledge, attitudes and practices of people in rural riverine communities are not responded to. Thus, the RGoC should expand the policy of charging a fee for

the use of plastic bags to include small retailers in rural communities nationwide. To support the RGoC's decision making, a further study assessing the effectiveness of the current policy of charging a price on plastic bags should be conducted in future research.

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Climate vulnerability, agricultural dependency and climate change adaptation in rural Cambodia: a case study in Tramkak District, Takeo Province

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សង្ខិត្តន័យ

ប្រមាណ ៧៦% នៃប្រជាជនកម្ពុជារស់នៅទីជនបទ និងតំបន់ដាច់ស្រយាល ហើយ ចិញ្ចឹមជីវិតដោយធ្វើស្រែចម្ការពឹងលើទឹកភ្លៀង។ ប៉ុន្តានឆ្នាំចុងក្រោយនេះ វិស័យ កសិកម្មបានទទួលនូវផលប៉ះពាល់ជាអវិជ្ជមានពីការប្រែប្រួលអាកាសធាតុ។ ការ ស្រាវជ្រាវនេះវាយតម្លៃភាពងាយរងគ្រោះដោយការប្រែប្រួលអាកាសធាតុ ដែលអ្នក ស្រែបានជួបប្រទះ វាយតម្លៃការអនុវត្តការបន្សាំខ្លួន និងពិចារណាអំពីរបៀបដែល កសិករចូលរួមក្នុងការបន្សាំទៅនឹងការប្រែប្រួលអាកាសធាតុនៅខេត្តតាកែវ ប្រទេស កម្ពុជា។ របកគំហើញនៃការសិក្សាស្រាវជ្រាវបានបង្ហាញថា៖ (១) ភាពងាយរងគ្រោះ ពីការប្រែប្រួលអាកាសធាតុរបស់កសិករមានកម្រិតពីមធ្យមទៅខ្ពស់ (ភាពប្រស ឬវេវទ យិតភាព ០.៧៨ ភាពប្រឈម ០.៥៨ និងសមត្ថភាពបន្សាំ ០.៤២)។ ប្រជាកសិករ បានទទួលនូវវាការប្រែប្រួលអាកាសធាតុកម្រិតខ្ពស់ ដ៏ងការប្រឈមនឹងការប្រែប្រួល អាកាសធាតុមានកម្រិតមធ្យម។ កសិករភាគច្រើនយល់ឃើញថា ពួកគាត់បានរង គ្រោះដោយការប្រែប្រួលអាកាសធាតុ។ ឧទាហរណ៍ កសិករបានសង្កេតឃើញការប្រែ ប្រួលនៃកម្រិតទឹក និងការធ្លាក់ភ្លៀងមិនទៀង ទាត់ ដែលនាំឱ្យប៉ះពាល់ដល់ប្រព័ន្ធ ជលសាស្ត្រ។ លើសពីនេះ សមត្ថភាពបន្សាំរបស់កសិករនៅមានកម្រិតទាប។ (២)

ការអនុវត្តការសម្របខ្លួនទៅនឹងការប្រែប្រួលអាកាសធាតុរបស់កសិករមានត្រឹមតែវិធី សាស្ត្រធ្វើស្រែបីយ៉ាងប៉ុណ្ណោះគឺ ការព្រួសគ្រាប់ពូជស្រូវ ការស្ទូងស្រូវ និងការភ្លួរដីឲ្យ សើម។ លើសពីនេះ កសិករនៅតែប្រើវិធីដាំដុះតាមបែបប្រពៃណី និងការផ្លាស់ប្ដូរ ពេលវេលានៃវដ្ដដំណាំ ដោយសារតែការផ្លាស់ប្ដូររបបទឹកភ្លៀង។ (៣) កត្តារួមផ្សំសំ ខាន់ៗ ចំនួនបួន ដែលលើកទឹកចិត្តកសិករឲ្យចូលរួមក្នុងសកម្មភាពបន្ស៊ាំនឹងការប្រែ ប្រួលអាកាសធាតុ គឺការរៀនចំណេះដឹង ការទទួលបានជំនាញថ្មីៗ ការទទួលបានការ អញ្ជើញចូលរួមសកម្មភាព និងការចូលជាសមាជិកសហគមន៍។ លើសពីនេះ កសិករ ទទួលបានឱកាសផ្លាស់ប្ដូរចំណេះដឹងជាមួយសហគមន៍ដទៃ និងទទួលបានការគាំទ្រពី អង្គការក្រៅរដ្ឋាភិបាល និងរាជរដ្ឋាភិបាល។

Abstract

Around 76% of Cambodian people live in either rural or remote areas and are largely dependent on rain-fed agricultural production for subsistence livelihoods. In recent years, the agricultural sector has been negatively impacted by climate change. This study assesses climate vulnerability as experienced by rice farmers, assesses adaptation practices, and considers how farmers are involved in climate change adaptation in Takeo Province, Cambodia. It was found that: (1) climate vulnerability experienced by rice farmers in the study area ranged from medium to high (sensitivity 0.78, exposure 0.58, and adaptive capacity 0.42). Rice farmers have become highly sensitized and moderately exposed to climate change. The majority of the rice farmers perceived that they had become vulnerable to climate change. For instance, farmers had observed changes in water levels and irregular rainfall, affecting irrigation systems. Moreover, the adaptive capacity of rice farmers remained low. (2) Climate change adaptation practices of rice farmers were limited to three methods of rice cultivation, including broadcast sowing of rice seedlings, planting rice seedlings, and constructing wetlands. Additionally, the rice farmers still deployed traditional cultivation methods; while changing the timing of crop cycles due to changing rainfall patterns. (3) Four key contributors to encouraging rice farmers to participate in climate change adaptation activities include: improving knowledge; gaining new skills, receiving

invitation letters to attend activities; and being a member of a community. In addition, rice farmers accessed opportunities to exchange knowledge with other communities and have received support from NGOs and the Royal Government of Cambodia.

Keywords: climate vulnerability, climate change adaptation, agriculture dependency, livelihoods

Introduction

Climate change has been acknowledged as a global issue of concern that requires joint national and international action. Cambodia is among the countries expected to be severely impacted by extreme weather, ranking as the 12th most vulnerable country globally between 1998 and 2018 (Eckstein et al., 2019), and the 19th most vulnerable between 1998 and 2017 (USAID, 2019). Climate change has become an increasingly concerning issue, especially concerning agricultural production (NCCC, 2013). At the same time, agriculture has contributed significantly to Cambodia's economic growth, job creation, poverty eradication, and food security for both rural and urban populations (Thomas et al., 2013). Cambodia has already experienced significant impacts from climate change, such as floods, droughts, typhoons and windstorms. Between 1996 and 2019, flooding caused 1,150 deaths, while lightning resulted in 1,031 deaths. Additionally, storms damaged 38,190 houses, while floods damaged 33,705 houses (NCDM, 2019).

Cambodia's high level of vulnerability to natural disasters is characterized by the frequency and intensity of extreme climatic events, and also increased climatic variability (Sour et al., 2014). Temperatures in Cambodia are expected to rise by between 0.5 C and 1.5 C by 2050 and by 3.1°C by 2090

(World Bank, 2021). Annual precipitation is expected to increase to around 1,400mm and 4,000mm in central low land and coastal zone regions, respectively (Heng & Pich, 2009). Increasing temperatures and precipitation are expected to reduce rainfall in the dry season, resulting in longer dry spells in the wet season, and an increase in the frequency of floods and droughts (Chem & Kim, 2013). For instance, a study on household vulnerability to climate change in *Kampong Spue* Province found that households experience stumpy exposure to climate impacts, moderate sensitivity, and low adaptive capacity. The study suggested that over half of the sampled population experienced average to very high vulnerability to climate change (Nyda et al., 2016).

In 2019, around 76% of the 16.5 million people living in Cambodia resided in rural areas and were largely dependent on agriculture activities for their livelihoods (World Bank, 2021). While the contribution of the agriculture sector to the Gross Domestic Product (GDP) reduced from 30.7% to 23.5% between 2014 and 2018 due to the growth of the manufacturing, construction, and services sectors, it is still significant (MoP, 2019). For instance, 53.4% of the national workforce is engaged in agricultural, forestry, and fishing activities (MoP, 2020). In 2016, rice cultivation alone occupied 3.11 million ha of land, with a total production of 9.95 million tons. Subsidiary crops such as vegetables, cassava, and maize occupied were cultivated on 93,200 ha of land producing 16 million tons; while other commodities such as soybean, peanuts, sesame, and sugar cane, were cultivated on 101,530 ha, producing 0.86 million tons (MAFF, 2017).

In contrast to this contribution, climate change has profoundly impacted Cambodia, especially the rice sector. For instance, between 1996 and 2019, drought had damaged more than one million hectares of rice production, whilst floods destroyed over two million hectares (NCDM, 2019). In 2012, drought impacted 11 out of 24 provinces, affecting 14,190 ha of rice paddies and destroying 3,151 ha of land (NCDM, 2014). Recently, flooding severely affected 10 provinces comprising 238 communes across 62 districts. Consequently, 93,319 households, were impacted with 11,579 being displaced. Approximately 51,824 ha of agricultural land was impacted (PCDM, 2019). Roughly 75% of Cambodian households owned less than 1 ha of agricultural land, with a further 17% owning between 1 and 3 ha (MoP, 2020). This exacerbates the level of climate risks experienced.

Increasingly frequent natural disasters and irregular results in damage to agricultural production, particularly rice cultivation disproportionally impact the vulnerable rural poor. This is particularly the case for rice farmers who have preserved traditional rain-fed methods that are dependent on climate-sensitive water resources. These farmers have limited livelihood diversity and poor access to assets to cope with disasters is remarkably poor (Bandeth et al., 2011). To respond effectively to extreme climatic events, it is important to understand their impact on vulnerable rural poor communities and their adaptive capacity. Enhancing adaptation practices required engaged participation from rural people, especially rice farmers, who have a high interest in responding to the serious impacts of change (UNDP, 2013).

Yet, the rural poor communities in Cambodia have limited adaptive capacity and until now, have lacked information and resources to support adaptation practices (UNDP, 2013). A low resilience to climate change impacts because of a shortage of financial resources (Phirun et al., 2014) and a lack of full participation from the community members (Sok et al., 2015). This exacerbates the situation for those in the country that are most vulnerable to these impacts (Phirun, 2013). Consequently, initiatives such as the Strategic Program for Climate Resilience led by the National Council for Sustainable Development have recommended increased local participation in the design and implementation of adaptation programs to better mobilize support for long-term community adaptation projects (MoE, 2013). With the context in mind, this research aims to 1) assess the vulnerability of rice farmers to climate change, 2) examine existing adaptation practices, and 3) identify key contributing factors that encourage farmers to become involved in climate change adaptation activities in Takeo Province, Cambodia.

Vulnerability and adaptation: a conceptual framework

Cambodia has encountered a high incidence of natural disasters including floods and drought, due to the negative impacts of climate changes in terms of both exposure and vulnerability. The country is considered to be one of the most disaster-prone counties in Southeast Asia (World Bank, 2021) and is highly vulnerable to these impacts due to a dependency on climate-sensitive sectors such as agriculture, water resources, forestry, fisheries, and tourism (IPCC, 2014). Climate change impacts manifest as a consistent trend of rising temperatures and more frequent and intense extreme weather events such

as cyclones, floods, hailstorms, and droughts (ADB, 2009). Efforts to adapt to these impacts have required comprehensive actions to reduce climate vulnerability.

The Intergovernmental Panel on Climate Change defines climate vulnerability as a function of the character, magnitude, and rate of climate variation to which a system is exposed and sensitized beyond its adaptive capacity. Vulnerability comprises three components - exposure, sensitivity, and adaptive capacity (IPCC, 2014). Exposure refers to the nature and degree to which a system experiences significant climatic variation such as droughts, floods, delayed rainfall, flash storms, and temperature surges. Sensitivity refers to the degree to which a system is adversely or beneficially affected by climate-related stimuli. For instance, Cambodian rice farmers may be considered highly sensitive to climate change impacts. Adaptive capacity refers to the ability of a system to adjust to climate change impacts to moderate any potential damage, take advantage of the opportunities it offers, and cope with its consequences (Mackay, 2008).

The concept of adaptation has been widely used in the context of climate change (Bryan et al., 2009) since it was introduced in the early 1990s. At this time, the concept was focused on humans responding to environmental variability (Adger & Vincent, 2005). Adaptation is defined in many different ways in the literature; however, the IPCC refers to *"the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some*

natural systems, human intervention may facilitate adjustment to the expected climate and its effects (IPCC, 2014, p. 1758).

Figure 1. Conceptual framework
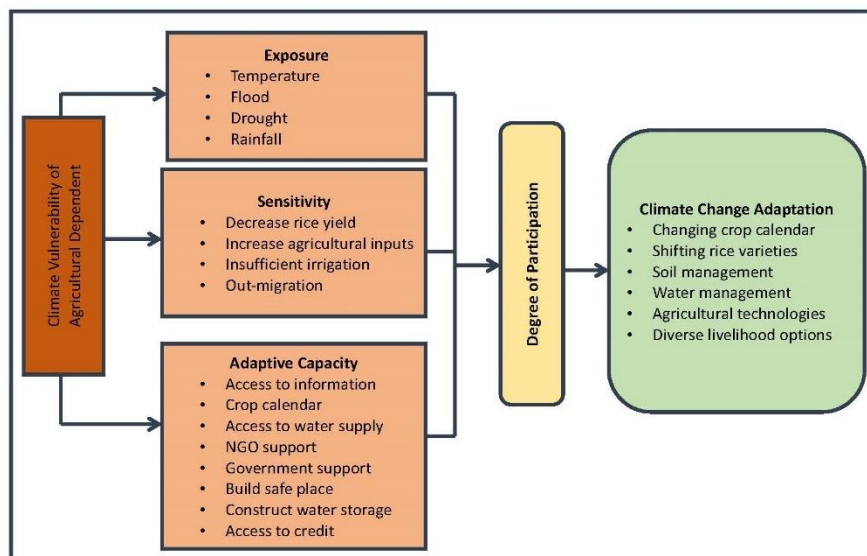
In the context of climate change, various methods can build the adaptive capacity to the serious impacts of climate change. Human livelihood systems, economic and natural resources, social networks, institutions, governance, and technology are the critical tools that may be used to support this capacity (Adger et al., 2007). Foster climate change adaptation practices, required the participation of the local people to be taken into account. For instance, Samaddar et al. (2020) highlighted tangible improvements in livelihood security resulting from engaged participation that enhances the skills of local people to operate effectively without acquiring external resources. Participation is an integral part of climate change adaptation initiatives, which are a relatively new agenda for many Cambodian people. This presents a

challenge for practitioners who are required to motivate local people to engage in meaningful, constructive, and sustainable activities and interactions to bring about positive changes (CCCA, 2014).

Study Area and Research Methods

This research applied both exploratory and descriptive methodologies. An exploratory methodology has been used to ascertain the degree of climate change vulnerability experienced by those dependent on agricultural livelihoods in Takeo province. A descriptive approach was used to elaborate on adaptation practices that motivate the participation of the farmers in responding to climate vulnerability. As outlined in the conceptual framework, the study analyzes the degree of sensitivity, exposure, and adaptive capacity concerning climate vulnerability in a specific study area. The indicators of each of these attributes are listed in Table 1.

Both qualitative and quantitative approaches were applied to collect data via a structured questionnaire and semi-structured interview. Before conducting the fieldwork, a desk review was performed by gathering secondary sources and conducting a scoping visit to better understand the situation in the proposed study area. Qualitative analysis was applied to the key informant interviews held with influential stakeholders – including local authorities and NGO staff. The aim was to deepen the understanding of climate change impacts in the study area, the adaptation practices that have been applied, and how farmers have been involved in these practices. Quantitative analysis was used to present data on climate change vulnerability, adaptation practices, and key factors that encourage the farmer

participation obtained via the household interviews. This analysis took into account the livelihood and socio-economic status of farmers.

Table 1. Vulnerability indicators in this study

Exposure indicators	Measurement
Degree to which rice farmers experienced (1) increasing temperatures; (2) decreasing water levels; (3) more frequent flooding; (4) more frequent drought; (5) more frequent flash storms; and (6) irregular rainfall.	**Social scale:** 1=Very low; 2=Low; 3=Moderate; 4=High; 5=Very high
Sensitivity Indicators	**Measurement**
Degree to which rice farmers experienced (1) impacts from a flash storm; (2) impacts from lightening leading to death; (3) impacts on rice paddies; (4) decreasing rice yields; (5) damage to equipment; (6) increased fertilizer use; (7) increasing insecticide use; (8) water scarcity; (9) a lack irrigation infrastructure; and (10) increased migration.	**Social scale:** 1=Very low; 2=Low; 3=Moderate; 4=High; 5=Very high
Adaptive capacity indicators	**Measurement**
The degree to which rice farmers (1) received climatic information; (2) changed crop cycles; (3) changed cultivation area; (4) accessed irrigation systems; (5) accessed credit; (6) received government or NGO support; (7) changed the location of cultivation; (8) established onsite water storages; and (9) constructing a safe place from flooding.	**Social scale:** 1=Very low; 2=Low; 3=Moderate; 4=High; 5=Very high

In 2020, Takeo province comprised 208,698 households and a population of 893,582 people (68% female), around 70% of whom lived in rural areas (MoP, 2020). In 2017, a total of 102,226 ha of land was cultivated, with 1,790 ha damaged (MoAFF, 2018). This province is classified as having medium

susceptibility to droughts and high susceptibility to flooding (World Bank, 2017). *Osaray* Commune in *Tramkak* District was selected as the study area.

Figure 2. Study location
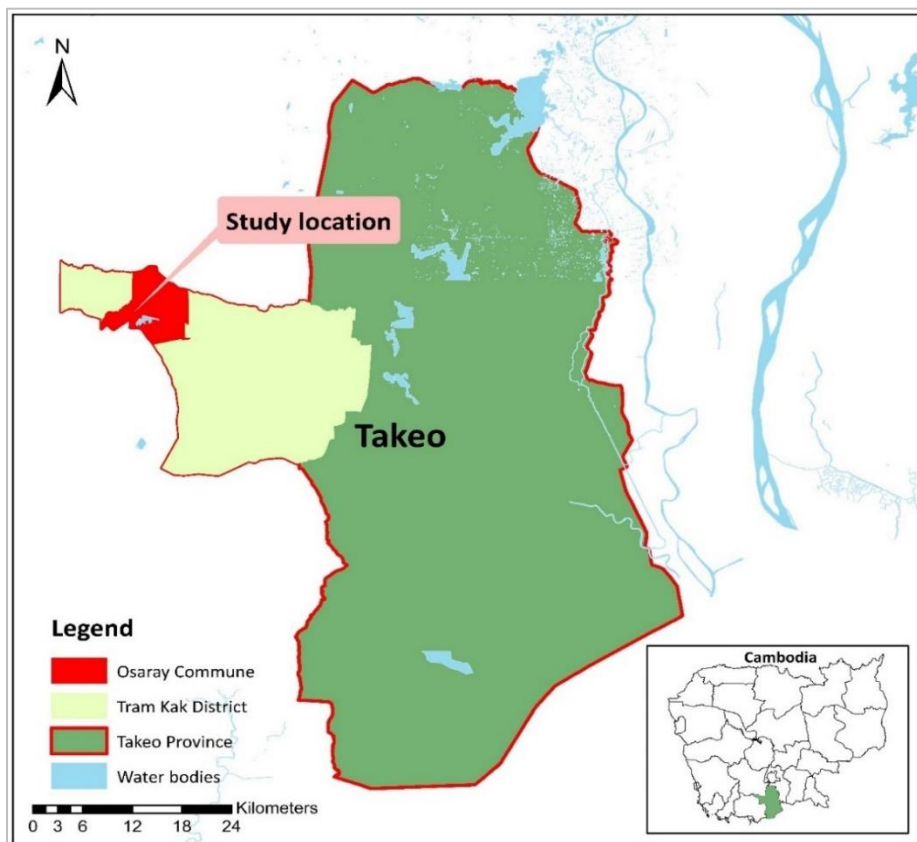
The commune comprised 12 villages with 3,293 households and a population of 13,549 people (MoP, 2020). Over half of this population (6,443 people) are dependent on agriculture for their livelihood and food security, with 5,993 people engaging in rice farming as a primary occupation. In 2014, *Osaray* Commune had a total of 2,886 ha of rice paddies under cultivation producing a total yield of 10,176 tons. However, this activity is affected by

climate-related impacts such as lightning, droughts and in particular floods (DoP, 2015).

The study area was selected for three reasons: (1) Of the ten communes in *Tramkak* District, *Osaray* Commune is considered the most adversely affected by climate change impacts; (2) The traditionally high yield of rice production has recently seen a significant decrease; and (3) the commune is a target area for NGO activities focused on climate change awareness-raising and adaptive capacity building in response to climate vulnerability. Research participants were samples from three out of the twelve villages in the commune, namely *Tropeang Doung Tuek*, *Sokroam*, and *Domnak Khlong*. These villages were selected based on observations about access to water resources, such as reservoirs and natural streams to support agricultural production. A systematic random sampling approach was applied to recruit households to the interviewee cohort.

Yamane's (1967) formula (below) was used to select an appropriate sample size with a 9% of margin of error as shown in Table 2. In total 106 interviewees were selected (31 families in *Tropeang Doung Tuek* Village, 46 in *Sokroam* Village, and 29 families in *Domnak Khlong* Village) from 718 households. To randomly sample respondents, the researcher identified a starting point at the house of the village chief and followed the right side of the road interviewing every fifth household. The head of the household was selected as the interviewee when available, however, they were replaced with another knowledgeable person in the house if they were not.

$$n = \frac{N}{1 + N(e^2)}$$

Table 2. Study areas and sample size

Study site (village)	Population	Number of sample size
Tropeang Doung Tuek	210	31
Sokroam	312	46
Domnak Khlong	196	29
Total	**718**	**106**

Data analysis was conducted using the Statistical Package for Social Sciences and Excel. Both descriptive and inferential statistical analyses were applied for processing, collating, and analyzing the data. To understand the poverty profile of the farmers in each village, a sample t-test was applied to determine if there was any significant difference between household incomes derived from the survey and the World Bank poverty threshold. In addition, multiple regression was applied to determine the significance of the relationship between a range of other attributes and household income; and whether these associations contributed toward participation in building climate resilience in each community.

Chi-squared analysis was used to determine the nature of the correlation between adaptive capacity with poverty status and primary occupation. Income and livelihood conditions are expected to benefit from improved adaptation practices as it enables financial and other resources to be acquired to manage climate vulnerability. Finally, vulnerability to climate change and other key contributors to promoting participation in climate change adaptation activities were transformed into a five-point weighted average index (0.00-0.20=Very low; 0.21-0.40=Low; 0.41-0.60=Moderate; 0.61-0.80=High; and 0.81-1.00=Very high).

Results and Findings
Livelihood and socioeconomic characteristics

In the study area, rice cultivation was considered to be the main source of livelihood and food security, with labour work as a secondary source of income, and small-scale business as a tertiary but equivalent source of income. Due to the study being remote, 88.7% of respondents were found to be highly dependent on rice production for daily subsistence. Several other agricultural activities, such as planting cash crops including pumpkins, watermelons, corn, and soybeans were also applied but these were predominately used for daily consumption, rather than producing a significant income. Rice cultivation usually commences in early April or May, while cash-crop cultivation is generally used as a livelihood strategy in the dry season once rice harvesting is completed in November or December each year.

Multiple regression analysis was applied to determine the correlation of various factors with daily household income. The resulting correlation, $R^2 = 0.25$; $F(6,96) = 6.730$; *p < 0.05* was derived from including three out of six proposed attributes, which were found to have a significant association with household income. These attributes included the number of income sources, and primary occupation, which correlated positively with household income; and the number of members of the household, which correlated negatively with household income. Another three proposed attributes were found to have no significant correlation with household income. i.e. level of education, age, and quantity of rice produced annually. Attaining a higher level of education is often not well-linked to higher income levels from traditional rice farming methods, as these skills are often attained on the job from other

family members. Similarly, annual rice yields did not correlate with household income due to challenges with drought conditions, with insufficient irrigation allocations available for year-round rice cultivation.

Table 3. Key attributes and their correlation with daily household income respondents

Attributes	Unstandardized Coefficients		ß	P-value
	B	Std. Error		
Number of jobs held	0.33	0.13	0.24	**0.010****
Education level	0.04	0.04	0.10	0.290
Number of household members	-0.31	0.07	-0.39	**0.000*****
Age of respondent	0.00	0.01	-0.04	0.670
Number of rice crops per year	-0.65	0.50	-0.11	0.200
Primary occupation	0.21	0.09	0.21	**0.010****

The reason rice farming persisted as a key livelihood activity was because of its value as a cultural obligation inherited from ancestors. Owning agricultural land also enabled households to grow crops for subsistence use in the dry season. Respondents were not only involved in rice production as a livelihood activity, but were also engaged in other income-generating activities, such as poultry, and other livestock raising, as well as planting cash crops. Family members also seek employment in domestic garment factories outside of the village during the dry season, returning when rice cultivation recommences. It was also found that on average households comprised 4.4 members, with 56.6% of respondents belonging to a household with between

4 and 6 people. Most households reported having a high number of aging or young dependents, which had a negative association with increased household income. Usually, household income was generated by either one or two family members only.

A *t*-test was applied to investigate the statistical significance of differences between average household income and the 2015 Cambodian poverty line (0.98 USD per capita per day). It was found that the average income of respondents was significantly higher than this benchmark at 1.46 USD per capita per day, $t(103) = 4.014$, $p = 0.00$). Local livelihoods in the study area may be considered to be diversified – comprising other activities such as planting cash crops, animal husbandry, and labour work in garment factories. Further analysis showed that three quarters (75%) of respondents were able to access an income of more than 2.00 USD per capita per day. The poverty rate in Cambodia has decreased considerably in recent years, although the decline now is more gradual than in the past. For instance, the poverty rate decreased from 47.8% to 13.5% between 2007 and 2014 (ADB, 2014). In the study area, 80.2% of respondents lived above the poverty line defined by the Royal Government of Cambodia.

Vulnerability of farmers to climate change impacts

Figure 3 demonstrates that respondents have been seriously threatened by negative climate change impacts and have experienced high levels of climate vulnerability over the past five years. Respondents indicated a high level of sensitivity (WAI=0.78) to these impacts, as involvement in agricultural production had become constrained due to exposure (WAI=0.58) to climate

change events. At the same time, the adaptive capacity of respondents was found to be considerably limited, with WAI at 0.43.

Figure 3. Weighted average index indicating the climate vulnerability of respondents
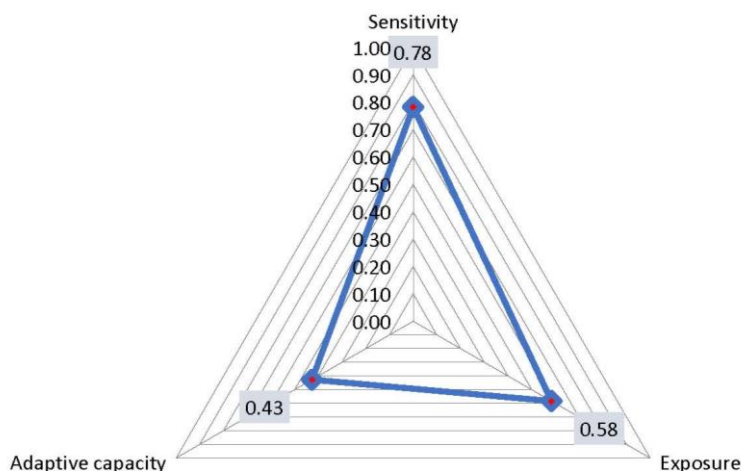
Note: 0.00-0.20=Very low; 0.21-0.40=Low; 0.41-0.60=Moderate; 0.61-0.80=High; and 0.81-1.00=Very high

Table 4 assesses and represents the climate vulnerability of the rice farmers. It also presents the analysis of the seven attributes of the exposure to climate change impacts. Respondents were found to be most commonly exposed to irregular or delayed rainfall (WAI = 0.92 and 0.91, respectively). Very low precipitation levels forced respondents to delay farming activities, which impacted yields. For instance, some rice paddies were left fallow because of water shortages. Beyond the impacts of delayed rainfall, rice yields were found to have continuously declined, while the price obtained for crops fluctuated. It was observed that while the annual rainy season has typically occurred between late April and September, recently rain events have been

delayed until rainfall in August or September, even as late as October in some years. The season has become shorter and later than previously. This delay is the primary cause of decreases in water levels in the study area, with dykes and ponds drying up.

Other challenging exposure attributes, included increasing temperatures, water shortages, fewer unexpected flood events and increases in unexpected droughts WAI = 0.78, 0.81, 0.82, and 0.89, respectively. Conversely, exposure to flash storms and high winds was less significant. Around 83% of respondents perceived that temperatures had increased, unexpected flood events had decreased, and unexpected drought had increased, rainfall had been delayed over the past five years. This result aligns with a series of severe drought events that occurred between 2013 and 2016, which reduce rice yields, increased the level of insect damage to crops, and required respondents to leave rice paddies fallow. Overall, 97% of respondents reported that drought was the most significant challenge for those dependent on rain-fed agriculture for their livelihoods.

Sensitivity to climate change was indicated by 10 attributes (Table 4), with two attributes found to have very high sensitivity, namely a lack of water supply for rice cultivation (WAI=0.82) and damaged rice paddies (WAI=0.81). Respondents also indicated a high level of sensitivity to three other attributes were indicated, namely low rice yields (WAI=0.80), a lack of water for irrigation (WAI=0.79), and increase out-migration for employment (WAI=0.64). These results are explained by delayed rainfall experienced in the study area and a high level of dependence on rain-fed agricultural systems.

Respondents did not report high sensitivity to flash storms or thunder, nor were they sensitive to the need for additional farming inputs such as fertilizers or pesticides.

Table 4. Climate change vulnerability assessment in the study area

Exposure	WAI	Sensitivity	WAI	Adaptive capacity	WAI
Hotter temperatures	0.78	Violent storms	0.28	Access to climatic information	0.48
Decreased water levels	0.81	Thunder leading to death	0.28	Change crop cycles	0.64
Decreases in unexpected flooding	0.82	Damaged rice paddies	0.81	Number of rice crops per year	0.45
Increase in unexpected drought	0.89	Low rice yield	0.80	Access to irrigation	0.42
Frequency of windstorms	0.35	Damaged equipment	0.60	Access to credit or crop insurance	0.66
Irregular rainfall	0.92	Increased fertilizer use	0.45	NGO support	0.42
Delayed rainfall	0.91	Increase pesticide use	0.38	Government support	0.38
		Lack of water supply	0.82	Changed farmland	0.32
		Lack of water for irrigation	0.79	Construct water storage reservoirs	0.43
		Increase out-migration	0.64	Building protection dykes (flood)	0.28
				Build a safe place (flood)	0.21

Note: 0.00-0.20=Very low; 0.21-0.40=Low; 0.41-0.60=Moderate; 0.61-0.80=High; and 0.81-1.00=Very high.

Almost 70% of respondents indicated a medium or very high sensitivity to climate change impacts, particularly concerning damages to rice paddies and decreasing rice yields. The vast majority (90%) of respondents suggested that damage to rice paddies was a major climate change impact, resulting in a reduction of yield of between 1 and 1.3 tons per ha per annum only. In total, it was reported that around 4,000 ha of cultivated paddy rice was destroyed due to climate change, particularly drought events. Drought alone was reported to have affected around 3,556 ha of rice paddies, while flood affect around 1,995 ha. Drought events were revealed to be the most significant impact and were linked to other attributes such as decreases in water levels,

and a lack of irrigation, which was experienced by 85% of respondents. A low adaptive capacity to manage these serious impacts was also reported, with many respondents (67.6%) becoming indebted to outstanding loans.

The adaptive capacity of respondents was also reported to be weak (Table 4), with nine out of 11 attributes being ranked from low to moderate. Only two attributes were considered to be strong, namely, access to finance (WAI=0.66) and changes to crop cycles (WAI=0.64). Flood Infrastructure attributes such as building safe places to better manage flood events (WAI=0.21) and building flood protection dykes (WAI=0.28) ranked lowly as no serious flood events had been experienced in the study area since 2012. Few respondents had constructed small water storage reservoirs as an alternative water supply (WAI=0.43). Additionally, changing farmland or crop rotation was not seriously taken into account (WAI=0.32) while support from NGOs and government agencies was ranked as moderate (WAI=0.42) and low (WAI=0.38), respectively. Respondents were also limited to one crop per annum due to either limitation in water supply or access to irrigation.

