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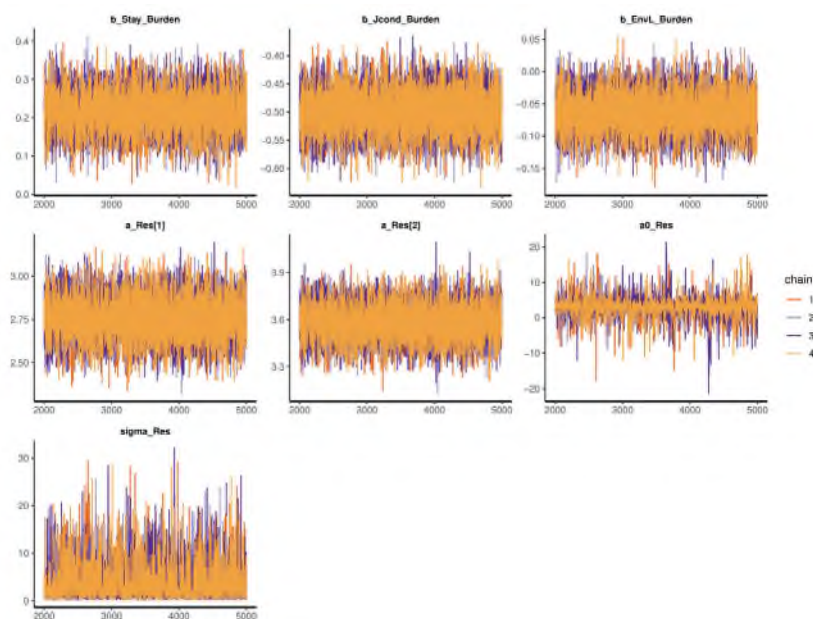
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Completing the most monumental series on the “National History” of Vietnam

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Abstract:

Vietnam has a long and rich history. In effort to recreate its heroic but equally tragic historical episodes, so far, many domestic and foreign works have been written on various topics. However, large-scale historical works are rare. As the country needs a national history series commensurate with the significance of Ho Chi Minh's era, and to follow the policy of the Party Central Committee Secretariat and the direction of the Government, the Ministry of Science and Technology has organised a state project (KHXXH-LSVN/14-18) to research and compile a special series on Vietnamese national history. In November 2021, the last volume of the series was finalised at the state level. The most recent domestic and international research has been covered in the present Vietnamese history series, which is a significant scientific accomplishment. Numerous historical events and eras are depicted in accordance with recently accepted study findings. Additionally, the series offers fresh viewpoints on touchy and contentious historical subjects. This is a great effort from the group of authors.

Keywords: monumental series, National History, Vietnamese history.

1. Previous significant publications on Vietnamese history

I begin by reviewing a number of works that are considered “National History” and some significant others written by domestic and international scholars [1-7]. The earliest is the *Dai Viet Su Luoc* (A summary of the history of Dai Viet). This chronicle was compiled at the end of the Tran Dynasty. It was then lost. Fortunately, on a very special occasion in the early 1960s, Vietnam received a book set titled *Viet Su Luoc* (越史略)¹. According to

researchers, this is the same historical document that was lost in the 15th century. Another text that has not survived to this day is the *Dai Viet Su Ky*, consisting of 30 volumes, compiled by Le Van Huu in 1272. This can be considered as the first large-scale series on “National History”, which received a commendation from Emperor Tran Thanh Tong. It is possible that this series was destroyed or taken away during the 20-year rule of Ming China.

Since the victory of the Lam Son uprising, the Le court attached great importance to history writing. Under Emperor Le Thanh Tong's attention, Ngo Sy Lien and other historians of the Le successfully compiled the *Dai Viet Su Ky Toan Thu* (Complete Annals of Dai Viet). As of 1492, it comprised 24 volumes, which were then supplemented further by later historians. The project lasted until the 18th year of Chinh

¹This may be the *Dai Viet Su Luoc* (大越史略) that the Ming brought to China in the 15th century. After being lost for a long period, the document was found in *Complete Library in Four sections* (四庫全書) and then published, but the word *Dai* was omitted. In the early 1960s, this document was given as part of a gift from the Chinese Government to Vietnam (reprinted). The original may still be kept in the *Complete Library* in Beijing.

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Ministry of Science and Technology of Vietnam received the "National History".

Hoa (1697) when it was first engraved and printed. Today, this series remains one of the most important original documents for the study of Vietnamese history. After this series, there was another "National History", *Dai Viet Su Ky Tien Bien*. It comprises 17 volumes, written in Chinese, compiled by Ngo Thi Sy, and edited by Ngo Thi Nham. The series was engraved in 1800 during the Tay Son era. Next is *Kham Dinh Viet Su Thong Giam Cuong Muc*, with 53 volumes, prepared by the Bureau of State Historiography at the order of Emperor Tu Duc. This project mobilised a large number of historians over nearly 30 years. Along with the national histories written from the founding of the country to the end of the Later Le, the Nguyen also commissioned the compilation of dynastic histories called the *Dai Nam Thuc Luc* (*Tien Bien* and *Chinh Bien*). This series is made up

of 584 volumes and was the largest series up until that time. Although it began in 1821, it was not until 1909 when the book was printed, which was under the reign of Emperor Duy Tan. Thus, by the August Revolution in 1945, there were many printed "National History" series available. But so far, only three of them remain to this day including *Dai Viet Su Ky Toan Thu*, *Dai Viet Su Ky Tien Bien*, and *Kham Dinh Viet Su Thong Giam Cuong Muc*. Although the *Dai Nam Thuc Luc* is massive, it focuses only on Nguyen rulership [1-3].

During the French colonial period, there were almost no complete works except for Tran Trong Kim's *Vietnam Su Luoc*. Published in 1920 and reprinted many times later, the work has a significance of its own as it was the first Vietnamese history written in Latinised

scripts and chronologically compiled by an erudite, professional historian. It is easy to read and understand. Despite its limitations, the text was widely received.

After the August Revolution, especially after northern Vietnam was liberated in 1954, Vietnam's modern historiography was rapidly resuscitated and developed. With many achievements, it has been vibrantly contributing to the mission of national liberation, defence, and development. Besides monographs, there are a number of works compiled in chronicle forms. Among these, the *Vietnamese History* series prepared by the Vietnam Social Science Committee can be considered national history. During the fiercest years of the resistance war against the US, the series is aimed at raising historical awareness about national and revolutionary traditions and promoting people's fighting spirits. The editorial board was working under the direction of the Steering Committee with Prime Minister Pham Van Dong as an advisor. Volume I of the series (from beginning to 1858) was published in 1971, volume II (1858 to 1945) in 1985, and volume III (from 1945 to 1975) is not yet published².

Over the past two decades, publications from history research and training institutions have come in various formats and genres. As for chronological historiography, we should take into account the three-volume *Dai Cuong Lich Su Vietnam* (General Outline of Vietnamese History) compiled by Hanoi National University of Education; *Tien Trinh*

Lich Su Vietnam (Vietnamese Historical Progress); and a four-volume *Vietnamese History* published by the University of Social Sciences and Humanities, Vietnam National University, Hanoi. The largest effort is the fifteen-volume *Vietnamese History* compiled and published by the Institute of History, Vietnam Academy of Social Sciences. Other than chronicles, thematic historiography is also prepared in a highly methodical and meticulous manner. We can mention various works on the Vietnamese history of the Communist Party, Government, National Assembly, and Military (including a 14-volume series on military history and a five-volume on military thought). These works are all valuable contributions [4].

Thus, after more than seven decades since the August Revolution, only a two-volume *Vietnamese History* has been compiled and published as a national history. However, the work is rather undetailed and carries a specific political purpose of supporting the fight for national independence and reunification. Today's necessities for developing and protecting the country require a new project on "National History" that serves the national mission of industrialisation, modernisation, and international integration [5, 6].

2. Organising activities

To complete the massive workload, the project management board³ has mobilised a team of more than 300 national historians and foreign researchers working continuously over five years. To address its important mission,

²Volume I of the series, the authors' names are subsumed under "Vietnam Social Science Committee", but volume II (published in 1985), under "Vietnam Social Science Committee", there are specific names: Nguyen Cong Binh, Van Tao, Pham Xuan Nam, Bui Dinh Thanh.

³The Board of Directors was established under Decision No.510/QĐ-BKHCHN, 26 March 2014 with the late Prof. Phan Huy Le as Chairman. Three Vice-Chairmen are Prof. Dr. Vu Minh Giang, Assoc. Prof. Dr. Tran Duc Cuong, and Prof. Dr. Nguyen Quang Ngoc together with two secretaries, Assoc. Prof. Dr. Vu Van Quan, and Assoc. Prof. Dr. Doan Minh Huan.

the Board had scrupulously organised various exchanges among domestic and international experts. On this basis, a scientific Council of 21 prestigious social scientists was chosen to be the editors of the volumes. The Council also developed regulations specifying the functions, task allocations, personnel management, and Council membership.

This is an enormous project with strict standards and is carried out by a large number of experts with diverse research and writing styles. Searching for common voices and methods is extremely important. The Board of Directors, therefore, prepared a specific manual on *The le bien soan bo Lich su Viet Nam* (Compilation Regulations of the *Vietnamese History* series).

To ensure the uniform quality across chapters in each volume, the management board first requested 'sample chapters' to be submitted for critical discussions and thereby providing lessons for subsequent chapters. This approach has brought many conveniences to the authors. It can be said that this is the premise for the series to be prepared in an utmost methodical, scientific, and scrupulous manner.

3. The structure of the series

Writing this *Vietnamese History* series that is, preparing a new "National History" series, is considered a national mission. It includes 25 volumes of chronicle history and 5 volumes of chronology.

The chronicles cover the entire historical process from primeval times to 2015, divided by time frames for each volume. Accordingly, the entire primeval era is presented in the

first volume. Volume II focuses on the first movement of state formation in the North from the 7th century to 179 BC, which is often called the Hung Vuong and An Duong Vuong eras. Volume III presents the Chinese domination period and the struggle against Sinic courts. It also includes state formations in the Central (Lam Ap, Champa) and South (Funan, Thuy Chan Lap) regions from 179 BC to 905. Volume IV is about an extremely exciting period with important historical milestones. It covers the end of the thousand-year domination of Chinese regimes, which opened the era of national independence. Volume V deals with the brilliant Dai Viet civilization created by the Ly dynasty (1009-1226). Volume VI writes about the achievements of martial arts and literary legitimacy under the Tran up until the middle of the 14th century. The last part is reserved for resistance against the Ming, which is further presented in Volume VII.

The entire Ancient - Medieval history is presented in the first thirteen volumes, ending with the event of the French - Spanish attack in Da Nang. The next twelve volumes cover periods of early modern history from 1858 to 1884. Then, each subsequent volume is commensurate with a historical period that begins and ends with a specific landmark event. For example, volume XIX begins in 1939 when the Communist Party of Vietnam made a strategic shift in revolutionary leadership to match the situation after the outbreak of World War II and ended with the victory of the August Revolution in 1945. The next volume covers the period after 1945 up to the 1954 Dien Bien Phu Victory and the Geneva Accords.

In addition to twenty-five volumes of chronicle history, chronological volumes serve as toolkits to help readers look up, study, and compare tens of thousands of events in Vietnamese history. Volume I of the chronological volumes covers events from primeval times to 1400 when the Tran collapsed; volume II covers subsequent events up until 1771 when the Tay Son movement broke out; volume III continues until the French colonial invasion in 1858; volume IV is devoted entirely to the events between 1858 and 1945; and the final volume highlights histories that took place from the August Revolution of 1945 up until 2015.

In addition to 30 volumes of chronicle and chronology, the project also introduces three sets of historical databases including General Directory (*Tong thu muc*) serving international research on Vietnamese history; Vietnamese history database (*Co so tu lieu ve lich su Vietnam*), which is extracted and compiled from multiple domestic and foreign databases; and finally, Digitised database (*Co so du lieu*) which will be updated continuously provides a search engine for Vietnamese history studies worldwide.

4. Highlights of the series

A new feature that stands out from all previous Vietnamese histories is the attention towards the comprehensiveness of national history. Following Party leadership and Ho Chi Minh's thought on issues related to Vietnamese history, and using modern research methodologies, the "National History" series is consistent with an approach that uses the contemporary territory of Vietnam as an inclusive space for understanding the past. By so doing, the series

covers the history of all communities, ethnic groups, and kingdoms that had existed within the territory. Previous historical narratives have begun Vietnamese history by observing primeval inhabitants and then moving towards a sequence of state formations from the Van Lang and Au Lac, Dai Viet, Vietnam, Dai Nam to the present day. In this trajectory, the history of Vietnam continues wherever the Vietnamese people went. With this conception, the history of the South-Central Coast and the South only began in the sixteenth and seventeenth centuries, hence, excluding the history of Champa and Funan.

Vietnam is a country with a long and rich history. In today's territory, since ancient times, there were civilisation centres associated with ancient kingdoms that exerted great influence on different historical eras. The residents in Northern Vietnam built up a brilliant Red river civilisation serving as the material and spiritual foundation for the formation and development of the Van Lang and Au Lac regimes; in the central coast, from the Sa Huynh culture, the state of Lam Ap and Champa gradually formed; with the Oc Eo civilisation in the lower Mekong region, the Funan state was once the centre of international trading posts. These three states established certain relationships but also were distinctive historical entities. For various reasons, quite a long time ago, writings on Vietnamese histories were often presented in a way that emphasised the movement of ethnic Vietnamese (the Kinh). As a consequence, ancient southern civilisations and kingdoms were presented very faintly or even completely absent from the historical records. This has led to a particular perception,

as commented by some foreign historians, “wherever Vietnamese people have gone to, Vietnamese history emerged”. This is not only a mistake in historical scientific awareness, but, more dangerously, it also affects the minds and emotions of many communities and is a loophole for reactionary forces to distort, divide, and introduce anti-government propaganda. Given the new principle of comprehensiveness, all content presented in the contemporary *Vietnamese History* series takes the current Vietnamese territory as the starting point. With this principle, history from primeval to modern times throughout Vietnam is explicated more faithfully in each respective period. Cultures of Sa Huynh, Dong Nai, Lam Ap, Champa, Funan, and Thuy Chan Lap are all included more commensurably in the series.

Another new feature of this “National History” series is to highlight the multidimensionality of Vietnamese history. In the history of Vietnam, anti-foreign aggression plays a decisive role in the survival of the nation. Therefore, these activities need a proper place in historical research so that objective truths are respected and valuable historical lessons can be drawn. Equally important, along with the history of anti-foreign aggression, the volumes on chronicle history have also adequately concentrated on many other historical dimensions ranging from politics, economy, and diplomacy to society and culture. Therefore, along with comprehensiveness, multidimensionality is also an important principle that has been thoroughly grasped in the process of preparing the series. This principle helps overcome the limitations of previous historiographies. Multidimensionality requires the series to

properly represent all historical aspects of Vietnam, in which the economy, society, and culture are fundamental and the most extensive, while impacts of politics and military are also well incorporated.

Because Vietnamese history is often driven by war, historians can be occupied by political and military topics. Thus, writing about war is often overwhelming, while economic activities and socio-cultural dimensions, which are also the fundamental aspects of history, are often in disproportionate positions or even forgotten. This situation has led to distorted perceptions about the history and people of Vietnam. There was a time when the Vietnamese themselves thought that the Vietnamese were only good at conducting resistance wars against foreign invaders, while foreigners thought of us as belligerents. These narrow perceptions make it easy to forget when a Vietnamese pianist won the prestigious Chopin competition in 1980, or the recent winning of the Field Medal - an award equivalent to the Nobel Prize in Mathematics.

The origins of these narrow views can be explained by many reasons, such as writing incomprehensive and biased history, being overwhelmed by wars, or one-sided praises of military victory that reduces the significance of social-economic and cultural factors and processes. Applying a comprehensive perspective to the preparation of the current *Vietnamese History* series empowers us with more objective and scientific views of national history that further enhances our understanding of the strengths and weaknesses of the Vietnamese so that they can turn everything they have into a competitive advantage in the

era of globalisation. The series has made this point very clear throughout.

One important scientific standard that have been achieved in preparing the current *Vietnamese History* series is that it has covered the most updated research both at home and abroad. Many historical events and periods are presented according to new research findings that have been widely accepted. The series also presents new arguments addressing controversial and sensitive historical issues. This is a great effort from the group of authors.