Only a minority (18.7%) of respondents perceived that they possessed a strong adaptive capacity to deal with climate change impacts. They were aware of the need to change how they managed crop cycles and could access credit or crop insurance from microfinance institutions (MFIs), yet the majority of respondents access loans to purchase agricultural inputs such as fertilizers, pesticides and labour to plant crops, which needed to be secured with collateral in their land. Some households sent family members away to

jobs in the garment factories and construction work to raise additional income to support the family and conduct ongoing agricultural activities.

The key informant interviews revealed that local authorities had played a crucial role in responding to climate change impacts through facilitating the development of climate action plans and integrating adaptation activities into the commune investment and development plans. These plans incorporate issues raised at the village level and tend to be mostly well integrated but are rarely supported by the development partners, especially the government, as the plans are principally focused on building physical infrastructure and providing public services. Of interest are the efforts that had been made by commune authorities to work collaboratively with local NGOs to raise awareness on climate impacts and adaptation strategies [personal communication with *Tropeang Doung Tuek* village chief, 12 June 2016].

However, as local NGO partners have no long-term execution and implementation strategies, consequently it is difficult for a community to prepare to implement the community activities by themselves when projects end. Communities often failed to take ownership of planning and implementation of activities, when NGO programs are phased out [personal communication with NGO officer, 12 June 2016]. Limitations in the capacity of the community leaders, and the commitment and willingness of the community committee to continue to allocate resources (especially financial resources) act as significant constraints to ongoing climate adaptation activities. A lack of government support to continue formulating plans, implementing activities, and monitoring and evaluating results exacerbates

the absence of a long-term plan to address climate vulnerability [personal communication with the *Osaray* Commune Council, 10 June 2016).

Respondents are discouraged by limitations in knowledge, support, and appropriate government investment in this capacity via the commune plan. Although NGOs play a vital role in partnership with the government to address local issues, short-term project implementation is unlikely to result in the sustainable capacity of respondents to adapt to climate change impacts [personal communication with an NGO official in *Tramkak* District, 11 June 2016].

Climate change adaptation practices

Water management strategies and irrigation systems play a vital role in ensuring the respondents have sufficient water for agricultural purposes when dealing with climate change impacts. As ensuring there are sufficient irrigation resource is a key requirement for this end in the study area, water reservoirs capable of storing water for agriculture are a consideration. However, the function of these reservoirs is challenged because of irregular rainfall. Table 5 presents the results of a chi-squared *(X^2)* test that demonstrates a significant correlation exists between access to irrigation and the degree of climate vulnerability experienced by respondents, X^2 (*1, N = 105) = 16.39, p = 0.000*. Respondents who are not able to access sufficient irrigation were found to have very high climate vulnerability when compared to those who do. This suggests that adaptation practices focused on developing irrigation infrastructure across the entire commune may be effective in reducing climate vulnerability and adapting to climate change.

Because of changing rainfall patterns and water shortage in the commune, respondents had applied various adaptation strategies to respond to climate change impacts. For instance, respondents reported that they had both broadcast rice seeds, planted rice seedlings, and constructed wetlands for rice cultivation. Before broadcasting and planting seed, respondents had applied soil management techniques including ploughing rice fields to improve soil quality soil and reduce the prevalence of insects. Other methods applied included selecting new rice varieties and changing crop cycles.

Table 5. Association between climate vulnerability and access to irrigation

Attributes	Access to the irrigation			X^2	P-*value*
Degree of climate vulnerability of respondents		No	Yes	Total		
	Low	6	15	21	16.39	**0.000*****
	High	64	21	85		
	Total	70	36	106		

Note: X^2(1, $N = 105$) = 16.39; **$p = 0.000$**, *p < 0.05; **p < 0.03; ***p = 0.000; Significant variables are shown in **bold**.

Shifting long-term rice varieties to medium-, and short-term rice varieties produced significant improvements for respondents. However, overall, the adaptation activities that were implemented were not sufficient in overcoming the continued use of traditional cultivation methods. These approaches are highly sensitive to climate impacts and constrain the capacity of respondents. Few interviewees had applied modern agricultural techniques that enable enhanced adaptation to climate change impacts. For instance, only 6.9% of the respondents had applied crop rotation techniques; 0.9% had applied integrated rice farming; 0.4% had applied water management strategies to optimise groundwater usage, and 0.4% of

respondents had applied the system of rice intensification principles to their rice paddies.

Climate adaptation projects should consider the need to strengthen leadership capacities within communities including the identification of climate risks; mapping of available resources; planning; engaging participation; and monitoring and evaluating outcomes. Moreover, adaptation projects should also consider how improved knowledge may be transferred to communities. This includes a focus on selecting appropriate rice varieties; producing rice seedlings with the capacity to cope with variable climatic conditions; rice cultivation methods; maintaining irrigation systems for sustainable water resource management; land use planning; value-adding; and sharing accurate and reliable knowledge about weather conditions and the lessons learned from the occurrence of natural disasters, such droughts and flash-storms. Additionally, the diversification of livelihood options is central to developing a capacity to cope with climate change impacts. When respondents can utilize their resources for responding to damages, they are less likely to be trapped within a cycle of indebtedness and poverty.

To determine the significance of the relationship between adaptive capacity and poverty status, a chi-squared analysis was conducted. No significant association between poverty status and adaptive capacity was found, X^2 (1, *N* = 106) = 0.447, *p > 0.05*. The income accessed by respondents was found to be derived mainly from on-farm sources (rice cultivation, horticulture, and livestock raising), and was highly vulnerable to negative climate change impacts. Villages situated far away from irrigation systems, i.e.

Sokrom and *Damnak Khlong*, were extremely affected by drought conditions. Both poor and non-poor respondents were highly sensitive to this climate variability.

Table 6. Relationship between adaptive capacity, poverty status, and primary income source

Attributes		Adaptive capacity			X^2	P-*value*
		Weak	High	Total		
a. Poverty status	Below	34	6	40	0.44	0.5040
	Above	59	7	66		
	Total	93	13	106		
b. Primary income source	On-farm	86	9	95	6.23	*0.010*****
	Off-farm	7	4	11		
	Total	93	13	106		

Note: a. $X^2(1, N = 106) = 0.447$; *P = 0.504*; **b**. $X^2(1, N = 106) = 6.625$; ***P = 0.01*** * $p < 0.05$; ** $p < 0.03$; *** $p=0.000$; Significant correlations are indicated in **bold**.

An additional chi-squared analysis illustrated that a significant relationship between adaptive capacity and primary occupation exists, especially for those who engage in on-farm activities as a primary occupation, $X^2(1, N = 106) = 6.625$, *$p < 0.05$*. These respondents had a weaker adaptive capacity than those with access to off-farm income. For instance, respondents with access to off-farm employment were more likely to be able to respond to climate change impacts. Overall, the daily household income of respondents was around USD 2.00 per capita, which is slightly higher than the national poverty line. For those dependent on agricultural production only, this income is likely to decrease rather than increase, when faced with the threat of natural disasters.

Participation in climate change adaptation

Climate change adaptation is a new agenda for many Cambodian people. Motivating engagement in this agenda is still a challenge. Local participation is vital for ensuring adaptation practices are representative of the concerns of the community. This may be achieved via building capacity in policy-making, planning, impact assessment, social mapping, resource mobilization, and advocacy about climate change. Opportunities to be engaged in community meetings that involve the active participation of community members in developing proposals for local authorities (commune councils) and development partners are required, as are opportunities to become organizers and leaders of such events. For these reasons, the level of participation in climate change adaptation activities remains a concern.

Thus, logistic regression was used to determine the motivation factors that significantly influence the participation of respondents in climate change adaptation activities. Four attributes (improving knowledge, receiving an invitation, being a member of a community, and accessing new skills) were found to have a significant correlation with motivation to participate, $R^2 = 0.66$, $F(9, 96) = 20.605$; $p < 0.05$. Respondents indicated that as a result of participation, they had likely improved their knowledge and been equipped with new skills. In this sense, participation was a crucial part of developing adaptive capacity. NGOs had worked in villages to provide training on how to manage water, cultivate rice sustainably, manage soil, and select appropriate rice varieties to cope with climate change impacts. Respondents were also provided with training on climate change mitigation and adaptation,

convening community meetings to identify problems, and identifying solutions [personal communication with an NGO official in Tramkak district, 11 June 2016]. Other factors that enhance community participation in climate adaptation practices were found to include receiving a personal invitation to become involved, and being part of a community.

Table 7. Key contributors to motivating rice farmers to participate in climate change adaptation

Attributes	Unstandardized Coefficients		Beta	*P-value*
	B	Std. Error		
Improved knowledge	0.37	0.08	0.42	*0.000****
Obtain community support	0.20	0.15	0.09	0.19
Accessed community resources	-0.01	0.08	0.00	0.94
Increased rice yield	-0.01	0.09	-0.01	0.93
Received an invitation	0.43	0.07	0.44	*0.000****
Became a community member	-0.25	0.11	-0.17	*0.030**
Received government support	0.04	0.07	0.04	0.59
Received NGO support	-0.05	0.08	-0.05	0.52
Equipped with a new skill	0.33	0.08	0.38	*0.000****

Note: R^2 = 0.66, F (9, 96) = 20.605; *$p < 0.05$; **$p < 0.03$; *** $p = 0.000$; Significant correlations are indicated in **bold**.

For instance, more than half of the respondents who participated in activities did not have essential roles in meeting as an organizer or facilitator. They had been invited to join events but were not closely involved. Interestingly, of the one-third of participants invited to discuss issues related to climate change and raise them with development partners, few were assigned to important roles as decision-makers, planners (5.3%), or on the

event organizing committees (2.0%). While participation is a critical requirement for building adaptive capacity, the frequency of participation of respondents was very low as they had concentrated on daily household income-generation, rather than activities. Commune investment plans and NGO support are typically intended to build capacity to cope with climate change impacts. In general, it may be observed that commune council activities focused on building physical infrastructures and livelihood development; while NGOs had support awareness-raising, and developing knowledge, and skills.

Discussion

Cambodia remains highly vulnerable to natural disasters, particularly floods, droughts, and windstorms due to the negative impacts of climate change (Sour et al., 2014). Rural communities face high vulnerability to climate change characterised by three factors - sensitivity, exposure, and adaptive capacity. In the study area, respondents have been exposed to climate change impacts such as irregular rainfall, frequent flooding, droughts, and flash storms that had seriously impacted rice production over the past five years. Yet, traditional rice production systems are high sensitivity to climate variability. Adaptive capacity in this context was perceived to be relatively low and long-term support from stakeholders such as government agencies and development partners remains uncertain.

Local (commune) development planning focuses more on physical infrastructure such as roads, rather than supporting climate change adaptation activities, especially those linked to household livelihoods

[personal communication with *Osaray* commune council, 10 June 2016]. NGOs implement short term projects to build adaptive capacity related to agricultural production, however, they are limited in their scope and often fail to sustain an ongoing response to deal with serious climate change impacts. Meanwhile, interviewees were observed to have some capacity to access information about climate change, crop insurance, the capacity to produce one crop of rice per year; yet were constrained by insufficient irrigation infrastructure, and limited access to NGO and government support [personal communication with an NGO official in *Tramkak* district, 11 June 2016]. This left interviewees with a limited skills base with which to address climate change impacts.

If the interviewees were able to further diversify agricultural production methods, they would save a greater adaptive capacity. Despite changing crop cycles and selecting more appropriate rice varieties, villagers will tend to apply traditional rice cultivation methods. For instance, broadcasting seeds by default as they are dependent on rain-fed irrigation. Achieving changes to climate adaptation practices required capital and the full engagement of community members (Phirun et al., 2014; Sok et al., 2015). Although a large reservoir and irrigation system is located close to the commune, it is not sufficient irrigation to respond to the needs of all those who require water resources for adapted rice production practices and also has a constrained capacity due to variable rainfall.

Selecting new crop varieties and planting dates, and increasing fertilizer use were the main adaptation methods available to interviewees (Abid et al.,

2014). For instance, changing from long-term rice crops to medium or short-term rice varieties was found to be a significant approach to coping with climate change impacts. Consequently, 23.0% and 31.7% of interview respondents had used short-term and medium-term rice varieties, respectively. Many farmers cultivate rice during the rainy season between June-September and harvest between October and December each year. Few interviewees were able to cultivate rice paddies in both the wet and dry and rainy seasons due to a lack of water resources. Those who did were less vulnerable to climate change impacts.

Most farmers broadcast seed (31.9%), rather than planting rice seedlings (31.5%) or constructing wetlands (28.0%). Using the long-term rice varieties resulted in a high sensitivity to climate impacts due to the length of time water resources were required and damage from insects. Beyond selecting shorter-term crop varieties, interviewees revealed that they also shifted planting dates to avoid low rainfall periods, constructed wetlands, and planted rice seedlings instead of broadcasting seeds to cope with climate change. For instance, 45.3% of respondents changed the date they planted crops due to variable rainfall and low water levels early in the rainy season. Interviewees also revealed that they conducted other income-generating activities such as raising poultry and other livestock and planting cash crops to sell at the local market.

Various climate adaptation activities were also implemented by the commune council in collaboration with NGOs to engage local people in building adaptive capacity to cope with climate change. Participation is an

essential component of these activities and people must have the opportunity to be involved in a community need assessment, project design, implementation, monitoring, and evaluation. Further critical appraising ideas, settling shared long-term goals, and contributing resources can also promote the sustainability of these activities. Eliciting meaningful, constructive feedback from participants is required to create interactions that lead to positive long term changes (CCCA, 2014).

Successful participation is characterised by situations where it contributes to tangible livelihood outcomes and develops the skills required for the activities to continue without acquiring external resources (Samaddar et al., 2020). This required developing an understanding of the key motivators of participants. In the study areas, interviewees indicated that they were more likely to participate in activities if they were regularly invited to and the experience involved accessing new knowledge or skills. This was the experience of most interviewees, who had previously attended training, and participated in savings groups facilitated by NGOs in partnership with local authorities. They had also been invited to meetings to define issues, and plan, implement and evaluate projects [personal communication with an NGO official in *Tramkak* district, 11 June 2016]. However, often it can be hard to engage the participation of rice farmers as they are concerned about spending time generating income.

Sometimes, participation is motivated by accessing a per-diem in the short term rather than thinking about a long-term development vision. It is important to reflect on this when considering the four key contributors found

to have encouraged the interviewees to participate in climate change adaptation activities. These include: receiving an invitation to attend a meeting; being a member of a community; being equipped with new skills (such as climate change adaptation techniques); and accessing improved knowledge. The frequency of participation was found to be a factor that required improvement, as infrequent involvement resulted in limited improvements in adaptive capacity. More than half of the respondents were found to have participated in climate adaptation activities within the past two years. However, in most cases, this did not include active and frequent participation. Constraints to participation were identified as low educational attainment and the need to spend time in income-generating activities. Interviewees were motivated by accessing practical information about rice production and marketing. To foster greater participation, local people should be engaged in making decisions about climate change adaptation [personal communication with an NGO official in *Tramkak* district, 11 June 2016].

Conclusion

The study found that the climate vulnerability of interviewees was assessed as medium to high (sensitivity 0.78, exposure 0.58, and adaptive capacity 0.42). This reflects the level of climate impacts that had been experienced in the past five years. Low water levels, irregular rainfall, and insufficient irrigation infrastructure had resulted in significant negative impacts. Moreover, the adaptive capacity of the respondents was also assessed as low, due to a dependence on rain-fed irrigation. Interviewees were found to have altered their cropping cycles, yet were still using long-

term crop varieties. To reduce the climate vulnerability: (i) irrigation systems or small dykes across rice paddies must be constructed and maintained; (ii) training and technical support need to be provided in diversified livelihood options, particularly for off-farm income generation; (iii) the adaptive capacity of a rice farmer in responding to climate change impacts needs to be enhanced with the support of climate change and agricultural experts; (iv) the commune investment plan should focus attention some financial resources on climate change adaptation and livelihood development; and (v) full participation in climate adaptation practices should be encouraged, providing opportunities for local people to take leadership roles.

This study had several limitations related to the timing and budget for conducting the fieldwork. This research did not receive a grant, thus the resources available to support data collection were limited and constrained. The research applied a small sample size to build a case study as was not it was not nationally representative. The results represent only the location of the study. Finally, this study focused primarily on the climate vulnerability of rice farmers, and the adaptation practices and key motivating factors involved in promoting participation in climate change adaptation activities. The researcher did not intend to study the policies of national and local governments in promoting adaptation practices, nor the government budget and policies required to reduce climate vulnerability.

Further research is required to continue to guide the improvement of the adaptive capacity and level of participation of rice farmers in climate change adaptation activities. This research should focus on: (i) the roles of rice

farmers in building adaptive capacity and resilience to climate change impacts; (ii) promoting sustainable livelihoods while considering the context of climate change; and (iii) climate change financing and government policies that may build climate-resilient communities.

Acknowledgements

Author Biography

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The impact of climate change on food security among farmers in a coastal Area of Cambodia: a case study in Banteay Meas District, Kampot Province

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សង្ខិត្តន័យ

គ្រោះមហន្តរាយទាក់ទងទៅនឹងការប្រែប្រួលអាកាសធាតុមានដូចជា ទឹកជំនន់ គ្រោះ
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របស់យើងក្នុងសតវត្សទី៤នេះ។ ការខូចខាតទាំងផ្នែកមើលឃើញនិងទាំងផ្នែក
មើលមិនឃើញមានទំហំខុសៗគ្នាទៅតាមប្រទេសនីមួយៗ។ អត្ថបទនេះមានគោល
បំណងពិនិត្យលើការយល់ឃើញរបស់កសិករទាក់ទងនឹងផលប៉ះពាល់នៃការប្រែប្រួល
អាកាសធាតុទៅលើការធ្វើស្រែ និងផ្តល់នូវយន្តការសមស្របដើម្បីកសាងសមត្ថភាព
បន្ស៊ាំទៅនឹងការប្រែប្រួលអាកាសធាតុនៅកម្រិតមូលដ្ឋាន។ ការស្រាវជ្រាវនេះបាន
ស្ទង់មតិកសិករចំនួន ២១៥នាក់ នៅឃុំចំនួន២ ក្នុងស្រុកបន្ទាយមាស ខេត្តកំពត
ដោយប្រើកម្រងសំណួរដែលបានរៀបចំ។ លទ្ធផលបង្ហាញថា កសិករវែងទទួលរង
នូវឥទ្ធិពលនៃអសន្តិសុខស្បៀងជាញឹកញាប់អស់រយៈច្រើនទសវត្សរ៍មកហើយ។ អ្នក
ភូមិនៅឃុំឆ្លាតចុងស្រង់ងាយប្រឈមនឹងអសន្តិសុខស្បៀង បន្ទាប់ពីគ្រោះធម្មជាតិ
ដូចជាទឹកជំនន់ ខ្យល់ព្យុះ គ្រោះរាំងស្ងួត និងការជ្រៀតចូលនូវសារជាតុប្រៃនៃទឹក
សមុទ្រមកលើដីស្រែជាដើម។ កសិករនៅឃុំបន្ទាយមាសខាងកើតបានដួបប្រទះនឹង

អសន្តិសុខស្បៀង និងភាពក្រីក្រឃ្យូមកហើយ ព្រោះធ្វើស្រែពុំសូវបានផល ដោយសារ ទឹកជំនន់ ខ្យល់ព្យុះ និងកំណើននៃការជ្រៀតចូលនូវទឹកសមុទ្រមកលើដីស្រែ។ ការ ស្រាវជ្រាវក៏បានរកឃើញដែរថា យន្តការបន្ស៉ានៅថ្នាក់មូលដ្ឋានសម្រាប់ដោះស្រាយ បញ្ហាប្រែប្រួលអាកាសធាតុអាចជួយបង្កើនសន្តិសុខស្បៀងបាន។ ជាងនេះទៅទៀត ស្ថានប័ន៣ក់ព័ន្ធសំខាន់ៗ ទាំងថ្នាក់ជាតិ និងទាំងថ្នាក់ក្រោមជាតិ គួរមានសកម្មភាព បន្ថែមដើម្បីធានាថា សហគមន៍ជនបទមានភាពធន់នឹងការប្រែប្រួលអាកាសធាតុ។ សកម្មភាពទាំងនេះគួរផ្ដោតលើការអភិវឌ្ឍកសិកម្មប្រកបដោយនិរន្តរភាព តាមរយៈ ការអភិវឌ្ឍប្រព័ន្ធធារាសាស្ត្រ ការផ្ដល់ពូជស្រូវដែលធន់នឹងភាពរាំងស្ងួត មធ្យោបាយ នានាសម្រាប់ការពារសុវត្ថិភាពសង្គម និងគម្រោងអភិវឌ្ឍនានាដែលប្រជាជនក្នុង សហគមន៍ជាអ្នកកំណត់។ ដើម្បីអនុវត្តសកម្មភាពទាំងនេះឱ្យបានជោគជ័យ អ្នកធ្វើ គោលនយោបាយ និងអ្នករៀបចំផែនការ ត្រូវបែងចែកនិងកំណត់ឱ្យបានច្បាស់រវាង អសន្តិសុខស្បៀងរយៈពេលវែង និងអសន្តិសុខស្បៀងរយៈពេលខ្លី។

Abstract

Climate change-related disasters, such as floods, droughts, windstorms, and heat waves have emerged as a severe threat in the 21st century. Different countries experience different scales of both physical and perceived damage. This paper examines farmer perceptions of climate change impacts on rice production and introduces an appropriate mechanism to build adaptive capacity at the local level. This research is based on a survey of 215 respondents from two communes in *Banteay Meas* District, Kampot Province. The results demonstrate that food insecurity has been a frequently perceived impact among farmers over the past decade. Farmers in Tnoat Chong Srang have faced transitory food insecurity after natural calamities such as floods, storm surges, droughts, and seawater intrusion. Farmers in *Banteay Meas Khang Kaeut* have encountered chronic food insecurity and poverty caused by reduced rice production caused by floods, windstorms, and increasing seawater intrusion. The research found that local adaptation strategies for climatic hazards can increase food security. In addition, all key stakeholders, both at the national

and local levels, should take more action to ensure the resilience of rural communities. These actions should apply sustainable agricultural development focused on irrigation infrastructure, drought-tolerant rice varieties, social safety nets, and community-based projects selected by villagers. To successfully implement these actions policymakers and planners need to be able to clearly distinguish between chronic and transitory food insecurity.

Keywords: food security; small-scale farmer; coastal; agriculture; Cambodia

Introduction

Climate change is a global challenge for development in the 21st century. In coastal areas, there has been an increase in the seawater temperature, rising sea levels, a decrease in sea ice, as well changes to seawater salinity, storm surges, and the conditions of the ocean circulation (IPCC, 2014). These effects have been apparent since the 20th century. For instance, the average sea level has risen from 10 to 20 cm since 1950. Likewise, sea ice cover in the Arctic Ocean has decreased between 10% and 15% over the same period (IPCC, 2014). Under current projections, it is anticipated that temperatures could increase by between 3 °C and 4 °C (Raghavan et al., 2019), and rainfall might increase by 40% by the end of the century. Reduced crop yields are likely to place pressure on global food supplies. An increase of just 2°C in temperature in Southeast Asia, alongside related impacts, such as tropical cyclones, sea level rises, saltwater intrusion and losses to pests and diseases are predicted to have a significant impact on food production (Wassmann et al., 2009). Such impacts on food security are also likely to trigger a reduction in economic growth in the region.

Globally, the number of people without sufficient food has increased from 804 million in 2016 to more than 820 million in 2018 (FAO, 2019). In Asia, around 418 million people experiencing food insecurity accounting for more than half of global hunger in 2020, with 282 million people in Africa accounting for another third (FAO, 2021). Climate variability and extreme weather events are the primary drivers of this rise. Approximately 28% of the global population lives in low-elevation coastal zones within 100 km of the coastline (Barbier, 2015). This is the experience of one-third of people in developing countries, and 47% of people in low-income economies. Widespread poverty in the coastal rural populations of many developing countries exacerbates the situation of those vulnerable to extreme short term climate change impacts, such as coastal flooding and storm surges, as well as long-term impacts caused by sea-level rise, seawater intrusion, and erosion (Barbier, 2015; FAO, 2015).

Cambodia is a predominantly rural country that relies heavily on rice as a critical commodity for economic growth, poverty alleviation and food security. Agriculture, especially rice cultivation, is a priority sector for rural development in the country as a staple food and a significant source of income (Yu & Diao, 2011). For instance, rice exports contributed around 20.7% of the GDP in 2019 (MAFF, 2019). Increasing rice yields via improved irrigation infrastructure and enhanced agricultural inputs have been prioritized in response to climate change impacts (Seaman et al., 2014). However, the significant impacts of climate change on agricultural infrastructure, and human health in coastal zones, often leave villagers with a

low capacity to mitigate shocks and stressors during the economic downturn experienced during floods and drought events.

Climate change impacts have led to altered land-use practices, inflated production and marketing costs, and the need to source income via off-farm activities. These factors have all significantly affected rice production over the past decade (CARD, 2014). Rapid changes to how water-related resources are managed in response to unpredictable natural disasters, and associated economic decline has resulted in extremely uncertain livelihoods for villagers. Many of which now may not be sustained without improvements in the adaptive capacity to cope with these imminent environmental and socio-economic dynamics.

Risks to agricultural production translate directly into the expansion of food insecurity and undernutrition for people who are heavily dependent on agricultural livelihoods. However, the development of the agricultural sector suffers from insufficient infrastructure, insecure land tenure, inefficient technology transfer and agricultural extension, less-than-comprehensive marketing information, limitations in managing natural hazards, and low public investment (Theng, 2010). For instance, insufficient irrigation infrastructure, coinciding with droughts has severely constrained rice production. Economic shocks and stresses occur frequently, invariably causing food shortages (FAO, 2017; Sok & Yu, 2015), especially among communities with a low adaptive capacity. Food security remains a priority issue if sustainable development and poverty reduction are to be realized (FAO, 2019).

In 2011, about 1.5 million people suffered from 630 million USD of damage associated with flooding in Cambodia. Drought, while less visible, is also costly, with around 7.8 million people affected (FAO et al., 2020). For instance, between 2015 and 2016, an El Niño weather event showed resulted in unseasonably low precipitation levels, and increased temperatures leading to the worst drought in Southeast Asia for over 50 years (WFP, 2020). Undernutrition remains a significant public health concern for Cambodians. It has been estimated that 15% of the population is undernourished. Up to 32% of children under five are stunted, 24% underweight, and 10% wasted. Generally, children living in rural areas are more likely to be stunted than children in urban areas (WFP, 2020). The Global Hunger Index Score (GHIS) remains high in Cambodia at 23.7% in 2018 (RGC, 2019) and food security is affected by a wide range of constraints. They include low agricultural productivity and diversification, a lack of sustainable access to natural resources for a significant proportion of the rural population, and insufficient rural employment. As a result, financial and economic crises continue to threaten the stability of food access for the rural poor (CARD, 2014).

In 2018, 10% of the Cambodian population remained below the national poverty line. Food security is expected to continue to be constrained by climate change impacts for at least the next 20 years in Cambodia due to a growing population, long coastlines, a heavy reliance on the agricultural sector, and dependence on natural resources (MRC, 2009) The Royal Government of Cambodia faces many challenges to improving this situation. While rice remains a priority economic sector contributing significantly to

food security, around 28% of the population is likely to be exposed to natural hazards annually (FAO et al., 2020). Sea-level rises in the Gulf of Thailand increase by 3 to 5.5 mm per year (IUCN, 2013), with Cambodia's 435 km of coastline likely to be impacted by saline intrusion in low-lying agricultural areas, diminishing rice production (IUCN, 2013).

The capacity to respond to emergencies in the country remains limited, while traditional agricultural systems remain highly vulnerable to a low adaptive capacity, characterized by a lack of diversification, and inefficient irrigation (SCO, 2016). This paper provides insight into the perceptions of rice farmers on the negative impacts of climate change and characterizes the types of food insecurity that occur as a result. Appropriate mechanisms for building adaptive capacity are discussed in light of these insights.

Conceptualizing food insecurity in developing countries

Over the past decade, food insecurity has increasingly become a global issue as a result of growing conflict over climate-related resources (Drysdale et al., 2019). Food security was discussed in the global context as early as December 10, 1948, when the UN General Assembly adopted the Universal Declaration of Human Rights, which recognized the right to food as a core element of an adequate standard of living (UN, 1948). Then, in 1974, the World Food Conference in Rome (UN, 1974) prompted an international undertaking to develop a long-term plan for global food security to mitigate hazardous fluctuations in food reserves and prevent food shortages from occurring (Biswas & R Biswas, 1975). Since this time, various critical reviews

of global food production and consumption have led to some 200 definitions of food security being proposed (Napoli et al., 2011).

In 1986, the World Bank defined the food insecurity occurring in developing countries as either transitory or chronic (Reutlinger, 1986). Transitory food insecurity was associated with short-term and temporary socio-economic shocks, caused by factors such as peaks in global food prices, economic recessions, or natural disasters. Chronic food insecurity was associated with a long-term and persistent lack of capacity to meet basic minimum food requirements over an extended period due to poverty, inadequate access to food, or limited access to land resources (CARD, 2014; Reutlinger, 1986).

This is consistent with food insecurity in Cambodia. Beyond, the long-term environmental impacts of climate change compromising food security; short terms impact such as instability in food prices, food production, or household incomes also have an impact. In this context, poverty is closely related to food insecurity and malnutrition. Often food insecurity is intergenerational. Poor farmers tend to have a less balanced food intake and less capacity to provide food for children. This leads to lower levels of human development, and lower-income levels, which persist (CARD, 2014; Reutlinger, 1986). The aim of this paper is thus, to explore how these concepts may better articulate how climate change impacts rice farmers in a coastal area of Cambodia.

Study Area and Methodology

Banteay Meas District in Kampot Province was purposively selected as the research site for this study due to its rural population and coastal location.

Within this district, stratified sampling was used to select two communes for a comparative study facing different situations concerning agricultural practices and capacity to respond to climate change impacts. The selected communes were *Banteay Meas Khang Kaeut* and *Tnoat Chong Srang* (see Figure.1). In line with Yamane's (1967) calculations, 215 interviewees were selected across six villages in these locations.

Figure 1. Location of the study area (ODC, 2020)
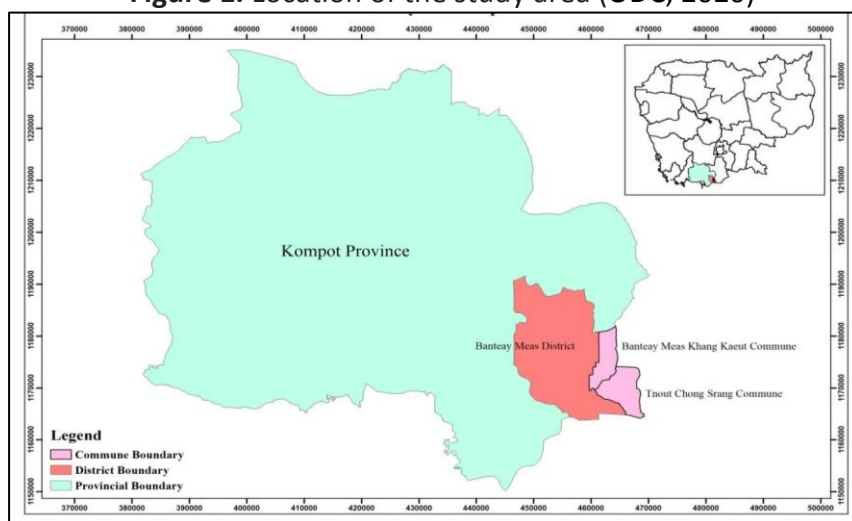
Banteay Meas Khang Kaeut is a rural commune with a population of 9024 people (4680 women) comprising 2111 households (MoP, 2020). In total 108 interviewees were sampled from three of the six villages in this commune. The majority of villagers in this commune are dependent on rice farming, home gardening, raising animals, and factory work as sources of income. *Tnoat Chong Srang* commune has a total population of 8410 people, comprising 2008 households. In total 105 interviewees were selected from three of the six villages in this commune. Farmers here are dependent on dry

land rice cropping and factory work for their income. During the past five years, villagers from this commune have migrated to Thailand seeking low skilled jobs in response to fluctuations in the rice market and high costs of production.

Information was collected from participants via a field survey, participant observation, focus group discussions, and other participatory rural appraisal methods. A range of key informants, such as government agencies, NGO staff, and local authorities were also consulted. Quantitative data were analyzed using the Statistical Package for the Social Sciences. A situation analysis, using statistical techniques for hypothesis testing; alongside the calculation of the mean, standard deviation, and gain coefficient of daily income across three sources (agriculture, non-agriculture, and others). This information was used to identify inequalities across each of the study communes. A chi-square test was used to test the relationship between access to land and household income. Further, a weighted average index (WAI), with a scale from (1) considerably low; (2) low; (3) moderate; (4) high; (5) very high, was used to assess the degree of satisfaction with available support mechanisms, institutional arrangements, and degree of dependency.