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Factors affecting consumer behaviour to use e-wallets: An empirical study from Vietnam context

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Abstract:

The purpose of this paper is to investigate the behaviour of using e-wallets (BE) and the factors affecting the use BE belonging to Vietnamese consumers. Research data is collected by sending online questionnaires to consumers who have been using e-wallets in Vietnam - people between the ages of 18 and 50 years old based on the convenient non-probability sampling method. The authors combine both qualitative and quantitative methods in our research to build and develop the research model. To take advantage of the theory of planned behaviour (TPB) and technology acceptance model (TAM), this research uses a combination of TPB and TAM models (C-TAM-TPB) to analyse two factors of the technology adoption model (perceived usefulness - PU and perceived ease of use - PE), the unified theory of acceptance, use of technology factor (social influence - SI), and perceived risk (PR). The research results show that (1) three factors that positively affect e-wallet usage (ranked in descending order) are the PE, SI, and PU and (2) PR does not affect Vietnamese consumer BE. Although the investigation and research on consumer behaviour are quite popular in Vietnam and around the world, the investigation documents the BE and the factors that determine it is still rare in Vietnam. Therefore, this study contributes to investigating and measuring the BE and the factors affecting it in Vietnam. In addition, the combined approach of the C-TAM-TPB model to estimate the influencing factors is a method rarely used in previous studies on consumer behaviour.

Keywords: e-wallets, factors influencing, perceived ease of use, perceived usefulness, perceptions of risks, social influence, Vietnamese consumers.

Classification number: 2.3

1. Introduction

Attached to the development of e-commerce, cashless online payment is becoming a trend all over the world and is being chosen by a large number of Vietnamese to replace traditional forms of payment. In addition

to the convenience, security and speed of cryptocurrencies and technology, the recent outbreak of COVID-19 has spurred the rapid development of online payment methods, including e-wallets (or digital wallets). E-wallets, which are also known as digital wallets or a type of online account, usually add

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up mobile applications or websites. It can be used to make online transactions, replace cash in shopping, pay bills such as electricity or water bills, and transfer money. E-wallets are similar to physical wallets. However, instead of physical money in a wallet, an e-wallet is a collection of money by linking bank accounts and/or linking cards.

By the end of 2019, Vietnam was in the top 15 markets with the highest number of smartphone users globally, 43.7 million people, or equivalent to 44.9% of the total population [1]. The percentage of consumers using mobile payments in Vietnam increased from 37% in 2018 to 61% in 2019, and this is also the highest increase among the six southeast Asian countries [2]. These figures show that Vietnam is a potential market for fast-growing mobile payment applications and for developing e-wallets. Although the Prime Minister has approved “The project to develop non-cash payments for the 2016-2020 period” [3], and e-wallets have been officially licensed by the State Bank of Vietnam since 2014 [4], Vietnam has just over 20 e-wallets that are active in the market such as Momo, Zalopay, Moca, Airpay, etc. Among them, Momo wallet, which is a partner of 12 banks and international card companies, has reached more than 5 million users. The market for the Vietnamese e-wallet has, therefore, great potential with many favourable conditions and the participation of both foreign service providers. The level of competition in the e-wallet market will increase dramatically even though the current volume of transactions via e-wallet in Vietnam is still relatively low.

Up to now in Vietnam, studies on the BE have mostly stopped at the introduction of

e-wallet payments [5], including outlining groups of customers using e-wallets, reasons for customers to use or not to use e-wallets [6], and analysing the impact of trust and individual innovation capacity in information technology on Vietnamese users’ BE [7]. Therefore, it is necessary to have an in-depth and extensive study on the BE and the factors affecting that behaviour to find appropriate solutions to strengthen and expand the e-wallet market in Vietnam, as well as a reference for future e-wallets to become more and more complete.

Therefore, we conduct this study to examine which factors and to what extent these factors influence the customers’ behaviour toward e-wallets in the Vietnamese market. This research will provide useful information about the e-wallet market in Vietnam as well as its driving factors.

2. Literature review

In this study, the authors apply the theory of reasoned action (TRA), which was developed in the social field [8, 9]. The TRA model emphasises the significance of intention in driving customer behaviours. The notion of intention refers to the combination of attitude and subjective norms.

To explain consumer behaviour in information technology, some researchers introduced the TAM, which is based on the logic of TRA [9-11]. However, in this TAM model, they replaced the two factors “attitude” and “subjective norm” with “PU” and “PE”, respectively.

In the line with behaviour theories, the TPB is an improvement of TRA with the introduction of the perceived behavioural control factor to the model [12, 13]. According to TPB,

motivation or intention plays an important role in shaping the consumer's behaviour. Motivation or intention is determined by three basic factors: attitude, subjective norm, and perceived behavioural control. By contrast, TRA and TAM underscore the importance of consumer self-determination in consumption.

S. Taylor, et al. (1995) [14] developed a new model by combining TPB's factors with TAM's factors. This model is known as the decomposed theory of planned behaviour (DTPB). The main components of the model are attitudes, SI, and perceived behavioural control. Of these components, attitude is determined by PU and PE. However, this study still has some limitations such as the survey environment, the causal relationship between the survey questions and answers, the impact of factors outside the model that have not been mentioned, and alternative approaches to research.

V. Venkatesh, et al. (2003) [15] introduced the unified theory of acceptance and use of technology (UTAUT) to explain user intentions in using information systems and usage behaviour. Accordingly, the theory underlines that there are three direct determinants of intended use and behaviour (performance expectancy, effort expectancy, and SI) and one direct determinant of user behaviour (facilitating conditions).

However, there are very few studies on the intention of using an individual customer's e-wallet service - a smart payment method, which is a popular online payment method nowadays. Based on the TAM of F.D. Davis, et al. (1989) [9], several studies in this area were carried out [16-18]. Some authors built

research models based on UTAUT [19-21] or based on the TPB model [22, 23].

For example, T.L.P. Do (2014) [24] outlined the popularity and advantages of non-cash payments at both individual and organizational levels. This research suggests the potential of cashless payment development and the challenges of delivering these services. Finally, the research suggests some solutions to improve the effectiveness of non-cash payment implementation in the future.

The study of H. Amin (2008) [17] expanded the applicability of TAM to mobile phone credit cards. This study showed that the PU, PE, perceived credibility, and the amount of information contained on mobile phone credit cards are important determinants of intention to use a mobile phone credit card, while the level of perceived expressiveness was not the deciding factor. Some researchers rely on TAM to build a new model that comprises different factors like PU, PE, subjective norm, PR, safety/security, attitude, and intent to use [18, 25, 26]. The research results reveal that ease of use and usefulness have a negligible effect on the customer's intention toward mobile wallets. Particularly, PR are positively correlated while safety and confidentiality are negatively associated with the intended use.

Several studies have looked at factors influencing consumer online buying behaviour [27-36]. To predict the intention to use mobile wallets from a mental cost perspective, the empirical study of D. Chatterjee, et al. (2018) [27] indicated the supremacy of the perceived behavioural control constructs over other constructs in predicting the intentions, to use mobile wallets. Junadi, et al. (2015) [28]

extended their unified theory of technology adoption and use UTAUT with security awareness and culture to identify which factors influence Indonesian consumers' intentions to use e-payments. The results demonstrated that not only technology influences consumer behaviour but also culture and perceptions of national security. P. Kaur, et al. (2020) [29] showed that relative advantage, compatibility, complexity, and observability were significantly associated with participants' intentions toward m-wallets. On the contrary, trialability had no relationship with participants' intentions to use and recommend m-wallets to others. C. Kim, et al. (2015) [30] suggested that the personalization, simplicity, and connectivity of m-shopping influences utilitarian value, hedonic value, and shopping value. Meanwhile, L.A. Nelloh, et al. (2019) [31] found that trust is more decisive in the intention to continue to use electronic payments than perception. Based on these research results, studies suggest some recommendations for mobile payment companies to improve their quality, reliability, information management, and the security protection that refers to personalization. For example, B. Shaw, et al. (2019) [32] found that the moderation of smartphone addiction plays a key role in popularizing mobile wallet payments in emerging economies. It also suggests the importance of communicating with the right consumers through the right channels and age groups. J. Sun, et al. (2018) [33] suggest that usefulness, ease of use, subjective standards, in-store compatibility, and experience in the past have a positive relationship with Chinese consumers' intentions to use apparel e-commerce. Other influencing factors are compatibility, relative advantages, and

subjective norms. The research results of [34, 35] showed that information and service quality positively affect initial trust, therefore, there is a positive correlation between endorsement and usefulness. At the same time, their results also show a positive relationship between PU and continued intention to use mobile-based payment methods. In addition, M. Zendehdel, et al. (2015) [36] examined which factors influence potential consumers' online buying attitudes, then found that consumer attitudes towards online purchases influence their purchasing intentions.

A recent study on COVID-19 and e-wallet usage intention found a strong impact of PR, government support, and PU on customers' intention to use e-wallets during the COVID-19 outbreak [37]. The results of the study show that the impact of government support on e-wallet intentions varies from country to country. In addition, PU completely mediates the intention to use a government's e-wallet and partially mediates the effect of PR on the intention to use an e-wallet.

3. Hypothesis, empirical model and research methods

3.1. Research hypotheses and model

In this research, TAM is the main model to explore factors influencing the use of e-wallets. However, TAM does not include social factors. Therefore, we combine two factors of TAM (PU and PE) with one factor of UTAUT (SI) and PR. In essence, the SI and PR belong to perceived behavioural control, which is a factor of TPB.

This combination will probably uncover new problems, not just purely from technology but also from society. This research also removes some intermediate variables, reduces the

indirect relationships between the variables of the reference models, and conducts research on the direct relationship between the independent variables to the dependent variables in the multivariable linear regression model. Finally, the selected factors include PU, PR, SI, and PE (Table 1).

Based on previous studies on the impact of

use [17, 18].

- *H3: There is a negative relationship between PR and BE.*

PR affects attitude towards m-wallet and attitude towards m-wallet affects intention in use [16, 18].

- *H4: There is a positive relationship between SI and BE.*

Table 1. Main models and studies reference.

Research	Model	Perceived behavioural control	Perceived usefulness	Perceived ease of use	Perceptions of risks	Social influence	Attitude	Subjective norm	Intention	Behaviour
	Code	PBC	PU	PE	PR	SI	AT	SN	IN	BE
[8, 9]	TRA					x	x	x	x	x
[9-11]	TAM		x	x			x		x	x
[12, 13]	TPB	x					x	x	x	x
[14]	DTPB	x	x	x		x	x	x		x
[15, 38]	UTAUT					x			x	x

independent variables (PU, PR, PE, and SI) on the dependent variable (BE of consumers in Vietnam), this study suggests the following hypotheses:

- *H1: There is a positive relationship between the PU and BE.*

PU affects attitude towards m-wallet and attitude towards m-wallet affects intention in use [16, 18].

- *H2: There is a positive relationship between the PE and BE.*

PE affects attitude towards m-wallet and attitude towards m-wallet affects intention in

To study the factors affecting the behaviour of Vietnamese consumers to use e-wallets, combined with qualitative research results, the authors built a regression model consisting of one dependent variable (BE) and four independent variables (PU, PR, PE, SI) with the support of SPSS version 20 software. The regression model looks like this:

$$BE = \beta_1 \times PU + \beta_2 \times PE + \beta_3 \times PR + \beta_4 \times SI + \epsilon.$$

in which: BE is the dependent variable that reflects the behaviour of city consumers to use electronic wallets. BE consists of 4 observed variables (codes from BE₁ to BE₄) to measure

the behaviour of the use component:

- BE_1 : I will use e-wallets regularly in the future.
- BE_2 : I will introduce others to use e-wallets.
- BE_3 : I will continue to choose to use existing e-wallets.
- BE_4 : I will sign up for other electronic wallets.

- PU is an independent variable reflecting the level of PU of using e-wallets. PU consists of 4 observed variables (codes from PU_1 to PU_4) to measure the PU component:

- PU_1 : Save time when shopping online.
- PU_2 : Can make transactions anytime, anywhere.
- PU_3 : Receive many incentives on prices and transaction fees when making payments or shopping.
- PU_4 : Performing many other functions such as paying for utilities, telephone, etc.

- PE is an independent variable reflecting the perceived level of ease of use of e-wallets. PE consists of 4 observed variables (codes from PE_1 to PE_4) to measure the perception of the ease component:

- PE_1 : Feeling very easy to learn how to use e-wallets.
- PE_2 : Feeling very simple when manipulating e-wallets.
- PE_3 : Usable proficient in e-wallets.
- PE_4 : Clear payment process to help users easily transact.

- PR is an independent variable reflecting the perceived level of risk of using e-wallets. PR consists of 4 observed variables (codes from PR_1 to PR_4) to measure the PR component:

• PR_1 : Using e-wallets can have personal information stolen.

• PR_2 : Using e-wallets can make the mistake of losing money.

• PR_3 : Using e-wallets without a transaction paper can bring risks.

• PR_4 : Using e-wallets will cause system errors and cannot respond promptly to payment transactions.

- SI is an independent variable reflecting the perceived level of SI of using e-wallets. SI consists of 4 observed variables (codes from SI_1 to SI_4) to measure the SI component:

• SI_1 : Using e-wallets is due to the current trend that everyone uses.

• SI_2 : Family and relatives recommend using electronic wallets.

• SI_3 : Friends and colleagues recommend using e-wallets.

• SI_4 : Use e-wallets because of the influence of the media.

- $\beta_1, \beta_2, \beta_3, \beta_4$ are coefficients.

- ε is the error.

The use of the C-TAM-TPB combined model in this study not only helps to identify specific beliefs that may affect the use of information technology but also increases the ability to explain behavioural decisions and modulate behavioural events. By removing some intermediate variables and reducing the indirect relationships between the variables of the reference model, the authors have studied the direct relationship between the independent and dependent variables in the multivariable linear regression model by selecting factors in the C-TAM-TPB scale model and model of P. Luarn, et al. (2005) [38] including PU, PR, SI, and PE (Fig. 1).

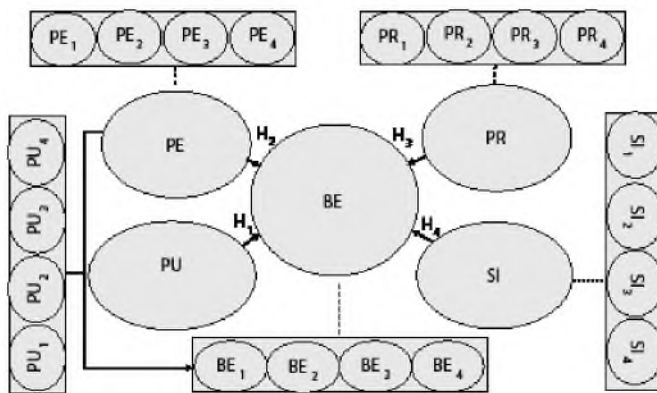


Fig. 1. Overview of the research model.

3.2. Research method

To determine the factors influencing the BE in Vietnam, in this study, we use both qualitative research and quantitative research. At the same time, to ensure the validity and reliability of the data, the research process was conducted according to the following steps (Fig. 2).

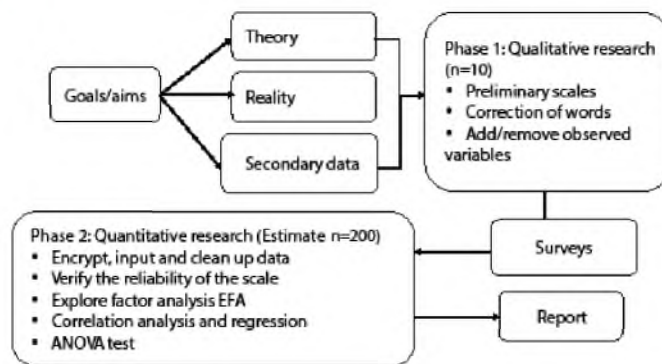


Fig. 2. Research process.

First of all, we establish a set of scales to meet the requirements of mathematical statistics in data analysis and processing. These data will be used to evaluate factors affecting the behaviour of the consumers in Vietnam to use e-wallets.

The testing of models and hypotheses is done through quantitative research e.g., interviews with an expected sample size of 200 responses. These interviews are self-

scoring questionnaires. Each answer is rated on a 5-point Likert scale (1=totally disagree, 2=disagree, 3=no idea, 4=agree, 5=totally agree) [39]. The questions in these questionnaires have been developed and tested to suit Vietnamese conditions. To find out if a respondent has ever used or is using an e-wallet in Vietnam, we use filtering, exclusion, and testing questions such as have you ever used an e-wallet? Or can you name any e-wallets that you have used or are using? We chose to exclude those who have not or do not use e-wallets or those who confuse using e-wallets with other payment methods.

The data collected is processed by SPSS. The work done in the formal research includes a preliminary evaluation of the scale, factor analysis of discovery, correlation analysis, regression analysis, and analysis of variance (ANOVA). In the scales of analysis, evaluation, and testing, we continue to type, group, or classify component variables according to their characteristic groups and are appropriately named by exploratory factor analysis (EFA).

The process of researching factors affecting Vietnamese consumer BE is conducted in two phases: phase one is qualitative research and phase two is quantitative research. Before building the official scale, we conducted preliminary research with experts by direct interviews (n=10) to edit words. In phase 1, based on the relevant theories and previous studies reviewed, the team proposed scales for the independent and dependent variables. Next, the sample surveys were sent to 10 experts to discuss ideas and suggestions for the drafted questionnaire. After receiving suggestions from experts, the group synthesized the opinions to adjust the scale and variables in the research model thereby completing the official

questionnaire for the survey to get primary data and conduct quantitative research.

The discussion results are four independent variables and one dependent variable as proposed by the research model, all of which are retained and are deemed necessary and appropriate in the analysis of the factors that influence consumer BE in Vietnam.

The research sample is consumers who have been using e-wallets in Vietnam and aged between 18 and 50 years old. Using the convenient non-probability sampling method based on the approach, and to ensure the required number of samples as well as increase the persuasion of the research results, the authors tried to ensure the required number of samples and increase the persuasion of the research results [40-42]. The authors then decided to submit 200 detailed online questionnaires (Google surveys) to 200 customers using e-wallets in Vietnam. The survey was conducted from December 1, 2019, to March 31, 2020, with 05 questions related to the personal information surveyed (gender, age, occupation, type of wallet used, and frequency of use) and 20 questions related to the behaviour to use the same factors that influence the behaviour to use.

Data collected through the survey was checked and cleaned with unsatisfactory surveys removed. The obtained survey results were 182 responses and, out of 182 responses, only 150 were accepted with 32 disqualified because only one answer was selected for all questions or some were left blank. All collected data was encrypted, input into Excel, then copied to SPSS 20.0 for analysis.

The demographic profile of respondents is presented in Table 2.

The results of the descriptive statistics show

that: (1) The sex ratio difference between men and women is very small and the difference is almost negligible. (2) In terms of age, respondents are mainly in the age group from 18 to 24 with a proportion of more than 53%. (3) regarding the profession, the proportion of pupils and students accounted for the highest rate at 52%; followed by self-employed at 19.3% and civil servants at 17.3%. These are the subjects that regularly have related activities and work and have a need to use e-wallets. (4) Regarding the types of wallets commonly used by people, Momo accounts for the highest proportion with 46%, followed by Moca with 17.3%, and Zalopay with 16%. This data is reasonable because Momo has many standards, familiar features and offers that attract more users. Finally, (5) in terms of frequency of use, using "occasionally" accounts for 36% (largest rate); followed by "1-3 times a week" accounting for 27.3% and "1-3 times a month" 24%, respectively. Vietnam consumers are still not accustomed to using e-wallets and the use of cash is still dominant.

In summary, the sample characteristics show quite good survey results. Respondents focus on answers, provide highly relevant answers, help avoid random errors, and conduct quantitative analysis more efficiently.

In phase 2, after having scale results for the variables in the model from qualitative research, the team designed the questionnaire and coded the observed components of the dependent variable and the independent variables. The reliability of the scale is assessed through Cronbach's alpha coefficients. Using Cronbach's alpha confidence coefficient method before analysing EFA factors eliminates inconsistent variables as these variables can create dummy factors. If Cronbach's alpha coefficient ≥ 0.6 , the scale factor is appropriate.

Table 2. Demographic profile of respondents.

Particulars (characteristics & distribution)		Frequency (people)	Percentage (%)
Gender	Male	63	42.0
	Female	87	58.0
	Total	150	100.0
Age (years)	<18	7	4.7
	18-24	80	53.3
	25-35	43	28.7
	36-50	15	10.0
	>50	5	3.3
	Total	150	100.0
Occupation	Student	78	52.0
	Public servants and officers	26	17.3
	Self-employed	29	19.3
	Worker and free labour	7	4.7
	Other	10	6.7
	Total	150	100.0
Types of electronic wallets used (units)	Moca	26	17.3
	Zalopay	24	16.0
	Momo	69	46.0
	Vnpay	20	13.4
	Other	11	7.3
	Total	150	100.0
Frequency of use (units)	Daily	16	10.7
	1-3 times a week	41	27.3
	1-3 times a month	36	24.0
	Sometimes	54	36.0
	Other	3	2.0
	Total	150	100.0

After removing the unreliable variables through Cronbach's alpha analysis, the EFA was used by the authors to evaluate two important values of the scale, the convergent validity and discriminant validity, and, at the same time set the estimated parameters by each group of variables.

4. Results and discussion

Factor matrix results with the rotated component matrix method show that variable PR_4 , which is "using e-wallets will cause system errors and cannot respond promptly to payment transactions" does not display results (Table 3). Therefore, PR_4 has a load factor of less than 0.5 and will be disqualified.

Table 3. Rotated component matrix^a.

	Component			
	1	2	3	4
PU ₁	.857			
PU ₄	.825			
PU ₂	.802			
PU ₃	.726			
PE ₃		.914		
PE ₂		.892		
PE ₁		.867		
PE ₄		.855		
PR ₁			.925	
PR ₂			.902	
PR ₃			.902	
PR ₄				
SI ₄				.855
SI ₂				.837
SI ₃				.701
SI ₁				.674

Note: ^a: dependent variable; extraction method: principal component analysis; rotation method: varimax with Kaiser normalisation; arotation converged in 5 iterations.

Analysis results showed that most of the observed variables met the criteria of Cronbach's alpha coefficient ≥ 0.6 and total variable correlation ≥ 0.3 . Finally, the study has a total of 20 observed variables before factor analysis was conducted to explore EFA. After testing Cronbach's alpha, the satisfactory variables will continue to be included in the exploratory factor analysis. The research team carried out the observed variables of the scale of factors affecting the behaviour of Vietnamese consumers to use e-wallets through EFA.

The first EFA result showed that four factors were accepted. These four factors explain 72.849% ($>50\%$) of the variability of the data, which proves that EFA analysis is appropriate. Factor loading values of each observed variable were greater than 0.5 indicating a high correlation between the observed variables with the factors. In addition, we can see that the variable PR₄ (using e-wallet will cause system errors and cannot respond promptly to payment transactions) does not represent the data, so we removed this variable. With the second EFA analysis (Table 4), we retained 15 observed variables and the coefficient KMO was 0.793, which is greater than 0.5, so it was suitable for the data. The Chi-squared statistic of Bartlett's test reached 1,411.083 with the significance level of Sig. =0.000, so the observed variables were correlated. Total variance extracted of 76% shows the factors explain more than 76% of the data variation. Therefore, the scales were accepted. The eigenvalue =4,869 and loading factors were all greater than 0.5.

Table 4. The results of eliminating variables through EFA analysis.

	First rotated component matrix	2nd rotated component matrix
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.779	0.793
Bartlett's Test of Sphericity	0.000	0.000

As recognised by the model, four factors affect the behaviour of consumers to use e-wallets in Vietnam. According to the results of the factor analysis of the dependent variable (in Table 4),

we have KMO coefficient=0.779, Bartlett's test has a significance level of Sig.=0.000<0.05, a variance extracted of 76%, and all variables have factor load coefficients greater than 0.5. Thus, the factor BE included 4 observed variables, which were BE₁, BE₂, BE₃, and BE₄.

After the factor analysis phase of EFA, the factors were included in the model test. Factor value is the average of observed components belonging to that factor. Pearson correlation analysis is used to consider the suitability of components in the regression model. The results of regression analysis will be used to test hypotheses H1 to H4. If the correlation coefficients are statistically significant (Sig.<0.05), the analysis shows that the PR factor is correlated with the dependent variable (-0.44 fails), so the PR factor can be eliminated

(Table 5). Despite this, the team still used the PR to run the test regression again.

The regression analysis results (Table 6) shows that both PU, PE and SI are accepted and have a positive relationship with the BE due to the coefficient Sig.<0.05. PR has an inverse linear relationship with the coefficient Sig.>0.05. Therefore, the authors can conclude that three independent variables, PU, PE, and SI, are significant in the model and positively impact the dependent variable because the regression coefficients are all positive. The variable PR is eliminated. The very small VIF magnification factor (VIF<2) shows that these independent variables do not have a close relationship, so no multicollinearity phenomenon occurs. Therefore, the relationship between the independent variables does not affect the interpretation results of the model.

Table 5. Correlations.

		BE	PU	PE	SI	PR
BE	Pearson correlation	1	.392**	.526**	.275**	-.044
	Sig. (2-tailed)		.000	.000	.001	.590
	N	150	150	150	150	150
PU	Pearson correlation	.392**	1	.487**	.270**	-.090
	Sig. (2-tailed)	.000		.000	.001	.274
	N	150	150	150	150	150
PE	Pearson correlation	.526**	.487**	1	.108	.065
	Sig. (2-tailed)	.000	.000		.187	.432
	N	150	150	150	150	150
SI	Pearson correlation	.275**	.270**	.108	1	-.045
	Sig. (2-tailed)	.001	.001	.187		.589
	N	150	150	150	150	150
PR	Pearson correlation	-.044	-.090	.065	-.045	1
	Sig. (2-tailed)	.590	.274	.432	.589	
	N	150	150	150	150	150

** : correlation is significant at the 0.01 level (2-tailed).

Table 6. Coefficients^a.

Model	Unstandardised coefficients		Standardised coefficients	t	Sig.	Collinearity statistics	
	<i>B</i>	<i>Std. Error</i>	<i>Beta</i>			<i>Tolerance</i>	<i>VIF</i>
(Constant)	1.683	.356		4.721	.000		
1 PU	.104	.073	.115	1.425	.036	.703	1.423
PE	.362	.062	.453	5.809	.000	.751	1.332
SI	.155	.057	.193	2.747	.007	.926	1.080
PR	-.033	.042	-.055	-.800	.425	.976	1.024

^a: dependent variable.

The adjusted coefficient of R^2 is 0.320, which shows that the independent variables explain 32% of the change in the dependent. Durbin-Watson achieved 1.850 (between 1 and 3) and accepted the hypothesis of no correlation in the model. To verify the suitability of the linear regression model, we consider the F value from the ANOVA analysis table. This test shows the linear relationship between the dependent variable and the independent variable. ANOVA analysis shows that the regression model has $F\text{-test}=77.796$; $\text{Sig.}<0.05$, which shows that the model is suitable for the dataset and can be extended to the whole population. Thus, the linear regression model satisfies the conditions. The regression equation is as follows:

$$BE=0.115*PU+0.453*PE+0.193*SI$$

The study results show there are three drivers of customers' intentions to use e-wallets in Vietnam. Their influence levels are arranged in descending order: PE ($\beta=0.453$), SI ($\beta=0.193$), and PU ($\beta=0.115$). This result is also completely consistent with the expert opinions of those that participated in the focus group discussions during the preliminary research phase.

5. Conclusions and policy implications

This paper examines the behaviour of Vietnamese consumers using e-wallets and measures the factors affecting the usage behaviour. Our argument is based on previous studies of the effect of independent variables on the dependent variable, and we suggest that there is a positive relationship between PU, PE, and SI on consumer BE in Vietnam, as well as a negative relationship between PR and attitude towards e-wallets. Using the C-TAM-TPB model, we tested this idea by conducting a study on the direct relationship between the independent variables and the dependent variables in a multiple linear regression model. Research results have proved part of our argument to be correct. We found that ease of use has a strong impact on Vietnamese consumer e-wallet usage behaviour. When the PE variable increases by 1 standard deviation, the user BE increases by 0.453 standard deviations. Similarly, when the SI and PU variables increase by 1 standard deviation, the BE variable increases by 0.193 and 0.115 standard deviations, respectively. The research results also show that risk perception does not

affect the BE for Vietnamese consumers. This is explained by the fact that e-wallets have just entered Vietnam and the e-wallet market is not fully developed. Additionally, the risks are also rare, so Vietnamese consumers are not aware of this problem.

This article contributes to the growing literature regarding the use of non-cash payment means including e-wallets. We provide detailed pieces of evidence on the factors affecting the behaviour of Vietnamese consumers to explain the trend of using e-wallets in terms of ease of use, social impact, usefulness, as well as potential risks when using e-wallets.

Regarding the sampling method in this study, while interviewing by the online survey is a convenient sampling method, the reliability may not be the best.

To encourage Vietnamese consumers to increase non-cash payments - including the use of e-wallets - we propose the following key implications:

The first is to increase the expected ease of use. According to the analysis results, PE is the factor that has the strongest impact on using e-wallets. Therefore, to increase the PE of the e-wallets, suppliers should improve technology and processes, increase the amount of readily available buyer information on electronic orders/invoices, shorten the time it takes to use the e-wallet, and increase the comfort and ease of transactions using e-wallets. Besides, specific instructions for customers before and during the payment transactions by e-wallets should be given.

The second is to promote SI - one of the factors most strongly influencing the behaviour of individual customers in Vietnam to use

e-wallets. Therefore, to promote this feature, service providers should take advantage of the pervasiveness of the media, television, social networks, and online forums to introduce and promote transmission and dissemination of electronic wallet products. Taking advantage of the influence of famous people and reputable people to promote the e-wallets product is another idea.

The third is to increase usefulness. Usefulness is the third strongest factor that influences the behaviour of individual customers in Vietnam to use e-wallets. Therefore, suppliers need to focus on solutions to increase the expected usefulness by users for their e-wallet products. Specifically, to upgrade the efficiency and convenience of customers using e-wallets, suppliers need to learn and catch up with the ever-expanding demands of e-payment by customers and integrate various payment facilities in many fields such as payment for travel reservations, etc., or even international money transfer for services purchased abroad. To help customers save time and money, suppliers should integrate with e-wallets to automatically search and propose to customers the most preferential price for the service that the customer needs.

The fourth is to upgrade e-wallets to become more and more trusted by customers. Suppliers need to pay attention to building a reasonable price policy to attract customers and improve the competitiveness of e-wallets compared to other electronic payment methods such as internet banking, mobile banking, ATM cards, credit cards, debit cards, etc. Service providers also need to develop and maintain low-cost policy incentives for customers, especially during new stages of development. In addition, suppliers need to actively link and cooperate with goods/service providers to offer

promotions and discount policies for customers when paying with e-wallets. Pay attention to demographic information depending on the goals, business strategies, target customers, and the influence of factors like age, gender, education experience, and income to build for themselves the right policies to help businesses thrive and achieve set goals and strategies.

In the future, we hope that this study will be expanded to not only investigate and measure the factors affecting the behaviour of Vietnamese consumers but also to consumers in other countries in Asia and other parts of the world associated with different cultures, lifestyles, incomes, personalities, trends, development levels, etc. We hope that this study will provide a deeper understanding of the trends and factors that affect the behaviour of consumers using e-wallets around the world so that the recommendations are more specific and useful.

CRedit author statement

Van Cong Nguyen: Data curation, Writing - Original draft preparation, Writing - Reviewing and Editing; Thu Hoai Ao: Conceptualisation, Software, Reviewing and Editing.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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Citizen science matters: Theorising citizen science and exploring its promises for addressing Mekong environmental problems

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Abstract:

Starting with the view that the emergence of citizen science initiatives proves the fullest potential to address environmental problems and promote sustainability from the ground up, this conceptual paper aims to explore why citizen science matters for a low-carbon future in the Mekong region. Based on a literature review and semi-structured expert interviews, this paper highlights the importance and unique impacts of citizen science in science, policy, and sustainability education spheres. These impacts are reflected in case studies of the United States and Belgium. Results from empirical data also reveal that citizen science is transforming research, educating and informing the public, and decentralizing and informing policy. The results further provide promises for addressing environmental problems in Mekong countries where environmental degradation seems to be getting murkier. The paper concludes with a discussion as to how citizen science should be embedded in local environmental governance as it revolutionizes our understanding of the environmental challenges and promotes evidence-informed policy making. In order to meet the nation's sustainable development goals, there's an urgent need to improve society's awareness of sustainability issues and to mobilise all citizens just as they have done in response to the current pandemic.