Findings and Results
The current status of food shortages

Over recent decades, a trend has emerged where income from a single source has not been sufficient to provide long-term security to a household in a rural area. Household spending on daily food consumption and agricultural inputs, such as fertilizers and pesticides, often exceeds agricultural incomes increasing the incidence of poverty rate in rural areas. In

each selected study area, almost all villagers access household income from more than one source. Agriculture contributes to job creation, providing food, and increasing the household income of the rural population. However, residents seek various forms of agricultural and non-agricultural income.

Table 1. Primary occupations between 2011 and 2020

Attributes	Banteay Meas Khang Kaeut *(n=108)*	Tnoat Chong Srang *(n=107)*	Overall *(n=215)*
Agricultural			
Rice farming	81	83	82.0
Vegetable growing	3.2	3.3	3.7
Fishing	0.0	0.8	0.4
Livestock raising	2.3	3.1	2.8
Sub-total	*86.5*	*90.2*	*88.9*
Non-agricultural			
Self-employment	3.2	0.9	2.1
Waged labour	3.0	6.0	4.5
Self-employment	3.1	1.0	1.5
Waged Labour	4.2	1.9	3.0
Sub-total	**13.5**	**9.8**	**11.1**

Note: 47.3% of respondents in Banteay Meas Khang Kaeut and 52.7% of respondents in Tnoat Chong Srang were engaged in more than one occupation.

The majority of residents work primarily in the agricultural sector, including rice production (82%), home gardening (3.7%), animal raising (2.8%), and fishing (0.4%). The proportion of workers primarily engaged in non-agricultural employment is much less (4.5%), however, is a more significant percentage of Tnoat *Chong Srang* commune (6.0%) than Banteay Meas Khang Kaeut (3.0%). They were employed (3.0%). Another 2.1% of the respondents are engaged in non-agricultural self-employment. The focus group discussions and interviews revealed that over the past five years, many villagers in each of the communes have migrated to Cambodia and other

countries seeking non-agricultural work at garment factories, NGOs, or private companies. *Table 1* provides a summary of the primary occupations of research participants between 2010 and 2020.

The average land size across both study areas was 1.8 ha per household. Overall, more land was available to farmers in *Tnoat Chong Srang* (2.1 ha per household) than in *Banteay Meas Khang Kaeut*, which was only (1.4 ha per household). However, just over half (50.6%) of respondents had access to less than 1ha (41.0% in *Tnoat Chong Srang* and 60.2% in *Banteay Meas Khang Kaeut*). Just over half of respondents in *Tnoat Chong Srang* (50.6%) had access to between 2 and 4 ha of land, with 8.2% having access to more than 5 ha of land. In contrast only 38.6% of respondents in *Banteay Meas Khang Kaeut* as access to more than 1 ha of land resources, with no farmers accessing more than 5 ha. That demonstrates that comparatively, villagers in Tnoat Chong Srang have greater opportunities for agricultural production.

Figure 2 displays the results for the proportion of villagers who experienced food shortages between 2011 and 2020. A respondent's primary occupation was used to determine the number of months in which a household could afford to purchase rice. For instance, a household supported by a non-agricultural occupation may buy rice between seven and nine months each year. Overall, 57.2% of the villagers in the two study areas were found to have experienced a food shortage in the past (74.8% of respondents in *Tnoat Chong Srang* and 39.8% of respondents in *Banteay Meas Khang Kaeut*). Food shortages were found to be especially prevalent during the period between 2011 and 2015.

Figure 2. Food shortages during the past 10 years
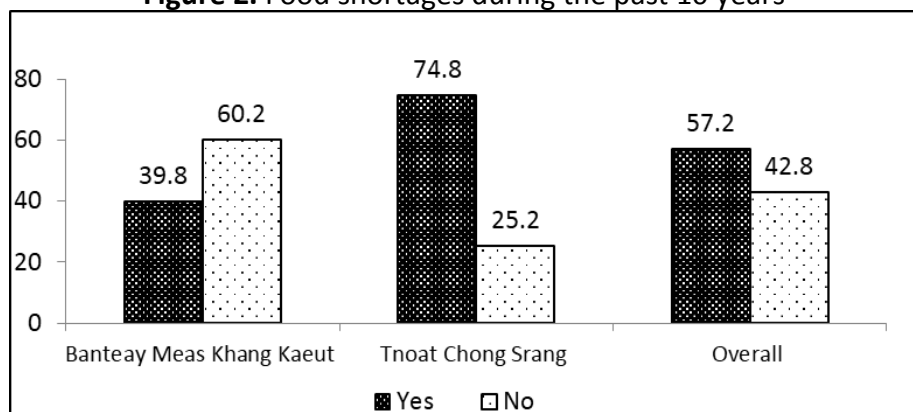
The causes of food insecurity

Overall, farmers in both communes have access to a similar amount of land sizes, however, the average landholding has increased by 33.5% over the past ten years. This has coincided with an increase in rice production of 58.1%; an increase in the proportion of farmers using their land for rice production to about 81.4%, and an increase in farmers who sell rice products to the market to 61.9%. This has led to an increased demand for land and other agricultural inputs, as well as an increase in the number of people working as farmers in both *Tnoat Chong Srang* (89.7%) and *Banteay Meas Khang Kaeut* (73.1%). This shift over the past decade has led to changes in income accessed from on- and off-farm activities in the two communes. Proportionally, off-farm income has decreased by 56.3% overall, however in *Banteay Meas Khang Kaeut* off-farm incomes still contributed around half of all income received.

The variation between the average monthly incomes of residents in each commune, across different income categories, as compared with the rural

poverty line. This was analyzed using a t-test to identify whether this variation was statistically significant. Overall, the variation between the average monthly household income (1,575,000 riel/HH/month) and the rural poverty line (1,637,000 riel/HH/month) was found to be not statistically significant (P-value= 0.537). This implies that the average monthly income of the respondents was close to the rural poverty line overall. However, when this test was applied to each commune, average monthly payments in the *Tnoat Chong Srang* (1,995,000 riel/HH/month) (P-value=0.000) were found to be significantly higher than this measure, while average monthly payments in *Banteay Meas Khang Kaeut* (1,158,000 riel/HH/month) (P-value=0.000) were found to be significantly lower. Notably, farmers in *Tnoat Chong Srang* were found to have access to a greater diversity of economic activities, which influenced this income. They tended to access income from a greater diversity of sources, both on-farm (rice farming and gardening, animal raising, fishing), and off-farm (labour work, self-employment, or skilled labour).

Proportionally, the average monthly income for each household was considerably different across each source. Agricultural income accounted for an overall monthly household income of 861,840 riels, yet, this was significantly higher in the *Tnoat Chong Srang* (1,231,710 riels). In the *Banteay Meas Khang Kaeut,* monthly household agricultural income was much lower (495,390 riels), and exceeded by monthly household nonagricultural waged labour (605,340 riels), and self-employment (107,860 riels). This is a significant outcome, especially in *Banteay Meas Khang Kaeut*, where the

agriculture sector is an important livelihood resource. Non-agricultural work tends to benefit a smaller proportion of young people and in-migrants.

Figure 3. Average monthly household incomes by source
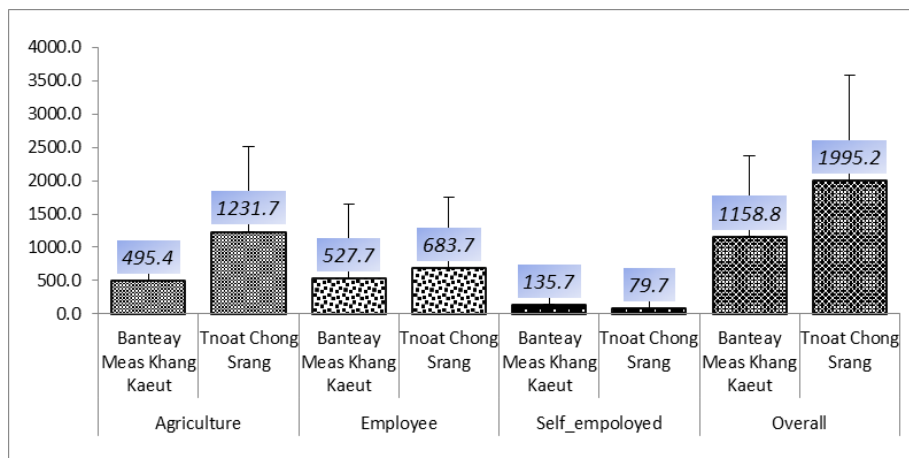
Note: average monthly incomes against the rural monthly HH consumption =1,637 thousand riels /HH/month

Farmers in *Tnoat Chong Srang* often access improved rice varieties from Vietnam, such as long-grain variety IR504. The rice seed is grown using more substantial agricultural inputs such as pesticides and fertilizers leading the higher production costs. That leads to local farmers borrowing money from Vietnamese merchants and local input suppliers on a promise that they will sell the harvested paddy to the merchant to repay the debt. This tends to result in minimal profits, with some households suggesting that they continue the practice for household consumption only. To supplement income from rice production, they work in construction and factory jobs or migrate to Phnom Penh, Sihanoukville, or other countries, such as Thailand and Korea. The farmers acknowledge a significant risk to their livelihood if Vietnamese partners decide to no longer purchase the rice and no substitute market is

found. Alternatively, farmers in *Banteay Meas Khang Kaeut* apply traditional wet rice cultivation methods with low production costs.

Although the monthly household income for respondents in *Tnoat Chong Srang* is higher than for those in *Banteay Meas Khang Kaeut*, food shortages are still commonly experienced due to the need to pay for agricultural inputs, such as fertilizers and chemical pesticides. Many farmers in *Banteay Meas Khang Kaeut* are required to see additional non-agricultural employment opportunities in other communities. The prices of staple foods and other commodities have fluctuated sharply in recent years linked to prices in international markets, which are not matched by increased incomes. Climate hazards have been another factor causing instability that severely impacts rice production via increased demand for scarce water supplies and low crop yields, especially in areas dependent on irrigation.

A chi-square analysis was also conducted to explore the relationship between monthly household income and the size of the landholding that respondents had access to. It was found that a statistically significant relationship exists between these two variables. Thus, if a household has access to a larger land area, they are likely to have a higher monthly household income.

Finally, a five-point weight averaged index was applied to measure the degree of severity of the food shortages experienced in each commune. Significant differences in severity were found, however overall the shortages were found to be moderate. In general, households tended to experience food shortages as a result of financial shortfalls when crops were lost due to

natural disasters. Interviews revealed that during these times, 70.7% of villagers would borrow money to purchase food for daily consumption (47.7% of respondents from *Banteay Meas Khang Kaeut* and 88.8% of respondents from *Tnoat Chong Srang*).

Figure 4. The relationship between income and agricultural land
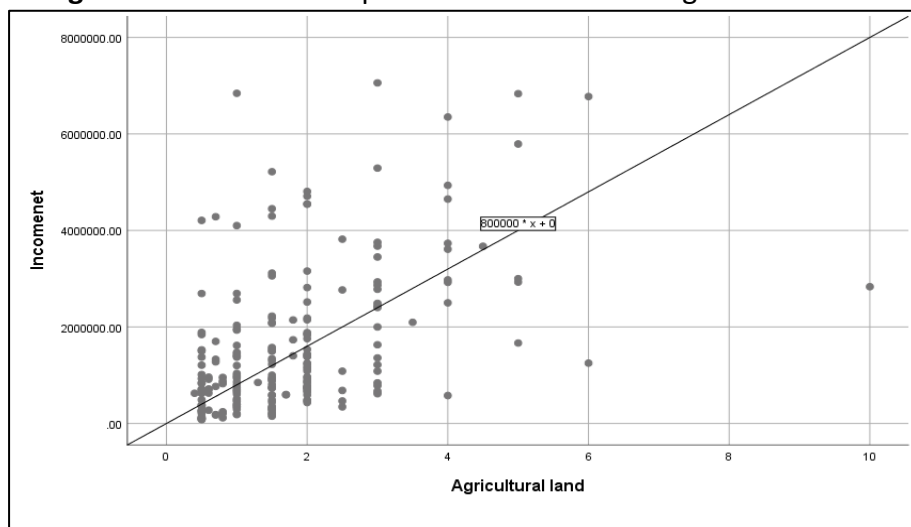
Perceptions about the short-term impacts of climate change on food security

Figure 5 outlines the perceived impacts of climate-related hazards over the last ten years in the study area. Overall, respondents expressed moderate concern about cooler temperatures, unexpected droughts, windstorms, increasing saltwater intrusion, unexpected flooding, and lightning, and significant concern about hotter temperatures. A weight averaged index revealed significant differences in the perceived impacts of climate change on the food security of farmers from each commune under study. For instance, significant differences in perceptions about increasing saltwater intrusion,

unexpected flooding, windstorms, rising sea levels, and thunder were revealed (P-Value=0.000). Respondents from *Tnoat Chong Srang* perceived there were greater challenges to food security as a result of climate change impacts than respondents from *Banteay Meas Khang Kaeut*. This is likely related to the flooding and droughts that impacted villagers in 2010, 2011, 2012, and 2015, which destroyed rice crops.

Tnoat Chong Srang commune is closely connected with Vietnam via *Prek Chik Vinh Te* and *Prek Ton Hon* canals that traverse the French border post No. 124. The commune also has links to the western arm of the Mekong River and the Gulf of Thailand. There is significant potential for the economic development of the rice cultivation area in the communed for both wet and dry production. However, this potential is at risk from sea-level rises in the Gulf of Thailand of about 5.5 mm per year. In recent years, natural disasters have occurred more frequently in *Tnoat Chong Srang* commune. For instance, 52 families were directly impacted when strong winds damaged 170 houses in 2020. Previously, in 2017, 9 households were impacted by violent storms. In total 43 dwellings were affected, with, four homes completely damaged. One farmer in the *Tnoat Chong Srang* recalled:

> "I have noticed changes in temperature over the last several years. It is getting hotter in the dry season. If I compared it to when I was young, the weather was cold between mid-December and the end of February, but three or four years ago, the weather became hotter. Over the last three years, our rice crops have been affected by salinity. In 2019, 1.5 hectares of rice were damaged, which caused the fields to dry out. Climate change has damaged my crops as a result of heavy rains and strong winds many times over the last

three years. My rice yield can sometimes be reduced after strong winds"
(Farmer, Tnoat Chong Srang, October 2011).

Figure 5. Climate change and perceived natural hazards (2010-2020)
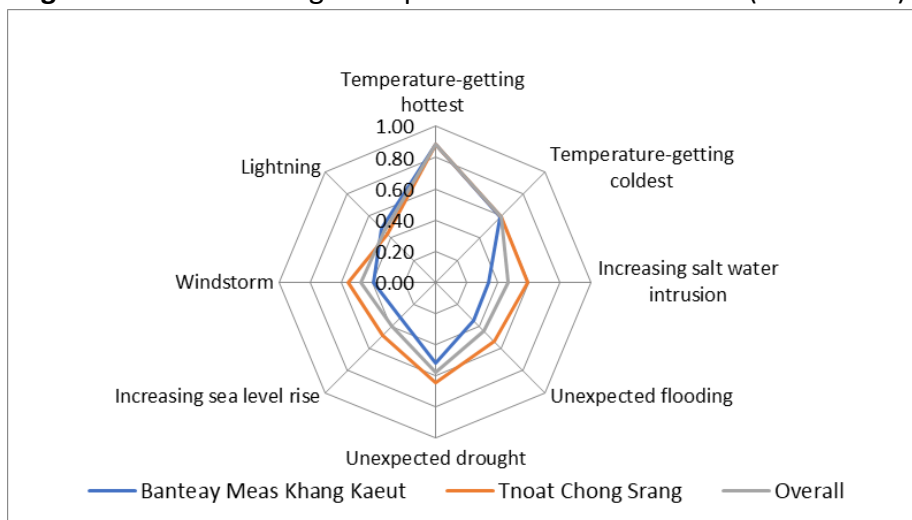
Notes: WAI = Weight Average Index measured on a five-point scale [Considerably Less (CL) = 0.00-0.20, Less (L) = 0.21-0.40, moderate (M) = 0.41-0.60, High (H) = 0.61-0.80, Very High (VH) = 0.81-1.00]; OA = Overall Assessment; *Significance at the 0.05 level; **Significance at the 0.01 level.

Many villagers expressed deep concern about recent increases in temperature and the increased frequency and intensity of droughts. For instance, in 2002, 2004, 2011, and 2015, respondents from *Tnoat Chong Srang* identified that they had noticed some water bodies drying out more frequently. The extension of irrigation systems has partially supported agricultural production during the dry season, however, insufficient water in *Tnoat Chong Srang*, threatens this livelihood activity due to low yield production. Farmers in *Tnaot Chong Srang* commune have created favourable conditions for growing dry-season rice, but are heavily reliant on irrigation to increase productivity.

The rehabilitation of irrigation systems built during the Khmer Rouge regime can enable two to three rice cultivation cycles per year. However, mismanagement of the distribution of this water has caused conflict and placed constraints on productivity. Other challenges faced in the commune include impacts from pests and diseases, especially during prolonged droughts, where saltwater intrusion problems increase. This reduces crop yields and, in some cases, causes crop failure. When this occurs, farmers often go into debt to buy agricultural inputs to produce rice for the market. However, the timing of this expenditure is often coupled with selling rice, when the market is weak.

Perceptions about long term trends related to climate change and their impact on food security

Overall, the perceptions of respondents about the negative impacts of climate change on food security vary significantly across each commune studied. For instance, farmers from *Tnoat Chong Srang* tended to acknowledge the impact of food shortages and access to nutrition in the commune; while farmers in *Banteay Meas Khang Kaeut* were undecided about whether this was significant (see Table 2).

Meanwhile, climate change was identified to be a significant threat to household food security, caused conflict over scarce water resources and affected children's schooling in both communes. In *Banteay Meas Khang Kaeut*, where traditional rice production is prevalent, villagers were able to supplement available rice stores, with meat intake to improve health, social, and cultural outcomes from rice production. People gather aquatic creatures,

such as frogs, crabs, and snails, as well as other wild animals to supplement

other meat consumption.

Table 2. Local awareness of climate change impacts on food security

Attributes	Banteay Meas Khang Kaeut (n=108)		Tnoat Chong Srang (n=107)		Overall (n=215)		P-*value*
	WAI	OA	WAI	OA	WAI	OA	
Climate change threatens household food security	0.57	U	0.67	A	0.62	A	0.000***
Climate change causes conflict over water resources	0.60	U	0.65	A	0.62	A	0.025**
Climate change results in no choice for food	0.64	A	0.68	A	0.66	A	0.007**
Climate change impacts child health	0.67	A	0.63	A	0.65	A	0.015**
Climate change causes child malnutrition	0.61	A	0.61	A	0.61	A	0.589
Climate change impacts early childhood development	0.62	A	0.65	A	0.63	A	0.010**
Climate change causes increased household debt	0.74	A	0.69	A	0.71	A	0.002**
Climate change impacts children's schooling	0.60	U	0.63	A	0.62	A	0.021**

Notes: WAI = Weight Average Index measured on a five-point scale [Strongly disagree (SD) = 0.00-0.20, Disagree (D) = 0.21-0.40, Undecided (U) = 0.41-0.60, Agree (A) = 0.61-0.80, Strongly Agree (SA) = 0.81-1.00]; OA = Overall Assessment; *Significance at 0.05 level; **Significance at 0.01 level.

Mrs Norn Sony, a farmer who lives in *Banteay Meas Khang Kaeut*, stated:

I have experienced food shortages almost every year for a period of about

five or six months. I only have access to a small plot of land for rice farming

and available non-agriculture work is not sufficient for meeting my daily expenses. I often borrow from relatives and sometimes from neighbours. My children do not enter the school because I cannot support them (Mrs Norn Sony, personal communication, October 2020).

Overall, the adaptive capacity of local people was found to be significantly different in terms of the use of water resources and other technical practices. There were differences in how farmers from each commune adapted their water consumption for rice cultivation, applied crop diversification practices, introduced drought-resistant rice varieties, accessed information about weather conditions, or used organic fertilizers. Farmers in *Tnoat Chong Srang* demonstrated a higher adaptive capacity to climate change than farmers in *Banteay Meas Khang Kaeut*.

Farmers in *Tnoat Chong Srang* have more frequently been impacted by climate change and as a result, have already altered their water consumption for rice cultivation via the use of ponds, and water conservation practices to reduce wastage during drought years. Other practices such as crop diversification, using organic fertilizers, developing on-farm water storage, planting fruit trees, and accessing reliable information about the weather have been applied to a moderate level; while the application of climate-smart agriculture practices, seasonal crop cultivation, and using drought-resistant rice varieties have been applied more intensively (see Table 3). Planting fruit trees has been used as a beneficial practise for improving the food security of respondents from both communes.

Table 3. Agricultural adaptations to climate change impacts

Attributes	Banteay Meas Khang Kaeut (n=108)		Tnoat Chong Srang (n=107)		Overall (n=215)		*P-value*
	WAI	OA	WAI	OA	WAI	OA	
Using less water for rice cultivation	0.48	M	0.45	M	0.47	M	0.06
Water harvesting using a farm pond, conservation practices	0.48	M	0.43	M	0.45	M	**0.010****
Reducing water wastage during the drought seasons	0.40	L	0.47	M	0.43	M	***0.000****
Crop diversification practice	0.44	M	0.42	M	0.43	M	0.320
Making organic fertilizers in the community	0.46	M	0.45	M	0.45	M	0.480
On-farm water storage: water harvesting	0.48	M	0.38	L	0.43	M	***0.000*****
Implementing climate-smart agricultural practices	0.57	M	0.71	H	0.64	H	***0.000*****
Improving the use of seasonal crops	0.61	H	0.50	M	0.56	H	***0.000*****
Planting fruit trees (mango, papaya banana, etc.)	0.60	M	0.54	M	0.57	M	***0.000*****
Introducing drought-resistant varieties	0.63	H	0.61	H	0.62	H	0.15
Accessing information about the weather	0.55	M	0.55	M	0.55	M	0.95

Notes: WAI = Weight Average Index measured on a five-point scale [Considerably Less (CL) = 0.00-0.20, Less (L) = 0.21-0.40, moderate (M) = 0.41-0.60, High (H) = 0.61-0.80, Very High (VH) = 0.81-1.00]; OA = Overall Assessment; *Significance at the 0.05 level; **Significance at the 0.01 level.

Using a weight averaged index revealed significant differences in the perceptions of the respondents about agricultural adaptations across the two communes (P-value=0.00). Table 4 indicates that farmer perceptions of adapting farming methods are stronger in *Tnoat Chong Srang* was better than in *Banteay Meas Khang Kaeut* for seed selection, water management, pest and disease management, and land levelling. Focus group discussion revealed that most farmers in the study lacked the technical skills and knowledge necessary to increase crop yields. For instance, farmers were constrained by a lack of understanding about how to use agricultural inputs, such as fertilizers and seeds effectively and efficiently. Improved awareness of these aspects is likely to improve productivity, as is the dissemination of knowledge about farming methods, such as crop husbandry, water monitoring, and pest management.

Table 4. The perception of agricultural adaptation and resilience

Attributes	Banteay Meas Khang Kaeut (n=108)		Tnoat Chong Srang (n=107)		Overall (n=215)		P-*value*
	WAI	OA	WAI	OA	WAI	OA	
Seed selection	0.78	H	0.88	VH	0.83	VH	*0.000****
Water management	0.75	H	0.87	VH	0.81	VH	*0.000****
Pests and disease management	0.74	H	0.83	VH	0.78	H	*0.000****
Land leveling	0.76	H	0.84	VH	0.80	H	*0.000****

Notes: WAI = Weight Average Index measured on a five-point scale [Considerably Less (CL) = 0.00-0.20, Less (L) = 0.21-0.40, Moderate (M) = 0.41-0.60, High (H) = 0.61-0.80, Very High (VH) = 0.81-1.00]; OA = Overall Assessment; *Significance at the 0.05 level; **Significance at the 0.01 level.

The interviews with villagers found that each of the communes in the study is highly dependent on rain-fed rice farming. Households in *Tnoat Chong Srang* commune have proportionally higher access to irrigation systems

(86.0%), compared to those in Banteay Meas Khang Kaeut (29.6%). Those who live in Tnoat Chong Srang are also more likely to have access to water resources from the rivers or streams for both wet and dry season rice cultivation (78.5%) when compared with farmers from *Banteay Meas Khang Kaeut* (2.8%). Groundwater is also a significant and supplementary source in both Tnoat Chong Srang (12.1%) and Banteay Meas Khang Kaeut (1.9%). Groundwater is used both during drought years and after prolonged rainfall.

Discussion and Conclusion

Storm surges and coastal flooding cause severe constraints on agricultural production and drive declining productivity (Zikra, 2015). When combined with the low socio-economic status of many countries in Asia, the impacts of weather events such as cyclones, storm surges, and floods have a significant adverse effect on the livelihoods, income, and food security of coastal farming communities (Huq et al., 2015). This study has revealed that these communities are expressing deep concern about increasing temperatures and sea-level rises and their impact on crop yields. Interviews with these farmers demonstrate that the level of concern about these climate impacts is related to differences in perceptions about other impacts such as saltwater intrusion, unexpected flooding, violent storms, and thunder. These differences can be ascribed to experiences with a decline in agricultural production, level of access to irrigation infrastructure, and longer terms environmental changes.

Cambodia has been affected by climate change almost every year since 2000. Since this time around 616,750 hectares of rice fields have been flooded, while 374,174 hectares of paddies have been destroyed (ADRC,

2003; Chan, 2001; Kent & Sanny, 2004). Between 2004 and 2005, some provinces of Cambodia experienced severe water shortages caused by drought; affecting 2 million people and 62,702 hectares of rice paddies (Mao, 2005). In 2016, serious droughts affected agricultural production in 18 provinces, causing 2.5 million to experience water scarcity (Laurien & Keating, 2019; MRC, 2019b). These events are reflected in this study, which found that farmers in *Tnoat Chong Srang* have faced impacts from many natural hazards over the past 10 years including floods, droughts, and windstorms. In particular, floods and droughts between 2010 and 2015 destroyed crops in the study area, especially rice.

Previous studies have shown that 42.2% of Cambodian farmers have experienced food shortages, including more severe food insecurity lasting for more than ten consecutive days. This has required them to seek support from others. Even brief periods of food shortages or starvation can result in serious deterioration of health (Sok et al., 2014). In this study, it was found that 57.2% of respondents have experienced a food shortage in the past 10 years (74.8% of respondents in *Tnoat Chong Srang*, and 39.8% of respondents in *Banteay Meas Khang Kaeut*).

These experiences have developed an understanding of how to manage water shortages for agricultural production, turning climate hazards into agrarian opportunities. These approaches make a significant contribution to sustainable development in the face of climate change impacts. They help to improve the resilience of rice farming systems and increase yields to ensure food security for smallholders in rural Cambodia. This study considered the

experience of farmers that were highly dependent on rain-fed rice farming. One commune, *Tnoat Chong Srang,* however, had significantly higher access to irrigation than the other.

Local adaptation strategies that respond to climate change impacts include: changing the timing of planting of crops; introducing new crop varieties including high-value crops; strengthening the extension services to rural families via appropriate technologies; and providing better information on production techniques and land management practices. These strategies are central to speeding up the adoption of appropriate adaptive practices. Technically support from NGOs will be required to play a significant role in improving household livelihoods through training, creating work opportunities for unskilled agricultural labour, and the provision of financial support.

In the future, all key stakeholders from the national to local level need to consider contributing towards: the enhanced resilience of rural communities and economies; the advancement of sustainable agriculture for farm households based on crop insurance, crop future trading, and income stabilization programs; the development of irrigation infrastructure; social safety nets and community-based projects; the selection of appropriate careers by villagers; and, clear differentiation between chronic and transitory food insecurity by policymakers, planners and practitioners. This study concludes by suggesting that future studies on this topic should (i) focus on the impact of saltwater intrusion on rice production; (ii) address sea-level rise and its impact on livelihoods in coastal zones; and (iii) consider the impact of

climate change on children's health-related quality of life and household food security indicators in rural communities.

Acknowledgements

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វិចារណកថាទៅលើកម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែរ

ខូយ បុិនឡុត[9][*]

[9]ស្ថាបនិកក្រុមហ៊ុន និងប្រធានផ្នែកផលិតសៀវភៅ "**សង្គ្រោះផ្គាក់ភាសា**"
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រាជធានីភ្នំពេញ

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សង្ខិត្តន័យ

សៀវភៅសិក្សាគោលមានតួនាទីយ៉ាងសំខាន់ក្នុងការបង្រៀននិងរៀន ជាពិសេស ក្នុងប្រព័ន្ធអប់រំ មានតែសៀវភៅសិក្សាទេដែលជាប្រកពចាំបាច់សម្រាប់គ្រូនិងសិស្ស។ ប៉ុន្តែទោះជាយ៉ាងនេះក្ដី សៀវភៅសិក្សាគោលភាសាខ្មែរនៅមានបញ្ហាខ្លះៗពាក់ព័ន្ធនឹង កម្រិតនៃភាពអាចអានបាន។ អត្ថបទនេះវិភាគភាពអាចអានបាននៃអត្ថបទអំណាន ក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែរ ដោយប្រើរូបមន្តរបស់ Flesch (1948) និង Kincaid et al. ដែលទាញអាគតដ្ឋានដោយ Dubay, 2004, p. 93។ ការស្រាវជ្រាវ នេះប្រើទិន្នន័យជាអត្ថបទអំណានដែលត្រូវបានដកស្រង់ពីសៀវភៅសិក្សាគោលភាសា ខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩ របស់ក្រសួងអប់រំ យុវជន និងកីឡា។ លទ្ធផលបានបង្ហាញ ថា កម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានរបស់សៀវភៅសិក្សាគោលភាសា ខ្មែរទាំងបីថ្នាក់នេះមិនសមស្របនឹងកម្រិតថ្នាក់របស់សិស្សនោះទេ។ ឧទាហរណ៍ អត្ថបទអំណានក្នុងសៀវភៅសិក្សាគោលទាំងបីថ្នាក់ បើគិតជាមធ្យម ក្នុងមួយឃ្លា មានចំនួនដល់ទៅ២០៣ក្យ ដែលត្រូវនឹងកម្រិតសិស្សថ្នាក់ទី១០ (Flesch, 1975)។ មិនតែប៉ុណ្ណោះ លទ្ធផលពុំបានបង្ហាញពីរបៀបរម្រួលធំដុំរវាងចំនួនពាក្យនិងឃ្លះក្នុង

អត្ថបទទាំងបីថ្នាក់នោះទេ ប៉ុន្តែបែរជាបង្ហាញការប្រែប្រួលរវាងចំនួនព្យាង្គនិងចំនួន ពាក្យទៅវិញ។ លទ្ធផលទាំងនេះមានប្រយោជន៍សម្រាប់គ្រឹះស្ថានបោះពុម្ពផ្សាយ និង អ្នកនិពន្ធក្នុងការតាក់តែងអត្ថបទអំណានឱ្យត្រូវនឹងកម្រិតថ្នាក់របស់សិស្ស ក៏ដូចជា សមត្ថភាពរបស់អ្នកអាន។

Abstract

Textbooks play a vital role in the process of teaching and learning, especially in education systems where they are the only resources available to teachers and students. Despite this indispensable role, textbooks in Cambodia have ongoing problems concerning their content and design. This paper analyzes the readability of passages in Khmer textbooks (Flesch, 1948); Kincaid et al., 1975, as cited in DuBay, 2004. Reading passages were extracted from the Grade 3, Grade 6 and Grade 9 Khmer textbooks published by the Ministry of Education, Youth and Sports. It was found that the readability of these textbooks was not in line with the reading level of students. For instance, on average, 20 words per sentence were used, which is equivalent to a Grade 10 level (Flesch, 1975). Further, while the number of words and sentences did not significantly vary across the three grade levels, the number of syllables and words did. These findings have implications for publishers and authors when designing reading passages in textbooks if they are to have an appropriate level of readability for their intended users at each grade level.