Keywords: citizen science, environmental governance, Mekong environmental problems, sustainable development.

Classification number: 4.1

1. Introduction

The promise of economic growth pulls Mekong countries to rapid urbanization and damming of the Mekong river. But, across the region, two of the most pressing problems facing their new-found strengths also come together: biodiversity degradation and environmental insecurity. These problems are human-induced, cross cutting in nature, and accelerating in pace and severity as urban areas swell. Businesses and people will be in danger

of a “double crisis” should human stressors intersect with climate change effects such as extreme weather conditions and geophysical disasters. While strong policy planning and technological innovations are essential in managing environmental insecurity issues, there exists little evidence that demonstrates the success of top-down policies and solutions.

Against this background, in recent years there has been an increasing popularity of “citizen science” in environmental, ecological,

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and climate change fora in the world. Even in times of global crises, such as COVID-19, numerous curious people across the world are online and contributing useful data for science [1]. In some pharmaceutical and biotechnology think tanks and universities, scientists are employing citizen science tools and strategies to harness the power of the crowd to generate robust and diverse data sets for predicting outbreaks, understanding infectious mechanisms and symptoms, and validating treatment models that might have been otherwise unavailable [1, 2].

Advances in science and technology, the rising penetration of the internet, and the ubiquity of smartphones are all currently fostering citizen science. The cooperation between researchers and local communities becomes less challenging thanks to easy data collection on mobile apps that facilitates user engagement. Current citizen science tools are designed on the basis of strict data management standards applied to both input and output including data quality assurance, data infrastructure, data documentation, data governance, and open-data access norms. Some widely known citizen science platforms include Scistarter, iNaturalist, OpenStreetMap, BioCollect, CitSci.org, Citizen Science Alliance, NASA's GLOBE Observer, PlantNet, Open Development Mekong, Zooniverse, and many others. Citizen science platforms are web-based infrastructures or portals that enable multiple functions including identifying real time projects; displaying data and information; providing guidelines and tools; and offering lessons, examples, and scientific outcomes [3].

Furthermore, multiple citizen-science organizations are banding together to form a worldwide group - the Citizen Science Global Partnership. This network seeks to promote and advance citizen science for a sustainable world. Launched in December 2017, it assists

in monitoring progress towards the United Nations' Sustainable Development Goals (SDGs) and brings together citizen science researchers and practitioners with advisory boards representing policy, business, and community-based perspectives.

Globalization and international scientific cooperation have promoted the presence of citizen science in policy advocacy nationwide, regionally, and globally. Recent research of the National Aeronautics and Space Administration (NASA) and the United Nations (UN) have stressed the role of citizen science in "democratizing science" and making scientific research more accessible. Community contributions to data collection are rapidly becoming more important and popular to researchers, think tanks, government agencies, and Non-Government Organizations (NGOs). The broader use of citizen science is reflected in biodiversity, environment, climate change, biogeography, agro-forestry-fishery, and the prevention and control of disasters and pandemics to name but a few. Many governmental agencies in countries like Australia, Canada, Ireland, Japan, Scotland, and the United States have institutionalized citizen science. Crowd-sourced data are being used by the UN bodies for humanitarian activities, disaster response, and implementing SDGs [4, 5].

The fresh surge of interest in citizen science across societies has resulted in an inevitable shift towards multi-actor and bottom-up environmental governance that enables and encourages public participation in collecting and sharing information of all kinds, in policy making process, and evaluation [4, 6]. It seems likely that breakthroughs in environmental governance - nationally and globally - will increasingly occur through citizen science fora

that support the society's growing demands for more participatory decision-making through interaction between government policy-making agencies and non-state actors, including scientists and citizen science communities [7-10]. But efforts to define and strengthen the role of citizen science within this shifting architecture of governance, and in environmental governance in particular, are still at early stages [11].

By acknowledging that the promise of economic growth pulls the Mekong riparian countries to urbanization, this narrative review aims to understand the promises of citizen science in the Lower Mekong countries where environmental security challenges are threatening to undermine their new-found strengths and where digital infrastructure is available for public participation in scientific work. Although citizen science is not the only participatory approach in environmental research and governance, it can generate crowdsourcing data more quickly, enhance the sustainability of research projects more effectively, and disseminate the research findings wider than other existing participatory approaches [11]. This paper first conceptualizes citizen science from a historical perspective to trace the origin of citizen science and explore its nature as an approach to scientific research. The second section discusses the importance of citizen science in terms of policy, science and public awareness. Case studies of two different countries are briefly presented to provide empirical evidence to the impacts of citizen science in environmental governance. The last section analyses some promises for citizen science in the Mekong countries and

prompts a call for mainstreaming citizen science in environmental action in the region as a bottom-up approach to addressing environmental challenges.

2. Conceptualising citizen science

Although citizen science has recently attained worldwide attention, there has been a long history of citizens supporting scientific research. Wells W. Cooke, a member of the American Ornithologists' Union, was arguably the first scientist to develop research programs that allowed for public participation in the United States in the late 19th century [12, 13]. Cooke built a network of volunteers in North America, mainly farmers and conservation agents, to collect data related to the patterns of bird migration and bird population figures, which were recorded on cards. Those data cards are currently being digitized and recorded into a public database for historical analysis [13]. His efforts to empower public participation in research activities triggered the birth of citizen science in the world.

Cooke's successful community-based bird research programs inspired the practice of citizen science in bird research and conservation for decades afterwards. The increasing availability of the internet in the western world in the late 1990s facilitated data collection and sharing without geographical constraints. This enabled scientists and organizations to employ Cooke's public participatory research methodology in their ecological and environmental research and conservation of rare plants and animals [13]. Given the rising role of public participation in research "citizen science", "open

science” or “community science” are termed interchangeably to label scientific research activities that involve ordinary citizens. “Citizen science” has been more formally used over the last decade. Environmentalists, climate change scientists, and urban planners, among others, have actively encouraged local public participation to collect field-based data.

As such, “citizen science” refers to community-based scientific research. Community members, from kindergarteners to senior citizens, are empowered and encouraged to collect and contribute information, knowledge, and data to enrich and test scientific theories [5, 6, 13]. Viewed in that light, citizen science is widely conceptualized as the public participation and collaboration in scientific research. In other words, the term “citizen science” is best described as the collaboration of scientists and volunteers to broaden the scope of research and enhance the compiling of scientific data [14].

Citizen science continues to distinguish itself by the following characteristics: the participation of citizens is voluntary, local communities are one of the major beneficiaries of the research, citizen science and crowdsourcing data are updatable and linkable, which allows further research at different levels and scopes, i.e., local, subnational, national, and international. The mobilization of citizens fosters an active stewardship toward their land and water among other natural assets.

The public participation and collaboration in scientific research are classified into three dimensions as follows: contributors (citizens act as data collectors), collaborators (citizens are employed to collect and analyse or interpret

data), and co-creators (citizens participate in research stages, from problem identification, question defining, to research design, to data analysing and visualization) [5, 15]. Co-creators are “citizen scientists” who are well-trained to lead and introduce mobile research tools to their communities in citizen science projects. They are local change agents.

3. Why is citizen science important?

Citizen science really matters owing to its positive impacts on science, education, and policy [15]. Researchers are primary beneficiaries of community-driven science. The standardized and globally contributed crowdsourcing data enable researchers to access data sources that are visually and explicitly presented without efforts and costs. In early 2020, the popular people-powered research platform zooniverse successfully recruited approximately 200,000 participants for its image-based animal classification project. With more than five million classifications within a week, the result they contributed is equivalent to that in 48 years of research [2]. Joining data sharing and information itself help communities enrich their scientific knowledge and realize challenges facing them, which inspire greater behavioural changes [15, 16].

Collective perceptual changes together with real-life experiences and rich data demonstrate significant policy information for local authorities. For example, community data on seasonal air pollution trends enable the authority to proactively adjust emission sources by, for example, relocating factories, and cutting coal-fired power, etc. Data on endangered animals tracking allow early warning and accelerate conservation plans [17].

In addition, community-contributed data, including indigenous knowledge and experience that cover new viewpoints or field evidence, ensure that research and policy match local contexts. This shows bottom-up approach and decentralized policymaking in citizen science, or evidence-based policy, in other words. However, the level of decentralized decision-making power in terms of resource management or rights to clean water has proven a challenge in a number of places, including Mekong countries, when laws and regulations do not always permit decentralized management actions. Consequently, the government faces mounting pushback from citizens who resent the damage wrought by pollution-intensive industries.

More importantly, citizen science becomes popular with more ambitious and broader connections [5]. The boom in citizen science data over a wide range of fields likely results in big data - solid foundations of the knowledge economy and key pillars for a transparent society and sustainable development in many countries. Big data is understood as data sets that are so large that they become difficult to analyse and manage with traditional means [18].

Finally, citizen science offers an opportunity to build public trust in science and authorities [19, 20]. Some scientists have placed their trust in the possibility of clearing public doubts from the collaboration of science and community [2, 5]. Consequently, investing in citizen science is not only an investment in the science-community partnership but also in public trust and support. The governments of Australia, the United States, the United Kingdom, and some other European countries have been aware

of the benefits of citizen science and have intensified investment in strategic community science programs regardless of environmental protection, climate resilience, public health, or policy review [21-23].

4. Addressing environmental problems through citizen science: Examples

Advanced science and technology help actualize community science-led ideas and generate practical impact in addressing environmental problems. A number of mobile apps have been developed to expedite the public research process. The number of open science projects surged to 800 in 2019 from 200 in 2010, which was revealed by the statistics from the crowd-sourced data platform SciStarter at Arizona State University, Tempe, Arizona. Community-controlled science has been applied in various fields, namely, air and water quality monitoring, plastic pollution, animal migration tracking, and observational astronomy [21-23]. The following case studies show how citizen science is used and the perspectives it offers for specific riparian and urban environmental problems.

4.1. Mississippi river plastic pollution initiative (the United States)

In 2018, policy makers and governments of cities along the Mississippi river were committed to reducing plastic waste in the basin by 20% by 2020. To make the goal possible, the United Nations Environment Programme (UNEP), the National Geographic Society, and the University of Georgia launched the Mississippi river plastic pollution initiative. The community science-led project records data and generates a plastic pollution map along the riverbank and in riverside

communities empowering policy makers and stakeholders to make proper decisions. The Debris Tracker mobile app simplifies steps like tracking plastic waste, taking photos with automatic locations, classifying them into types (industrial or household use, nylon, bottles, etc.), counting debris on-site, and uploading to a public database.

Debris Tracker is also a popular community science-driven software for global plastic waste tracking. The open database stores roughly three million observations on plastic trash collected by a network of more than 50,000 volunteers. Its convenience and significance enable the app's continued popularity and user loyalty. As a result, the Debris Tracker generates new daily downloads from increasing numbers of land and ocean stewards from the largest producers of plastic waste like China, India, Indonesia, and the United States.

4.2. "Street science" (CurieuzeNeuzen) in Belgium

Filip Meysman, a biogeochemist at the University of Antwerp in Belgium, conducted an air quality monitoring project in Flanders, Belgium, in May 2018. With the support of the Flanders Environment Agency and local media, the air quality measurement campaign drew approximately 20,000 urban participants who paid EUR10 each to install devices on their windows (of the first floor) that faced the street. The month-long project ended with the results from 17,800 spots measured by 99% of sensors installed. The data enabled the team to measure nitrogen dioxide (NO₂) concentrations at "nose height" - a level of the atmosphere that can't be discerned by satellite. The community contributions generated reliable data on the air pollution situation in Flanders.

5. Dawn of citizen science in the Lower Mekong subregion

The Lower Mekong subregion, a transnational region in mainland Southeast Asia, spans the following five countries: Myanmar, Laos, Thailand, Cambodia, and Vietnam. While it has survived the trauma of wars, the region now faces mounting environmental threats from climate change, upstream dams, deforestation, and declines in biodiversity, food security and water resources. Since Conservation International places this rich biodiverse basin as one of the five most threatened hotspots, the ranks of professional scientists, researchers, and policy experts may not prove sufficient to reduce the escalating dire environmental problems.

Since more dams are planned for the Mekong river and rapid industrialization of riparian countries, there has been an increasing number of technocrats and policymakers recognizing the potential benefits of greater connectivity to promote openness and transparency in decision making. This environmental awakening has been on a fast growth trajectory with the advent of new technology and smartphone apps to monitor the environment.

Katherine Rowland, a journalist, wrote in *Nature* about the capacity of citizen science to empower local citizens explains, "the next generation of citizen science attempts to make communities active stakeholders in research that affects them, and uses their work to push forward policy progress" [24]. Thus, citizen science action represents a greater attention shift in the region enabling local NGOs and international development partners to mobilize local voices and democratize science

in response to the widening transboundary injustice along the Mekong.

Citizen science projects have been available in the Lower Mekong countries for at least a decade. In Thailand, several citizen science teams of students and environmentalists from 13 provinces in the central, western, and eastern parts of Thailand brought together by Sornmuang Jongmeewasin, an environmental management lecturer at Silpakorn University International College in Bangkok, successfully investigated and developed a database of 40 illegal dumps of hazardous industrial waste, which were previously unreported by government agencies [25]. In Vietnam, a small-scale collective research into illegal sand mining in the Red river and air pollution were carried out in Hanoi. Meanwhile, a group of students and young journalists who were trained to collect data and report environmental news in the Cham islands attempted to clean up the maritime environment from plastic waste and restore local ecosystems towards sustainable community-based tourism.

In the Mekong delta, the Mekong Environment Forum (MEF) based in Can Tho city (Vietnam) has held a number of impactful citizen-science projects in recent years in the disaster-prone areas of the Mekong delta. The Mekong Security Atlas was recognized and established in March 2019, which was supported by the Earth Journalism Network that built an open-access web-GIS citizen platform enabling citizen scientists to contribute datasets and report about environmental issues. Locals, including environmental practitioners, students, provincial government representatives, and experts were encouraged to identify major

issues threatening their livelihoods and ecosystems in their communities and then post their stories and observations, suggestions, and photos/video clips about the issues. The platform serves as a gateway for marginalized groups to engage in reporting environmental and natural resource-management issues that threaten their communities. MEF has trained a number of students, women, and provincial government representatives from diverse backgrounds and different universities in Southern Vietnam.

The chart in Fig. 1 outlines the major approach to citizen science in MEF projects. First, young professionals and students are trained in citizen science training workshops. They work in groups, and each group is usually comprised of two senior researchers, four to six undergraduate students majoring in environmental studies, social science, or geography, and two local liaisons that help handle administrative and logistics arrangements. Local liaisons fully participate in the training workshops and a field research design course to be fully aware of the research objectives and fieldwork plans. Their knowledge and updates about local situations were helpful for the field research groups to timely adjust the fieldwork plans. These research groups network scientists and experts with local farmers by introducing new techniques and solutions to local communities. Some field schools are established in host villages to implement and test new techniques or solutions. The cooperation of citizen scientists and local communities in the field in turn provides evidence and data back to the scientists to enrich their theory or research findings.



Fig. 1. Key stakeholders engaging in a citizen science project. Source: MEF.

Local men and women take part in the fieldwork and learn new solution. By doing so, they act as the change agents who learn to master new techniques introduced by academic and solution partners. Another key to the impacts of citizen science is that it focuses on economic self-reliance and nature protection by networking local stakeholders to build local value chains and bottom-up sustainability. This enables local communities to sustain their livelihood without degrading environmental resources. As farmers are trained to get familiar with the new technologies, they are able to adjust the solutions to fit within future changes.

Citizen science illustrates how to translate multi-stakeholder governance down to local levels in a centralized, top-down administrative context. As the citizen science projects involve

different disciplines and sectors to address the complexity of food-water-energy security nexus, they also reflect the inter-sectorial coherence and interconnectedness in coping with the environmental changes.

6. Concluding remarks: Promises and a need for mainstreaming citizen science in environmental action

This article is the very first to conceptualise citizen science as a crowdsourcing approach to scientific research and a grassroots, bottom-up approach to environmental action. For more than a decade, citizen science has been receiving increased attention because of its potential as a cost-effective method of gathering data sets and as a way to bridge the intellectual divide between citizens and scientists.

Worldwide, media-based citizen science is changing how science is communicated to the public, how the voice and concerns of local disadvantaged groups are heard, and on-the-ground data contributors can contribute their stories to enrich the scientific theories and support policy reforms. In short, this new generation of citizen science attempts to make active community stakeholders in research that directly affects them. So, citizen science becomes a potential solution strategy for grassroots communities in the Lower Mekong region and the rest of the developing world where they currently experience top-down, centralized political administration.

The Lower Mekong Subregion, in particular, is poised to become a necessary destination of community science projects to better address its environmental challenges such as climate change, resource degradation, wildlife trade, sea and river pollution, natural disasters, pandemics, etc. Although citizen science has not been formally institutionalized and recognized by the riparian governments, many state agencies such as those in Vietnam have begun to receive feedback regarding policy [26]. Furthermore, the advances of social media and open-data sharing, together with the growing rate of smartphone and internet users, work as an important digital platform that supports the growth of citizen science across the region. For example, with Vietnam's professional ranks of software developers and the increasing interest in digital-age technology, there are increased opportunities to draw upon the talents of young citizen scientists who are watchful environmentalists. For that reason, guiding/directing part of the public in community science forums both

helps enrich their scientific knowledge, curb fake news-related consequences, and avoid wasting open data resources as well.

Throughout the region, incubators of the power of citizen science are visible. In the most hardscrabble villages, access to a smartphone is beyond the reach of many. Based on the past, current, and upcoming citizen science workshops in Thailand and Vietnam as mentioned above, there is compelling evidence to support students and the broader public in helping to mitigate the environmental challenges in rural and urban areas. For Mekong countries, one of the most pressing issues is environmental pollution and the immediate need to mitigate and adapt to climate change, which is an issue that overlaps with the UN SDGs of combating global issues and promoting sustainability.

Local governments can and should take a leadership role in embracing the benefits in citizen science as part of an overall educational initiative. The purpose is to engage young citizens to help bolster the country's environmental enforcement and monitor the rapidly growing anthropogenic stressors. Rollouts of citizen science workshops in schools foster a participatory turn in science policy and support the claim in this paper, which is that citizen science can and does lead to a democratization of science by turning science from a closed to an open activity [27]. These trained citizen scientists can support the efforts of local government agencies to work closely with the public to complete data collection on the impacts of a wide range of issues from transboundary environmental degradation, water crisis, strengthening food

systems, preserving agricultural biodiversity through seed exchanges, tidal flooding and air pollution in cities, and they are cost-effective in the promotion of sustainability in resource-limited economies.

In order to meet the nation's sustainable development goals, policy planners realize that there's an urgent need to improve society's awareness of sustainability issues and to mobilize all citizens just as they have done in response to the current pandemic. The success in the implementation of the 2030 Agenda for a better, safer, and more secure future for all its citizens require a complete "buy-in" from all. The key is to train more student volunteers or citizen scientists as it is an important vehicle in democratizing science and promoting the goal of universal and equitable access to scientific data and information. It is our recommendation that institutions and think tanks established alongside select NGOs, like MEF, create a task force on the contributions of citizen science that will help advance local government objectives to meet the 2030 SDGs.

COMPETING INTERESTS

The author declares that there is no conflict of interest regarding the publication of this article.

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Stakeholders' perceptions and responses to climate change impacts on agricultural sector in mountainous areas of Thua Thien Hue province

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Abstract:

This study aims to analyse stakeholder perceptions and responses on climate change (CC) impacts on agricultural sector in the mountainous areas of Thua Thien Hue province. Data was collected by surveying 462 farmers in Nam Dong and A Luoi districts with a structure questionnaire; in-depth interviews of 29 agricultural officials; 12 agricultural input suppliers, and representatives of 18 community organizations. The research results show that stakeholders have very different perceptions regarding the causes, impacts, and responses to CC (P value <.00). Most stakeholders believe that CC has many causes of which deforestation and too much waste were the two main factors. However, more than 45% of farmers believe that CC is due to God. Regarding CC impacts, a large percentage (81.4%) of interviewed farmers were most concerned about drought due to its increased intensity and widespread effects. Meanwhile, agricultural officials were focused on foreseen and shocked extreme events such as landslides and flash floods, which occur only at particular sites along the streams. Agricultural enterprises are often proactive and aware of people's concerns to provide related services such as resistant seeds, irrigation facilities, and fertilizers. However, very few (8.44%) farm households in the region have access to these services because of limited financial capacity.

Keywords: climate change, impacts, mountainous, perceptions, responses, Thua Thien Hue.

Classification number: 4.4

1. Introduction

Vietnam is a country with a large proportion of agricultural laborers and agriculture plays a very important role in the country's economy. The strong development of agriculture is a solid premise for other economic sectors to develop [1]. Over the past decade, under the impact of CC, the frequency and intensity of natural disasters has increased causing serious damage to mankind, property, economy, culture, and society [2]. According to some CC scenarios [3], temperatures in Thua Thien Hue will

increase by 0.5°C in 2020, 1.4°C in 2050, and 2.6°C in 2100. The average annual rainfall will increase by 3.7% in 2050 and 6.8% in 2100 with a decreasing trend in the dry season and an increase in the rainy season. In the last 20 years, under the impact of CC, the number of floods increased by 26% and the peak of floods increased by 11% [4]. People in mountainous areas of Thua Thien Hue are faced with many livelihood risks due to the impact of CC [5].

Faced with these challenges, the government as well as domestic and foreign agencies and

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organizations have implemented numerous policies, programs, and projects to improve the capacity to respond to adverse impacts of CC on the environment. To minimize losses in agricultural production as well as human lives, programs such as the National Target Program to respond to CC 2008, 2016; action plan to respond to CC of Thua Thien Hue province 2016-2020; Green growth strategy 2012; smart agriculture (GACSA) have been introduced. However, the capacity of people in mountainous areas to respond to CC is still low [6] and one of the main reasons for this is limited awareness and understanding of the local residents about CC causes and impacts responses [7] This situation is consistent with the results of many previous studies indicating the decisive role of “perceptions and attitudes on CC impacts and responses of the people and stakeholders” in building CC resilience for farmers and communities [8, 9]. To have a scientific foundation for proposing solutions that improve the adaptive capacity and ensure livelihoods of people in mountainous areas in Thua Thien Hue province, this study analyses the perception of related stakeholders on CC causes, impacts, and the existing response strategies in agricultural production of local communities.

2. Methodology

2.1. Study site

The four mountainous communes of Thua Thien Hue province selected for the study include the Thuong Long and Thuong Quang communes in the Nam Dong district and the Hong Ha and A Roang communes in the A Luoi district. The field survey lasted from April 2019 to March 2020. These communes were

representative for the whole studied districts in terms of typical livelihood activities, ethnicity, and poverty rate. In addition, the natural conditions of the communes were also representative for the districts in terms of typical extreme weather conditions.

2.2. Data collection

Secondary information includes data on extreme weather events; reports on the socio-economic situation of the communes in the period of 2015-2019; data on agricultural production of each commune and related studies in the two districts have been collected from international and national journals, reports from related departments and statistical offices.

Primary data was collected through interviews with 462 farm households; 29 agricultural officers at the four studied communes, Nam Dong and A Luoi districts, Thua Thien Hue province; 12 owners of agricultural input suppliers (AISs); and 11 individuals who were representatives of community-based organizations (CBOs) in the two studied districts. Households were randomly selected from the list of farm households provided by the commune people's committee. Based on time and budget availability, 120 households from each commune were selected for the study. Random sampling was conducted without repetition, and one household from every 5 was selected for the survey until the sample size was sufficient. The total number of households interviewed was 480, however, 18 households were removed due to inadequate information or incomplete survey questionnaires. The sample size, thus, contained 462 farm households. Community based organizations include

agricultural extension clubs, livestock groups, agricultural production cooperation groups, and forest protection groups. The content of the questionnaire focused on farmers' level of awareness about CC and concern about weather extreme events; impacts of CC on agricultural production in the locality; their perspectives on the response strategies that have been implemented; and the results.

2.3. Data analysis

Descriptive statistics was the main method used to analyse the data collected from the household survey. Mean, frequency, and percentage were applied to analyse all variables related to households' CC awareness and perception of impacts and response strategies. Besides, the study employed the Chi-squared test (X^2) to compare the related indicators among stakeholder groups including farm

households, agricultural officials (commune, district, province), AISs, and CBOs.

3. Results and discussion

3.1. Major socio-economic characteristics of the study area

The mountainous region of the Thua Thien Hue province covers a total area of about 1,256 km², which belongs to 5 districts including Phong Dien, Huong Tra, A Luoi, Nam Dong, and Phu Loc. Nam Dong and A Luoi are two districts that have their entire land area within the mountainous area of the province. Ethnic minorities occupy a very high proportion with over 46% and 76% of the total population of the Nam Dong and A Luoi district, respectively (Table 1). Ethnic minorities include Ta Oi, Pako, Bru Van Kieu, Co Tu, and Pa Hy. They have been living in the same territory for many decades. With collective livelihood activities

Table 1. Major socio-economic characteristics of the study area in the year 2020.

Socio-economic characteristics	Unit	Nam Dong district	A Luoi district
Population	Person	28,267	49,611
Households	Household	6,809	13,448
Kinh households	Household	3,887	3,103
Ethnic households	Household	2,922	10,345
Poor households	%	10.16	25.94
Near poor households	%	7.10	13.14
Income structure			
- Agriculture-fishery	%	45.5	44.8
- Industry-handicraft	%	28.8	33.4
- Services	%	25.7	21.8
Total land area	ha	64,777.90	122,521.21
Agriland	ha	4,897.68	6,194.84
Forestland	ha	55,305.67	109,591.9
Non-agricultural land	ha	2,181.53	5,335.22

Source: Nam Dong and A Luoi People's Committee, 2020.

and intermarriage among the ethnic groups, the boundaries of culture and customs have, thus, gradually disappeared or become eliminated.

Table 1 also shows that the percentage of poor and near-poor households in the two districts in 2020 was still very high. The average poverty rate of the whole district in 2020 of Nam Dong was 10.16% and that of A Luoi was 25.94%. However, in some communes of the two districts, the poverty rate was extremely high with over 24% in Thuong Long commune, Nam Dong district, and over 35% in the A Roang, A Dot communes, A Luoi district. Besides, the rate of near-poor households was also more than 7% in Nam Dong and 13% in A Luoi. The high poverty rate in this area is possibly because the majority of households are ethnic minorities and their livelihoods heavily depend on natural resources, especially forest resources that have been exhausted. In addition, due to the implementation of “closing forests” policies¹ in the study area, the forest exploitation activities - a key income source of the majority ethnic households in the two districts - has become strictly controlled. As a consequence, livelihoods of most households in the two districts have been significantly affected. Agriculture fishery production makes up a large proportion of household income (45.5% in Nam Dong district and 44.8% in A Luoi district) and has been becoming more important for local people’s livelihoods due to the reduction of income from forest exploitation

activities. However, agricultural land is limited compared to forestland (4,897.68 ha compared to 55,305.67 in Nam Dong district and 6,194.84 ha compared to 109,591.9 ha in A Luoi) and has been reduced over time due to CC impacts, particularly, drought and landslides [6, 10]. Upland rice, cassava, and maize are three dominant crops while cows and local pigs are dominant house animals in the two districts. The majority of forest land in the two districts is covered by acacia and rubber plantation.

3.2. Stakeholders’ perceptions about CC impacts

The level of awareness about CC plays a decisive role in building a household’s resilience and limiting damages caused by CC impacts. The higher the awareness level, the more people become concerned while looking for effective solutions, and they will be more willing to adapt [11]. Data in Table 2 shows that most of the interviewed farmers and stakeholders have heard about CC and shared others their opinion that CC occurs due to many causes in which deforestation and excessive waste discharged to the environment are two key causes. These findings are consistent with many previous research efforts [12, 13]. However, a significant proportion (over 50%) of the respondents have heard about CC but do not understand or clearly understand its causes and potential impacts. More than 45% of people still believe that the main cause of changes in weather and increasingly climate extreme events is the naturedly decision of God.

Understanding causes and potential impacts of CC on agricultural production and livelihoods

¹Decision No 07/2012/QĐ-TTg dated 08/02/2012 of the Prime Minister promulgating a number of policies to strengthen forest protection, including policies to promote socialization, to attract economic sectors, social organizations and residents to participate in forest protection, create jobs, increase income, contribute to poverty reduction and improve living standards for local communities.

Table 2. Stakeholder's perception about climate extreme events and causes (% respondents).

Perception	Farmers (n=462)	Agricultural officers (n=29)	AISs (n=12)	CBOs (n=18)	X ²	P value
Have heard about CC	71.0	100	100	100	23.4	.00
CC causes						
<i>Ozone depletion</i>	4.8	100	100	100	356.2	.00
<i>Urbanization</i>	22.1	100	100	100	148.8	.00
<i>Deforestation</i>	74.0	100	100	100	19.9	.00
<i>Industrialisation</i>	32.3	100	100	100	100.1	.00
<i>Overpopulation</i>	9.7	24.1	2,5	5.5	9.0	.03
<i>Discharging too much waste into the environment</i>	66.9	100	100	100	27.7	.00
<i>Due to God</i>	45.0	1.0	100	11.1	23.9	.00
Weather extreme events have greatest impact on agricultural production in mountainous areas of Thua Thien Hue province						
<i>Drought and heat stress</i>	81.4	37.9	66.7	72.2	22.8	.00
<i>Abnormal weather</i>	27.9	3.4	8.3	16.7	11.4	.01
<i>Heavy rain</i>	2.6	0	66.7	0	132.1	.00
<i>Flash floods, landslides</i>	19.5	55.2	16.7	11.1	21.8	.00
<i>Tornadoes, storms</i>	1.5	0	0	0	.9	.00

Source: Field surveys, 2020.

is key to motivate farmers and stakeholders to search for and adopt effective response solutions [13]. Table 2 shows that the perception about CC causes and impacts significantly varied among stakeholders (P value <.00). Over 71% of interviewed farmers considered heat stress and drought to be the extreme event that has the most serious impact on agricultural production and their livelihoods. A majority of interviewed AISs (66.7%), as well as representatives of CBOs (72.2%), shared the same views on CC impacts as local farmers. Meanwhile, over 55% of the agricultural staff indicated landslides and flash floods as the most critical natural disasters. The interview

results showed that up to 10 out of 12 officials at the provincial and district levels believed that landslides and flash floods were the key problems of agricultural production and the livelihoods of the people in the mountainous areas. The differences in the identification of risks in agricultural production caused by CC may significantly affect the decision on responses as well as the effectiveness and sustainability of response strategies [14, 15].

3.3. Stakeholder concerns about impacts of CC on agricultural production in the study area

Results in Table 3 show that the concerns

Table 3. Stakeholder concerns about CC response in agricultural production (% of respondents).

Criteria	Farmers (n=462)	Agricultural officers (n=29)	AISs (n=12)	CBOs (n=18)	X ²	P value
Regularly seek information about CC, discuss and share with other individuals	79.4	44.8	0.75	100	24.4	.00
Worried about impacts of CC on agricultural production	79.4	37.9	66.7	100	37.1	.00
More accurate predictions of CC and impacts are needed	80.5	100	100	100	14.1	.00
Interested in accessing knowledge and technologies to cope with CC	45.9	100	100	100	61.4	.00
Need to raise awareness about CC impacts	80.5	100	100	100	114.9	.00
It is necessary to have a plan to respond to CC in the field of agricultural production	28.6	100	100	100	14.1	.00

Source: Field surveys, 2020.

regarding responses to CC impacts in agricultural production significantly varied among stakeholders (p value $< .00$). The majority of farmers (nearly 80%) and representatives of CBOs (100%) were worried about negative impacts of CC and regularly seek related information to share with others. They were also very interested in accessing information on CC responses in the agriculture sector. However, around 20% of interviewed farmers did not care or did not recognise the need to raise awareness or to have CC response plans.

Most of them were farmers who still believe that CC is caused by God.

AIS representatives were very interested in accessing information on CC. However, their concerns and worries were about the accessibility and ability of farmers to pay for their services due to negative impacts of CC. Many of them mentioned the cases of serious storms in 2015 and 2016 that greatly damaged the acacia and rubber plantation in the mountainous region of the province. The effect

was that households could not afford to pay for fertilizer and other supplies they purchased. Similarly, the severe drought during the 2018-2019 crop resulted in many rice fields in A Luoi having no harvest, and, as a consequence, farmers could not afford to buy rice new seeds for replanting.