Keywords: readability, Khmer language textbooks, grade level

សេចក្ដីផ្ដើម

កម្រិតនៃភាពអាចអានបានត្រូវបានពិពណ៌នាថាជាកម្រិតនៃភាពស្រួលឬយល់នៃអត្ថបទ ដែលគេបានអាន។ Kouame (2010) បានពន្យល់ថា ស្ថិតិអំពីកម្រិតនៃភាពអាចអានបាន មិនត្រឹមតែផ្ដល់ព័ត៌មានអំពីកម្រិតលំបាកនៃការអានអត្ថបទប៉ុណ្ណោះទេ វាថែមទាំងជួយឱ្យ អ្នកនិពន្ធអាចវាស់កម្រិតយល់ដឹងរបស់អ្នកអានបានកាន់តែច្បាស់ថែមទៀតអំពីអត្ថបទដែល ខ្លួនបានសរសេរ។ រូបមន្តសម្រាប់គណនាកម្រិតនៃភាពអាចអានបានអាចកំណត់ភាពសមស្រប

នៃអត្ថបទមួយទៅនឹងកម្រិតរបស់អ្នកអាន និងជួយជំរុញកម្រិតជំនាញសិក្សាគោលរបស់ក្រសួងអប់រំ យុវជន និងកីឡាឲ្យកាន់តែសមស្របតាមកម្រិតថ្នាក់នីមួយៗ។ រូបមន្តនេះក៏អាចយកមក អនុវត្តសម្រាប់វាយតម្លៃស្ដង់ដារកសារប្រើប្រាស់ក្នុងកិច្ចការរាជរដ្ឋាភិបាល ជំនួញ សេដ្ឋកិច្ច និងឯកសារផ្សេងៗទៀតផងដែរ។

ក្នុងចំណោមរូបមន្តជាច្រើន ដែលត្រូវបានប្រើសម្រាប់គណនារកកម្រិតនៃភាពអាចអាន បាន ដូចដែលបានបញ្ចាក់នៅក្នុងវិចារណនិពន្ធន៍ មានតែរូបមន្តរបស់ Flesch (1948) និង Kincaid et al. (ទាញអាគតដ្ឋានដោយ Dubay, 2004, p. 93) ទេ ដែលត្រូវបានប្រើច្រើន ជាងគេក្នុងកិច្ចការស្រាវជ្រាវៗ។ ដូច្នេះ អ្នកសិក្សាបានសម្គាល់ឃើញថា រូបមន្តរបស់ Flesch (1948) ដែលកំណត់អំពីកម្រិតនៃភាពអាចអានបាន និង រូបមន្តរបស់ Kincaid et al. (ទាញអាគតដ្ឋានដោយ Dubay, 2004, p. 93) ដែលគណនារកកម្រិតថ្នាក់នៃអត្ថបទ អំណាននីមួយៗ ដោយផ្ដែកលើចំនួនល្បះសរុប ចំនួនពាក្យសរុប និងចំនួនព្យាង្គសរុប មាន លក្ខណៈសមស្របនឹងភាសាខ្មែរដោយរូបមន្តផ្សេងៗទៀត។ Khodadady និង Mehrazmay (2017), Yulianto (2019), Turkben (2019) និង Telaumbanua និង Umiyati (2019) បានគាំទ្ររូបមន្តរបស់ Flesch (1948) និងរូបមន្តរបស់ Kincaid et al. (1975) ដែលមានភាពជឿជាក់ខ្លស់ក្នុងការវាស់កម្រិតនៃភាពអាចអានបានរបស់អត្ថបទ។ ជាងនេះ ទៅទៀត សម្រាប់ភាសាខ្មែរ ពុំទាន់មានអ្នកនិពន្ធណាបានកំណត់កម្រិតនៃភាពអាចអានបាន នៃអត្ថបទអំណានទូទៅ ក៏ដូចជាអត្ថបទក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែររបស់ក្រសួងអប់រំ យុវជន និងកីឡា ឲ្យត្រូវនឹងកម្រិតថ្នាក់នៅឡើយទេ។ ដូច្នេះ ការសិក្សានេះគឺជាមគ្គុទេសក៍ ដំបូងក្នុងការផ្ដួចផ្ដើមយករូបមន្តសម្រាប់គណនាកម្រិតនៃភាពអាចអានបានតាមកម្រិតថ្នាក់ ដើម្បីជួយពង្រឹងនិងពង្រីកវិសាលភាព និងអាចឈានទៅកាន់ចំណុចស្ដង់ដារជាតិរួមមួយ។ ជាង នេះទៅទៀត ការស្រាវជ្រាវនេះមានគោលបំណងស្វែងរកកម្រិតនៃភាពអាចអានបាន និង កំណត់កម្រិតថ្នាក់នៃអត្ថបទអំណានភាសាខ្មែរឲ្យបានច្បាស់លាស់ ដើម្បីវាស់កម្រិតអត្ថបទ ជាភាសាខ្មែរឲ្យបានត្រឹមត្រូវដូចប្រទេសវៀតណាម ថៃ អង់គ្លេស និងសហរដ្ឋអាមេរិកដែរ។ ដូច្នេះ សំណួរស្រាវជ្រាវសម្រាប់ការសិក្សានេះត្រូវបានបែងចែកជាបីដូចខាងក្រោម៖

១. តើភាពអាចអានបាននៃអត្ថបទអំណានក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែរ ថ្នាក់ទី៣ ទី៦ និងទី៩ ស្ថិតក្នុងកម្រិតថ្នាក់ទីប៉ុន្មាន?

២. តើចំនួនពាក្យជាមធ្យមក្នុងល្បះនីមួយៗនៃអត្ថបទអំណានក្នុងសៀវភៅសិក្សាគោល
ភាសាខ្មែរ ថ្នាក់ទី៣ ទី៦ និងទី៩ ស្ថិតក្នុងភាពអាចអានបានកម្រិតណា ? ហើយត្រូវ
នឹងកម្រិតថ្នាក់ទីប៉ុន្មានដែរ ?

៣. តើមានទំនាក់ទំនងគ្នារវាងចំនួនព្យាង្គ ចំនួនពាក្យ និងចំនួនល្បះក្នុងអត្ថបទអំណាន
ក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩ ដែរឬទេ ?

វិចារណនិពន្ធ
និយមន័យនៃភាពអាចអានបាន

អ្នកស្រាវជ្រាវភាគច្រើនបានអធិប្បាយអំពីកម្រិតនៃភាពអាចអានបាន ដោយប្រើប្រាស់
ឧបករណ៍ស្រាវជ្រាវផ្សេងៗគ្នាទៅតាមឆ្នាំដែលបានកំណត់។ Platt និង Platt (1992) បាន
ពន្យល់ថា កម្រិតនៃភាពអាចអានបានគឺជាបែបបទសៀវភៅសិក្សាគោល ដែលអាចឱ្យអ្នក
អានយល់ពីខ្លឹមសារមេរៀន ដោយត្រូវមានកត្តាមួយចំនួនដូចជាប្រវែងពាក្យជាមធ្យម ចំនួន
ពាក្យជាមធ្យមក្នុងល្បះ និងប្រភេទសម្តីនូវល្បះក្នុងអត្ថបទអំណាន។ Soyibo (1996) បាន
ឱ្យនិយមន័យថា កម្រិតនៃភាពអាចអានបានផ្តោតទៅលើប្រវែងល្បះ និងភាពស្មុគស្មាញនៃ
ការប្រើពាក្យក្នុងភាសានីមួយៗ។ Fry (2002) បានកំណត់ថា ភាពអាចអានបានអាច
បញ្ចាក់បានទាំងល្បឿនអំណាននិងកម្រិតយល់ដឹងអំពីអត្ថបទដែលសិស្សបានអាន។ DuBay
(2004) បានឱ្យនិយមន័យថា ភាពអាចអានបានគឺជាការយល់ដឹង ឬការត្រិះរិះពិចារណាទៅ
លើទម្រង់លក្ខណៈនៃការរៀបចំនិងខ្លឹមសារមេរៀន។ លើសពីនេះ ការវេញគែស្វ្រាភាពអាចអាន
បានទាក់ទងនឹងការរាប់ចំនួនព្យាង្គ ចំនួនពាក្យ ចំនួនល្បះ និងចំនួនកថាខណ្ឌ ដើម្បីប៉ាន់
ស្មានពីកម្រិតលំបាកនៃភាពអាចអានបាននៃអត្ថបទអំណាន។ Kasule (2011) បានបញ្ជាក់
ថា ភាពអាចអានបាននៃអត្ថបទអំណានក្នុងសៀវភៅសិក្សាបង្កប់អត្ថន័យនៃការវាយតម្លៃជំពូក
នីមួយៗ។ ក្នុងន័យនេះ ភាពអាចអានបានគឺជាកត្តាកំណត់គុណភាពនៃសៀវភៅសិក្សាគោល។
ការដឹងច្បាស់ពីកម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណាន អាចជួយសិស្សឱ្យចេះកំណត់
អត្ថបទអំណានដែលសមស្របនឹងកម្រិតថ្នាក់របស់ខ្លួន។ Handayani (2014) បានពន្យល់
ថា ភាពអាចអានបានគឺជាការវាស់ភាពសមស្របនៃការអានជាក់លាក់សម្រាប់អ្នកអាន ដើម្បី

ដាក់ចំណាត់ថ្នាក់ពិតប្រាកដរបស់អ្នកអាន។ នេះបាននិយថា ភាពស្រួលអានគឺជាកត្តា សំខាន់សម្រាប់ផ្តល់ផ្តួងការអានជាមួយនឹងកម្រិតយល់ដឹងរបស់អ្នកអាន។

បរិមាណពាក្យក្នុងល្បះ

ដោយផ្អែកលើលទ្ធផលសិក្សា អ្នកស្រាវជ្រាវជាច្រើនបានអះអាងថា កម្រិតនៃភាពអាច អានបានគឺអាស្រ័យលើចំនួនពាក្យជាមធ្យមក្នុងល្បះនីមួយៗ។ Borbély និង Kornai (2019) បានសិក្សាក្នុងភាសាជាច្រើនអំពីចំនួនពាក្យជាមធ្យមក្នុងល្បះ។ លទ្ធផលបាន បង្ហាញថា៖ (១) ភាសាស៊ុយអែត និងហ្វាំងឡង់មានចំនួនជាមធ្យម ១៦ពាក្យក្នុងមួយល្បះ, (២) ភាសាលីទុយអានី និងអង់គ្លេសមានចំនួន ១៧ពាក្យ, (៣) ភាសាដាណឹម៉ាក ហូឡង់ អាន់ត្រេឡង និងនីវែនមានចំនួន ១៩ពាក្យ, (៤) ភាសាប៉ូឡូញ និងថែកមានចំនួន ២០ពាក្យ, (៥) ភាសាស្លូវ៉ាគីមានចំនួន ២២ពាក្យ, (៦) ភាសាក្រូអាត និងពណ៌ណេស៊ីមានចំនួន ២៤ ពាក្យ, (៧) ភាសាព័រទុយហ្គាល់មានចំនួន ២៥ពាក្យ, (៨) ភាសាកាតាឡានមានចំនួន ២៧ ពាក្យ, និង (៩) ភាសារ៉ូម៉ានី និងអេស្ប៉ាញមានចំនួន ២៩ពាក្យក្នុងមួយល្បះ។ Biber et al. (1999) បានបញ្ជាក់យ៉ាងច្បាស់ថា តាមការសិក្សាក្នុងសៀវភៅវេយ្យាករណ៍ភាសាអង់គ្លេស ល្បះ៖ Longman ទាំងភាសានិយាយ ទាំងភាសាសរសេរ មានចំនួនពាក្យក្នុងល្បះនីមួយៗ ជាមធ្យម ចំនួន២០ពាក្យ។ Smith និង Butcher (2007) បានផ្តល់យោបល់ទៅអ្នកសរសេរ សារព័ត៌មានថា ត្រូវប្រើពាក្យក្នុងល្បះនីមួយៗ ជាមធ្យម ចំនួន២០ពាក្យ ដើម្បីឱ្យអ្នកអាន អាចទទួលបានព័ត៌មានច្បាស់លាស់ពីអត្ថបទដែលបានផ្សព្វផ្សាយនោះ។ Russell (1993) បានអះអាងថា ចំនួនពាក្យក្នុងល្បះជាមធ្យមត្រូវស្ថិតក្នុងចន្លោះពី ១៥ ដល់ ២៥ពាក្យ ទើប អ្នកអានអាចយល់បានព័ត៌មានក្នុងការទាក់ទងជាសាធារណៈ។

រូបមន្តកម្រិតនៃភាពអាចអានបាន

រូបមន្តដែលគេនិយមប្រើត្រូវបានអ្នកស្រាវជ្រាវជុំវិញពិភពលោកចងក្រងទុកសម្រាប់ គណនាកម្រិតនៃភាពអាចអានបាន។ ខាងក្រោមនេះគឺជាតារាងរូបមន្តកម្រិតនៃភាពអាច អានបានរបស់ Flesch (1948), Dale និង Chall (1948), Farr et al. (1951), Nguyen និង Henkin (1982), និង Greenfield (1999)។

តារាង ២.១ រូបមន្តកម្រិតនៃភាពអាចអានបាន

អ្នកនិពន្ធ និងឆ្នាំ	រូបមន្តកម្រិតនៃភាពអាចអានបាន
Flesch, (1948)	ពិន្ទុ = ២០៦,៨៣៥ – ១,០១៥ [(ចំនួនពាក្យសរុប)/(ចំនួនឃ្លាៈសរុប)] – ៨៤,៦ [(ចំនួនព្យាង្គសរុប)/(ចំនួនពាក្យសរុប)]
Dale & Chall (1948)	ពិន្ទុ = ០,១៥៧៩ [(ចំនួនពាក្យសរុបដែលមិនមាននៅក្នុងបញ្ជីពាក្យ Dale Chall)/(ចំនួនពាក្យសរុប)] + ០,០៤៨៦ [(ចំនួនពាក្យសរុប)/(ចំនួនឃ្លាៈសរុប)] + ៣,៦៣៦៥
Farr et al. (1951)	ពិន្ទុ = ១,៥៩៩ (ចំនួនពាក្យមួយព្យាង្គក្នុងចំណោម ១០០ពាក្យ) – ៨៤,៦ [(ចំនួនពាក្យសរុប)/(ចំនួនឃ្លាៈសរុប)] – ៣១,៥១៧
Nguyen & Henkin (1982)	ពិន្ទុ = ២ [(ចំនួនអក្សរ[1]សរុប)/(ចំនួនពាក្យសរុប)] + ០,២ [(ចំនួនពាក្យសរុប)/(ចំនួនឃ្លាៈសរុប)] – ៦
Greenfield (1999)	ពិន្ទុ = ១៦៤,៩៣៥ – ១៩,៧៩២ [(ចំនួនអក្សរសរុប)/(ចំនួនពាក្យសរុប)] – ១,៩១៦[(ចំនួនពាក្យសរុប)/(ចំនួនឃ្លាៈសរុប)]

ពិន្ទុមានចាប់ពី ០ ដល់ ១០០ និង កម្រិតពណ៌នាមានចាប់ពី "ស្រួលខ្លាំង" ដល់ "លំបាកខ្លាំង" សម្រាប់ផ្ទៀងផ្ទាត់ថា ពិន្ទុស្ដើប៉ុន្មាន និងស្ថិតនៅក្នុងកម្រិតពណ៌នាមួយណា។ ខាងក្រោមនេះគឺជាតារាងលម្អិតពិន្ទុ និងកម្រិតពណ៌នាៈ

តារាង ២.២ កម្រិតពណ៌នានៃភាពអាចអានបាន

ពិន្ទុ	កម្រិតពណ៌នា
០ ដល់ ៣០	លំបាកខ្លាំង
៣១ ដល់ ៥០	លំបាកមធ្យម
៥១ ដល់ ៦០	លំបាក
៦១ ដល់ ៧០	ស្ពុង់ដា
៧១ ដល់ ៨០	ស្រួលមធ្យម
៨១ ដល់ ៩០	ស្រួល
៩១ ដល់ ១០០	ស្រួលខ្លាំង

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[1] អក្សរមានន័យថាការរាប់ព្យញ្ជនៈ ជើងព្យញ្ជនៈ ស្រៈនិស្ស័យ ស្រៈពេញតួ និង វណ្ណយុត្តិ

រូបមន្តក្រិតថ្នាក់នៃភាពអាចអានបាន

អ្នកនិពន្ធបានកំណត់រូបមន្តក្រិតថ្នាក់នៃភាពអាចអានបានទៅតាមទម្រង់ផ្សេងៗដើម្បី គណនារកក្រិតថ្នាក់ក្នុងអត្ថបទអំណានដូចបានចែងខាងក្រោមនេះ៖

តារាង ២.៣ កម្រិតពណ៌នានៃភាពអាចអានបាន

អ្នកនិពន្ធ និងឆ្នាំ	រូបមន្តក្រិតថ្នាក់នៃភាពអាចអានបាន
Gunning (1952)	ថ្នាក់ = ៤ {[(ចំនួនពាក្យសរុប)/(ចំនួនឃ្លាៈសរុប)] +១០០[(ចំនួនពាក្យពិបាក²សរុប)/(ចំនួនពាក្យសរុប)]}
Powers et al. (1958)	ថ្នាក់ = ៣,០៦៨០ + ០,៨៧៧ [(ចំនួនពាក្យសរុប)/(ចំនួនឃ្លាៈសរុប)] + ៩,៨៤[(ចំនួនពាក្យពិបាកសរុប)/(ចំនួនពាក្យសរុប)]
Kincaid et al. (ទាញ អាគតដ្ឋានដោយ Dubay, 2004, p. 93)	ថ្នាក់ = ០,៤ [(ចំនួនពាក្យសរុប)/(ចំនួនឃ្លាៈសរុប)] +១២ [(ចំនួនព្យាង្គ សរុប)/(ចំនួនពាក្យសរុប)] –១៥
(Crawford, 1984)	ថ្នាក់ = ០,០៨៩ (ចំនួនពាក្យមួយព្យាង្គក្នុងចំណោម ១០០ពាក្យ) – ០,២០៥ (ចំនួនឃ្លាៈក្នុងចំណោម ១០០ពាក្យ) – ៣,៤០៧

កិច្ចការសិក្សាពីមុន

ការសិក្សាជាច្រើនពាក់ព័ន្ធនឹងក្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានមានសណ្ឋាន ជាក់លាក់តាមក្រិតនៃការសិក្សារបស់អ្នកនិពន្ធ។ Yulianto (2019) បានវិភាគទៅលើ ក្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានក្នុងភាសាអង់គ្លេសសម្រាប់ថ្នាក់ទី៨ ដោយប្រើ ប្រាស់រូបមន្តក្រិតនៃភាពអាចអានបានរបស់ Flesch និង Kincaid Readability។ លទ្ធផល នៃការវិភាគនេះបានបញ្ជាក់យ៉ាងច្បាស់ថា អត្ថបទអំណានទាំងនោះមានលក្ខណៈសមស្រប នឹងក្រិតសិស្សអនុវិទ្យាល័យនោះណាស់។ Turkben (2019) បានសិក្សាទៅលើអត្ថបទ អំណានក្នុងភាសាតួកគីសម្រាប់ក្រិតអនុវិទ្យាល័យ ដែលលទ្ធផលនៃការសិក្សានេះបញ្ជាក់ ថា ក្រិតនៃភាពអាចអានបានគឺពិតជាអាស្រ័យទៅលើការយកចំនួនពាក្យក្នុងឃ្លាៈនីមួយៗ និងចំនួនព្យាង្គក្នុងពាក្យនីមួយៗ។ មកផ្ទៀងផ្ទាត់នឹងសមត្ថភាពនិងក្រិតយល់ដឹងរបស់អ្នក

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² ពាក្យពិបាក គឺជាពាក្យដែលមានលើសពី ២ ព្យាង្គ

អានប្រាកដមែន។ ការសិក្សាមួយទៀត ដែលលើកឡើងដោយ Telaumbanua និង Umiyati (2019) បានវិភាគទៅលើម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានក្នុងភាសាអង់គ្លេស សម្រាប់ថ្នាក់ទី៩ នៅប្រទេសឥណ្ឌូនេស៊ី។ លទ្ធផលនៃការសិក្សានេះបានបញ្ជាក់ថា អត្ថបទ អំណានទាំងនោះមិនសមស្របនឹងម្រិតសិស្សថ្នាក់ទី៩ទេ ព្រោះវាមានកម្រិតស្រួលផង និង ពិបាកមធ្យមផងច្របូកច្របល់គ្នា។ Khodadady និង Mehrazmay (2017) បានសិក្សាទៅ លើកម្រិតភាសាអង់គ្លេសមធ្យមកម្រិតខ្ពស់ក្នុងសៀវភៅសិក្សាគោលនៃមុខវិជ្ជាភាសាអង់គ្លេស ជាភាសាបរទេស (English as a foreign language) និងមុខវិជ្ជាភាសាអង់គ្លេសជាភាសា ទីពីរ (English as a second language) ដែលមានកម្រិតជំនាញភាសាដូចគ្នា។ លទ្ធផល នៃការសិក្សានេះក៏បានបង្ហាញថា ភាពអាចអានបាននៃសៀវភៅសិក្សាគោលគឺពុំមានការ ប្រែប្រួលទេ។

អ្នកនិពន្ធខ្លះទៀតបានបង្ហាញពីទំនាក់ទំនងការវាងកម្រិតនៃភាពអាចអានបាន។ Luong et al. (2020) បានសិក្សាការវាយតម្លៃកម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានដើម្បី សរសេរអត្ថបទ ឲ្យត្រូវតាមសមត្ថភាពអ្នកអាននៅប្រទេសវៀតណាម។ ចំណែក Tongtep et al. (2014) បានសិក្សាអំពីកម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានក្នុងភាសាថៃ។ ក្រុមអ្នកនិពន្ធបានយកសៀវភៅសិក្សាគោលមុខវិជ្ជាភាសាវៀតណាមនិងថៃ ទាំងថ្នាក់បឋម សិក្សា ទាំងអនុវិទ្យាល័យ និងវិទ្យាល័យ មកវិភាគរកកម្រិតនៃភាពអាចអានបាន។ លទ្ធផល នៃការវិភាគបានបញ្ជាក់ថា មានកម្រិតទំនាក់ទំនងគ្នាវាងអត្ថបទក្នុងសៀវភៅសិក្សាគោល ទាំងនោះ ទាំងកម្រិតបឋម អនុវិទ្យាល័យ និងវិទ្យាល័យ។ ជាងនេះទៅទៀត Çetinkaya និង Uzun (2012) បានសិក្សាអំពីទំនាក់ទំនងរវាងកម្រិតនៃភាពអាចអានបាននៃអត្ថបទ និង លក្ខណៈនៃគ្នូអក្សរ ហើយការសិក្សានេះបានបញ្ជាក់ថា វាពិតជាមានទំនាក់ទំនងរវាងគ្នានិង គ្នាយ៉ាងប្រាកដ។

វិធីសាស្ត្រស្រាវជ្រាវ
ប្រភពទិន្នន័យនៃការស្រាវជ្រាវ

ទិន្នន័យសម្រាប់ការស្រាវជ្រាវនេះបានមកពីសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩ របស់ក្រសួងអប់រំ យុវជន និងកីឡា ដែលត្រូវបានបោះពុម្ពដោយគ្រឹះស្ថានបោះពុម្ព

និងចែកផ្សាយនៅឆ្នាំ២០១៦។ លទ្ធផលនៃការធ្វើតេស្តវាយតម្លៃរបស់ក្រសួងអប់រំ យុវជន និងកីឡា (២០១៥) ទៅលើសមត្ថភាពភាសាខ្មែររបស់សិស្សថ្នាក់ទី៣ និងទី៦ បានបង្ហាញ ថា សិស្សដែលបានធ្វើតេស្តនោះជាប់មិនដល់ ៥០% ទេ។ ម្យ៉ាងវិញទៀត អំណានថ្នាក់ទី៩ ពុំ មានការធ្វើតេស្តវាយតម្លៃមុនថ្នាក់ជាតិទេ ទើបអ្នកស្រាវជ្រាវជ្រើសរើសបន្ថែម ដើម្បីស្វែង រកភាពខុសគ្នានៃអត្ថបទអំណានទាំងនោះ ដោយផ្អែកលើចំនួនព្យាង្គ ចំនួនពាក្យ និងចំនួន ល្បះ។ ដូច្នេះ ក្នុងសិក្សាស្រាវជ្រាវនេះ សៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩ របស់ក្រសួងអប់រំ យុវជន និង កីឡា ត្រូវបានជ្រើសរើសយកមកអង្កេតពិនិត្យ។ តារាង ៣.១ បង្ហាញទិន្នន័យជាចំនួនមេរៀន ចំនួនអំណាន និងចំនួនទំព័រក្នុងសៀវភៅសិក្សាគោលភាសា ខ្មែរនីមួយៗ ដែលត្រូវបានវិភាគ។

តារាង ៣.១ ចំនួនមេរៀន អំណាន និងទំព័រក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែរ

សៀវភៅសិក្សាគោលភាសាខ្មែរ	ចំនួនមេរៀន	ចំនួនអំណាន	ចំនួនទំព័រ
ថ្នាក់ទី៣	៦៤	២១	២២៦
ថ្នាក់ទី៦	១០	១៩	១៥៦
ថ្នាក់ទី៩	១០	២២	២៥២

វិធីសាស្ត្រនិងឧបករណ៍ស្រាវជ្រាវ

អ្នកស្រាវស្រាវប្រើប្រាស់វិធីសាស្ត្របរិមាណវិស័យ ដើម្បីធ្វើឧច្ចិនកម្មទិន្នន័យសម្រាប់ ឆ្លើយតបនឹងសំណួរស្រាវជ្រាវ។ អ្នកស្រាវជ្រាវបានប្រើឧបករណ៍ស្រាវជ្រាវចំនួនពីរសម្រាប់ ពណ៌នាលម្អិតអំពីកម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានក្នុងសៀវភៅសិក្សាគោល ភាសាខ្មែរ។ ឧបករណ៍ស្រាវជ្រាវដែលត្រូវបានប្រើដំបូងគឺរូបមន្តរបស់ Flesch (1948) ដោយយក ២០៦,៨៣៥ ដកផលគុណរវាង ១,០១៥ និងផលចែករវាងចំនួនពាក្យសរុបនិង ចំនួនល្បះសរុប រួចយកផលសងនេះដកផលគុណរវាង ៨៤,៦ និង ផលចែករវាងចំនួនព្យាង្គ សរុបនិងចំនួនពាក្យសរុប។ លទ្ធផលនៃការគណនានេះគឺជាពិន្ទុ ដែលត្រូវស្ថិតក្នុងចន្លោះពី ០ ដល់ ១០០ ហើយកម្រិតពណ៌នាត្រូវស្ថិតក្នុងចន្លោះពី ៉លំបាកខ្លាំង៉ ដល់ ៉ស្រួលខ្លាំង៉។ ឧបករណ៍ស្រាវជ្រាវទី២ គឺរូបមន្តរបស់ Kincaid et al. (ទាញអាគតដ្ឋានដោយ Dubay, 2004, p. 93) ដើម្បីកំណត់រកកម្រិតថ្នាក់នៃអត្ថបទអំណាន ដោយយក ០,៤ គុណនឹងផល ចែករវាងចំនួនពាក្យសរុបនិងចំនួនល្បះសរុប រួចយកផលគុណនេះបូកនឹងផលគុណរវាង ១២

និង ផលចែករវាងចំនួនព្យាង្គសរុបនិងចំនួនពាក្យសរុប រួចយកផលបូកនេះដក ១៥។ ខាងក្រោម នេះគឺជារូបមន្តសម្រាប់គណនាកម្រិតនៃភាពអាចអានបាន និងកម្រិតថ្នាក់នៃអត្ថបទអំណាន៖

ពិន្ទុ = ២០៦,៨៣៥ – ១,០១៥ [(ចំនួនពាក្យសរុប)/(ចំនួនល្បះសរុប)] – ៨៤,៦ [(ចំនួនព្យាង្គសរុប)/(ចំនួនពាក្យសរុប)]

ថ្នាក់ = ០,៤ [(ចំនួនពាក្យសរុប)/(ចំនួនល្បះសរុប)] + ១២ [(ចំនួនព្យាង្គសរុប)/ (ចំនួនពាក្យសរុប)] – ១៥

ពិន្ទុ (Flesch Reading Ease Score)	កម្រិតពណ៌នា
០ ដល់ ៣០	លំបាកខ្លាំង
៣១ ដល់ ៥០	លំបាកមធ្យម
៥១ ដល់ ៦០	លំបាក
៦១ ដល់ ៧០	ស្តង់ដា
៧១ ដល់ ៨០	ស្រួលមធ្យម
៨១ ដល់ ៩០	ស្រួល
៩១ ដល់ ១០០	ស្រួលខ្លាំង

វិធីសាស្ត្រងួច្នៃនកម្មទិន្នន័យ

អ្នកស្រាវជ្រាវបានប្រើប្រាស់សៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩ របស់ ក្រសួងអប់រំ យុវជន និង កីឡា ដែលបានបោះពុម្ពក្នុងឆ្នាំ២០១៦ ដើម្បីកំណត់អត្ថបទដែល ត្រូវយកមកវិភាគ។ ជាបឋម អ្នកស្រាវជ្រាវស្វែងរកអត្ថបទអំណានក្នុងសៀវភៅសិក្សាគោល ភាសាខ្មែរទាំងបីថ្នាក់ និងជ្រើសរើសបាន ២១អត្ថបទពីសៀវភៅថ្នាក់ទី៣, ១៨អត្ថបទពី សៀវភៅថ្នាក់ទី៦ និង ២២អត្ថបទពីសៀវភៅថ្នាក់ទី៩។ បន្ទាប់មក អ្នកស្រាវជ្រាវបំប្លែង អត្ថបទទាំងនោះទៅជាអត្ថបទក្នុងកម្មវិធីកុំព្យូទ័រម្ចួយហៅថា Microsoft word ដោយបូអត្ថបទ ទាំងនោះពីទម្រង់ PDF ទៅជាទម្រង់ PNG។ ក្រោយមក អ្នកស្រាវជ្រាវដាក់អត្ថបទដែលជាប់ ទម្រង់ PNG ទាំងនោះចូលទៅក្នុងកម្មវិធី Google Drive រួចបំប្លែងអត្ថបទទាំងនោះចូលទៅ ក្នុងកម្មវិធី Google docs រួចចម្លងអត្ថបទទាំងនោះចូលទៅក្នុងកម្មវិធី Microsoft word និង ផ្ទៀងផ្ទាត់ឡើងវិញដើម្បីបញ្ជាក់ពីភាពច្បាស់លាស់នៃអត្ថបទអំណាន។ បន្ទាប់ពីទទួលបាន

អត្ថបទអំណានទាំងនោះហើយ អ្នកស្រាវជ្រាវបានប្រើកម្មវិធី PAN Khmer Line Breaking ដើម្បីញែកពាក្យទាំងនោះចេញពីល្បះ ព្រោះពាក្យនីមួយៗក្នុងសំណេរភាសាខ្មែរមិនដាច់ពីគ្នាដូចភាសាបារាំង ឬអង់គ្លេសនោះទេ។ កម្មវិធី PAN Khmer Line Breaking នេះស្គាល់ពាក្យខ្មែរចំនួន ១០០០០០ពាក្យ ដែលក្នុងនោះ មានទាំងពាក្យនៅក្នុងវចនានុក្រមសម្តេចសង្ឃរាជ ជួន ណាត វចនានុក្រមអក្ខរាវិរុទ្ធនៃភាសាខ្មែរ និង ១០០០០ពាក្យទៀតជាឈ្មោះភូមិ ឃុំ/សង្កាត់ ស្រុក/ខណ្ឌ និងខេត្ត/ក្រុង និងមានសម្ភាពកាត់ពាក្យចេញពីគ្នាក្នុងអត្ថបទអំណាន ដើម្បីជានានុភាពច្បាស់លាស់នៃពាក្យទាំងនោះ។ បន្ទាប់ពីកាត់ពាក្យនីមួយៗរួចហើយ អ្នកស្រាវជ្រាវបានយកអត្ថបទទាំងនោះទៅដាក់នៅក្នុងកម្មវិធី Microsoft word ម្ដងទៀតដើម្បីរាប់ពាក្យ និងល្បះដោយឧបករណ៍មួយក្នុងកម្មវិធី Microsoft word ដែលមានឈ្មោះថា Find and Replace ក្នុងការទម្លាក់ពាក្យមួយៗដាច់ដោយឡែកពីគ្នា រួចហើយយកពាក្យទាំងនោះទៅរាប់និងទុកនៅក្នុងកម្មវិធី Microsoft Excel ដើម្បីវិភាគរកចំនួនល្បះ ចំនួនពាក្យ និងចំនួនព្យាង្គក្នុងអត្ថបទនីមួយៗ។ ចំពោះការរាប់ល្បះត្រូវបានកំណត់ដោយសញ្ញាខណ្ឌ (។) សញ្ញាឧទាន (!) និងសញ្ញាសួរ (?)។ ទីបំផុត អ្នកស្រាវជ្រាវអាចប្រមូលទិន្នន័យចេញពីសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និង ទី៩ បានដោយជោគជ័យ។