Results of the field survey also indicate that all interviewed agricultural officers were interested in learning about CC and expressed that it was very necessary to raise awareness about CC for farmers and all related stakeholders as well as to develop CC response plan for mountainous areas of the province. However, they all confirmed that CC is not a single-top concern for agricultural departments, but it is an integrated issue that all sectors and related departments must consider integrating into their strategic plans. The agricultural development plans of the province deal with many issues and targets other than CC such as productivity, quality, biological systems, and market demand. Thus, funds to agriculture sector have been prioritised to respective items accordingly.

3.4. Stakeholders' strategies to respond to CC impacts in agriculture

Response approaches and satisfaction with existing response strategies partly reflect concerns and efforts of stakeholders to respond to CC impacts. The satisfaction level was measured by the average mean score of a 5-point Likert scale measurement. Table 4 shows that stakeholders had diverse approaches to respond to CC impacts in agriculture at their own position and roles in the sector. The level of satisfaction with their response strategies also varied significantly among

strategies and groups of stakeholders. Most farmers learn from their neighbours, relatives, community organizations, or from experience of older generation to cope with CC impacts. Meanwhile, a very low percentage of farmers consult AISs (8.4%) or agricultural officials at any levels (11.5%) for coping strategies. Besides, the level of farmers' satisfaction with these two stakeholders was not high. It was explained that the AISs were good in that they are proactive in updating information and new technologies, but they only did their best for the regular clients. It is difficult for those who do not regularly purchase supplies from them to get consultations from AISs. In addition, their services were costly and thus not all farmers were able to afford AIS services. Regarding agricultural officials, almost all farmers expressed that it was difficult to contact them. Those who work at the commune were not capable, thus, farmers do not trust them. Those who work at higher levels (district and province) are more capable and strategic but difficult to contact to get a consultation. The consultations from CBOs, neighbours, and friends are mainly experience-based but were highly appreciated by the interviewed farmers for being flexible and understandable. This is particularly important to ethnic minority farmers that have characteristics of being hesitant in communication and have limited receptive capacity.

Table 4 also shows that all groups of stakeholders regularly seek information on weather, climate, and impacts of CC to share to others or to integrate into their short and long-term plans. CBOs and AISs are quite satisfied with what they have done to build farmers' resilience to CC impacts because their efforts

Table 4. Stakeholders' responses to CC impacts on agriculture sector.

Stakeholders	Response strategies	Percentage of respondents agree (%)	Average mean score of satisfaction scale*
Farmers (n=462)	Self-change to cope with the situation	19.2	3.4
	Consult officials at all levels	11.5	3.0
	Consult AISs	8.4	3.4
	Consult CBOs	27.5	4.2
	Consult others	58.9	3.9
Agriculture officials (n=29)	Search for CC information to disseminate to farmers	100	3.5
	Communicate and provide trainings to raise farmers' awareness	13.8	2.7
	Do trials and demonstrate adaptive livelihood models	17.2	4.0
	Integrate CC into annual working plan	82.8	3.7
	Policy advocacy for climate responses in agriculture sector	20.7	2.6
AISs (n=12)	Search for CC information in the region	100	4.0
	Search for relevant adaptation models and related services	100	4.3
	Support demonstrating adaptive livelihood strategies	0	-
	Consult farmers and integrate CC adaptation in to their business plan	100	4.3
CBOs (n=18)	Seek and share CC related information for CBOs' members	90.9	4.5
	Share and exchange successful experience and adaptive cases	100	3.2
	Mobilise and support members to cope and build their resilience capacity	100	4.8

Source: Field survey, 2020.

*Satisfaction scale from 1 to 5 indicating lowest to highest level of satisfaction with the response strategy.

have been, to some extent, appreciated by local farmers. Meanwhile, agricultural officials at all levels were not very satisfied with their activities of integration, consultation, communication, as well as policy advocacy to respond to CC particularly for the mountainous communities. The main reason for this is almost all officials indicated that it was the matter of a prioritized issue. Since CC is not prioritised and just an integration issue, there is no funding for this matter and not many officials have been formally educated, fully trained, or even assigned to take part in the related communication programs, trainings, or policy advocacy activities. This finding needs to be explored further because in order to meet other targets of the agriculture sector such as productivity, quality, biological sustainability, and profitability, climate must be among the key deciding factors in the long run [13]. In other words, finding ways to ensure productivity, quality, and profitability of agriculture production is the pathway to building farmers' adaptive capacity and vice versa [15]. Results in Table 4 also show that there was almost no collaboration among stakeholders in building farmer resilience to CC. This may be the key reason leading to the mismatch in identifying and prioritising extreme events and the respective coping solutions between farmers and related departments.

4. Conclusions and recommendations

CC is a major challenge for agricultural production in the mountainous areas of Thua Thien Hue province. However, the levels of awareness, perception, and concern of CC impacts and responses were significantly different among stakeholders (P value <.00).

Most stakeholders have similar perceptions about the causes of CC, however, up to 45% of farmers still believed that CC is caused by God. This partly affects farmers' interest in seeking CC information as well as their willingness to change or respond. An important finding was the significant differences in perception of CC impacts of agricultural officials and local farmers. Agricultural officials have paid more attention and respond to flash floods and landslides, while farmers are more concerned about and prioritize drought responses. Lack of comprehensive analyses and communication programs could be the main reason for this difference. The difference may create difficulties for the coordination of implementing agricultural development programs in the context of CC and livelihood of farmers. Therefore, to enhance the effectiveness of agriculture production and ensure livelihoods of farmers in the context of CC, relevant stakeholders need their knowledge and awareness on CC strengthened and should collaborate with other stakeholders to identify a common approach to support farmers effectively coping with CC. This research also suggests that related departments and institutions give priority to comprehensive assessments of CC impacts; build up a climate database and CC related information that accessible for stakeholders, particularly farmers and extension practitioners; and provide agriculture services suitable to the socio-economic conditions of the local communities.

CRedit author statement

Thi Hoa Sen Le: Writing - Original draft preparation, Writing and Editing; Tien Dung Nguyen: Reviewing and Editing.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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The UK's foreign strategy toward ASEAN and prospect of UK - Vietnam relationship post Brexit

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Abstract:

After leaving the European Union (EU), the United Kingdom (UK) needs to re-assert its status as a traditional power on the international stage. To prepare for development in the post-Brexit period, the UK has had many orientations to promote and develop its influence and interests in the world. Since 2016, the three main orientations have been their relationship with the EU, Asia-Pacific, and Africa. Among its partners in Asia, the UK has been making efforts to come up with solutions to strengthen its ties with ASEAN. This paper uses some research methods on international relations, such as policy research methods, in order to clarify the objectives, content, and ways of implementing the UK's foreign policy towards ASEAN in general and Vietnam in particular. This article studies some key features of the position of ASEAN in the UK's foreign strategy and efforts to strengthen the UK - ASEAN relations thereby making some comments on the prospect of the relationship between the UK and Vietnam.

Keywords: ASEAN, Global Britain, post-Brexit, relations, the UK, Vietnam.

Classification number: 5.2

1. Introduction

Since becoming a member of the EU, the UK of Great Britain and North Ireland jointly established their position and role on the international stage as a part of the EU. However, during the decades of being an EU member, the UK did not completely rely on the EU and its relationship with its partners in the world, yet remained one of the world's most influential countries. Indeed, the UK is known as the world's sixth-largest economy with global trade, a sea power, one of five permanent members of the United Nations Security Council, an ally of the United States,

a member of the Commonwealth, as well as being a member of other alliances and partnerships.

After leaving the EU (Brexit), the UK had to promote its own influence and interests around the world. To prepare for the official Brexit, and to promote an international identity for itself, the "Global Britain" strategy was laid out. Being formally launched in October 2016 by Prime Minister Theresa May, "Global Britain" has depicted the UK, after withdrawing from the EU, as "a free, open, inclusive and outward-looking global power" that will play a vital role on the international

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stage. To achieve that goal, “Global Britain” demands reinvestments in its relationships worldwide by “advocating free trade and an international rules-based system” and “using its soft power” to demonstrate its values and advance the nation’s interests. The UK global strategic vision consists of three pillars: “The first pillar of our Global Britain strategy will be to continue to prove that we are the best possible allies, partners and friends with our European neighbours”, then “The next pillar of our Global Britain strategy will be the UK’s role as an energetic champion of free and open trade” and “Finally, the third pillar of our Global Britain will be the UK as an even stronger force for good in the world” [1]. The Kingdom has advocated free trade for centuries, and today EU and the USA are its two largest markets. In recent years, to prepare for the new stage of an independent UK’s development, there is a number of aspirations that the Kingdom needs to fulfill around the world of which the first priority is “investment in all our relationships across Europe”, and the second is deepening the ties with the ally United States “in the area of trade” [2]. The UK also seeks to strengthen and expand its partners worldwide, of which, Asia is listed in the UK’s aspirations and its “All of Asia policy” needs to be developed.

In Asia, the UK determines three main partners, which are China, India, and the ASEAN. To strengthen the UK’s presence in this rapidly growing continent, the UK’s government has introduced an “All of Asia” policy, which includes enhanced relationships with China, India, and Southeast Asia and affirms that they are “committed

to strengthening our relationship with [the regional bloc ASEAN] after EU Brexit” [2]. Thus, besides the two powers China and India, the UK has been trying to achieve a closer relationship with ASEAN to access the potential to become an important partner of the association.

2. Materials and methods

2.1. Materials

The paper uses primary and secondary sources from reliable sources of the UK, ASEAN, and Vietnam related to the development of policies and strategic orientations and refers to research by other scholars to analyse relationships in the fields of politics-diplomacy, economy, security-defence, etc., between the UK and ASEAN as well as the UK - Vietnam relationship.

2.2. Methods

The paper uses an approach based on theoretical frameworks on international relations including realism, liberalism with basic arguments about the nation, power issues, national interests, the issue of harmonisation of interests to explain the UK’s foreign policy with ASEAN, and especially analysis based on the UK’s role and position in the international system after leaving the EU.

This paper also applies a systems approach because Vietnam is a part of ASEAN in particular and the Indo-Pacific in general and is affected by the UK’s foreign policy implementation. Meanwhile, the UK’s foreign policy is also a system of which the policy towards ASEAN and Vietnam is a large component.

This paper uses some research methods on international relations, such as policy research methods, in order to clarify the objectives, content, and ways of implementing the UK's foreign policy towards ASEAN in general and Vietnam in particular.

3. Literature review

Since the UK government made its decision to exit the EU in 2016, there have been articles related to UK's foreign policy changes toward the EU and other allies and partners all over the world. In recent years, there have also been some works directly concerned about the relationship between the UK and ASEAN, in general, and UK - Vietnam relations, in particular.

Regarding the multifaceted relationship between the UK and ASEAN, several articles have been published, such as I. Storey (2019) [3], "The United Kingdom and Southeast Asia after Brexit", and T.T.K. Ha (2020) [4], "Prospects of UK - ASEAN relationship after Brexit". The former explores the UK's efforts to enhance its influence and interests all over the world including its engagements in Southeast Asia, specifically, seeking to formalise a new relation with ASEAN, strengthening bilateral bonds with each bloc's member, and raising its defence presentation in the region. However, the article leaves the possibility of the UK's success open because ASEAN's response depends on its consideration of the UK's role and contribution to the security and prosperity of the region. The latter article examines outlooks of the UK - ASEAN and UK - Vietnam relations in the post-Brexit era.

Findings show that the prospect of cooperation is positive as the UK is an important partner of the Association as a whole and Vietnam in particular through strong economic, political, and military ties as well as potentials from parties.

Other works have concentrated on the economic ties between the UK and ASEAN, J. Haacke, et al. (2018) [5], *Future options for the UK - ASEAN economic relationship*, is a briefing for a workshop co-organised by the UK - ASEAN Business Council (UKABC) and the LSE Saw Swee Hock Southeast Asia Centre (LSE SEAC) that was held on June 27, 2018. The paper examines the UK's economic performance with Southeast Asia, the EU context to UK relations with Southeast Asia, and concentrates on future options for the UK - ASEAN economic relationships such as a multilateral UK - ASEAN Free Trade Agreement (FTA), bilateral FTAs with each member country, or Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP).

In an article by L.A. Reumann (2019) [6], "ASEAN's European trade relations in the wake of Brexit", the author examined how Brexit will affect ASEAN and its member states in terms of European trade, and its impact on the UK's and EU's trade relations with Southeast Asia. The findings show that ASEAN's financial markets and trade configurations will not be affected. The bloc and its members will also think about political and security aspects as Britain tries to become an independent trading actor after Brexit.

J. Wood, et al. (2017) [7] in their work titled "Brexit: The economic and political implications for Asia" provide a brief synopsis of Britain's decision to leave the EU. Then, offer a detailed analysis of how the Brexit decision will impact the Asian region. As part of this discussion, a series of relevant policy issues are considered.

On the British military presence in the Southeast Asia region, there is an article by L. Jianwei, et al. (2019) [8] named "British naval activities in the South China Sea: A double-edged sword?" that focuses on the emerging presence of the British navy in the region that poses a threat in some perspectives. It also mentions Vietnam as a UK significant partner.

The present article systematically analyses, from the UK's perspective on UK - ASEAN and UK - Vietnam relations and especially from official UK and ASEAN documents, efforts to build formal relations between the UK and ASEAN post-Brexit, which has not been mentioned in many texts.

4. The position of ASEAN in the new strategy of the UK

ASEAN, an association with 10 member countries, is a potential partner for the UK. The association of these 10 Southeast Asian countries covers a total area of 4.46 million square kilometres, accounts for 3% of the total land area of Earth, and has a large sea area that is especially important for global trade flow, which has always attracted the attention of other countries and world powers. The 10 countries combined have created a common

political voice that cannot be ignored. Indeed, ASEAN plays an increasingly important role in maintaining stability and development of the Asia-Pacific region and the world. As a result, ASEAN warrants Britain's spotlight during their post-Brexit period. Therefore, in recent years, the UK has focused its foreign policy on ASEAN, in addition to China and India, and has considered the importance of ASEAN in the UK's relations to the region and the world at the same time [9, 10]. This stems from several reasons:

First, the UK needs to establish its international status as an independent power in the post-Brexit period, then the UK has to present and participate with different regions of the world. Practice shows that, in the Asia-Pacific region, ASEAN plays an increasingly important role, and it is an indispensable partner in the regional policies of external actors, especially large countries. More broadly, the UK sees ASEAN as a group of 10 influential members in the Indo - Pacific region. Therefore, the UK, with its new global strategic vision, will not pass up the opportunity to have a more active presence in this region. The UK already has relatively close relationships with many countries in the region and multilateral cooperation with ASEAN. This is a strong point that the UK will take advantage of for a new phase of development.

Second, the UK has many interests related to the East Sea, and a deep relationship with ASEAN would be more favourable for British activities in the region. Britain was once the

dominant sea power since the seventeenth century, but after World War II, in search of a new direction of development, Britain gave up efforts to maintain its maritime hegemony by abandoning the pursuit of the “one-world economic system” policy in which the British pound was a central currency [11]. Instead, Britain prioritised integration with European countries in the European Economic Community (EEC). At the time, Britain believed that the EEC had strong growth potential and that Britain could expand its influence by becoming a member of the bloc. In addition to its obligations, the UK would also enjoy great benefits from being a member of the EEC.

Returning to the identity of an independent country, the UK must prove its extreme strength and promote its advantage of being a sea power, especially when the Kingdom’s economy is heavily dependent on seaborne trade (with 95% of UK trade being based in the maritime sector) [12] in which the East Sea plays a meaningful role. According to a report by The Henry Jackson Society, “nearly 12% of UK seaborne trade - £97 billion in imports and exports - passes through the south China sea each year” [13]. This volume is certainly not the highest as Southeast Asian economies continue to strongly develop and surely account for a higher share of the international economy in the future. In addition, this region is the third-largest market for Britain defence exports. Thus, maintaining the safety and security of the East Sea is of great importance to the UK.

Therefore, Asia, especially the Pacific - Asia region, plays an important role in the UK’s interests. In particular, the East Sea, which is the shortest route connecting the Indian Ocean with the Pacific Ocean, is the gateway for international trade. It is also a gateway for Britain’s commercial relations with Southeast and East Asian countries. Thus, close cooperation with ASEAN countries will be very beneficial to Britain’s presence in this area.