ការវិភាគទិន្នន័យ

បន្ទាប់ពីប្រមូលទិន្នន័យបានហើយ អ្នកស្រាវជ្រាវបានយកទិន្នន័យទាំងនោះមកគណនាតាមរូបមន្តរបស់ Flesch, 1948 និង Kincaid et al. (ទាញអាគតដ្ឋានដោយ Dubay, 2004, p. 93) ដែលបង្ហាញក្នុងចំណុច ៣.២ ដើម្បីរកពិន្ទុក្នុងអត្ថបទអំណាន និងបញ្ជាក់ថាអត្ថបទអំណានស្ថិតក្នុងកម្រិតនៃភាពអាចអានបាន និងដើម្បីគណនាកម្រិតថ្នាក់ក្នុងអត្ថបទអំណានដែលបានដកស្រង់ចេញពីសៀវភៅគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩។ បន្ទាប់មក អ្នកស្រាវជ្រាវបានប្រើប្រាស់ស្ថិតិពណ៌នានាដើម្បីគណនា អប្បបរមា អតិបរមា ធម្យម និងភាគរយ (%) នៃចំនួនព្យាង្គក្នុងពាក្យ ចំនួនពាក្យក្នុងល្បះនិងក្នុងអត្ថបទ និងចំនួនល្បះក្នុងអត្ថបទ ដើម្បីកំណត់ភាពអាចអានបាននៃអត្ថបទអំណាននៅថ្នាក់ទាំងបី និងស្ថិតិសន្និដ្ឋានដើម្បីរកទំនាក់ទំនងរវាងចំនួនព្យាង្គ ចំនួនពាក្យ និងចំនួនល្បះ ក្នុងអត្ថបទអំណាននីមួយៗ ។

លទ្ធផលស្រាវជ្រាវ

បន្ទាប់ពីធ្វើឌីជីថលកម្មនៃទិន្នន័យដែលបានពីសៀវភៅសិក្សាគោលភាសាខ្មែរទាំងបីថ្នាក់រួច អ្នកស្រាវជ្រាវបានយកទិន្នន័យទាំងនោះមកវិភាគរកចម្លើយសម្រាប់សំណួរស្រាវជ្រាវទាំងបី។ មុននឹងបង្ហាញលទ្ធផល អ្នកស្រាវជ្រាវសូមបង្ហាញទិន្នន័យមូលដ្ឋានអំពីសៀវភៅសិក្សាគោល ភាសាខ្មែរ ដោយសង្ខេបទៅតាមចំនួនអំណាន ចំនួនពាក្យ ចំនួនល្បះ និងចំនួនព្យាង្គ ដែល មានក្នុងតារាង ៤.១ ខាងក្រោមនេះៈ

តារាង ៤.១ ការកំណត់ចំនួនអំណាន ល្បះ ពាក្យ និងព្យាង្គនៃសៀវភៅសិក្សាគោលភាសា ខ្មែរ

សៀវភៅសិក្សាគោលភាសាខ្មែរ	ចំនួនអំណាន	ចំនួនល្បះ	ចំនួនពាក្យ	ចំនួនព្យាង្គ
ថ្នាក់ទី៣	២១	១៧៧	២៨៩៨	៣៨៩៩
ថ្នាក់ទី៦	១៨	៣៥៤	៥៧៦៤	៧៥៨៥
ថ្នាក់ទី៩	២២	៧៧៧	១៦០២២	២៤៣១០
សរុប	*៦១*	*១៣០៨*	*២៤៦៨៤*	*៣៥៨៩០*

តារាង ៤.១ បានបញ្ជាក់យ៉ាងច្បាស់ថា សៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី ទី៣ ទី៦ និង ទី៩ មានអត្ថបទអំណានរៀងគ្នា ចំនួន ២១, ១៨, និង ២២។ ឯចំនួនព្យាង្គ ចំនួនពាក្យ និង ចំនួនល្បះ មានការកើនឡើងជាខ្លាំងទៅតាមកម្រិតថ្នាក់គួរឱ្យកត់សម្គាល់ ដោយថ្នាក់ទី៣ មានចំនួន ១៧៧ល្បះ ២៨៩៨ពាក្យ និង ៣៨៩៥ព្យាង្គ។ ចំនួននេះកើនឡើងទ្វេដងនៅថ្នាក់ ទី៦ ដែលមានចំនួន ៣៥៤ល្បះ ៥៧៦៤ពាក្យ និង ៧៥៨៥ព្យាង្គ និងស្ទើរឡើងយ៉ាងខ្លាំងនៅ ថ្នាក់ទី៩ ដែលមាន ៧៧៧ល្បះ ១៦០២២ពាក្យ និង ២៤៣១០ព្យាង្គ។ ដូច្នេះ គេអាច សន្និដ្ឋានថា ចំនួនព្យាង្គ ចំនួនពាក្យ និងចំនួនល្បះក្នុងអត្ថបទអំណានមានការកើនឡើងខ្លាំង តាមលំដាប់ថ្នាក់ពីទី៣ ទៅទី៦ រូចទៅទី៩ទៀត។

លទ្ធផលនៃការស្រាវជ្រាវស្ដីពីកម្រិតនៃភាពអាចអានបាន

សំណួរស្រាវជ្រាវទី១គឺ "តើអត្ថបទអំណាននៅក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី ៣ ទី៦ និងទី៩ ស្ថិតនៅក្នុងភាពអាចអានបានកម្រិតណា? និងស្ថិតនៅកម្រិតថ្នាក់ទី ប៉ុន្មាន?"។ ដើម្បីកំណត់កម្រិតនៃភាពអាចអានបាន គេត្រូវអនុវត្តតាមរូបមន្ត Flesch "ពិន្ទុ = ២០៦,៨៣៥ – ១,០១៥ [(ចំនួនពាក្យសរុប)/(ចំនួនល្បះសរុប)] – ៨៤,៦ [(ចំនួនព្យាង្គ

សរុប)/(ចំនួនពាក្យសរុប)]″។ ខាងក្រោមនេះ អ្នកស្រាវជ្រាវនឹងបង្ហាញលម្អិតអំពីការអនុវត្ត រូបមន្ត Flesch ដោយលើកយកឧទាហរណ៍គំរូអំពីអត្ថបទអំណានមួយក្នុងសៀវភៅថ្នាក់ទី៣ និងដាក់បញ្ចូលអត្ថបទអំណានទាំងអស់នៃថ្នាក់នីមួយៗទៅក្នុងតារាងដាច់ដោយឡែកពីគ្នា។

អ្នកស្រាវជ្រាវបានសង្កេតឃើញថា ក្នុងអត្ថបទអំណានទី១ មានចំនួន ១៨០ព្យាង្គ ១៤១ពាក្យ និង ៨ល្បះ។

តាមរូបមន្ត Flesch   ពិន្ទុ = ២០៦,៨៣៥ – ១,០១៥ [(ចំនួនពាក្យសរុប)/(ចំនួនល្បះ សរុប)] – ៨៤,៦ [(ចំនួនព្យាង្គសរុប)/(ចំនួនពាក្យសរុប)]

ចំនួនពាក្យសរុប/ចំនួនល្បះសរុប   = ១៤១/៨   = ១៧,៦២៥
ចំនួនព្យាង្គសរុប/ចំនួនពាក្យសរុប   = ១៨០/១៤១ = ១,២៧៦
ពិន្ទុ = ២០៦,៨៣៥ – (១,០១៥ x ១៧,៦២៥) – (៨៤,៦ x ១,២៧៦) = ៨០,៩៤១
ពិន្ទុនៃអត្ថបទអំណានទី១ ស្មើនឹង ៨០,៩៤១ ដូចច្នេះ កម្រិតពណ៌នានៃភាពអាចអាន បានរបស់អត្ថបទនេះគឺ "ស្រួល″។

តាម Kincaid et al. (ទាញអាគតដ្ឋានដោយ Dubay, 2004, p. 93) ដើម្បីគណនាកម្រិត ថ្នាក់នៃអត្ថបទអំណាន គេអនុវត្តរូបមន្តខាងក្រោមនេះ៖

{កម្រិតថ្នាក់ =   ០,៤ [(ចំនួនពាក្យសរុប)/(ចំនួនល្បះសរុប)])
                  + ១២ [(ចំនួនព្យាង្គសរុប)/(ចំនួនពាក្យសរុប)] – ១៥}
ចំនួនពាក្យសរុប/ចំនួនល្បះសរុប   = ១៤១/៨   = ១៧,៦២៥
ចំនួនព្យាង្គសរុប/ចំនួនពាក្យសរុប   = ១៨០/១៤១ = ១,២៧៦
កម្រិតថ្នាក់ = (០,៤ x ១៧,៦២៥) + (១២ x ១,២៧៦) – ១៥ = ៧
ដូចច្នេះ អត្ថបទអំណានទី១ មានកម្រិតស្មើនឹងថ្នាក់ទី៧។
សរុបមក អត្ថបទអំណានទី១ នៅថ្នាក់ទី៣ មានកម្រិតស្រួលសម្រាប់សិស្សថ្នាក់ទី៧។
ខាងក្រោមនេះជាតារាងលទ្ធផលនៃការគណនាភាពអាចអានបាននៃអត្ថបទអំណានក្នុង សៀវភៅសិក្សាគោលកាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩។

សៀវភៅសិក្សាគោលកាសាខ្មែរថ្នាក់ទី៣
តារាង ៤.២ លទ្ធផលស្តីពីកម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានថ្នាក់ទី៣

សៀវភៅសិក្សាគោលភាសាខ្មែរ ថ្នាក់ទី៣	ចំនួន ឃ្លាង	ចំនួន ពាក្យ	ចំនួន ឃ្លា	ចំនួនពាក្យ ក្នុងឃ្លាជា មធ្យម	ពិន្ទុ	កម្រិត ពណ៌នា	កម្រិត ថ្នាក់[3]
អំណានទី១	១៨០	១៩១	៨	១៩	៨០,៩៩៦	ស្រួល	៧
អំណានទី២	១២៤	១០៤	៨	១៣	៩២,៧៧៩	ស្រួលខ្លាំង	៥
អំណានទី៣	១៣៤	១១១	៨	១៦	៨៨,៦១០	ស្រួល	៦
អំណានទី៤	១៥៣	១៤០	១០	១៤	១០០,០០	ស្រួលខ្លាំង	៤
អំណានទី៥	១៣៩	៩៨	៦	១៧	៧០,២៦៣	ស្រួលមធ្យម	៨
អំណានទី៦	១៦២	១១៧	៩	១៣	៧៦,៥០២	ស្រួលមធ្យម	៧
អំណានទី៧	១៥២	១២៨	៧	១៤	៩១,៩៣៧	ស្រួលខ្លាំង	៥
អំណានទី៨	១៥៣	១១៥	៧	១៧	៧៧,៦០៥	ស្រួលមធ្យម	៨
អំណានទី៩	១៥៦	១៤៧	១២	១១	១០០,០០	ស្រួលខ្លាំង	២
អំណានទី១០	១៩២	១២៥	៧	២១	៥៥,៧៤៤	លំបាក	១២
អំណានទី១១	១៦១	១១៨	៨	១៥	៧៦,៤៣៥	ស្រួលមធ្យម	៧
អំណានទី១២	២៦៩	២០២	៩	២៣	៧១,៣៩៣	ស្រួលមធ្យម	១០
អំណានទី១៣	១៨៤	១៣៦	៨	១៧	៧៥,១២១	ស្រួលមធ្យម	៨
អំណានទី១៤	២២២	១៧៧	១២	៩	៩២,១៧២	ស្រួលខ្លាំង	៣
អំណានទី១៥	២១៤	១៤៥	១០	១៥	៦៧,២៦០	ស្ទង់ដា	៩
អំណានទី១៦	២១៥	១៣២	៧	១៩	៩៩,៩០០	លំបាកមធ្យម	១២
អំណានទី១៧	១៧៥	១១៩	៦	២០	៦៩,៤០៧	ស្ទង់ដា	១១
អំណានទី១៨	២២៤	១៦៨	១៣	១៣	៧៨,៩០៤	ស្រួលមធ្យម	៦
អំណានទី១៩	៣០៤	១៩០	៨	២៤	៤៧,៣៦៩	លំបាកមធ្យម	១៤
អំណានទី២០	២៩៦	១៩៩	៨	១៧	៥៥,០៨៦	លំបាក	១១
អំណានទី២១	២៣២	១៣១	៦	២២	៣៤,៨៤៨	លំបាកមធ្យម	១៥
សរុប	**៣៩៩៥**	**២៨៩៩**	**១៧៧**	**១៦**	**៧៤,៥៦៥**	**ស្រួលមធ្យម**	**៨**

តារាង ៤.២ បង្ហាញលទ្ធផលនៃការគណនាកម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណាន ក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣។ លទ្ធផលបង្ហាញថា អត្ថបទអំណានទាំង២១នេះ

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[3] កម្រិតថ្នាក់ ១-១២ (ថ្នាក់ទី១-ទី១២), កម្រិតថ្នាក់ ១៣-១៦ (បរិញ្ញាបត្រ), កម្រិតថ្នាក់១៧-១៨ (បរិញ្ញាបត្រជាន់ខ្ពស់), និង កម្រិតថ្នាក់ចាប់ពី ១៩ ឡើង (បណ្ឌិត)

មានចំនួនសរុប ៣៩៤៥ញ្ញាង្គ ២៨៩៣ពាក្យ ១៧៧ល្បះ ជាមធ្យម១៦ពាក្យក្នុងមួយល្បះ មានពិន្ទុសរុប៧៤,៥៦៥ មានកម្រិតពណ៌នា "ស្រួលមធ្យម" ហើយត្រូវនឹងកម្រិតថ្នាក់ទី៧។ ក្នុងចំណោមអត្ថបទអំណានទាំង២១ អត្ថបទទី២ ទី៤ ទី៧ ទី៩ និងទី១៤ ស្ថិតក្នុងកម្រិត ស្រួលខ្លាំង, អត្ថបទទី១ និងទី៣ ស្ថិតក្នុងកម្រិតស្រួល, អត្ថបទទី៥ ទី៦ ទី៨ ទី១១ ទី១២ និងទី១៣ ស្ថិតក្នុងកម្រិតស្រួលមធ្យម, អត្ថបទទី១៥ និងទី១៧ ស្ថិតក្នុងកម្រិតស្ទង់ដា,អត្ថបទ ទី១៦ ទី១៩ និងទី២១ ស្ថិតក្នុងកម្រិតលំបាកមធ្យម និងអត្ថបទទី១០ និងទី២០ មានកម្រិត លំបាក។ អំណានទី២ មានចំនួនញ្ញាង្គតិចជាងគេ (១២៤ញ្ញាង្គ), អំណានទី៥មានចំនួន ៣ពាក្យតិចជាងគេ (៩៨ពាក្យ), និងអំណានទី៥ ទី១០ ទី១៧ និងទី២១ មានល្បះតិចជាងគេ (៦ល្បះ)។ អំណានទី១៩ មានចំនួនញ្ញាង្គច្រើនជាងគេ (៣០៤ញ្ញាង្គ), អំណានទី១២ មាន ចំនួន៣ពាក្យច្រើនជាងគេ (២០២៣ពាក្យ), និងអំណានទី១៤ និងទី៩ មានចំនួនល្បះច្រើនជាង គេ (១២ល្បះ)។ ក្នុងចំណោមអត្ថបទអំណានទាំង២១នេះ អត្ថបទអំណានទី១៤ ត្រូវនឹង កម្រិតសិស្សថ្នាក់ទី៣, អត្ថបទអំណានទី៩ ត្រូវនឹងកម្រិតសិស្សថ្នាក់ទី២, ៥អត្ថបទត្រូវនឹង សមត្ថភាពសិស្សពីថ្នាក់ទី៤ ដល់ ទី៦, ៧អត្ថបទត្រូវនឹងកម្រិតសិស្សអនុវិទ្យាល័យ, ៥អត្ថបទ ស្ថិតក្នុងកម្រិតវិទ្យាល័យ, និង ២អត្ថបទស្ថិតក្នុងកម្រិតឧត្តមសិក្សា។ លទ្ធផលនេះត្រូវបាន សន្និដ្ឋានថា កម្រិតថ្នាក់គឺអាស្រ័យទៅលើចំនួនញ្ញាង្គ ចំនួន៣ពាក្យ និងចំនួនល្បះក្នុងអត្ថបទ អំណាន។ កាលណាចំនួនញ្ញាង្គប្រហាក់ប្រហែលចំនួន៣ពាក្យ និងចំនួនល្បះដែលមាន៣ពាក្យជា មធ្យមតិចដែរ គេអាចសន្និដ្ឋានថា អត្ថបទអំណាននោះស្ថិតក្នុងថ្នាក់ទាបដែរ។ ដូច្នេះ អត្ថបទ អំណាននៃសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ មានកម្រិតហួសពីសមត្ថភាពសិស្សថ្នាក់ ទី៣រហូតទៅដល់ជិតពាង៣។

តារាង ៤.៣ បង្ហាញលទ្ធផលនៃការគណនាកម្រិតនៃភាពអាចអានបានក្នុងអត្ថបទអំណាន នៃសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៦។ លទ្ធផលបង្ហាញថា អត្ថបទអំណានទាំង១៨នេះ មានចំនួនសរុប ៧៥៨៥ញ្ញាង្គ ៥៧៦៤ពាក្យ ៣៥៤ល្បះ, ជាមធ្យមមាន១៦ពាក្យ ក្នុងមួយ ល្បះ មានពិន្ទុសរុប៧៩,៤៧៩ និងមានកម្រិតពណ៌នា "ស្រួលមធ្យម" សម្រាប់កម្រិតថ្នាក់ទី៧។ អត្ថបទអំណានចំនួន៣ស្ថិតនៅក្រោមកម្រិតថ្នាក់ទី៦ ៥អត្ថបទត្រូវនឹងកម្រិតថ្នាក់ទី៦ និង ១០អត្ថបទទៀតមានកម្រិតខ្ពស់ជាងថ្នាក់ទី៦។ ដូច្នេះ អត្ថបទអំណានក្នុងសៀវភៅសិក្សា គោលភាសាខ្មែរថ្នាក់ទី៦ ពុំត្រូវតាមកម្រិតសិក្សារបស់សិស្សថ្នាក់ទី៦នោះទេ។

សៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៦

តារាង ៤.៣ លទ្ធផលស្ដីពីកម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានថ្នាក់ទី៦

សៀវភៅសិក្សា គោលភាសាខ្មែរ ថ្នាក់ទី៦	ចំនួន ព្យាង្គ	ចំនួន ព្យាក្យ	ចំនួន ឃ្លា	ព្យាក្យក្នុង ឃ្ល:ជា មធ្យម	ពិន្ទុ	កម្រិត ពណ៌នា	កម្រិត ថ្នាក់³
អំណានទី១	៤០០	៣០៩	២២	១៤	៨៣,០៦៤	ស្រួល	៦
អំណានទី២	៥៩១	៤៥៥	៤០	១៣	៩,៥៥៧	ស្រួលខ្លាំង	៥
អំណានទី៣	៥១៣	៣៩៩	៣៤	១១	៨៦,៨៩៤	ស្រួល	៥
អំណានទី៤	៣៣៨	២៣៣	១៤	១៧	៦៧,២៩៨	ស្ទង់ជា	៩
អំណានទី៥	៣៦៧	២៦០	១៤	១៩	៦៨,៥៦៨	ស្ទង់ជា	៩
អំណានទី៦	៤៩៧	៤០០	២៦	១៣	៨៩,០៣២	ស្រួល	៥
អំណានទី៧	៤៧៨	៣៥៧	២៣	១៣	៨០,១៤០	ស្រួល	៦
អំណានទី៨	៥៦៩	៤៩៨	១៩	២២	៧៣,០៥២	ស្រួលមធ្យម	៩
អំណានទី៩	៤៩២	៣៩៧	២៣	១៧	៨៤,២០១	ស្រួល	៦
អំណានទី១០	៣៩៩	៣០៩	២០	១៦	៨៩,៩៩២	ស្រួល	៧
អំណានទី១១	៣៩១	៣០៨	១៦	១៩	៨៩,០៨៨	ស្រួល	៧
អំណានទី១២	៤២២	៣២៦	១៥	២២	៧៥,២៦៣	ស្រួលមធ្យម	៩
អំណានទី១៣	៣៦៦	២៦២	១២	២២	៦៦,៩៩២	ស្ទង់ជា	១០
អំណានទី១៤	២៥៤	១៣៩	៦	៣០	៥៦,៥០៧	លំបាក	១៤
អំណានទី១៥	៣៦៣	២៨៤	១៦	១៩	៨០,៦៨៦	ស្រួល	៧
អំណានទី១៦	៣៩៥	៣១៣	២៣	១៤	៨៦,៩៥៨	ស្រួល	៦
អំណានទី១៧	៤៥៧	២៧៤	១៣	២១	៤៧,៤២៧	លំបាកមធ្យម	១៣
អំណានទី១៨	៣៤៤	២៧០	១៩	១៥	៨៣,៨២៣	ស្រួល	៦
សរុប	**៧៥៨៥**	**៥៧៦៤**	**៣៥៤**	**១៦**	**៧៩,៤៧៩**	**ស្រួលមធ្យម**	**៧**

សៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៩

តារាង ៤.៤ បានបង្ហាញលទ្ធផលនៃការគណនាកម្រិតនៃភាពអាចអានបាននៃអត្ថបទ អំណានទាំង២២ក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៩។ លទ្ធផលសិក្សាបានបង្ហាញ ថា ក្នុងអត្ថបទអំណានទាំង២២នេះ មានចំនួនសរុប ២៥៣១០ព្យាង្គ, ១៦០២២ព្យាក្យ, ៧៧៧ឃ្ល:, ជាមធ្យម មាន២១៣ព្យាក្យក្នុងមួយឃ្ល:, មានពិន្ទុសរុប ៥៧,៤៨៧។ អ្វីដែលគួរឱ្យ

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កត់សម្គាល់យ៉ាងខ្លាំងនោះគឺៈ មានអត្ថបទអំណានចំនួន២ ស្ថិតនៅក្រោមកម្រិតនៃថ្នាក់ទី៩ និងមានតែ១អត្ថបទប៉ុណ្ណោះដែលត្រូវនឹងកម្រិតថ្នាក់ទី៩។

តារាង ៤.៤ លទ្ធផលស្ដីពីកម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានថ្នាក់ទី៩

សៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៩	ចំនួនព្យាង្គ	ចំនួនពាក្យ	ចំនួនឃ្លា	ពាក្យក្នុងឃ្លាជាមធ្យម	ពិន្ទុ	កម្រិតពណ៌នា	កម្រិតថ្នាក់³
អំណានទី១	៧៦៩	៤៩០	២១	២៤	៥០,៣៨៩	លំបាកមធ្យម	១៣
អំណានទី២	១៣៩៧	៨៩១	៣៨	២៥	៥០,៥៨៨	លំបាក	១៤
អំណានទី៣	១៣៣៨	៧៤៣	១៩	៥០	៤,២៩០	លំបាកខ្លាំង	២៦
អំណានទី៤	៦០៧	៣៩៩	២០	២០	៥៦,៧៨៣	លំបាក	១១
អំណានទី៥	១០៧៦	៧៦០	៣៥	២៣	៦៤,៣៧១	ស្ទង់ដា	១១
អំណានទី៦	៩៦៣	៦៦៧	២៧	២៥	៥៩,៦១៧	លំបាក	១២
អំណានទី៧	១៨៨៨	១២០៨	៦៥	១៩	៥៨,៨៣៦	លំបាក	១១
អំណានទី៨	៦៩៨	៤៩២	១៦	២៦	៩៥,៣៣០	លំបាកមធ្យម	១៩
អំណានទី៩	១១៦៥	៨៣៨	៣៥	២៤	៦៤,៩២១	ស្ទង់ដា	១១
អំណានទី១០	៨០៧	៤៩០	២៥	២០	៤៧,៦៩០	លំបាកមធ្យម	១៣
អំណានទី១១	៧៥៨	៤៩០	១៧	២៩	៤៦,៧៩៨	លំបាកមធ្យម	១៩
អំណានទី១២	១៧២៥	១២២៨	៧១	១៩	៦៩,៣៩២	ស្ទង់ដា	៩
អំណានទី១៣	១៦១៥	១០២៥	៥៣	២០	៥៣,៩០៩	លំបាក	១២
អំណានទី១៤	៦៨៧	៤០៥	១៣	៣២	៣១,៧០៧	លំបាកមធ្យម	១៨
អំណានទី១៥	៧៥៥	៤៩១	២៥	២០	៦៩,៩៨០	ស្ទង់ដា	១១
អំណានទី១៦	១២៩០	៧៩០	៤០	២១	៥២,៤៩៤	លំបាក	១២
អំណានទី១៧	១១៧៩	៦៧៦	២៦	២៦	៣២,៨៨៦	លំបាកមធ្យម	១៦
អំណានទី១៨	១៩២៨	៩៤៤	៤៦	១៩	៥៩,៦៦៦	លំបាក	១១
អំណានទី១៩	១២៥៥	៧៧៦	៣៩	២០	៤៩,៨៩៨	លំបាកមធ្យម	១២
អំណានទី២០	៩៩៩	៧៦០	៦០	១៣	៨៨,៩៥០	ស្រួល	៥
អំណានទី២១	១៥៩៩	១១៧៨	៨៤	១៧	៧៩,៩៩៦	ស្រួលមធ្យម	៧
អំណានទី២២	៥៦៧	៣៩៥	១៦	២២	៤៥,៩១១	លំបាកមធ្យម	១៣
សរុប	**២៤៣១០**	**១៦០២២**	**៧៧៧**	**២១**	**៥៧,៤០៧**	**លំបាក**	**១២**

រើង ១៩អត្ថបទទៀតមានកម្រិតខ្ពស់ជាងថ្នាក់ទី៩។ ជារួម សៀវភៅនេះស្ថិតក្នុងកម្រិត លំបាកអាន ហើយត្រូវនឹងកម្រិតសិក្សាថ្នាក់ទី១២។ ដូច្នេះ សៀវភៅសិក្សាគោលភាសាខ្មែរថ្នា ក់ទី៩ មិនត្រូវនឹងកម្រិតសិក្សារបស់សិស្សថ្នាក់ទី៩ នោះទេ។

លទ្ធផលកម្រិតពណ៌នានៃភាពអាចអានបាននិងល្បះជាមធ្យមតាមថ្នាក់

តារាង ៤.៥ កម្រិតពណ៌នានៃភាពអាចអានបានរបស់អត្ថបទអំណានថ្នាក់ទី៣ ទី៦ និងទី៩

កម្រិតពណ៌នា	ថ្នាក់ទី៣		ថ្នាក់ទី៦		ថ្នាក់ទី៩		សរុប	
	ចំនួន	%	ចំនួន	%	ចំនួន	%	ចំនួន	%
ស្រួលខ្លាំង	៥	២៣,៨១	១	៥,៥៦	-	-	៦	៩,៨៤
ស្រួល	២	៩,៥២	១០	៥៥,៥៦	១	៤,៥៥	១៣	២១,៣១
ស្រួលមធ្យម	៧	៣៣,៣៣	២	១១,១១	១	៤,៥៥	១០	១៦,៣៩
ស្ទង់ដា	២	៩,៥២	៣	១៦,៦៧	៤	១៨,១៨	៩	១៤,៧៥
លំបាក	២	៩,៥២	១	៥,៥៦	៧	៣១,៨២	១០	១៦,៣៩
លំបាកមធ្យម	៣	១៤,២៩	១	៥,៥៦	៨	៣៦,៣៦	១២	១៩,៦៧
លំបាកខ្លាំង	-	-	-	-	១	៤,៥៥	១	១,៦៤
សរុប	**២១**	**១០០**	**១៨**	**១០០**	**២២**	**១០០**	**៦១**	**១០០**

តារាង ៤.៥ កម្រិតពណ៌នានៃភាពអាចអានបានរបស់អត្ថបទអំណានថ្នាក់ទី៣ ទី៦ និង ទី៩ មាន ៧កម្រិតចាប់ពី ៉ស្រួលខ្លាំង៉ រហូតដល់ ៉លំបាកខ្លាំង៉។ ចំពោះថ្នាក់ទី៣ កម្រិត ស្រួលមធ្យម មានអត្រា ៣៣,៣៣%, កម្រិតស្រួលខ្លាំងមាន ២៣,៨១%, កម្រិតលំបាកមាន ១៤,២៩%, កម្រិតស្រួល កម្រិតស្ទង់ដា និងកម្រិតលំបាកមាន ៩,៥២ % ដូចគ្នា, និងគ្មាន កម្រិតលំបាកខ្លាំងទេ។ ចំពោះថ្នាក់ទី៦វិញ មានអត្រាគួរឱ្យកត់សម្គាល់ខ្លាំងជាងគេ គឺកម្រិត ស្រួលមាន ៥៥,៥៦%, កម្រិតស្ទង់ដាមាន ១៦,៦៧%, កម្រិតស្រួលមធ្យមមាន ១១,១១%, កម្រិតស្រួលខ្លាំង លំបាក និងលំបាកមធ្យមមាន ៥,៥៦% ដូចគ្នា, និងគ្មាន កម្រិតលំបាកខ្លាំងទេ។ ចំណែកអត្ថបទអំណានថ្នាក់ទី៩កម្រិតលំបាកមធ្យមមានអត្រាខ្ពស់ ជាងគេរហូត ៣៦,៣៦%, កម្រិតលំបាកមាន ៣១,៨២%, កម្រិតស្ទង់ដាមាន១៨,១៨%, កម្រិតស្រួល ស្រួលមធ្យម និងលំបាកខ្លាំងមាន ៤,៥៥%, និងគ្មានកម្រិតស្រួលខ្លាំងទេ។ សរុបមក អត្ថបទអំណានទាំង៣ថ្នាក់មានគ្រប់កម្រិតទាំងអស់។ ប៉ុន្ដែ ៉កម្រិតស្រួល៉ មាន អត្រាខ្ពស់ជាងគេរហូតដល់ ២១,៣១%, កម្រិតលំបាកខ្លាំងមាន ១,៦៤%, កម្រិតស្រួលខ្លាំង

មាន ៩,៨៤%, កម្រិតស្តុងជាមាន ១៤,៧៥%, កម្រិតស្រួលមធ្យម និងលំបាកមាន ១៦,៣៩%, និងកម្រិតលំបាកមធ្យមមាន១៩,៦៧%។

តារាង ៤.៦ កម្រិតពណ៌នានិងកម្រិតថ្នាក់នៃអគ្គបទអំណានថ្នាក់ទី៣ ទី៦ និងទី៩

កម្រិតពណ៌នា	ចំនួនពាក្យក្នុងឃ្លា			កម្រិតថ្នាក់		
	អប្ប	អតិ	មធ្យម	អប្ប	អតិ	មធ្យម
ស្រួលខ្លាំង	៩	១៤	១២,៣៣	២	៥	៤
ស្រួល	១៣	១៨	១៥,០៨	៥	៧	៦
ស្រួលមធ្យម	១៣	២៣	១៧,៦	៧	១០	៨
ស្តុងដា	១៥	២៤	១៩,៨៨	៩	១១	១០
លំបាក	១៧	៣០	២១,៧	១១	១៤	១២
លំបាកមធ្យម	១៩	៣២	២៣,៧៥	១២	១៨	១៤
លំបាកខ្លាំង	-	៥០	៥០	-	២៦	២៦

តារាង ៤.៦ បានបង្ហាញថា ឃ្លាជាមធ្យមតាមកម្រិតថ្នាក់ក្នុងអគ្គបទអំណានថ្នាក់ទី៣ ទី៦ និងទី៩ មានកម្រិតពណ៌នាចាប់ពីកម្រិតស្រួលខ្លាំងរហូតដល់កម្រិតលំបាកខ្លាំង ដោយ ផ្អែកលើចំនួនពាក្យក្នុងឃ្លា និងកម្រិតថ្នាក់ជាអប្បបរមា អតិបរមា និងមធ្យម។ លទ្ធផលបាន បង្ហាញថា ឃ្លាខ្លះមានពី ៩ ដល់ ១៤ពាក្យ ស្ថិតក្នុងកម្រិតស្រួលខ្លាំង, ឃ្លាមាន១២៣ពាក្យ ស្ថិតក្នុងកម្រិតមធ្យម ដែលត្រូវនឹងកម្រិតថ្នាក់ពីទី២ ដល់ ទី៥ និងកម្រិតធម្មសម្រាប់ថ្នាក់ ទី៤។ កម្រិតស្រួលនៃឃ្លាជាមធ្យមស្មើនឹង ១៥៣ពាក្យ និងកម្រិតថ្នាក់ជាមធ្យម ថ្នាក់ទី៦ និង កម្រិតស្រួលមធ្យមជាមធ្យមស្មើនឹង ១៨៣ពាក្យត្រូវនឹងថ្នាកទី៨។ ឃ្លាខ្លះមានចំនួនពាក្យជា មធ្យម ២០៣ពាក្យ ដែលស្ថិតក្នុងកម្រិតស្តុងដាសម្រាប់ថ្នាក់ទី១០ រួមទាំងស្ថិតនៅក្នុងកម្រិត លំបាកមានពាក្យជាមធ្យមស្មើនឹង ២២៣ពាក្យក្នុងមួយឃ្លាត្រូវនឹងថ្នាក់ទី១២។ កម្រិតលំបាក មធ្យមមានចំនួនពាក្យជាមធ្យម ២៤៣ពាក្យត្រូវនឹងថ្នាក់បរិញ្ញាបត្រឆ្នាំទី២ និងកម្រិតលំបាក ខ្លាំងគឺមានចំនួនពាក្យជាមធ្យម ៥០៣ពាក្យ ត្រូវនឹងថ្នាក់ក្រោយបណ្ឌិត។

កម្រិតទំនាក់ទំនងវាងចំនួនពាក្យ ចំនួនឃ្លា និងចំនួនព្យាង្គនៃអគ្គបទអំណាន

ដើម្បីវាស់កម្រិត ក៏ដូចជាបកស្រាយលទ្ធផលនៃការធ្វើតេស្តរកទំនាក់ទំនងវាង ចំនួនព្យាង្គ ចំនួនពាក្យ និងចំនួនឃ្លាក្នុងអគ្គបទអំណានរបស់សៀវភៅសិក្សាគោល

ភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩ អ្នកស្រាវជ្រាវបានប្រើឧបករណ៍ស្រាវជ្រាវរបស់ Evans (1996) ដែលបានអធិប្បាយដូចខាងក្រោមនេះ៖

តម្លៃទំនាក់ទំនងអរបៃ Pearson	កម្រិតពណ៌នាទំនាក់ទំនងអរបៃ
0,00 - 0,១៩	ខ្សោយខ្លាំង
0,២0 - 0,៣៩	ខ្សោយ
0,៤0 - 0,៥៩	មធ្យម
0,៦0 - 0,៧៩	ខ្លាំង
0,៨0 - ១,00	ខ្លាំងណាស់

តារាង ៤.៧ ទំនាក់ទំនងរវាងចំនួន៣ក្យ ចំនួនឃ្លាង្គ និងចំនួនល្បះ

		ចំនួន៣ក្យ	ចំនួនល្បះ	ចំនួនឃ្លាង្គ
ចំនួន៣ក្យ	Pearson Correlation	១		
	Sig, (២-tailed)			
	N	២១		
ចំនួនល្បះ	Pearson Correlation	0,៩៩៦	១	
	Sig, (២-tailed)	0,០៥៨		
	N	២១	២0	
ចំនួនឃ្លាង្គ	Pearson Correlation	0,៩៩៩ *	0,៩៩១	១
	Sig, (២-tailed)	0,0២៧	0,0៨៥	
	N	២១	២១	២១

*. Correlation is significant at the 0.05 level (2-tailed).

 តារាង ៤.៧ បង្ហាញលទ្ធផលនៃការធ្វើតេស្តរកកម្រិតទំនាក់ទំនងរវាងចំនួនឃ្លាង្គ ចំនួន ៣ក្យ និងចំនួនល្បះក្នុងអត្ថបទអំណានរបស់សៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩។ លទ្ធផលនេះបង្ហាញថា ពុំមានទំនាក់ទំនងរវាងចំនួន៣ក្យនិងចំនួនល្បះក្នុងអត្ថបទ អំណានទាំងអស់នោះទេ (Pearson r = 0,៥៨, p > 0,0៥) ហើយក៏ពុំមានទំនាក់ទំនង រវាងចំនួនឃ្លាង្គ និងចំនួនល្បះដែរ (Pearson r = 0,៨៥, p > 0,0៥)។ ប៉ុន្តែ ចំនួនឃ្លាង្គ

និងចំនួនពាក្យនៃអត្ថបទអំណានទាំងបីថ្នាក់មានទំនាក់ទំនងគ្នាជាវិជ្ជមានដល់កម្រិត "ខ្លាំង ណាស់" (Pearson r = 0,២៧, p < 0,០៥)។ ដូច្នេះ មានតែចំនួនពាក្យនិងចំនួនឃ្លាង ប៉ុណ្ណោះ ដែលមានទំនាក់ទំនងជាវិជ្ជមាន។

ការពិភាក្សានិងសន្និដ្ឋានលទ្ធផលសិក្សា

ការសិក្សាស្រាវជ្រាវនេះព្យាយាមវិភាគរកកម្រិតនៃភាពអាចអាន បាននៃអត្ថបទអំណាន ក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩ ដើម្បីឆ្លើយតបទៅនឹងសំណួរស្រាវជ្រាវ ទាំងបី។

លទ្ធផលសិក្សាសម្រាប់សំណួរស្រាវជ្រាវទី១ បានបង្ហាញថា អត្ថបទអំណានក្នុងសៀវភៅ សិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩ ពុំសមស្របតាមកម្រិតសិក្សារបស់សិស្សទាំង៣ ថ្នាក់នោះទេ។ សៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ត្រូវនឹងកម្រិតថ្នាក់ទី៨ ដែលបង្ហាញពី ភាពលំបាកអានយ៉ាងខ្លាំង ព្រោះខុសហួតដល់ទៅ៥កម្រិតងណោះ។ ក្នុងចំណោមអត្ថបទ អំណានទាំង២១នោះ៖ (១) មានតែមួយអត្ថបទប៉ុណ្ណោះ ដែលត្រូវនឹងកម្រិតថ្នាក់ទី៣ ដោយជាមធ្យម ក្នុងមួយអត្ថបទ មានប្រហែល ២៣២ឃ្លាង, ១៧៧ពាក្យ, ១២ល្បះ និង ៩ ពាក្យក្នុងមួយល្បះ, (២) មានមួយអត្ថបទដែលត្រូវនឹងកម្រិតថ្នាក់ទី២ ដោយ ជាមធ្យម ក្នុង មួយអត្ថបទ មានប្រហែល ១៥៦ឃ្លាង, ១៤៧ពាក្យ, ១២ល្បះ, និង ១១ពាក្យក្នុងមួយល្បះ, (៣) មាន ៥អត្ថបទទៀតដែលស្ថិតក្នុងកម្រិតពីថ្នាក់ទី៤ ដល់ ទី៦ ដោយជាមធ្យម ក្នុងមួយ អត្ថបទ មានប្រហែល ១៥៨ឃ្លាង, ១៣០ពាក្យ, ៩ល្បះ និង ១៤ពាក្យក្នុងមួយល្បះ, (៤) មាន ៧អត្ថបទត្រូវនឹងកម្រិតមធ្យមសិស្សាបឋមភូមិពីថ្នាក់ទី៧ ដល់ ទី៩ ដោយជាមធ្យម ក្នុង មួយអត្ថបទមាន ១៧០ឃ្លាង, ១២៥ពាក្យ, ៨ល្បះ និង ១៦ពាក្យក្នុងមួយល្បះ, (៥) មាន ៥អត្ថបទត្រូវនឹងកម្រិតមធ្យមសិក្សាទុតិយភូមិ ពីថ្នាក់ទី១០ ដល់ ទី១២ ដោយជាមធ្យម ក្នុង មួយអត្ថបទមាន ២១៩ឃ្លាង, ១៤៦ពាក្យ, ៧ល្បះ និង ២០ពាក្យក្នុងមួយល្បះ និង (៦) មាន ២អត្ថបទត្រូវនឹងកម្រិតឧត្តមសិក្សា ដោយជាមធ្យម ក្នុងមួយអត្ថបទមាន ២៦៨ឃ្លាង, ១៦១ពាក្យ, ៧ល្បះ និង ២៣ពាក្យក្នុងមួយល្បះ។ បើគិតជារួម ចំពោះសៀវភៅសិក្សាគោល ភាសាខ្មែរថ្នាក់ទី៣ របស់ក្រសួងអប់រំ យុវជន និងកីឡា ដែលបានបោះពុម្ពនៅឆ្នាំ២០១៦ ជា មធ្យម ក្នុងមួយអត្ថបទ មាន ១៩០ឃ្លាង, ១៣៨ពាក្យ, ៨ល្បះ និង ១៦ពាក្យក្នុងមួយល្បះ។

ក្នុង២១អត្ថបទនេះ មានដល់ទៅ ១៩អត្ថបទទៅហើយ ដែលខ្ពស់ជាងកម្រិតថ្នាក់ទី៣ និង ចូលរហូតដល់កម្រិតឧត្តមសិក្សាទៀត។ ដូច្នេះ សិស្សថ្នាក់ទី៣ពិតជាពិបាកអាននិងពិបាក យល់អត្ថបទទាំង១៩នេះណាស់។

ចំណែកសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៦ ត្រូវនឹងកម្រិតថ្នាក់ទី៧។ ហេតុនេះ សិស្សជួបការលំបាកអានតែបន្តិចបន្តួចទេ ព្រោះវាខុសតែមួយកម្រិតប៉ុណ្ណោះ។ ប៉ុន្តែទោះជា យ៉ាងនេះក្ដី អ្នកស្រាវជ្រាវអាចសង្កេតឃើញកាន់តែច្បាស់ថាៈ (១) មានអត្ថបទអំណាន ចំនួន៣ ដែលត្រូវនឹងកម្រិតថ្នាក់ទី៥ ដោយជាមធ្យម ក្នុងមួយអត្ថបទ មាន ៥២០ព្យាង្គ, ៤១៨៣ក្ស, ៣៥ល្បះ និង ១២៣ក្សក្នុងមួយល្បះ។ (២) មាន ៥ អត្ថបទ ដែលត្រូវនឹងកម្រិត ថ្នាក់ទី៦ ដោយជាមធ្យម ក្នុងមួយអត្ថបទមាន ៤២២ព្យាង្គ, ៣២៩ក្ស, ២៣ល្បះ និង ១៥៣ក្សក្នុងមួយល្បះ។ (៣) មាន ៧អត្ថបទត្រូវនឹងកម្រិតមធ្យមសិក្សាបឋមភូមិ ដោយជា មធ្យម ក្នុងមួយអត្ថបទ មាន ៤០៧ព្យាង្គ, ៣០៧ក្ស, ១៧ល្បះ និង ១៩៣ក្សក្នុងមួយល្បះ។ (៤)មាន ១អត្ថបទត្រូវនឹងកម្រិតមធ្យមសិក្សាទុតិយភូមិ ដោយជាមធ្យម ក្នុងមួយអត្ថបទមាន ៣៦៦ព្យាង្គ, ២៦២ក្ស, ១២ល្បះ និង ២២៣ក្សក្នុងមួយល្បះ និង (៥) មាន ២អត្ថបទ ត្រូវនឹងកម្រិតឧត្តមសិក្សា ដោយជាមធ្យម ក្នុងមួយអត្ថបទមាន ៣៥១ព្យាង្គ, ២២៧ក្ស, ១០ល្បះ និង ២៦៣ក្សក្នុងមួយល្បះ។ បើគិតជារួម ចំពោះសៀវភៅសិក្សាគោលភាសាខ្មែរ ថ្នាក់ទី៦ របស់ក្រសួងអប់រំ យុវជន និងកីឡា ដែលបានបោះពុម្ពនៅឆ្នាំ២០១៦ ជាមធ្យម ក្នុង មួយអត្ថបទ មាន ៤២១ព្យាង្គ, ៣២០ក្ស, ២០ល្បះ និង១៦ក្សក្នុងមួយល្បះ។ ដូច្នេះ សិស្សថ្នាក់ទី៦ ពិតជាជួបការលំបាកខ្លះៗដែរក្នុងការអាននិងការយល់អត្ថបទក្នុងសៀវភៅនេះ។

រីឯសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៩ ត្រូវនឹងកម្រិតថ្នាក់ទី១២។ សៀវភៅនេះក៏មាន ភាពលំបាកអានខ្លាំងដែរ ព្រោះវាខុសរហូតដល់ទៅបីកម្រិតឯណោះ។ ក្នុងចំណោមអត្ថបទ អំណានទាំង ២២ នោះមានៈ (១) តែ ១អត្ថបទប៉ុណ្ណោះ ដែលត្រូវនឹងថ្នាក់ទី៩ ដោយជា មធ្យម ក្នុងមួយអត្ថបទមាន ១៧២៥ព្យាង្គ, ១២២៨ក្ស, ៧១ល្បះ, និង ១៩៣ក្សក្នុងមួយ ល្បះ។ (២) ២អត្ថបទស្ថិតក្រោមកម្រិតថ្នាក់ទី៩ ដោយជាមធ្យម ក្នុងមួយអត្ថបទមាន ១២៣៩ ព្យាង្គ, ៩៦៣ក្ស, ៦៧ល្បះ និង ១៥៣ក្សក្នុងមួយល្បះ។ (៣) ១០អត្ថបទស្ថិតក្នុងកម្រិត មធ្យមសិក្សាទុតិយភូមិ ដោយជាមធ្យម ក្នុងមួយអត្ថបទមាន ១១៩៦ព្យាង្គ, ៧៩១ក្ស, ៣៩ល្បះ និង ២១៣ក្សក្នុងមួយល្បះ។ (៤) ៧អត្ថបទស្ថិតក្នុងកម្រិតឧត្តមសិក្សា ដោយជា

មធ្យម ក្នុងមួយអត្ថបទមាន ៨៧៤ឃ្លាឃ្លង, ៥៤២ពាក្យ, ២៣ឃ្លា និង ២៥ពាក្យក្នុងមួយឃ្លា
និង (៥) ២អត្ថបទទៀតស្ថិតក្នុងកម្រិតក្រោយថ្នាក់បរិញ្ញាបត្រ ដោយជាមធ្យម ក្នុងមួយអត្ថ
បទមាន ១០១៣ឃ្លាឃ្លង, ៥៧៨ពាក្យ, ១៤ឃ្លា និង ៤៩ពាក្យក្នុងមួយឃ្លា។ បើគិតជារួម
ចំពោះសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៩ របស់ក្រសួងអប់រំ យុវជន និងកីឡា ដែល
បានបោះពុម្ពនៅឆ្នាំ២០១៦ ជាមធ្យម ក្នុងមួយអត្ថបទ មាន ១១០៥ឃ្លាឃ្លង, ៧២៨ពាក្យ,
៣៥ឃ្លា និង២១ពាក្យក្នុងមួយឃ្លា។ ដូច្នេះ សិស្សថ្នាក់ទី៩ ពិតជាជួបការលំបាកមិនតិចដែរ
ក្នុងការអាននិងការយល់អត្ថបទក្នុងសៀវភៅនេះ។

លទ្ធផលនៃការស្រាវជ្រាវទៅលើអត្ថបទអំណានទាំងបីថ្នាក់ខាងលើនេះ បានបង្ហាញឲ្យ
យើញនូវកម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណាន ដោយផ្អែកលើចំនួនឃ្លាឃ្លង ចំនួនពាក្យ
ចំនួនឃ្លា និងចំនួនពាក្យក្នុងឃ្លានីមួយៗ។ កាលណាចំនួនឃ្លាឃ្លងនិងចំនួនពាក្យកាន់តែ
ប្រហាក់ប្រហែលគ្នា នោះចំនួនពាក្យក្នុងមួយឃ្លាតិចជាងឬស្មើ ១២ពាក្យ សម្រាប់អត្ថបទ
អំណានថ្នាក់ទី៣។ កាលណាចំនួនឃ្លាឃ្លងច្រើនជាងចំនួនពាក្យ ២៥% នោះចំនួនពាក្យក្នុង
មួយឃ្លាតិចជាងឬស្មើ ១៥ពាក្យ សម្រាប់អត្ថបទអំណានថ្នាក់ទី៦។ កាលណាចំនួនឃ្លាឃ្លង
ច្រើនជាងចំនួនពាក្យ ៣០% នោះចំនួនពាក្យក្នុងមួយឃ្លាតិចជាងឬស្មើ ១៩ពាក្យ សម្រាប់
អត្ថបទអំណានថ្នាក់ទី៩។ រីឯចំនួនឃ្លាមិនត្រូវបានកំណត់ទេ ទោះបីអត្ថបទនោះមានឃ្លា
ច្រើនយ៉ាងណាក៏ដោយ ក៏កម្រិតនៃភាពអាចអានបាននៅតែគ្រឹមត្រូវតាមកម្រិតថ្នាក់នីមួយៗ
ដែរ បើអនុលោមទៅតាមចំនួនឃ្លាឃ្លង ចំនួនពាក្យ និងចំនួនពាក្យក្នុងមួយឃ្លា។

ចំពោះសំណួរស្រាវជ្រាវទី២ អ្នកស្រាវជ្រាវបានគណនាចំនួនពាក្យជាមធ្យមក្នុងឃ្លា
នីមួយៗនៃអត្ថបទអំណានក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩ ដែល
មានកម្រិតពណ៌នា ៧កម្រិត ពី "ស្រួលខ្លាំង" រហូតដល់ "លំបាកខ្លាំង" និងកម្រិតពណ៌នា
ចន្លោះនៃកម្រិតថ្នាក់។ លទ្ធផលបង្ហាញថា កម្រិតពណ៌នា "ស្រួលខ្លាំង" សម្រាប់សិស្សថ្នាក់ទី
៤ មានចំនួន ១២ពាក្យក្នុងមួយឃ្លា និងកម្រិតពណ៌នា "ស្រួល" សម្រាប់សិស្សថ្នាក់ទី៦ មាន
ចំនួន ១៥ពាក្យក្នុងមួយឃ្លា។ បន្ទាប់មក កម្រិតពណ៌នា "ស្រួលមធ្យម" មានចំនួន ១៨
ពាក្យក្នុងមួយឃ្លាសម្រាប់សិស្សថ្នាក់ទី៨ និងកម្រិតស្ដង់ជាមានចំនួន ២០ពាក្យក្នុងមួយ
ឃ្លាសម្រាប់សិស្សថ្នាក់ទី១០។ បន្ទាប់មកទៀត កម្រិតពណ៌នា "លំបាក" មានចំនួន ២២
ពាក្យក្នុងមួយឃ្លាសម្រាប់សិស្សថ្នាក់ទី១២ និងកម្រិតពណ៌នា "លំបាកមធ្យម" មានចំនួន

២៨ក្យក្នុងមួយឃ្លាៈសម្រាប់សិស្សថ្នាក់ឧត្តមសិក្សា។ ជាចុងក្រោយ កម្រិត “លំបាកខ្លាំង” មានចំនួន ៥០ក្យក្នុងមួយឃ្លាៈសម្រាប់ថ្នាក់ក្រោយឧត្តមសិក្សា។ ដូច្នេះ លទ្ធផលនេះបាន កត់សម្គាល់ចំនួន ២០ក្យជាកម្រិតស្ដង់ដានៃចំនួនក្យក្នុងមួយឃ្លាៈ និងបានកំណត់ខ្នាត មួយនៃការប្រើក្យក្នុងឃ្លាៈនីមួយៗឲ្យបានត្រឹមត្រូវទៅតាមកម្រិតនៃភាពអាចអានបាន និង កម្រិតថ្នាក់នីមួយៗ។ លទ្ធផលនេះជាក៏ស្តុតាងជាក់ស្តែងមួយសម្រាប់អ្នកសរសេរអត្ថបទជា ភាសាខ្មែរចាប់ផ្ដើមយកចិត្តទុកដាក់ទៅលើកម្រិតនៃភាពអាចអានបាន ដោយផ្ដោតទៅលើ ចំនួនព្យាង្គ ចំនួនក្យ និងចំនួនឃ្លាៈឲ្យត្រូវទៅតាមកម្រិតថ្នាក់នីមួយៗ ក៏ដូចជាកម្រិតស្ដង់ ដានៃឃ្លាៈនីមួយៗ ដើម្បីឲ្យត្រូវនឹងសមត្ថភាពអ្នកសិក្សាឬអ្នកអាន។ ជាពិសេស ស្មេរ ដែល ប្រើប្រាស់កម្រិតនៃភាពអាចអានបាន អាចបញ្ចាក់ពីកម្រិតស្មាដែលខ្លួនបានបោះពុម្ពផ្សាយជា សាធារណៈ ដើម្បីតម្រូវចិត្តនិងបំពេញបំណងអ្នកអានប្រកបដោយប្រសិទ្ធភាពខ្ពស់។

ចំពោះសំណួរស្រាវជ្រាវទី៣ អ្នកស្រាវជ្រាវបានពិនិត្យទំនាក់ទំនងរវាងព្យាង្គ ៣ក្យ និង ឃ្លាៈក្នុងអត្ថបទអំណានថ្នាក់ទី៣ ទី៦ និងទី៩។ លទ្ធផលបានបង្ហាញថា ចំនួនក្យ និង ចំនួនឃ្លាៈនៃអត្ថបទអំណានពុំមានទំនាក់ទំនងរវាងគ្នានោះទេ (Pearson r = ០,៥៨, p > ០,០៥)។ រីឯចំនួនព្យាង្គ និងចំនួនឃ្លាៈក៏ពុំមានទំនាក់ទំនងរវាងគ្នាដែរ (Pearson r = ០,៨៥, p > ០,០៥)។ លទ្ធផលនេះអាចមានន័យថា ក្នុងការសរសេរសៀវភៅសិក្សាភាសា ខ្មែរទាំង៣ថ្នាក់នេះ ស្មេរទំនងជាមិនបានផ្ដោតការយកចិត្តទុកដាក់លើចំនួនក្យ ចំនួនព្យាង្គ និងចំនួនឃ្លាៈក្នុងអត្ថបទអំណាននីមួយៗនោះទេ។

សរុបមក ការសិក្សានេះបានវិភាគទៅលើកម្រិតនៃភាពអាចអានបាន និងកម្រិតថ្នាក់នៃ សៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩ របស់ក្រសួងអប់រំ យុវជន និង កីឡា ដែលបានបោះពុម្ពនៅឆ្នាំ២០១៦។ លទ្ធផលសិក្សាដែលឆ្លើយទៅនឹងសំណួរស្រាវជ្រាវទី១ បានបង្ហាញថា កម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានក្នុងសៀវភៅសិក្សាគោលភាសា ខ្មែរទាំង៣ថ្នាក់នេះ មិនត្រូវនឹងកម្រិតថ្នាក់របស់សិស្សនោះទេ។ សៀវភៅថ្នាក់ទី៣ ត្រូវនឹង សិស្សថ្នាក់ទី៨។ សៀវភៅថ្នាក់ទី៦ ត្រូវនឹងសិស្សថ្នាក់ទី៧។ រីឯសៀវភៅថ្នាក់ទី៩ ត្រូវនឹង កម្រិតសិស្សថ្នាក់ទី១២។ លទ្ធផលស្រាវជ្រាវ ដែលឆ្លើយទៅនឹងសំណួរស្រាវជ្រាវទី២ បាន បង្ហាញថា កម្រិតនៃភាពអាចអានបាននៃចំនួនក្យស្ដង់ដាជាភាសាខ្មែរក្នុងសៀវភៅសិក្សា គោលទាំងបីថ្នាក់មានចំនួន ជាមធ្យម ២០ក្យក្នុងមួយឃ្លាៈ ដែលត្រូវនឹងកម្រិតសិស្សថ្នាក់

ទី១០។ ចំណែងចំនួនពាក្យក្នុងល្បះនីមួយៗក្នុងអត្ថបទអំណានថ្នាក់ទី៤ ទី៦ ទី៨ ទី១២ និងកម្រិតថ្នាក់ឧត្តមសិក្សាត្រូវមានចំនួនរៀងគ្នា ១២ពាក្យ ១៥ពាក្យ ១៨ពាក្យ ២២ពាក្យ និង២៤-៥០ពាក្យ។ លទ្ធផលសិក្សា ដែលធ្វើឡើយទៅនឹងសំណួរស្រាវជ្រាវទី៣ បានបង្ហាញថា ពុំមានទំនាក់ទំនងវាងចំនួនពាក្យ និងចំនួនល្បះនៃអត្ថបទអំណាននោះទេ ព្រោះអ្នកនិពន្ធ បានសរសេរចំនួនពាក្យ និងចំនួនសម្បុិន្នល្បះតាំងពីកម្រិតថ្នាក់ទាបរហូតដល់កម្រិតថ្នាក់ខ្ពស់ ឡើកាន់តែវែងទៅតាមភាពចេះដឹងរបស់ស្បេ។ ប៉ុន្តែមានទំនាក់ទំនងវាងចំនួនព្យាង្គ និងចំនួនពាក្យក្នុងអត្ថបទអំណាននៃសៀវភៅសិក្សាគោលភាសាខ្មែរ ដោយសារអ្នកនិពន្ធមានទេព្យកោសល្យក្នុងការជ្រើសរើសពាក្យ ដែលមានច្រើនព្យាង្គយកមកប្រើកាន់តែច្រើនតាមលំដាប់ពីកម្រិតទាបទៅកម្រិតខ្ពស់។ ដូច្នេះ លទ្ធផលសិក្សានេះអាចយកជាមូលដ្ឋានគ្រឹះសម្រាប់អ្នករៀបចំសៀវភៅសិក្សាគោល គ្រឹះស្ថានបោះពុម្ពផ្សាយ និង អ្នកធ្វើលិខិតរដ្ឋបាល និងឯកសារផ្សេងៗ។ ធ្វើការពិចារណាអំពីកម្រិតនៃភាពអាចអានបាននៅពេលសរសេរអត្ថបទនីមួយៗឡើ្យបានសមស្របទៅតាមកម្រិតថ្នាក់របស់អ្នកសិក្សា ក៏ដូចជាសមត្ថភាពរបស់អ្នកអានផងដែរ។

ការផ្ដល់អនុសាសន៍

ការសិក្សានេះវិភាគរកកម្រិតនៃភាពអាចអានបាននៃអត្ថបទអំណានក្នុងសៀវភៅសិក្សាគោលភាសាខ្មែរថ្នាក់ទី៣ ទី៦ និងទី៩។ យោងតាមលទ្ធផលនៃការស្រាវជ្រាវនេះ អ្នកស្រាវជ្រាវសូមផ្ដល់អនុសាសន៍សម្រាប់ការតែងនិពន្ធសៀវភៅសិក្សាគោលភាសាខ្មែរទាំងបីថ្នាក់របស់ក្រសួងអប់រំ យុវជន និងកីឡា ដូចខាងក្រោមនេះ៖

១. សៀវភៅថ្នាក់ទី៣ គួរតែលៃឡ្យមានចំនួនព្យាង្គនិងចំនួនពាក្យប្រហាក់ប្រហែលគ្នា។ ចំនួនពាក្យក្នុងមួយល្បះនីមួយៗមិនគួរលើសពី ១២ពាក្យទេ។ ចំណែកការផ្ដោតលើចំនួនល្បះក្នុងអត្ថបទនីមួយៗពុំសូវជាចាំបាច់ប៉ុន្មានទេ។

២. សៀវភៅថ្នាក់ទី៦ គួរតែមានចំនួនព្យាង្គច្រើនជាងចំនួនពាក្យប្រហែលមួយភាគបួន (១/៤)។ ចំនួនពាក្យជាមធ្យមក្នុងល្បះនីមួយៗមិនគួរលើសពី ១៥ពាក្យទេ ប៉ុន្តែមិនបាច់កំណត់ចំនួនល្បះនោះទេ។

៣. សៀវភៅថ្នាក់ទី៩ គួរតែមានចំនួនព្យាង្គច្រើនជាងចំនួនពាក្យប្រហែល៣០%។ ចំនួន ពាក្យជាមធ្យមក្នុងឃ្លានីមួយៗមិនគួរលើសពី ១៩ពាក្យទេ ប៉ុន្តែមិនបាច់កំណត់ចំនួនឃ្លា នោះទេ។

៤. ជាទូទៅ នៅពេលសរសេរអត្ថបទ ស្នូវទាំងឡាយគួរតែយកចិត្តទុកដាក់លើចំនួន ព្យាង្គ ចំនួនពាក្យ និងចំនួនឃ្លា ដើម្បីឱ្យភាពអាចអានបាននៃអត្ថបទរបស់ខ្លួនមានកម្រិត សមស្របទៅតាមកម្រិតរបស់អ្នកសិក្សា ឬសមត្ថភាពរបស់អ្នកអាន។

៥. ការសិក្សាស្រាវជ្រាវបែបនេះគឺជាការបើកផ្លូវទៅរកការស្រាវជ្រាវបន្ថែមឱ្យបានកាន់តែស៊ី ជម្រៅនិងទូលំទូលាយថែមទៀតអំពីកម្រិតនៃភាពអាចអានបាននៃសៀវភៅសិក្សាគោល ភាសាខ្មែរគ្រប់កម្រិតថ្នាក់ ក៏ដូចជាអត្ថបទជាភាសាខ្មែរដទៃទៀតផងដែរ។

៦. ការសិក្សាស្រាវជ្រាវក្រោយៗទៀត គួរតែសិក្សាដោយប្រើប្រាស់វិធីសាស្ត្រស្រាវជ្រាវ ចម្រុះដើម្បីវាស់វែងវិសាលភាព និងប្រសិទ្ធភាពនៃភាពអាចអានបាន និងកម្រិតថ្នាក់កាន់តែ ជាក់លាក់ជាងនេះទៅទៀត។

ជីវប្រវត្តិ

លោក ខួយ ប៊ុនឡុច បានបញ្ចប់ការសិក្សាថ្នាក់បរិញ្ញាបត្រ ផ្នែកភាសាអង់គ្លេសពីសាកល វិទ្យាល័យធនធានមនុស្សនៅឆ្នាំ២០១១ និងថ្នាក់បរិញ្ញាបត្រជាន់ខ្ពស់ ផ្នែកអប់រំពីសាកល វិទ្យាល័យភូមិន្ទភ្នំពេញនៅឆ្នាំ២០១៦។ លោក ប៊ុនឡុច កំពុងសិក្សាថ្នាក់បណ្ឌិត ផ្នែកខេមរ សិក្សានៅមហាវិទ្យាល័យសង្គមសាស្ត្រ-មនុស្សសាស្ត្រនៃសាកលវិទ្យាល័យភូមិន្ទភ្នំពេញក្នុង ឆ្នាំ២០១៩។

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ក្រសួងអប់រំ យុវជន និង កីឡា (២០១៦) *ភាសាខ្មែរថ្នាក់ទី៣*។ ភ្នំពេញៈ គ្រឹះស្ថានបោះពុម្ព និងចែកផ្សាយ។

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Safe school programs and disaster risk reduction in hazard-prone primary schools in Cambodia

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សារគន្លឹះ

- សាលាបឋមសិក្សាពុំទាន់មានសុវត្ថិភាពទាំងស្រុងសម្រាប់សិស្សនៅឡើយទេ។ ដូច្នេះការអនុវត្តកម្មវិធីសាលារៀនប្រកបដោយសុវត្ថិភាព និងការកាត់បន្ថយហានិភ័យនៃគ្រោះមហន្តរាយមានសារៈសំខាន់យ៉ាងខ្លាំងក្នុងការការពារសិស្ស និងគ្រូពីការស្លាប់រប្បួស និងគ្រោះថ្នាក់ផ្សេងៗ។ សាលារៀនដែលកម្មវិធីទាំងនេះបានជ្រើសរើសយកមកអនុវត្តនៅពេលបច្ចុប្បន្ន ដោយសារសាលារៀនទាំងនោះបានរងផលប៉ះពាល់យ៉ាងខ្លាំងដោយទឹកជំនន់ និងដង្កើវកត្ស្បាត ហើយរងផលប៉ះពាល់កម្រិតមធ្យមដោយគ្រោះរាំងស្ងួត ខ្យល់ព្យុះ គ្រោះថ្នាក់ចរាចរណ៍ និងសត្វអាសិពិស។
- គ្រូបង្រៀននៅសាលាមិនមែនគោលដៅក្រុមមានគំរិវិយាបទចំពោះកម្មវិធីគ្រប់គ្រងហានិភ័យគ្រោះមហន្តរាយល្អជាងគ្រូនៅសាលាដែលកំពុងអនុវត្តកម្រោង និងគ្រូនៅតាមសាលាដែលកម្មវិធីត្រូវបានដកចេញ។
- លោកគ្រូ អ្នកគ្រូ ជាពិសេស អ្នកមកពីសាលាមិនមែនគោលដៅ និងអ្នកមកពីសាលាដែលកំពុងអនុវត្តគម្រោងនាពេលបច្ចុប្បន្ន ចូលរួមយ៉ាងសកម្មក្នុងសកម្មភាពកម្មវិធីសាលារៀនសុវត្ថិភាព ដូចជាការបណ្ដុះបណ្ដាល ការធ្វើផែនការ សិក្ខាសាលា ការគូសផែនទីមុខសញ្ញាគ្រោះថ្នាក់ និងការប្រជុំជាមួយក្រុមប្រឹក្សាឃុំ។
- គ្រូបង្រៀនបានវាយតម្លៃខ្ពស់ចំពោះសកម្មភាព និងវិធានការទាំងឡាយដែលបានប្រើប្រាស់ក្នុងការកាត់បន្ថយគ្រោះថ្នាក់ និងវាយតម្លៃមធ្យមចំពោះកិច្ចខិតខំប្រឹងប្រែងដើម្បី

ការពោរហានិភ័យដែលបណ្ដាលមកពីអគ្គិសនី។ គ្រូនៅសាលាមិនមែនគោលដៅ ឬសាលាដែលកម្មវិធីត្រូវបានដកចេញបានរាយតម្លៃសកម្មភាពទាំងនេះថាមានប្រសិទ្ធភាពខ្ពស់ ចំណែកឯគ្រូនៅសាលា ដែលកំពុងអនុវត្តកម្មវិធីនាពេលបច្ចុប្បន្ន មានការចូលរួមកម្រិតមធ្យម។

- កម្មវិធីសាលារៀនមានសុវត្ថិភាពគួរតែត្រូវបានអនុវត្តតាមរយៈការអភិវឌ្ឍហេដ្ឋារចនាសម្ព័ន្ធ ការកសាងសមត្ថភាព កិច្ចសហប្រតិបត្តិការជាមួយអាជ្ញាធរមូលដ្ឋាន និងការចូលរួមពីមាតាបិតា។ នៅពេលមានគ្រោះមហន្តរាយមួយៗ ឪពុកម្ដាយតែងចង់ឲ្យកូននៅផ្ទះជាជាងទៅសាលារៀន ដោយសារព្រួយបារម្ភអំពីសុវត្ថិភាពរបស់កូន។ ការកសាងសមត្ថភាពជូននាយកសាលានិងគ្រូបង្រៀនមានសារៈសំខាន់ចំពោះការវិភាគ លម្អកម្មវិធីសាលារៀនប្រកបដោយសុវត្ថិភាព ពីព្រោះពួកគាត់ជាអ្នកពាក់ព័ន្ធសំខាន់ ដែលទទួលបានអំណាចក្នុងការផ្លាស់ប្ដូរនិងធ្វើសកម្មភាពនានា ដែលធ្វើឲ្យស្ថានភាពសាលារៀននិងគុណភាពអប់រំបានប្រសើរឡើង។

Key messages

- Primary schools are not yet entirely safe for students. Thus, the implementation of safe school programs and disaster risk reduction is important to protect students and teachers from death, injury, and harm. Schools, where these programs are currently implemented, were selected as they were extremely affected by floods and epidemic diseases and moderately affected by drought, storms, traffic accidents, and poisonous reptiles.
- Teachers at non-target project schools have better attitudes towards disaster risk management programs than those where projects are currently being implemented, as well as those where programs have been phased out.
- Teachers, especially those from non-target schools and those where the project is currently being implemented, actively participate in safe school program activities such as training, planning, workshops, hazard mapping, and meetings with the Commune Council.
- Teachers assessed the degree to which actions and measures were used to minimize hazards as high, while efforts to prevent risks resulting from

electricity were ranked as moderate. Teachers at non-target schools or those where the program had been phased out rated these actions as high, while those where the program was currently being implemented suggested a moderate level of involvement.