Third, ASEAN is a promising market for British high-end exports. After Brexit, the UK will lose its preferences in the intra-EU market and will need to expand its ties with global trading partners as well as strongly promote its highly open economy to compensate for this loss. The UK needs to strengthen its global trade links, in which ASEAN - a fast-growing and dynamic economic region - is an important partner for Britain’s trade relations as demonstrated by: i) ASEAN is the fifth largest economy with an estimated combined GDP of over 3 trillion USD (it is forecasted that by 2030, ASEAN will rank fourth after the EU, the US and China) and already is the world’s third-most populous region with 650 million people; and ii) over the last ten years, trade between the UK and ASEAN has grown by almost 70%, reaching nearly 42 billion GBP [14].

In 2019, two-way trade between Britain and ASEAN reached 41.7 billion GBP, an increase of 12.2% compared to 2018. The total value of Britain’s exports to ASEAN was 11.4 billion GBP (58.4% of goods, 41.6% of services), and

its imports from ASEAN were 22.3 billion GBP (70.2% of goods, 29.8% of services) [4]. The UK is one of the top 10 investors in ASEAN. Southeast Asia is the UK's third-largest non-EU export market. Furthermore, Southeast Asia is the UK's third-largest export market for defence products. Indeed, the strong growth in the region presents many opportunities for British businesses.

Accordingly, we can see the importance of ASEAN to the UK in the post-Brexit period. Global Britain's strategy poses three of the UK's main Indo-Pacific partners including China, India, and ASEAN, respectively [2]. As a part of the preparations for a new phase of development, the UK has worked to foster a formal relationship with the Association.

5. Promoting the UK - ASEAN relations

"For the first time in post-war history, the British Parliament is taking steps to reverse decades of economic and political orientation towards Europe, in favour of re-igniting its own relations with the countries of East Asia and the Pacific rim" [15].

Historically, the UK has played an important role in Southeast Asia, and it now still maintains a regular presence in the region. During its integration process in the EU, besides being a dialogue partner of ASEAN through the Union, the UK also had independent activities in the region. Therefore, Britain's return to seeking influence in Southeast Asia in the process of preparing for Brexit is understandable and predictable. The UK now seeks to gain ASEAN's dialogue partnership.

Britain hopes to become the 11th ASEAN dialogue partner to promote economic growth, social progress, and cooperation in the region, which will create new opportunities for cooperation in trade, education, science, and security. According to British Foreign Secretary Dominic Raab:

"As Asia grows in importance, Global Britain will cooperate even more closely with our friends in the region. We aim to boost trade by joining the Trans-Pacific trade agreement. And by becoming one of ASEAN's Dialogue Partners, we can strengthen our ability to cooperate across the Indo-Pacific region, as a force for good, on everything from climate change to regional stability" [16].

The appointment of a UK ambassador to ASEAN (previously concurrently held by the UK ambassador to Indonesia), then the launch of the UK mission to ASEAN, along with diplomatic missions in its 10 member countries, shows that the UK appreciates the importance of ASEAN and wants to reshape the relationship with an association in the context of current development. The UK also wants to discuss extensive cooperation programs with ASEAN including measures to respond to global pandemics, climate change, and terrorism, etc.

This begs the question: How will the UK shape its relationship with ASEAN? After the official Brexit time (December 31, 2020), this country would no longer be a dialogue partner of ASEAN through the EU. Given the existing

relationships with ASEAN and recognising the increasing importance of Southeast Asia, Britain does not want to lose its status as an ASEAN dialogue partner. As Asia and Pacific Secretary Heather Wheeler noted, ASEAN would be a “key partner” for London after it leaves the EU [17]. On June 5, 2020, the UK’s government issued a statement proposing to become a dialogue partner of ASEAN. The establishment of a dialogue partnership as an independent country would give Britain new opportunities for cooperation in many fields such as trade, education, science, and security.

On the other hand, the UK can be seen as a goodwill partner in the region as it is a major development partner of Southeast Asia. Over the last 10 years, the UK has provided more than 3.5 billion GBP of ODA in the region. Indeed, the UK’s Intellectual Property Office (IPO) assists ASEAN countries in building a rules-based intellectual property system. The UK Better Health Program (BHP) will be operating until September 2022 with a total investment of GBP 20.3 million (USD 25.4 million) in five ASEAN members including Malaysia, Myanmar, Philippines, Thailand, and Vietnam for better healthcare systems. The UK currently has cooperated with the ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management (AHA Centre) in Jakarta (Indonesia) and the ASEAN - Singapore Cyber Security Centre of Excellence. In addition, since 2018, the UK has supported the ASEAN Economic Reform Programme

(worth 19 million GBP) and the ASEAN Low Carbon Energy Programme (worth 15 million GBP). It has also helped Southeast Asian countries to deal with climate change [18].

The UK also has a lot of potentials to contribute to regional security and stability. More importantly, the COVID-19 epidemic has further enhanced the value of the UK. With its advanced medical achievements and vaccine development, the UK will be able to bring many benefits to ASEAN. In addition, the UK pledged to provide 1 million GBP to the ASEAN COVID-19 Response Fund [18].

Besides the favourable conditions for Britain to become a dialogue partner of ASEAN, there are also obstacles. The voice that wants to retain the moratorium on dialogue partners believes that admitting the UK, a former colonial master of four of the ASEAN’s members, could bring unknown consequences [19]. Meanwhile, granting dialogue partner status, as well as suspending it, also involves designing the foreign policy of its members and major partners to ensure a sustainable strategic balance between the parties.

In addition, disputes in the East Sea have become increasingly fierce and have attracted the attention of many external forces. It is suggested that, while ASEAN countries are more and more concerned about the increasingly tense competition between China and the US in the region.

“The perception of the UK’s enhanced military presence will undoubtedly

cause concerns about increased external militarization in the region, which will not be welcomed by ASEAN. Such perceptions will have serious repercussions for the UK itself, and negatively affect its promotion of Global Britain in a broader sense” [8].

Otherwise, in disputed issues in the region, especially those about the East Sea, Britain has resolutely opposed activities that violate the sovereignty and interests of other countries and those that go against international law. This is in line with the interests of some Southeast Asian countries related to maritime and island disputes. The UK is increasingly concerned about security and freedom of navigation in the region, in particular, and around the world, in general, and has shown its readiness to deploy military forces in the region if the security situation in the region deteriorates.

In addition, there are also some questions about the extent to which the UK can contribute to Southeast Asia when it has other potential priorities in the post-Brexit period.

Regarding free trade agreements, when leaving the EU, Britain is no longer a partner of the two FTAs that the EU signed with two members of ASEAN, namely the EU - Singapore FTA (EUSFTA) and EU - Vietnam FTA (EVFTA), as well as not a participant in the FTAs that EU is negotiating with other ASEAN members. Because ASEAN is certainly a potential market for British high-value exports, Britain has therefore actively negotiated to sign FTAs with Singapore and

Vietnam separately, based on the principle of inheriting commitments of EUSFTA and EVFTA, along with necessary changes to ensure that the bilateral trade framework between partners is properly complied with.

The two FTAs, including the UK - Singapore FTA (UKSFTA) and the UK - Vietnam FTA (UKVFTA) signed on December 10, 2020, and December 29, 2020, respectively, have been urgently completed by the parties to comply with the provisions of each party's laws to ensure the implementation of these FTAs from 11 pm on December 31, 2020. These bilateral FTAs create favourable conditions for promoting the economic recovery of member countries after the COVID-19 crisis. UKSFTA and UKVFTA are considered as positive factors promoting bilateral economic and trade relations between UK - Singapore, and UK - Vietnam. At the same time, it has a positive effect for the UK to expand economic and trade cooperation with the association, especially when other bilateral FTAs between the UK and other Asian partners are unlikely to be signed in the next few years.

In addition, the UK has an active military presence in ASEAN under the Five-Power Defence Arrangements (FPDA), which includes five members: Australia, Malaysia, Singapore, New Zealand, and the UK, while there are still some units of the UK military in Brunei in order support and train Brunei's army. Thus, there is an increased regular presence of British troops in the East Sea to protect important UK economic and political interests in the Asia - Pacific [4].

When the UK's government issued a notice requesting to become a dialogue partner of ASEAN on June 5, 2020, ASEAN began to consider and debate this proposal. After the consultation process within ASEAN and between ASEAN and the UK, the Chairman's Press Release on the ASEAN - UK Open-Ended Troika Meeting on April 8, 2021, stated:

"... noted the publication of the UK's Integrated Review of Security, Defence, Development and Foreign Policy. The meeting welcomed the UK's commitment to strengthening ties with ASEAN, including through the UK's application for ASEAN Dialogue Partner status. The meeting looked forward to continued and closer cooperation between ASEAN and the UK, and further strengthening the ASEAN - UK relationship towards achieving common interests in order to accelerate sustainable socio-economic growth of the region" [20].

One month later, on August 5, 2021, ASEAN officially granted its dialogue partner status for the UK. This action broke the block's moratorium on adding dialogue partners since 1999 when ASEAN decided to deepen existing relationships instead of expanding dialogue partners.

This decision, on the one hand, showed positivity and openness in ASEAN's foreign relations while, on the other hand, showed that ASEAN highly values the UK's role and contributions in the region and highly appreciates its commitments and potential for cooperation in political-security, economic,

and socio-cultural aspects. After becoming a full dialogue partner of ASEAN, the UK is expected to promote its role and strength to bring the ASEAN - UK relations to a substantive development and contribute to peace, security, stability, and prosperity in the region [21, 22].

The UK considers ASEAN and Southeast Asia to be important parts of its global foreign policy as mentioned while committing to attach importance to ASEAN's central role in regional priorities. Cooperation priorities include economic cooperation, promoting green growth, building sustainable infrastructure to adapt to climate change, and responding to emerging regional and global challenges. The UK is also ready to enhance cooperation with ASEAN in the response to and control of the COVID-19 pandemic by providing vaccines for ASEAN and supporting the region to improve preventive medicine capacity. Emphasising the strengthening of maritime cooperation, the UK and ASEAN will enhance maritime law enforcement capabilities that contribute to upholding the value and role of international law, especially the 1982 United Nations Convention on the Law of the Sea (UNCLOS) [23].

6. Prospects for the development of UK - Vietnam relations

The UK and Vietnam officially established diplomatic relations in 1973, but it's only from the 1990s when the two countries' relations turned into reality. Then, in 1995, Vietnam joined the ASEAN. Thus, in addition to the

bilateral relationship, the bonds between the two countries have also been shaped within the framework of the EU - ASEAN multilateral relationship. In this regard, the authors consider the UK - Vietnam relation development to date correlating to the UK's relations with ASEAN and other members.

On September 8, 2010, representatives of the UK and Vietnam signed a Joint Statement officially upgrading the UK - Vietnam relations to a strategic partnership, which created a framework for the comprehensive development of bilateral relations. The seven major areas of cooperation include politics-diplomacy, global and regional affairs, trade-investment, development cooperation, socio-economics, education training, security-defence, and people-to-people exchanges. At the same time, cooperation was promoted at multilateral forums and especially at the United Nations, WTO, ASEAN - EU, and ASEM. Therefore, the two sides are committed to strongly strengthening economic-trade-investment cooperation between the two countries.

In recent years, economic cooperation between Vietnam and the UK has developed remarkably. In 2019, the total import-export value between the two countries was approximately 6.6 billion USD, of which Vietnam exported more than 5.75 billion USD and imported 857 million USD. In 2020, despite impacts of COVID-19, the total trade turnover between Vietnam and the UK was estimated to have reached 5.64 billion USD of which Vietnam's exports and imports

were estimated to reach 4.95 billion and 687 million USD, respectively [24]. In the first five months of 2021, Vietnam exports were worth 2.36 billion USD to the UK, while imports from the UK were worth 325 million USD. This decline in 2021 was due to the impact of the COVID-19 pandemic as consumption in both countries has been decreasing. Currently, the UK is Vietnam's third-largest trading partner in Europe and Vietnam's ninth-largest export market in the world. In addition, Vietnam enjoys a large trade surplus from the UK.

According to the Ambassador of Vietnam Hoang Long Nguyen to the United Kingdom of Great Britain and Northern Ireland, the bilateral relationship between Vietnam and the UK is in the best stage so far but still has a lot of potential for further development [25]. While the two countries' markets have a very high level of complementarity, and the UK is a leading importer and exporter in the world, the total value of Vietnam's exports to the UK only accounts for 0.88% of the UK's total imports while UK goods exported to Vietnam account for only 0.17% of its total value of goods exported worldwide. In the field of foreign direct investment, there are 400 valid investment projects of UK investors in Vietnam with a total registered investment of 3.6 billion USD making this country the 16th largest investor among Vietnam's 137 partner countries and territories. This amount of money is quite small compared to the total 300 billion USD that the UK invests all over the world. On the other side, Vietnamese investors have run nine projects with total

registered capital of 11.5 million USD in the UK [26]. The UKVFTA is expected to create more advantages for economic cooperation between the two countries. The two countries have set a target of doubling the bilateral trade value to 10 billion USD within the next five years. The potential for the UK - Vietnam trade cooperation is still very significant in the context that Vietnam, a large potential market, is entering a new stage of economic development with a goal of GDP per capita reaching 3,500 USD by 2025, and to double it to 7,000 USD by 2030. As one of Vietnam's leading partners, the UK can meet Vietnam's economic development needs in fields of strength such as science and technology [25]. However, achieving these targets acquire efforts at all levels from the government to business.

In Vietnam, the UK is stepping up its support for inclusive and sustainable economic growth. Over the next three years, the UK will launch programs to develop low-carbon energy, infrastructure, and promote health and trade reforms. The UK government is also working closely with the government of Vietnam on fighting corruption in the private sector, reforming the economy and governance, as well as finding better ways to raise capital for public investment.

Generally, this special interest is aligned with the UK's relations with its largest Asian partners. Since August 2021, the UK has officially become one of ASEAN's dialogue partners, which shows that the bloc recognises its increasingly important role in the region.

On the UK side, strengthening ties with ASEAN as a whole and each member country of the Association separately is relevant to its "All of Asia" strategy. This is why the UK has 11 diplomatic missions in ASEAN so far.

UK's largest partner in ASEAN is Singapore, and it is considered as a gateway for the UK to enter the ASEAN market. While Vietnam is perceived as an important strategic partner of the UK and also considered a strong driver of ASEAN's international trade, the UKVFTA brings great opportunities for economic cooperation between the two countries. Vietnam must make every effort to make good use of opportunities and advantages in the UK - Vietnam strategic partnership, especially in the context that the economies have been hit hard by the COVID-19 pandemic.

The UKVFTA was signed and took effect just before Brexit (along with UKSFTA), and that is recognised as a strategic step of the UK. Both Vietnam and the UK can benefit from opening their markets to each other. Vietnam's economy relies on exports, so expanding economic ties with the UK is one of Hanoi's priorities after the UK's withdrawal from the EU. On the British side, after Brexit, the country needs to step up market diversification through a series of agreement tracks, while negotiating a new trade agreement with the EU is more difficult and complicated.

Furthermore, Brexit is an opportunity to reshape and strengthen UK relationships, and this is also the case for the strategic partnership between Vietnam and the UK. In recent

years, there have been visits by UK officials that aim to deepen cooperation between the two sides across many fields. Both parties will continue to consult each other about the UK's negotiation process to become a member of the CPTPP. After Brexit, the UK needs the ASEAN market and its member states. In our opinion, if a bilateral FTA between the UK and any other Asian country is not feasible in the near future, the possibility of signing an FTA between the UK and ASEAN is even more difficult.

The UK is also an increasingly important partner of Vietnam. It is also an advantage for the UK while Vietnam is implementing the foreign policy of diversification, multilateralisation of international relations, and maintaining balance among partners. British opposition to China's destabilising actions in the East Sea, as well as the UK's military presence in the region, will contribute to curbing illegal Chinese activities in the sea area with core interests of Vietnam [4, 27]. The UK supports the early signing of the East Sea Code of Conduct (internationally known as the Code of Conduct for the South China Sea) by ASEAN and China.

In general, both Vietnam and the UK attach great importance to the bilateral relationship between the two countries and are willing to deepen cooperation in all fields. Now that the UK has officially become a dialogue partner of ASEAN, with the contribution of Vietnam's 2020 ASEAN Chairmanship the possibility of bilateral and multilateral

cooperation of the two countries is even more open. However, more time is needed to evaluate it.