- Safe School Programs should be implemented via infrastructure development, capacity building, cooperation with local authorities, and parent involvement. During disasters, students tend to stay home and miss classes when parents become concerned about safety. Capacity building for principals and teachers is significant for improving safe school programs as these stakeholders because they become empowered to initiate and conduct activities that improve the condition of the school, and the quality of education.

Keywords: safe school program, disaster risk reduction, hazard-prone schools, primary schools, education, Cambodia

Background: safe school programs and disaster risk reduction

Disaster risk reduction (DRR) has become a crucial part of the school curriculum in Cambodia. Over time, the integration of DRR with safe school programs has arisen through various policies and frameworks to ensure student safety before, during, and after hazards. Key documents include the (1) *Cambodia Education Sector Emergency Preparedness and Response Plan (ERRP)*; (2) *Climate Change Strategic Plan for Education*; (3) *National Action Plan for Disaster Risk Reduction*, (4) *Child-Friendly School Policy*, and (5) Guideline on the Curriculum Development *for Integrating the Concepts of Disaster Risk Reduction and Resilience to Climate Change* produced by Save the Children. Further, the *National Action Plan for Disaster Risk Reduction (2019-2023)* continues to build adaptive capacity and establish resilience within communities for sustainable development.

In 2007, the Ministry of Education, Youth, and Sport (MoEYS) introduced the *Child-Friendly Schools Policy* to promote safe schools, focused on health, safety, and child protection. This framework paved the way for a more concrete strategy for the integration of DRR in schools (MoEYS, 2007). While the *Child-Friendly Schools Policy* promoted school safety initiatives, a DRR and climate change adaptation (CCA) integrated curriculum was developed for Grades 4, 5 & 6. The DRR curriculum also integrated Earth Science and Geography subjects in Grade 8. To ensure a safe learning and teaching activities during disasters, the MoEYS also produced guidelines on setting up temporary learning shelters for use in flood emergencies for its Provincial Departments (MoEYS, 2014a).

In 2013, two policies were introduced to contribute to DRR education at schools in Cambodia. First, relevant line ministries developed a *Climate Change Strategic Plan for Education*. The benchmark was designed to support DRR in response to climate change. Second, the *National Action Plan for Disaster Risk Reduction (2014-2018)* provided a framework for improving school safety and the resilience in Cambodia, improving the resilience of primary and secondary education resilient (NCDM, 2013). In 2014, Cambodia's *EPRP* outlined the activities expected before, after, and during a disaster. It has been used by all ministries and institutions, in line with the *Law on Disaster Management* (MoEYS, 2014b).

Implementing safe school programs is important if students and teachers are to be protected students from harm. These programs strengthen DRR and resilience through education. The MoEYS has been strengthening cooperation

with development partners and mobilizing resources to reduce hazards to minimum standards and ensure the timely provision of education with safety at all levels. This includes early childhood, primary, and secondary education (MoEYS, 2014a). Under the ASEAN Safe Schools Initiative (ASSI), Plan International has implemented school safety programs in a range of countries since 2012. Additionally, Save the Children developed DRR materials for the school curricula. In 2019, the UNDP supported the Disaster Management Unit of the MoEYS to prepare a standard curriculum for Training of Trainer programs on school safety and disaster preparedness in Cambodia (CFE-DM, 2020).

In Cambodia, schools provide education over a period of ten months, commencing in November and finishing by August, the following year. Ordinarily, the school vacation period is in September and October. This academic calendar is challenged due to climate variability, especially floods and drought. Schools in flood-prone areas may face flooding in the early part of the academic year, as October tends to coincide with peak rainfall conditions. Schools also may face drought in May. To safeguard schools from natural hazards, child interests, needs, and rights need to be promoted. Building the capacity of parents and children with basic knowledge of disaster management helps reduce the risks of negative impacts on children (World Vision, 2014). Thus, child participation in DRR implementation is essential in schools.

Using existing systems, *student councils* have increasingly paid more attention to the role of national and international NGOs in engaging children

in civic duties in supporting societal behavioural change. The explicit objectives of the *student councils* are to (1) develop children as good children, good students, and good friends; (2) to educate children to feel affection for their country, culture, and traditions - to protect the environment - to obtain a profession - and to follow the teachings of Buddha; (3) to train and provide opportunities for children to work individually and in groups – to express opinions and to carry out voluntary activities for one's self, family, the school, and society; (4) to promote awareness about and implement child rights and democratic principles; (5) to promote awareness on how to control the spread of diseases, such as AIDS, avian flu, and drug addiction; and (6) to prevent child trafficking, child exploitation, and child labour (KAPE, 2009).

In 2003, the UNICEF and Kampuchea Action to Promote Education (KAPE) developed a formal implementation manual for *student associations*. It supported NGOs to implement child-friendly school programs in various provinces. Then, in 2007, the MoEYS, with support from UNICEF, developed a handbook outlining specific roles, policies and guidelines for *student councils*. These guidelines were intended to be relevant to Grades 4 to 9, working closely *Child-Friendly Schools Policy* framework. This framework defined six key dimensions of an inclusive child psycho-social learning environment (KAPE, 2009).

In 2013, the MoEYS, with support from Child Rights Foundation (CRF), and in partnership with Plan International, developed safe school guidelines, backed by Dimension Three of the *Child-Friendly Schools Policy* framework. The guideline has provided specific directions on the implementation of the

three pillars of safe schools: (1) a safe learning environment, (2) DRR, and (3) disaster reduction and resilience education, support mechanisms, and monitoring and evaluation. It aims to reduce disaster risks caused by humans, as well as other school hazards, thereby improving access and better continuity of education for children in Cambodia.

In 2015, the MoEYS, with support from Save the Children, developed a new Guideline on Curriculum Development for Integrating the Concepts of DRR and Resilience to Climate Change. The guideline integrates the concepts of DRR, climate change adaptation, and resilience in science and a social science subject for students in Grades 4, 5, & 6 and aimed to improve capacity and provide knowledge to teachers regarding learning about DRR and CAA for students in primary schools. This knowledge of DRR was adopted from international and regional experiences and translated into the local context. The guideline provides knowledge about (1) natural hazards (floods and drought); (2) land mines and explosive remnants of war (EWR); (3) climate change; (4) agriculture, food security and nutrition; (5) personal safety; and (6) health and sanitation. It featured teaching methodologies, case studies, role-play activities, games, and research results translated into the local context. In general, the approach helps teachers learn how to teach primary school students about DRR and CCA (MoEYS, 2015).

This policy paper examines school-based climate risks and vulnerability, caused by hazards at primary schools. It has three specific objectives: (1) to identify hazard-prone schools; (2) to explore the knowledge and attitudes of primary school teachers about DRR and CCA; (3) to describe the integration

of the safe school program into the curriculum; and examine the level of engagement in the safe school program. The findings of the research will be useful for policymakers, planners, practitioners and researchers interested in the success of the safe school program in Cambodia and beyond.

Research Methodology

The research collected data from both primary and secondary sources regarding DRR integration and safe school programs in Cambodia linked to the project, *Promoting Safe Schools Initiative in Cambodia (PSSIC) Phase II*. This project is implemented by the Child Rights Foundation in partnership with Plan International, Cambodia. Two structured questionnaires to collect quantitative data. One was used to interview students and the other to interview school principals, teachers, school support committee members, and influential adults. An unstructured questionnaire was also used to collect qualitative data from key informants from the Provincial Office of Education (PoE), principals, and teachers. Further, a standardized questionnaire was used to collect quantitative data from primary school teachers from five primary schools in *Stung Treng* Province (where the project is currently implemented), as well as two schools in *Kampong Cham* Province and three schools in *Phnom Penh* Municipality (where the project has been phased-out), and five schools in *Takeo* Province (which are not a target of the project). A total sample of 116 teachers (49 female) was selected as interviewees (Table 1).

In addition to the interviews, field observations were carried out at all 15 schools to access additional contextual information about school safety

regarding physical infrastructure, social events, and student participation (especially for girls) in disaster risk management activities. These observations were also used to validate data collected from phone interviews with the principals and teachers from the three schools in Phnom Penh. This was important as it was not possible to interview students from the schools in Phnom Penh. Focus group discussions were also held with teachers from each school to discuss relevant issues at each of the participating schools in the research. Finally, a consultative meeting was organized with the Joint Action Group on Disaster Risk Reduction Education Working Group (JAG-DRR-EWG). Participants in this group included the NGOs Save the Children, World Vision, Plan International, CRF, and ChildFund Cambodia. The meeting was organized to present preliminary findings from the research, collect feedback, and discussed policy implications and plans. The meeting took the form of a forum, facilitating interactions between the researchers and participating organizations to validate and clarify the initial results.

Table 1. Interviewees for the standardized questionnaire

Name of schools	Number	Total sample size
Current project schools (Stung Treng)	5	39 (21 females)
Phased-out schools (Kampong Cham)	2	16 (8 females)
Phased out schools (Phnom Penh)	3	21 (8 females)
Non-target schools (Takeo province)	5	40 (12 females)
Total		**116 (49 females)**

A desk review was used to conduct a qualitative problem and situation analysis that collected, organized, and synthesized available information from reports, previous assessments, and raw data from the projects. This enabled

the project context to be explored in detail and assessed against indicators to identify problems and gaps faced by the project over a specific period. The goal of this research is to develop key insights into the successes and challenges that the project has faced, particularly the participation and leadership of girls in implementing disaster risk management activities. This research is intended to go beyond a project evaluation to inform the nationwide advocacy on this topic.

The study employed advanced descriptive statistical methods using the Statistical Package for Social Science software for data processing and analysis. Quantitative analysis tools include ANOVA or f-test, t-test, and chi-square analyses. A weighted average index was used to rate the degree of vulnerability and satisfaction that teachers and students held towards disaster risk management programming at the study schools. The five-scales were: (1) considerably less; (2) less; (3) moderate; (4) high; (5) very high. F–test (ANOVA) was applied to test whether there was a significant difference between the average results from each type of school studied, namely, schools where the project is currently implemented; schools where the project has been phased out; and schools that are not a target of the project. An f-test was applied to the teacher questionnaires, while chi-square analysis was used to test the association between two categorical variables. For instance, an association with involvement in a safe school program.

Results and Findings

Identifying hazard-prone primary schools

Table 2 shows that overall, teachers indicated a low degree of both vulnerability and satisfaction with the different hazards present at each

primary school. However, these perceptions differed significantly for each type of school assessed. Principals and teachers shared similar views about the risk of floods, hot weather, water shortages, and windstorms at the five schools in *Stung Treng*.

Table 2. Perception of teachers toward a hazard-prone school

Attributes	Phased-out project		Current implementation		Non-target project		Overall		P-*value*
	(n=37)		(n=39)		(n=40)		(n=116)		
	WAI	OA	WAI	OA	WAI	OA	WAI	OA	
Floods	0.48	M	0.67	H	0.02	VL	0.38	L	***0.000******
Droughts	0.22	L	0.57	M	0.18	VL	0.32	L	***0.000******
Storms	0.31	L	0.48	M	0.12	VL	0.30	L	***0.000******
Death from lightning	0.08	VL	0.43	M	0.10	VL	0.20	L	***0.000******
Traffic accidents	0.26	L	0.62	H	0.16	VL	0.34	L	***0.000******
Epidemics	0.16	VL	0.12	VL	0.02	VL	0.10	VL	**0.021***
Poisonous reptiles	0.04	VL	0.43	M	0.01	VL	0.16	VL	***0.000******
Falling trees	0.10	VL	0.13	VL	0.06	VL	0.10	VL	0.210

Note: weight average index measured on a five-point scale [very low (VL) = 0.00–0.20, less (L) = 0.21– 0.40, moderate (M) = 0.41–0.60, high (H) = 0.61–0.80, very high (VH) = 0.81–1.00]. OA = Overall assessment.

While seasonal flood has regularly interrupted classes, other hazards occur only occasionally. In comparison, other schools where the project is currently implemented or has already been phased out were more prone to these other threats. While teachers at the school where the project is currently implemented perceived a high degree of vulnerability to floods and traffic accidents, they indicated a moderate degree of vulnerability to droughts, storms, death from lightning, and poisonous reptiles. Many schools

in Stung Treng have been built from wood, which is less resilient to hazards such as floods and storms than brick. While schools are often located on high ground, hazards such as floods and heavy rains create difficulties for students and teachers when travelling to school. For instance, roads to *O'Trel* Primary School were often very slippery or covered with water during the rainy season. The teachers at this school were female, and experience difficulty in travelling to school during these times.

Figure 1: (a) An old school building destroyed by the storm; and **(b)** The new school building supported by United World Schools

The principal at *O'Rey* Primary School indicated that climate change was resulting in increased temperatures, especially during the dry season. Over the past two years, this had resulted in insufficient water for use at the school. Teachers have resorted to requesting students to bring bottles of water from home to consume at school. At *Pong Tuek* Primary School, floods and storms were rated as the two most significant hazards as the school buildings were been damaged when the roof was blown away.

Similarly, a storm destroyed a building at *Veal Ksach* Primary School in 2011, which required students to move to the pagoda to study. With the financial and technical support from United World Schools and resources

contributed by the community, a new wooden building with four classrooms was constructed. During the focus group discussions, teachers from *Takeo*, *Kampong Cham*, and *Stung Treng* identified different types of risks experienced when travelling to and from school including accidents, as well as physical and emotional violations. Students were not entirely safe when not accompanied by an adult. These risks were indicated to be more significant during the rainy season. For some children, it became necessary to travel to school by boat, and parents worried about their safety. During flood events, students from islands found it difficult to travel to school and tended to stay at home. This was a particular problem for students without a parent that stayed at home during the day to help bring them to school. In these cases, the student missed class, for fear of accidents during travel to school.

Teachers from schools that were not targeted by the project, or those where the project has been phased out indicated a very low, or low degree of vulnerability for all attributes except for flooding, which was perceived to be a moderate hazard. Seasonal flooding has affected *Boeung Trav Bun Rany Hun Sen* Primary School, where a child drowned during a flood. The principal shifted classes to the pagoda during flood events to discourage children from playing in ponds on the school campus following this.The epidemics were perceived to have a low degree of vulnerability as the study did not consider COVID-19. Epidemics that were considered included cholera and diarrheal diseases, malaria, and dengue fever. While COVID-19 was not considered in the research, key informants revealed that it had a significant impact on access to education. Students suffered when schools were closed

to help manage the pandemic. In Takeo, students could not access alternative online classes as they did not own smartphones. Other students had access to a smartphone, but could not afford to pay for an internet connection. COVID-19 did not impact the health of students as they wore masks and washed their hands regularly.

Knowledge and attitudes held by teachers

Teachers and students were requested to answer five different questions, as a measure of their knowledge of the definition of disaster (Figures 2 - 4). A small percentage of teachers claimed they could not define what a disaster is, compared to one-third of students.

Figure 2. The definition of *disaster* by teachers
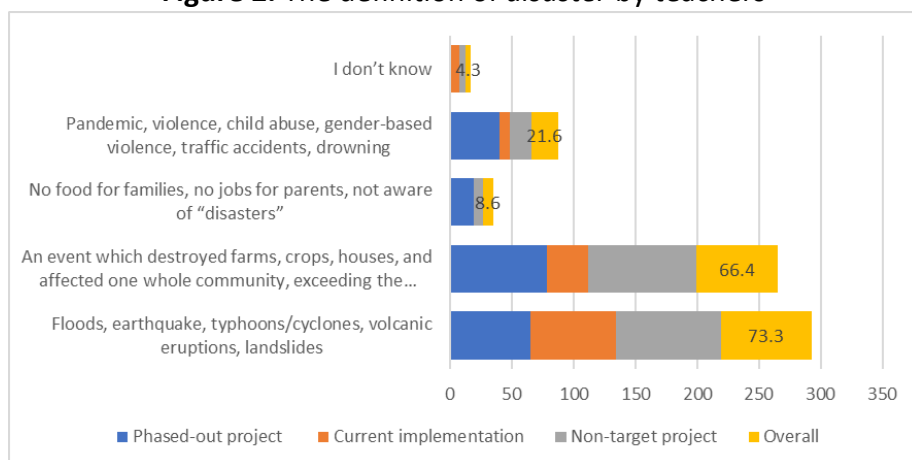
Focus group discussion in *Takeo*, *Stung Treng*, and *Kampong Cham* revealed that while students learned about events happening in their community, such as floods, storms, and water scarcity, this did not translate into knowing the definition of a disaster. Overall, when defining a disaster, a high proportion of teachers (73.3%) referred to different hazards, such as

floods or cyclones; 66.4% referred to the destruction of an asset such as houses or crops; while 21.6% referred to the personal tragedies such as the pandemic, traffic accidents, or violence. Only 8.6% of teachers specified food security or unemployment. These results were in contrast to teachers from schools not targeted by the project, who referred mainly to different types of hazards (85.0%), or the destruction of assets (87.5%).

Figure 3. The definition of a *safe school* by teachers
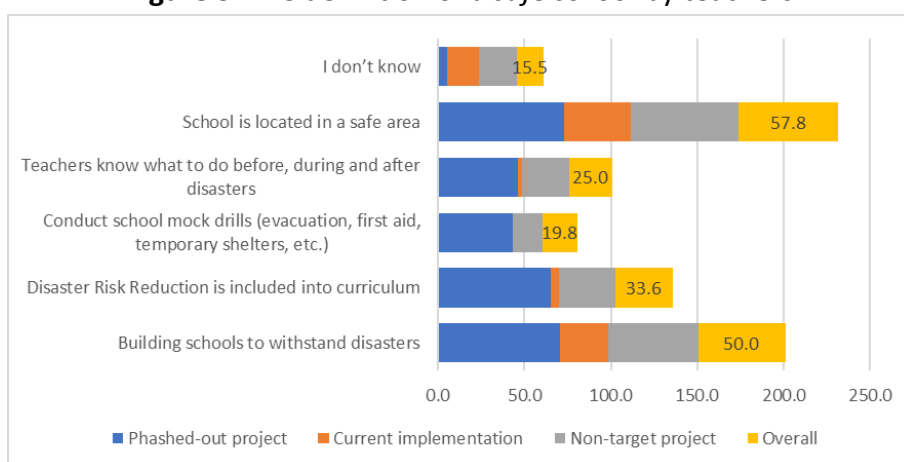
Teachers from the schools where the project had been implemented and later phased out defined the destruction of assets (78.5%) and different types of hazards (64.9%) as the definition of disaster. Other definitions include around 40.5% of teachers mentioned impacts such as the pandemic, traffic accidents, drownings, and violence; while 18.9% and food insecurity and unemployment (18.9%). None of the teachers from these schools suggested that they did not know the definition of a disaster. None of the teachers at schools where the project was currently being implemented defined a disaster as food insecurity and unemployment. Instead, they mentioned

different types of hazards (69.2%) or the destruction of houses or crops (33.3%). Notably, only 7.7% of these teachers did not know the definition of a disaster, while in schools that were not targeted by the project, this was much higher (17.5%).

When asked to define a safe school, around half of all teachers identified secure locations (57.8%), buildings that can withstand disasters (50.0%), DRR being integrated into the curriculum (33.6%), and teachers knowing how to conduct disaster risk management activities (25.0%). Teachers at schools where the project was currently being implemented had limited knowledge of safe schools. For example, only 38.5% referred to a secure location, and 28.2% referred to a building designed to withstand disasters. Teachers where the program had previously been phased out fared better.

For instance, 73% mentioned a secure location; 70.3% mentioned a building designed to withstand disasters, 64.9 % mentioned DRR being integrated within the curriculum, 45.9% mentioned teachers knowing how to conduct disaster risk management activities (45.9%), and 43.2% mentioned the practice of holding simulation drills (43.2%). At schools not targeted by the project, 62.5% mentioned a secure location, 52.5% mentioned a building designed to withstand disasters, 32.4% mentioned DRR curriculum integration, and 27.5% mentioned teachers knowing how to conduct disaster risk management activities.

A weight averaged index revealed that teachers rated their attitude towards preparation for disaster, engagement in disaster risk reduction with

children, knowledge sharing and understanding, and life-saving skills and knowledge as low.

Table 3. The attitude of teachers towards disaster risk management

Attribute	Phased out schools (n=37)		Current implementation (n=39)		Non-target schools (n=40)		Overall (n=116)		P-*value*
	WAI	OA	WAI	OA	WAI	OA	WAI	OA	
I believe that people need to prepare for disasters, including myself and my family.	0.29	L	0.30	L	0.39	L	0.33	L	**0.001****
In school, I want to participate with other children to do DRR activities such as knowing the hazards, preparing for disasters, practising evacuation, etc.	0.24	L	0.31	L	0.37	L	0.31	L	**0.000*****
I want to share my knowledge and understanding of disaster risk reduction and safety measures with my peer through an awareness campaign and child-to-child learning.	0.26	L	0.31	L	0.37	L	0.32	L	**0.000*****
I believe that life-saving skills and knowledge should be trained to and owned by girls, boys, and women and men.	0.29	L	0.33	L	0.33	L	0.32	L	0.306

An ANOVA analysis indicated that teachers from schools not targeted by the project perceived had much higher perceptions of the program than schools where the project had been phased out, especially regarding disaster preparation, engaging in DRR activities with children, knowledge sharing, and understanding (Table 3).

Figure 4. How teachers responded to disaster events
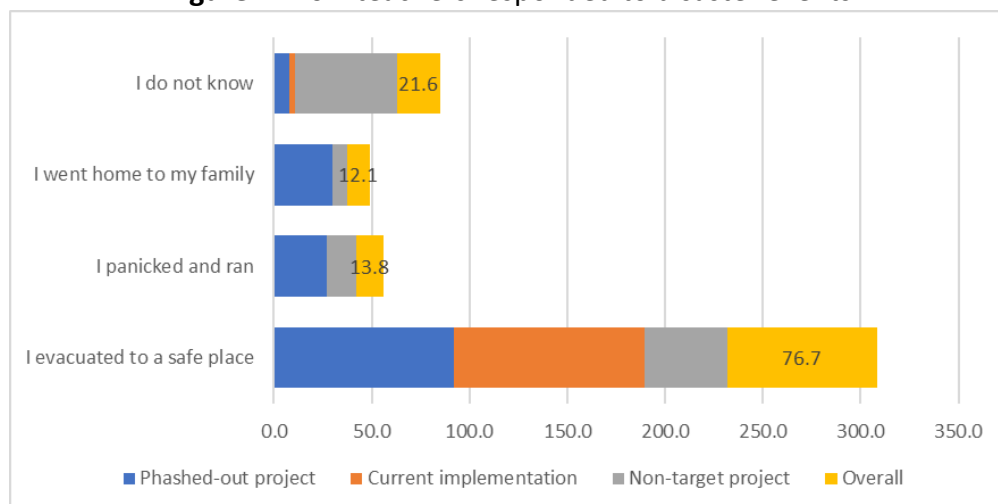
Teachers worked with NGOs such as Plan International, CRF, and World Vision to organize simulation drill exercises to gradually improve their capacity. Principals and teachers were thankful to NGOs for supporting these activities. However, teachers raised concerns after the project at the school did not have the budget to continue these exercises.

Integrating the Safe School Program within Primary Schools

Overall, teachers at each type of school actively participated in implementing a Safe School Program. This generally involved training, planning a workshop at the school, and hazard mapping. More than half of

the teachers also participated as volunteers in events, school simulation exercises, and meetings at the commune level. However, only about one-fifth of teachers participated in workshops in other provinces.

Table 4. Teacher participation in supporting Safe School Programs

Attributes	Phased-out projects	Current implementation	Non-target project	Overall
	(n=37)	(n=39)	(n=40)	(n=116)
Workshop at school	81.1	87.2	77.5	81.9
Workshop in another province	29.7	17.9	7.5	18.1
Training	78.4	82.1	95.0	85.3
School simulation exercise	64.9	74.4	47.5	62.1
Safe school planning	73.0	87.2	85.0	81.9
Volunteer work	54.1	87.2	55.0	65.5
Hazard mapping identification	70.3	82.1	82.5	78.4
Meeting at Commune Council	45.9	53.8	57.5	52.6
Meeting at NGO	62.2	82.1	92.5	79.3

This opportunity was only accessed by 7.5% of teachers from schools where the project was not being implemented and 17.9% of teachers from where the project is currently being implemented and 29.7% of teachers from schools where the project has been phased out. Teachers from non-target project schools had less opportunity to participate in workshops at schools to conduct simulation exercises than teachers where the project was being implemented. Teachers from non-target project schools tended to join training and meetings at the Commune Council or NGOs instead (Table 4).

Table 5. Relationship between teachers' participation and the three types of projects

Attribute		Types of school			X^2	P-*value*
		Phased-out school	Current implementation	Non-target school		
Are you involved in any activity for promoting school safety?	No	0	2	1	1.073	0.585
	Yes	16	37	39		
	Total	16	39	40		
Do you have a role in supporting a safe school for disaster risk reduction?	No	2	14	17	4.576	0.101
	Yes	14	25	23		
	Total	16	39	40		
Does the school have the infrastructure for disabled students within the school premises or access to the school?	No	0	0	2	2.809	0.245
	Yes	16	39	38		
	Total	16	39	40		
Are you getting training on first aid, prevention, and response to disasters?	No	3	14	13	1.571	0.456
	Yes	13	25	27		
	Total	16	39	40		

A consultative meeting organized by NGO members of the JAG-DRR-EWG confirmed that a Safe School Program is essential for reducing hazards at schools. It was also discussed that as a national project, it required more financial support from public investment, as NGOs could only partial support school development activities. Furthermore, the school required more investment in infrastructure. The principal at *Kah Dach* Primary School outlined that CRF had helped to organize meetings and prepare paperwork to respond to disaster risk management, but that the school could not continue to hold these events in an ongoing manner due to a lack of resources. It was

agreed that the workshops, meetings, and training were useful in disaster risk management, but they were not managed by the school, but rather by the NGO.

Chi-square analysis was used to explore the relationship between the three types of schools: the promotion of school safety, teacher support for the Safe School Program, infrastructure for disabled students, and training received on first aid, prevention, and disaster responses (Table 5). The analysis reveals no significant differences among the three types of schools for each of these attributes. For example, if there was a storm event during class time, all students would be supported by the teachers to evacuate to a safe area. In particular, students are not permitted to play in the rain due to the health impacts of doing so. Lightning strikes are one serious risk that may occur when playing in storms. Principals and teachers at *Srey Bandith* Primary School work closely with NGOs and local authorities to prepare for disasters and to manage their risks. NGOs and schools also work to develop the capacity among students to protect themselves. The school also has a hotline for students and parents to communicate with the school.

Table 6 demonstrates that most teachers are involved in events, especially at the schools where the project is not a target and where the project is currently being implemented. However, less than half of the teachers were given roles and responsibilities in the discussion (42.2%), decision-making (32.8%), or a presenter (31.0%). In total, only 6.9% of teachers experienced being speakers at the events they participated in. This was higher in non-target schools (10.0%). Teachers from non-target schools were also more

likely to be involved in the discussion (67.5%) or decision making (60.0%), compared with 10.3% and 5.1%, respectively in the schools where the project is being implemented.

Each year, the commune council organizes a meeting where the annual commune investment plan is prepared. Teachers, school principals, and parents are invited to indicate their priorities for community development activities. A teacher from *Ang Soklang* Primary School reported that disaster risk management is often not prioritized in the budget as it is not a severe problem in the community. However, local authorities do work with NGOs and schools to disseminate information that may help mitigate any possible disasters. However, while the school action plans in each study schools indicated support for disabled students, the school infrastructure was found to be insufficient to meet their needs. Further, the researchers did not observe any disabled students at the school during to interview.

Table 6. Roles and responsibilities of teachers at the events participated

Attributes	Pashed out projects	Current implementation	Non-target project	Overall
	(n=37)	(n=39)	(n=40)	(n=116)
Speaker	5.4	5.1	10.0	6.9
Presenter	35.1	5.1	52.5	31.0
Participants	75.7	94.9	97.5	89.7
Decision maker	32.4	5.1	60.0	32.8
Discussant	48.6	10.3	67.5	42.2

More than half of the issues raised during the events by teachers were discussed with authorities, especially in the schools where the project is

currently implemented (Table 7). Teachers believed that the ideas presented at events were used for improving school disaster management plans (39.7%) and shared with local authorities (32.8%). In total, about one-quarter of teachers suggested that their contribution was actioned, however, this was as low as 2.6% in the schools where the project is currently implemented. A higher proportion of teachers (61.5%) in these schools acknowledged that their ideas has been discussed, but they had not seen any action or improvement in the management plan. The teachers at non-target project schools were more optimistic that their ideas were used to enhance management plans, discuss, provide input to local authorities, and take action. The teachers at phased-out project schools also shared similar experiences to teachers at non-target project schools.

Figure 5. Warning signs alerting students to the risk of trees falling

A PoE officer describes how the provincial government and NGOs worked to support safe schools through capacity building and infrastructure development. The local government and NGOs also organized various events to allow principals, teachers, and parents to discuss and share their opinions and suggestion to improve the quality of education and safe schools.

Similarly, an officer at the Provincial Department of Education, Youth and Sport in Stung Treng also agrees on the importance of the involvement of principals and teachers as follows:

'The suggestions and concerns raised by principals and teachers are beneficial for establishing safe schools, but the provincial governments cannot respond to all their needs. In rural communities, NGOs play a significant role in contributing to building capacity, raising awareness, and improving school infrastructure.' [Personal communication, Teacher, Stung Treng].

Table 7. Results of engagement of teachers at events participated

Attributes	Phased-out projects	Current implementation	Non-target project	Overall
	(n=37)	(n=39)	(n=40)	(n=116)
Improving school disaster management plan	40.5	25.6	52.5	39.7
Taking action	32.4	2.6	40.0	25.0
Giving inputs to government authorities, school principals	45.9	5.1	47.5	32.8
Issues discussed	43.2	61.5	50.0	51.7
Nothing happens	8.1	0.0	0.0	2.6

Engagement in Safe School Programs at Primary Schools

Table 8 reveals that most teachers actively participated in school disaster management activities, including the establishment, planning, development of a warning system, slogans for risk reduction, and coordination with stakeholders. Both schools where the project has been phased-out and where the project was currently implemented tended to be more active in preparing emergency materials, developing early warning systems, slogans, and safety

signs, practising simulation drills, and maintaining school materials. In schools that were not a target of the project, teachers tended to be more active in establishing committees, risk assessment, and planning. The consultative meeting concluded that the management team and teachers were crucial in establishing safe schools as they led students to conduct activities each day. The role of NGOs in building capacity in DRR at schools was also significant as it empowered principals and teachers to initiate and conduct activities to improve the school condition and the quality of education for children. A principal at *Hun Sen Svay Sronos Nos* Primary School stated:

> 'Before I accessed training in disaster risk management, I had no idea how to manage risk. Now I know how to work with teachers and student councils to establish a safe school. An NGO also helped our school to prepare simulation drills, which have increased awareness among students about disasters. Knowledge received in training by NGOs have provided us with the knowledge and skills about how to deal with disasters. I did not have any idea on how to deal with catastrophes before the training'.

Equipment provided by NGOs was beneficial for waste management, disaster risk management, and other emergencies. NGOs also prepared washing areas and waste management equipment to support the development of a green campus. The school also helped to develop a structure for a disaster risk management program, however, most schools did not have the resources to implement these activities. Despite this, the schools were still optimistic about the development of disaster risk reduction action planning. The consultative meeting called for additional funding to support schools to implement a safe school program as part of a national

policy via the MoEYS to reduce risks from hazards faced by students at schools. As schools have clear structures, they often cannot continue NGO programs after they are completed, except when they do not require a budget.

Table 8. Engagement of teachers in school disaster management

Attribute	Phased-out projects	Current implementation	Non-target school	Overall
	(n=37)	(n=39)	(n=40)	(n=116)
Establishment of committee for disaster management	70.3	84.6	80.0	78.4
Identification of roles and responsibilities for the committee for disaster management	70.3	84.6	77.5	77.6
Assessment of risks, hazards, vulnerability, and capacity	78.4	71.8	80.0	76.7
Development of school safety plan or disaster risk reduction action plan	75.7	71.8	80.0	75.9
Preparation of emergency materials in responding to disasters	86.5	89.7	85.0	87.1
Development of an early warning system for disasters (microphone, whistle, siren, and information board)	83.8	84.6	70.0	79.3
Document development or slogans for risks deduction in school	86.5	89.7	75.0	83.6
Development of safety signs	94.6	89.7	82.5	88.8
Putting up warning signs at dangerous places	94.6	92.3	87.5	91.4
Practice and improve simulation drills in school to respond to disaster	94.6	89.7	77.5	87.1
Maintenance of school materials and documents during disasters	67.6	74.4	55.0	65.5
Prepare an education continuity plan that is inclusive, free from abuse and violence	86.5	89.7	92.5	89.7
Coordinate with community and government for networking, advocacy, and fundraising/resource mobilization	78.4	87.2	80.0	81.9

The participation of teachers in risk education activities across each type of school was high, particularly in terms of disseminating information (91.4%) and integrating DRR into the curriculum (89.7%). The teachers at schools where the project was currently being implemented focused on these two aspects curriculum integration, information dissemination, as well as first-aid training, and disaster response (Table 9).

Figure 6. (a) An incinerator   (b) A hand washing area

Meanwhile, teachers at schools where the project was not implemented focused more on capacity building in disaster risk education. At *Hun Neang Bakheng* Primary School there was a strong focus on hazard reduction. The school both incorporated DRR activities into the curriculum, while also purchasing the necessary equipment and materials to mitigate risks among students. The integration of DRR into the curriculum requires both financial and human resources, and many schools lack sufficient resources to conduct activities without the support of the MoEYS and its associated line departments, or NGOs. In particular, schools experience difficulties in developing action plans and training new staff without external support.

The teachers also assessed the actions and measures made by teachers to minimize hazards as high, except for efforts to prevent risks resulting from electricity, which were rated as moderate (**Table 10**). Teachers at schools where the project has been phased out rated these efforts higher than those where the project was currently being implemented. The teachers from the different categories of schools held various perspectives about school hazards, except for the prevention of risks from falling into ponds or uncovered wells, which concerned teachers significantly.

Table 9. Engagement of teachers in risk reduction education

Attribute	Phased-out schools	Current implementation	Non-target schools	Overall
	(n=37)	(n=39)	(n=40)	(n=116)
Integration of DRR in the primary school curriculum	83.8	94.9	90.0	89.7
The conduct of DRR education in extracurricular activities	83.8	66.7	70.0	73.3
Capacity building for teachers on disaster risk reduction	86.5	82.1	90.0	86.2
Regularly disseminate information to students about Do and Don't to be safe during disasters	91.9	94.9	87.5	91.4
Training on first aid, prevention, and response to disasters	81.1	94.9	77.5	84.5
Coordination with the community for common key messages on safe school	83.8	87.2	87.5	86.2
The DRR materials in school are gender and culture-sensitive e.g.: use of the local language, all children can play any role in SDMC regardless of their gender	86.5	89.7	82.5	86.2

Teachers from schools where the project has been phased out rated efforts to prevent risks associated with electricity, and dangers from school fences, highly. All schools had developed action plans to mitigate the impacts of disasters, however, they did not have the financial resources to implement the activities within them, and required NGOs to sponsor these efforts.

Table 10. School activities to minimize risks from hazards

Attribute	Phased-out project		Current implementation		None-target project		Overall		P-*value*
	(n=37)		(n=39)		(n=40)		(n=116)		
	WAI	OA	WAI	OA	WAI	OA	WAI	OA	
Actions to prevent disasters from physical infrastructures (falling objects, sharp table edge)	0.73	H	0.65	H	0.73	H	0.70	H	**0.021*****
Actions to prevent risks resulting from electricity	0.69	H	0.44	M	0.61	H	0.58	M	**0.000******
Measures to prevent risks from fire hazards	0.71	H	0.70	H	0.68	H	0.69	H	**0.000******
Measures to prevent risk from school fence to prevent people from outside or animals to enter the campus	0.80	VH	0.52	M	0.68	H	0.66	H	0.504
Measures to prevent risks from falling into the pond, uncovered well, fragile roof.....etc.	0.65	H	0.57	M	0.69	H	0.64	H	**0.000******
Check old trees that may cause harms	0.76	H	0.58	M	0.76	H	0.70	H	0.128

Each school worked with local authorities to improve school infrastructure and the school environment. Commune Councils helped schools to fill ponds

with soil, or construct fences. Fences were observed to be very important in protecting children from an accident. Commune Councils also worked with police to facilitate the travel of students to and from school, with traffic accidents identified as a significant issue by many teachers. In addition, students were informed about the fall of trees, old buildings, and drug issues.

Table 11 demonstrates that schools in the study area had prepared to mitigate impacts from hazards via the establishment of response and preparedness committees. In total, five committees were established, comprising teams focus on early warning and information dissemination; evacuation; search and rescue; first aid; and security. Different types of school committees focused on different tasks, with schools where the program had been phased out, having established more committees than other schools. Schools not targeted by the program were more focused on establishing response and preparedness committees. Both principals and teachers were aware of how to respond to hazards, especially more frequent one-off floods, traffic accidents, and water shortages.

Table 11. Teachers' response and preparedness committees

Attributes	Phased-out schools	Current implementation	Non-target schools	Overall
	(n=37)	(n=39)	(n=40)	(n=116)
Early warning and information disseminating teams	91.9	84.6	67.5	81.0
Evacuation Team	94.6	84.6	67.5	81.9
Search and Rescue Team	94.6	84.6	67.5	81.9
First aid Team	94.6	84.6	75.0	84.5
Security Team	89.2	84.6	75.0	82.8

First-aid materials were readily available at schools to help respond to disasters and were essential for both teachers and students to adhere to the plans (Table 13). These materials were less available at schools not targeted by the project than in other schools, while schools where the project was currently implemented tended to have less access to face masks. All key stakeholders were observed to work towards ensuring that each school was equipped with sufficient materials and infrastructure to manage disasters via the treatment of minor injuries. Often these materials were sponsored by the government, local authorities, or NGOs.

Table 13. Available first aid materials for prevention and response to disasters

Attribute	Phased out schools	Current implementation	Non-target schools	Overall
	(n=37)	(n=39)	(n=40)	(n=116)
Scissor and nail-cutter	91.9	100.0	97.5	96.6
Forceps	67.6	100.0	97.5	88.8
Gloves	97.3	100.0	100.0	99.1
Cotton	100.0	100.0	97.5	99.1
Alcohol	100.0	100.0	100.0	100.0
Betadine	100.0	100.0	100.0	100.0
Anti-bacterial ointment	100.0	59.0	95.0	84.5
Sterilized bondages	91.9	100.0	97.5	96.6
Plasters	100.0	100.0	100.0	100.0
Balm	100.0	94.9	77.5	90.5
Triangular bondages	100.0	100.0	100.0	100.0
Face-mesh	97.3	76.9	95.0	89.7

These key stakeholders also financially supported schools to respond to urgent hazards, such as severe floods. For instance, CRF provided lifejackets for students at *Veal Ksach* Primary School for use when travelling to school

during flood events. Despite this, parents still hesitated to send their children to school at these times and additional awareness-raising activities were required. Another example from Takeo observed where local authorities provided masks and alcohol to reduce the impact of COVID-19. Schools also wished to be provided with soap and other materials to maintain student hygiene.

Figure 7. Pillars of the safe school Program

Picture 8. First aid box at schools for DRR response

Conclusion and Policy Implications

The findings from the 15 schools surveyed in *Stung Treng*, *Takeo*, *Kampong Cham*, and *Phnom Penh*, in addition to a review of the literature on Safe Schools Programming across Cambodia, have led to the following

insights: (1) Primary schools in Cambodia are not yet entirely safe for students. Schools, where the project was currently being implemented, were highly affected by flood and epidemic diseases and moderately affected by droughts, storms, traffic accidents, and poisonous reptiles. Better school infrastructure was observed in *Phnom Penh* and *Kampong Cham* than in *Takeo* and *Stung Treng*. In general, students were not safe while travelling to and from schools on foot or by water, as traffic measures facilitated by each school were not sufficient; (2) Teachers could define a disaster well. For instance, they were able to easily identify different kinds of hazards (73.3%) and observed that the destruction of houses and farms was an example of this (66.4%).

However, 15.5% of teachers were not aware of the concept of a safe school. Regardless of this, teachers devoted attention to providing secure locations (57.8%), buildings that could withstand disasters (50.0%), and integrating DRR activities into the school curriculum (33.6%). Teachers at schools not targeted by the project were observed to have a more positive attitude toward disaster risk management programming than other schools; (3) Teachers, especially at the schools not targeted by the project, and those where the project was currently being implemented were found to have actively participated in the Safe School Programs, including engaging in training, planning, workshops, hazard mapping exercises, and other meetings with the Commune Council; (4) Teachers indicated that they had implemented actions and measures to minimize hazards to a high degree, except those related to electricity, where efforts were rated as moderate.

Teachers in schools that the project did not target or those where the project has been phased out, rated these measures higher than those where the project was currently being implemented.

DRR integration into schools occurs through the implementation of the Safe Schools Program from the national to the sub-national level. This study at 15 schools has demonstrated that this process has been useful in reducing vulnerabilities to hazards at schools. Thus, schools should continue to be supported in this endeavour as follows:

- **Improving school infrastructure**. NGOs have shifted their focus from a software to a hardware approach. This reflects the findings of this study that improved physical infrastructure is critical to building disaster resilience at schools. At the same time, the adaptive capacity of principals, teachers, and students is also dependent upon capacity building and awareness-raising. In future projects, the budget for physical infrastructure at schools should be increased.

- **Increasing cooperation with local authorities.** The study observed limited cooperation between schools and local authorities, especially the police. Commune councils may play a more active role in facilitating greater collaboration in this context. Existing policies on Safe Villages and Safe Communes may help gain the support schools require from the police. In particular, improved collaboration may reduce hazards related to traffic accidents, school-based violations, and even rescue activities during floods.

- **Improving the capacity of teachers and principals using existing resources.** Schools need to consolidate the experiences gained from NGO programs on DRR integration and Safe School Programming to enable these concepts to the transferred to new schools. NGOs such as CRF, World Vision, and Plan International have worked to initially build capacity and raise awareness in select schools, yet, now the focus should shift to principals and teachers from these schools as focal persons to share their experiences with others.

- **Engaging support from parents and the community.** Parents are key local resources for supporting schools physically and financially. In *Stung Treng* and *Kampong Cham*, schools were observed to be built with assistance from parents. Schools should continue to work closely with parents to mobilize local resources to improve school infrastructure.

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Book Review. Industrial and Organizational Psychology: Research and Practice. 8th Edition. By Paul E. Spector. John Wiley & Sons, 2021. 416 pp. Price: $75.95 (Paperback) and $67.00 (eBook).

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Psychology refers to the study of human behaviour and mental processes. Psychologists employ a range of evidence-based practices and methods to understand and respond to complex social problems. They may work within family and community contexts, at schools, in clinical settings, as well as in the workforce (Riggio, 2018; Gruman, Schneider, & Coutts, 2017; Spector, 2017; Norcross, VandenBos, Freedheim, & Krishnamurthy, 2016). Currently, there are 54 divisions of the American Psychological Association, representing different sub-disciplines (APA, 2021). The 14th division is known as the Society

for Industrial and Organizational (I-O) Psychology, which covers practice in all types of organizational and workplace settings. The division focuses on skills assessment, leadership development, staff management, teamwork, occupational health and safety, diversity in the workplace, and work-life balance.

Numerous benefits may be realized by employers with the capacity to manage the health, safety, and well-being of employees through the use of psychological practice aimed at meeting organizational needs. Nevertheless, expertise in I-O psychology requires development among organizational leaders, supervisors and workers in Cambodia. For example, in Cambodia's workplaces, I-O psychology should have been playing an effective role in improving leadership and job satisfaction in the workplace; as well as in enhancing intrinsic and extrinsic motivational factors such as recognition of work and effective interpersonal communication (Sorm & Gunbayi, 2018; Anastasiou & Garametsi, 2021). Further, expertise in I-O psychology has been applied successfully to the hotel services industry in Cambodia to better understand the nature of interpersonal communication, emotional dissonance, and attitudes to work among leaders and employees (Rabiul, Patwary, & Panha, 2021). These examples demonstrate the potential for I-O psychology to play a practical role in evaluating and improving workplace behaviour in the country.

With the above context in mind, the 8th e-book edition of the text *Industrial and Organizational Psychology: Research and Practice*, recently published by well-known American psychologist, Paul E. Spector (2021) is

reviewed in this paper. The content of the book is summarized, with key changes noted; while important theoretical contributions made to the sub-discipline are evaluated. Insights are then provided on how to apply these ideas in the workplace. The book is presented in five parts, retaining 14 chapters from previous editions (Spector, 2012; 2016). In the preface of the 8th edition, the structure of the book is briefly outlined, highlighting the updated range of topics drawing from sources published by experts in the field since previous editions were published. A brief paragraph summarizing these topics has also been included at the end of each chapter.

The first part of the book is the *"Introduction"*, which comprises two chapters providing an overview of the I-O psychology. Chapter 1 defines the field, its history, and the accredited pathways to becoming an I-O psychologist. A comprehensive list of graduate programs at the Masters and PhD level in various country contexts is provided. The chapter discusses the ethical standards professionals are expected to adhere to. Practitioners in I-O psychology are expected to be committed to using their skills to promote workplace health and safety. However, this may be particularly challenging in countries where the occurrence of unhealthy or hazardous conditions is common. In providing an overview of the I/O psychological practice, the important role the field plays in managing human behaviour, cognition, emotions, and motivation in these types of employment settings is highlighted.

In Chapter 2, the basic principles of I-O research methods are introduced. These may be of value to students or early career researchers who may wish

to apply them either in the field or the laboratory. Several research design methodologies, data collection methods, and analytical approaches are presented alongside the ethical principles of conducting research in I-O psychology. There is a focus in this chapter on evidence-based practice, whereby psychologists employ scientific methods to collect and analyze and interpret data to aid in addressing organizational issues.

The second part of the book, *"Assessment of Jobs, Performance, and People"*, focuses on methods for assessing the psychological capacity of human resources within organizations. There are three chapters in this section, which address various aspects of job analysis. Various techniques used by I-O psychologists to characterize jobs and the personal attributes required for the successful placement of employees and the evaluation of their performance in the workplace are presented.

Chapter 3 outlines a series of both job-oriented, and person-oriented approaches to analyzing jobs. For instance, one person-oriented approach is outlined in the analysis of knowledge, skills, abilities, and other personal characteristics (KSAOs) held by employees. A range of job-oriented approaches such as the evaluation of job performance via interviews, observations, and self-reporting questionnaires are outlined. These methods may be used by a job analyst or I-O psychologist for working on problems such as addressing gender-based salary inequities among employees, as an example.

Chapter 4 focuses on performance appraisal in the workplace. It discusses the objective and subjective nature of appraising job performance by

supervisors or managers. In doing so several types of rating methods are presented that may minimize bias and human error in managing employees. These include behaviorally anchored rating scales, mixed standard scales, behaviour observation scales, and 360-degree feedback.

Chapter 5, the final chapter of Part 2, covers some assessment methods used for the selection and placement of staff. It describes the most common psychological tests used to identify the KSAOs essential for successful performance in a job and how they may be administered using printed or electronic forms. In this chapter, a range of new technical terms has been newly defined by the author including automated web-based interviews, gamification in assessment, situational interviews, situational judgement tests, and social media for assessment.

The third part of the book, *"Selecting and Training Employees"*, discusses the specialization of some I-O psychologists in issues related to evidence-based methods for selecting and training employees. This topic is central to human resource development within organizations and is covered in two chapters. Chapter 6 describes the process of recruiting new employees using scientific methods. It describes the four steps of the recruitment process, including (1) planning the need for new employees, (2) getting the right people to apply for vacant positions (recruitment), (3) deciding who to hire (selection), and (4) motivating the selected candidates to accept the position. The third step of this process is elaborated upon in-depth. It is described as being supported by the development of an effective selection system that utilizes a validation study based on KSAOs as predictors of job performance.

The chapter delves into the legal issues that may be faced by organizations that adopt discriminatory selection practices that do not adhere to this approach.

Chapter 7 describes the use of training programs for both new and experienced staff, driven by a needs assessment for the organization, job, and person employed (Goldstein, 1993). Using a list of KSAOs alongside an effective process for designing training programs within an organization; as well as scientific methods for evaluating training outcomes are the main focus of this chapter. The book suggests that this is one of the most important aspects of human resource development as it enables an employee's knowledge, skills, and capacity to perform their job effectively to be upgraded. The five steps of designing an effective training program are discussed including (1) determining training needs through needs assessment; (2) setting objectives for the training; (3) designing the training; (4) delivering the training; and (5) evaluating the training.

The fourth part of the book discusses the relationship between *the individual and the organization.* It comprises four chapters that discuss the relationship depicted in the title. Chapter 8 discusses nine theoretical aspects of employee motivation. One significant change in the 8th edition is the replacement of the two-factor theory presented in the 6th and 7th editions with the theory of *self-determination*. The discussion of motivation theories in this chapter aids the understanding of workplace behaviours among different groups of employees from widely diverging perspectives.

Chapter 9 focuses specifically on how employees perceive their jobs. It provides details of various assessments of job satisfaction, affectivities, and commitment to the organization. This interplay between job satisfaction, emotions related to work, commitment to the organization, absenteeism, and employee turnover is the focus of this chapter.

Chapter 10 presents key concepts of productive and counterproductive workplace employee behaviours, which is a key area of concern for I-O psychology. The performance of an organization as a whole is often highly dependent on the interplay between the ability and motivation of employees and their level of job satisfaction. Thus, understanding the personality characteristics of employees, and supervisors that positively influence behaviour is important. For this reason, the chapter focuses on how to evaluate employee attitudes and how these attitudes impact job performance.

The most interesting chapter in Part 4 is Chapter 11, which is concerned with occupational psychology related to the health, safety, and well-being of employees. The chapter describes the negative consequences of poor physical and nonphysical work conditions. It is informed by updated findings specific to the 8th edition. These draw on research highlighting the importance of providing respite that enhances the mental health of employees. Types of respite activities outlined in the book include micro-breaks, meal breaks, and vacations. Respite activities are shown to help employees psychologically detach from their work. However, as the book outlines, employees require training in how to take advantage of these activities. Both work and family

conflicts experienced by men and women require flexible working schedules that provide opportunities for reflective practices. Burnout of often associated with both physical and psychological job stressors. Thus, this chapter discusses strategies that may be used to enhance an employee's health safety and well-being.

The final part of the book, *"The Social Context of Work"*, emphasizes the importance of an inclusive organizational culture driven by leadership, teamwork, and the necessary presence of others for improving job performance. The importance of tailoring work to meet common organizational goals is discussed across three chapters.

Chapter 12 describes the difference between workgroups and teamwork. It outlines some fundamental concepts that may maintain and improve job performance via working as a team. The author highlights the psychosocial phenomena related to the presence of others, be it an audience or coworker, on individual job performance. In this regard, the effects of social facilitation and social inhibition introduced by Triplett (1897) and Zajonc (1965) remain the most widely accepted explanation of how this phenomenon affects task performance. The chapter also addresses how an understanding of group decision-making practices is fundamental to realizing a high-performing workgroup.

In Chapter 13, the author discusses leadership and supervision in the workplace, in particular, the theoretical understanding of the factors that influence the attitudes and working behaviors of leaders toward their followers. Various approaches to studying leadership are highlighted. For

instance, the Vroom–Yetton model (1973) is used to provide a practical framework for identifying five approaches used in the decision-making process in the workplace. These may range from autocratic to democratic.

The final chapter of the book is Chapter 14, which discusses three major aspects of organizational psychology: climate, culture, and organizational development. Four organizational theories are also presented. For instance: (1) sociotechnical systems theory; (2) management by objective; (3) survey feedback and team building; and (4) Theory Y (McGregor, 1960). These theories are used to demonstrate how organizational management and leadership may promote productivity, job satisfaction, and occupational health and safety.

Overall, the book collates a broad range of practical and evidence-based approaches, which may be used by leaders, human resource management professionals and organizational psychologists to enhance Cambodian workplaces. New content in the 8th edition embraces concepts such as moral leadership, the use of technology in the workplace, creativity, and innovation. It also provides up-to-date methods for assessing job performance. However, it is important to note that majority of the new content is based on references citing empirical data from developed countries such as the US, UK, and Canada, with very few examples from Asian contexts. Thus, while the 8th edition may be useful for Cambodian students and practitioners, some limitations remain in how effectively it may apply I-O psychology to human resource development and leadership in the country.

The *I-O Psychology in Practice* case studies developed by experts from Part 2 onwards and the related reflective questions are valuable. They draw attention to the key principles of each chapter using an authentic practical workplace context. Methods for selecting and training employees, evaluating job performance, and promoting productivity, job satisfaction and mental health at work are clearly explained; and may be used to good effect by Cambodian professionals. Relevant research findings demonstrating the importance of enhancing collective trust across divergent perspectives in the workplace may be useful in complementing the book in this regard. These additional inputs may lead to an enhanced level of reflection and insight into how to optimize healthy communication, job performance, and effective teamwork in Cambodian organizations (Mayer, Davis, & Schoorman, 1995; Gillespie, 2021; Salanova, Acosta-Antognoni, Llorens, & Le Blanc, 2021). The context on *I-O Psychology in Practice* is recommended for helping enhance the use of I-O psychology by leaders in human resource management contexts. It may be useful in both improving the theoretical understanding of workplace behaviour in Cambodia, as well as providing practical advice on how to boost the health and well-being of Cambodian workers (Riggio, 2018).

I-O psychologists have an important role to play in the management of human resources for the future development of Cambodia. This book reviewed in this paper may be of use to leaders and professionals in Cambodia in better understanding workplace relations. It presents best practice approaches to job analysis, recruitment and selection, training and development, incentives and reward systems, and performance appraisal.

This is central to enhancing the attitude and motivation of employees, improving their performance, and realizing organizational goals. Overall, the book is well organized, comprehensive and practical. It can complement the roles of leaders in organizational development in Cambodia; as well as students and professionals who may wish to gain practical knowledge and insights into the field of I-O psychology.

Author Biographies

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Instructions for Authors

Frequency of Issue

Insight: Cambodia Journal of Basic and Applied Research is a bilingual journal, where manuscripts may be published in either English or Khmer. However, all manuscripts must have abstracts in both English and Khmer. Two issues of the journal are published each year:

- Issue 1: January-June
- Issue 2: July- December

Each volume will comprise one editorial, five research papers, one policy paper, and a book review.

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Insight A: **Humanities, Social Science, Development Studies, Education, and Languages**

- Original/research paper (6,000-10,000 words, including references)
- Short communication/policy paper (3,000-4,000 words, including references)
- News (<1000 words)

Insight B: **Natural Science, Mathematics, Science, Engineering, and Technology**

- Original/research paper (4,000-6,000 words, including references)
- Short communication/policy paper (3,000-4,000 words, including references)
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Paper Structure

An original research paper may vary in structure based on specific requirements of the topic, or the disciplinary background of the author(s), in terms of experiments, surveys, case studies, and so on. However, authors will need to collect and analyze new data and conduct an original study. The paper should be based on the analysis and interpretation of this data. The suggested structure for a paper in this category is as follows:

- Introduction,
- Conceptual framework/literature review,
- Methodology,
- Discussion,
- Conclusion,
- References, and
- Supplementary Data (if required).

A book review is an analysis of a book, including its contents, style, and merit. A book review may be written as an opinion piece, summary, or scholarly review. The suggested structure for a book review is as follows:

- Introduction,
- Body (a review of the contents of the book),
- Analysis and evaluation,
- Conclusion, and
- References.

A short policy paper is a communication piece focusing on a specific policy issue, which provides clear recommendations for policymakers. It is

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- Abstract,
- Introduction,
- Research methodology,
- Results,
- Discussion,
- References, and
- Supplementary Data (if required).

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- Introduction,
- Aims and objectives,
- Research methodology,
- Preliminary results (if relevant),
- Discussion, and
- References.

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The Journal is publishing 1 volume per annum. Each volume contains 2 issues. Each issue includes: 1 editorial, 5 original/research papers, 1 policy paper and 1 book review. The outline of each issue is structured as follows:

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- Original/Research Paper 2,
- Original/Research Paper 3,
- Original/Research Paper 4,
- Original/Research Paper 5,
- Policy Paper, and
- Book Review.

Papers from Field of Study

Science and Engineering

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- Computer science
- Environmental science
- Climate change
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- Mathematics
- Physics
- IT Engineering
- Information technology engineering
- Telecommunication and electronic engineering
- Bioengineering

Social Science and Humanities

- Geography

- History

- Khmer literature

- Media and communication

- Philosophy

- Psychology

- Sociology

- Social work

- Tourism and resource management

- Clinical psychology

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- Thai

- English

- French

- Japanese

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Publication Charges

There are no submission fees, publication fees or page charges for this journal. Submitted papers should be well formatted and in good English or Khmer. The Research Office of the RUPP covers the cost of the peer-reviewed process, English editing, and printing of the Journal. The author is responsible for translating the abstract from English into Khmer if she or he is not a Khmer native speaker.

Referencing Style

Insight: Cambodia Journal of Basic and Applied Research (CJBAR) has adopted the 7th Education of American Psychological Association (APA) style as referencing style. The example below is derived from https://middlebury.libguides.com/citation/apa7.

Print Book Examples

Author, A. A. (Year of publication). Title of work. Publisher.

Calfee, R. C., & Valencia, R. R. (1991). APA guide to preparing manuscripts for journal publication. American Psychological Association.

E-Book Example

Author, A. A. (Year of publication). Title of work. [Ebook]. Publisher.

Nondatabase URL

De Huff, E. W. (n.d.). Taytay's tales: Traditional Pueblo Indian tales.

Ebook]. http://digital.library.upenn.edu/women/dehuff/taytay/taytay.html

Print Journal Example

Author, A. A., Author, B. B., & Author, C. C. (Year). Title of article. Title of

Periodical, volume number(issue number), page range.

Harlow, H. F. (1983). Fundamentals for preparing psychology journal articles.

Journal of Comparative and Physiological Psychology, 55(2), 893-896.

Online Journal Example

Author, A. A., & Author, B. B. (Date of publication). Title of article. Title of

Journal, volume number(issue number), page range .https://doi.org/

Brownlie, D. (2007). Toward effective poster presentations: An annotated

bibliography. European Journal of Marketing, 41(3), 1245-

1283. https://doi.org/10.1108/03090560710821161

Print Magazine Example

Cite like a print journal article, but give the year and the month for

monthly magazines. Add the day for weekly magazines.

Henry, W. A., III. (1990, April 9). Making the grade in today's schools. Time,

135, 28-31.

Online Magazine Example

Cite like a print magazine article, except: a) no page numbers, and b) add a

DOI (preferred) or full URL.

Auerback, M. (2019, January 27). In antitrust, size isn't everything.

Salon. https://www.salon.com/2019/01/27/in-antitrust-size-isnt-

everything_partner/

Online Newspaper Example

Cite like an online magazine article except that in most cases, you'll include a URL because no DOI will be available.

Author, A. A. (Year, Month Day). Title of article. Title of Newspaper. URL

Parker-Pope, T. (2008, May 6). Psychiatry handbook linked to the drug industry. The New York

Times. https://well.blogs.nytimes.com/2008/05/06/psychiatry-handbook-linked-to-drug-industry/

Website Example

Author, A. A., & Author, B. B. (Date of publication). Title of page. Title of Website. URL

Martin Lillie, C. M. (2016, December 29). *Be kind to yourself: How self-compassion can improve your resiliency*. Mayo

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Insight

Cambodia Journal of Basic and Applied Research (CJBAR)

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The preparation and printing of the Journal are generously supported by the Research Office of the RUPP, who also provided technical support in hosting, editing, and publishing the CJBAR. This is a bilingual Journal where an author may decide to publish his/her manuscript either in English or Khmer. However, all manuscripts published in the CJBAR must have abstracts in both English and Khmer. The Journal publishes two issues per annum:

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The CJBAR is an academic, policy, and practice-oriented Journal covering all aspects such as mathematics, science, technology, engineering, environment, social sciences, humanities, education, development studies, and languages. Academic or applied research manuscripts from within Cambodia; or from outside Cambodia that contribute to the social, economic, or environmental development of Cambodia, ASEAN, or the Greater Mekong Subregion may be submitted to the Journal. The Journal welcomes manuscripts from any discipline, where theories, concepts, innovations, new technologies, or best practices. However, the Journal reserves the right to prioritize research topics aligned with the courses offered at RUPP.

The Royal University of Phnom Penh (RUPP) is the largest public university in Cambodia. It hosts more than 12,000 scholarship and full-fee paying students across a diverse range of undergraduate and postgraduate programs. The university is a full member of the ASEAN University Network (AUN) and has a unique vision 'to become Cambodia's flagship university with a reputation in the region for teaching, learning, research, innovation, and social engagement.' The current strategic plan of the institution prioritizes the development of a strong research capacity incorporating peer-reviewed publications, as well as links to industry and community networks, which is well-aligned with Cambodia's National Education Strategic Plan (NESP) 2014-2018 aimed at supporting the transition of the country from a lower-middle to upper-middle income country by 2030; and obtaining 'developed country' status by 2050.

The Royal Government of Cambodia (RGC) through the Ministry of Education, Youth, and Sport (MoEYS) promote the publication of scientific research in the national higher education strategy. For instance, one of the eight key strategies in the Policy on Higher Education Vision 2030 is 'to ensure that RUPP staff and students, especially postgraduate students, contribute to improving the research and development culture in Cambodia to serve national development needs.' The publication of scientific research is considered to be a crucial aspect of promoting the Cambodian Industry 4.0 Policy. This policy aims to engender the creativity and innovation, required to drive economic growth and social development.