7. Conclusions

When the UK leaves the EU, Southeast Asia, with its economic, political, and strategic importance, is an area of great significance for the UK to enhance cooperation. ASEAN lies at the heart of Asian multilateralism and plays an important role in maintaining a rules-based international system. A challenge for the UK will be to develop a clear policy towards Southeast Asia that takes into account the UK's broader security and geopolitical interests while enhancing its comprehensive relationship with this region. The UK must also balance a long-term strategy to engage ASEAN through the pursuit of new FTAs with member countries of the association along with an increased military presence in the region.

Becoming ASEAN's full dialogue partner is a big step that marks the UK's deep attachment to the region after Brexit. Moreover, this event is a turning point in the UK's strategy towards the Indo - Pacific region, and also affirms the influence of ASEAN in Britain's Indo - Pacific policy.

For Vietnam, the Vietnam - UK strategic partnership has been developed for more than a decade and the relationship between Vietnam and the UK has grown substantially as both sides have actively cooperated, which includes the exchange of experience in sea operations of the two navies. The bilateral

FTAs that the UK signed with Singapore and Vietnam, which quickly came into force, are seen as an effort to strengthen relations with Southeast Asian countries, while the UK is also trying to become a member of the CPTPP. The UK has also repeatedly made it clear that developing comprehensive relations with Vietnam is one of its priorities, and, in turn, this is an opportunity for Vietnam to further strengthen its strategic partnership with the UK.

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COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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Is waiving IP protection a magic wand to make COVID-19 vaccines quicker and cheaper?

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Abstract:

The COVID-19 waiver proposal put forward by India and Brazil in October 2020 has stirred public debate over the role of the intellectual property (IP) system. Many countries, including Vietnam, have expressed their support for this initiative. The waiver proponents argued that IP rights, mainly patents, have stalled global vaccination supplies. However, this paper challenges this view arguing that waiving IP rights is not a magic wand to make vaccines cheaper and quicker. Bottlenecks that slow vaccine rollout do not lie with the IP system but with manufacturing capacity, supply chain, and export restrictions. Therefore, instead of discussing the waiver proposal, world leaders should redirect their effort to address trade restrictions and improve global manufacturing partnerships. Countries with a low pharmaceutical manufacturing capacity like Vietnam should start thinking about being more well-prepared for the next pandemic. A classic but essential recommendation for a country like Vietnam is to build up its local manufacturing capacity and attract partnerships with research-based pharmaceutical companies. Given the complexity of the vaccine industry and manufacturing process, it usually takes between 5 to 10 years to build physical infrastructure and standardise the local industry to comply with international standards; hence, Vietnam should invest more into R&D, starting now, to be more self-sufficient in the future.

Keywords: COVID-19, intellectual property, patent, vaccines, waiver.

Classification number: 6

1. Introduction

At a World Trade Organization (WTO) meeting in early October 2020, India and South Africa proposed a temporary waiver of IP rights including patents, copyrights, industrial designs, and undisclosed information (trade secrets) [1]. The waiver aims at preventing, containing, or treating COVID-19 “until widespread vaccination is in place globally, and the majority of the world’s population has developed immunity”. The proposal, which had a rather ambitious scope, targeted a wide

range of “medical products including vaccines and medicines or to scaling-up of research, development, manufacturing and supply of medical products essential to combat COVID-19”.

Although the potential adoption of the waiver will be optional and will not result in a direct application in all WTO members because each country will have to implement the waiver into their national laws, this idea has ignited fierce public debate. High-income economies such as the UK, the US, Australia, Japan, Canada, Norway, and the EU vigorously

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protested this ambitious proposal claiming that it would not speed up the slow vaccine rollout in developing countries [2]. However, headlines were made when the US, under the Biden administration, reversed their initial stance to support the proposal [3]. Such a change has influenced the dynamics and the whole gamut of the debate over the waiver, given the US's global leadership role and its well-established position as a patent fighter.

On the other hand, low and middle-income countries, including Vietnam, expressed enthusiastic support to the initiative in hopes that more vaccines would be produced due to this waiver [4]. COVID-19 proposal supporters have claimed that patent-holding companies should give up their IP protection to help other less fortunate countries [5]. Therefore, the waiver is considered a solution to unequal access to COVID-19 vaccines.

However, some developing countries, for example, Chile, Mexico, and Brazil voiced their opposition to the waiver and demanded a more data-first approach [6]. These countries required the waiver proponents to share examples where the IP system has blocked COVID-19 vaccine manufacturing and the extent to which such a waiver will give rise to widening access to COVID-19 vaccines in national laws. However, the answers to these questions remain unsubstantiated since these cited examples are sporadic and not systemic [2].

The disagreement amongst WTO members has led to a revision of the proposal published on 25 May 2021. The revised waiver would be limited only to "health products and technologies" for COVID-19 prevention, treatment, and containment. These would include vaccines, therapeutics, diagnostics, medical devices, and personal protective

equipment [7]. While the original text suggested the waiver would be in place “until widespread vaccination is in place globally, and the majority of the world’s population has developed immunity”, the revision stated that the waiver “shall be in force for at least three years” and subject to annual review. If the General Council of the WTO agrees that the “exceptional circumstances” leading to the waiver cease to exist, it will decide a termination date for the waiver.

This paper claims that neither patents nor other forms of IP rights, but rather the complex vaccine manufacturing and trade restrictions, have hindered vaccine distribution. This conclusion is supported by two WTO studies that have confirmed that tariffs, trade-related bottlenecks, and trade-facilitating measures have caused delays in making and distributing vaccines [8]. When the world is faced with difficulties and uncertainties, it seems easy to point the finger at the patent system and turn it into a scapegoat.

2. Is waiving IP a magic wand to make vaccines quicker and cheaper?

It seems that the proposal is built on the assumption that patent (and other IP) protection is an obstacle to vaccine accessibility. Removing them will open the floodgates for better vaccine distribution. Further, once IP rights are taken down, it is assumed that COVID-19 vaccines will be made cheaper and quicker. This belief is not valid because second-generation vaccines will not be more affordable, unlike generic drugs. After all, the capital outlay for second-generation vaccines will not change [9]. The authors argue that removing the IP system might produce a countereffect to Vietnam, where vaccines

produced by inexperienced manufacturers might uncontrollably infiltrate the market.

Unlike small-molecule drugs having bioequivalent generics, there is nothing called generic vaccines. Instead, second-generation vaccines are called biosimilars, which are highly similar in structure, function, and clinical effect to the innovator product. According to the FDA’s report, bioequivalence refers to the absence of “a significant difference in the rate and extent that an active ingredient in pharmaceutical equivalents has contact with the site of the drug’s action” [10]. Generic manufacturers can demonstrate the bioequivalence between patented medicines and generics through limited types of clinical tests. These companies merely imitate what others have made to offer a much lower price than the originator. They can omit the clinical trials, the most costly and laborious phase during the pharmaceutical R&D process, to save a substantial amount of money and thereby reduce the cost of the generics.

Meanwhile, bioequivalence cannot be shown in the case of vaccines because every new vaccine is considered a new creature. Regardless, companies used the same technology, which was not used to manufacture previously available vaccines [9]. Being a living product makes vaccines fragile. They are sensitive to heat and prone to microbial contamination. Therefore, even the simplest biologicals must undergo clinical trials because simple bioequivalence cannot determine efficacy and safety. All vaccines must pass human studies and bear the related costs to be circulated on the market [9]. Any subtle modifications in the production process, whether in scale, process, or presentation, may change the final product and affect its

purity, safety, or efficacy. Therefore, regulatory authorities must assess and approve such changes again to ensure that the quality of the final product does not change before its widespread implementation [11]. For complex vaccines like COVID-19, hundreds of quality control checks are required for the approval of each batch [9]. Having to conduct clinical trials is one of the reasons why the second-generation COVID-19 vaccines are unlikely to be cheaper, as is the case for generic medicines.

Quality controls are applied throughout the vaccine manufacturing process and represent up to 70% of the manufacturing time from the manufacturing standpoint [11]. To underscore the difficulties of producing COVID-19 vaccines, even by experienced third parties in the context of contractual technology transfer, companies like Emergent had issues in making the Johnson & Johnson vaccine. Indeed, they had to discard up to 15 million doses in May 2021 [12]. AstraZeneca, the company whose principal activities are not vaccine manufacturing, also had challenges at the beginning of the production, which caused a delay in supplying vaccines to certain countries. Challenges in making vaccines can also be well illustrated by Sanofi's decision to abandon the development of a Pfizer-style vaccine, even though this French pharmaceutical company is one of the very few vaccine manufacturers in the world [13].

Difficulties in vaccine manufacturing do not lie only in physical infrastructure but also in human labour. For example, the Swiss government helped recruit staff for Lonza, a Swiss company, to operate the production lines at Lonza's facility in Visp city (Switzerland) [14]. However, they could only find 25

qualified employees to fill critical positions, whereas Lonza was reported to need 75 skilled workers.

The US export restrictions have also aggravated the situation. The US Defence Production Act of 1950, which allows for the rating of specific medical items and reserves them to produce vaccines for Americans, has severely affected the availability of particular inputs to manufacture the vaccines. Such abovementioned trade restrictions have disrupted vaccine supplies where there is essential interdependency across all vaccine manufacturers. For example, manufacturing the Pfizer vaccine involves "280 components, 86 suppliers, 19 countries" [15]. Therefore, the lack of a single component could stop the entire manufacturing process and may result in the disposal of a batch that might already have been in production for several weeks.

Developing countries also need to take responsibility. The Indian government's decision to temporarily stop AstraZeneca's vaccine from being exported hit other poorer countries badly. The Indian-made AstraZeneca vaccine has been given to the Serum Institute of India, the world's largest vaccine maker and the most significant supplier to COVAX, a scheme through which many less developed countries receive their doses. India has adopted a two-faced approach. On the international front, it suggested that other countries should waive IP protection. On the national level, India has confessed that even discussions or a mention of exercising governmental power for essential drugs or vaccines that have patent protection "would have serious, severe and unintended adverse consequences" and "any exercise of statutory powers [...] can only prove to be counter-productive at this stage" [16].

Compared to many other traditional therapeutics, vaccine manufacturing is one of the most challenging industries regarding its components and the technologies required to produce vaccines. The complication and difficulty of production, the rigidity of quality assurance and control, and numerous regulations require an enormous investment and production cost to set up a manufacturing facility in the industry. These requirements are considered barriers to market entry for new manufacturers [9]. As a result, the vaccine market is relatively small compared to the traditional pharmaceutical industry. The bottlenecks to vaccine manufacture are factual and significant, and for that reason, collaboration, not division, is needed to ensure global partnership and remove all roadblocks. The authors of this paper maintain that the hindrance of the inoculation program has nothing to do with IP rights but, instead, lies in manufacturing, supply chain, transportation, and other non-IP factors.

3. Potential dangers behind the removal of the IP eco-system

The innate complexity of vaccine production has turned IP rights into a quickly blamed target. We should accept that vaccine rollout is not a one-dimensional issue of IP rights but a multi-faceted problem where know-how, manufacturing facilities, skilled labour logistics, etc., are jointly needed to vaccinate the globe.

Following the above analysis, while it is unclear whether the waiver proposal would improve the vaccines inaccessibility, such an emotionally charged approach would potentially disincentivise vaccine development in response to new COVID-19 variants. For a country like Vietnam, waiving IP might

adversely impact Foreign Direct Investment. The government is in a more vulnerable position than ever since it has just come out of a mysterious wave of COVID-19, which started in May 2020. Eroding IP rights, including the patent system, will send the wrong signal to the investors who might reconsider investing in exploring uses of future vaccine technology such as mRNA. Moreover, the comprehensive waiver of all IP rights ignores the stark reality that coronaviruses mutate swiftly and are more deadly.

It is naïve to hope that relinquishing the IP system will facilitate a vaccine blueprint. As mentioned above, vaccine manufacturers will need knowledge transfer, know-how, or trade secrets [17]. This information is, nonetheless, not disclosed in patent applications. Trade-secret and know-how are especially critical to producing complex vaccines, such as mRNA, where a “recipe” from a patent is hardly sufficient for production. In addition, new vaccine manufacturers might not even know what they need to know to make the vaccine. It is hard to imagine that the waiver proposal will force the rights holders to pass on these non-registered IP rights. Even with no IP protection, we should ask if any generic companies would embark on a precarious and research-intensive business without specific outcomes? The answer is probably no. Although Moderna assured others that they would not take legal actions regarding their COVID-19-related patents [18], no manufacturer has seized this opportunity to make the Moderna vaccine.

Existing legal tools, such as compulsory licensing, are not practical for vaccine production. Since the pandemic began, many countries such as Canada, Chile, Ecuador, France, Israel, Indonesia, and Germany

modified their current laws or passed a new law to issue a compulsory licence once COVID-19 treatment was found. Nevertheless, not one country has granted such a licence. Neither has a request for a voluntary licence ever been made. Lack of vaccine manufacturing capacity is, probably, one of the main reasons behind such inaction. As mentioned above, the vaccine manufacturing process requires highly sophisticated technology and rigorous quality control to preserve its safety and efficacy. Therefore, removing the entire ecosystem of IP rights is, indeed, attacking the wrong root cause.

The authors argue that world leaders would need months to negotiate and then agree on the language of the COVID-19 waiver. Then WTO members will have to transpose the waiver into their domestic laws. Such effort should be redirected to tackle real problems of vaccine manufacturing and not wasted discussing the proposal text while COVID-19 is quickly mutating.

Furthermore, dismantling patent protection might lead to substantial risks. Suppose patent-holding companies either decline to collaborate with local partners in obtaining marketing authorisation (by sharing required data and know-how) or cannot impose specific quality controls due to the IP waiver [19]. In those cases, ineffective vaccines manufactured by inferior processes could cause public distrust. Speeding up vaccine manufacturing must not be done at the expense of vaccine quality, efficacy, or safety. While patents and other IP rights are generally viewed as an incentive to fuel innovation, little know that they also suppress counterfeiting. Indeed, the WHO has determined that counterfeiting is facilitated where “[...] there is lack of effective intellectual

property protection” [20]. Consequently, dismantling the IP system can result in a more widespread pharmaceutical crime.

4. Conclusions

The COVID-19 waiver proposal is ambiguous, impractical, and time-consuming. While it is understandable that world leaders who are bound by moral obligations to their citizens are rushing to push for radical changes, the proposal, nevertheless, shifts the attention away from the real barriers to vaccine accessibility. The proposal is overly simplistic and unfairly blames patent protection. Abolishing patents and other IP rights on the false faith that it will accelerate the current slow vaccine rollout is illusory. While it is true that “no one is safe until everyone is safe”, instead of trying to bring the whole IP system down, we can achieve this without compromising high levels of quality assurance. A classic but essential recommendation for a country like Vietnam is to build up their local manufacturing capacity and attract partnerships with research-based pharmaceutical companies. Given the complexity of the vaccine industry and manufacturing process, it usually takes between 5 to 10 years to build physical infrastructure and standardise the local industry to comply with international standards; hence, Vietnam should invest more into R&D, starting now, to be more self-sufficient in the future.

CRedit author statement

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COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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Toward a sustainable food system and agroecology transition in Vietnam

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Abstract:

Even with the impressive results of agricultural growth and food security during last nearly 40 years of Renovation, the Vietnam Socio-economic Development Strategy for 2021-2030 seeks to accelerate agricultural restructuring and develop a modernity-oriented agriculture. Vietnam also aims to improve the resilience and adaptability of the agricultural sector against climate change, and to align this sector with the processing industry, markets, export activities, and global value chains. In 2021, Vietnam has actively contributed to United Nations Food System Summit (UNFSS) dialogue with more than 1000 participants involved in National Dialogues. Vietnam is willing to contribute to the transformation of global food systems as a food-providing country that upholds “transparency, responsibility, and sustainability”. This will serve to create comprehensive and sustainable breakthroughs for the entire system and will fulfill the 2030 Sustainable Development Goals (SDGs). For the solution, Vietnam wishes to become a Food Innovation Hub of Asia. Vietnam has made digital transformation a key priority in the agricultural sector and has encouraged the application of digital technology to agricultural production and business activities. Vietnam’s food systems need to be transformed into green, sustainable, and low-emission agriculture and due attention should be given to agroecological production. Vietnam also commits to achieving nutrition security in 2030. A National Action Plan for a sustainable food system will be built.

Keywords: agroecology, food system, sustainable, Vietnam.

Classification number: 7

1. Introduction

Vietnam is a country with a small land area of 33 million hectares, of which agricultural and forestry land takes up about 26.0 million hectares (with 10.3 million hectares of agriculture and close to 16.0 million ha is forestry land) with per capita agricultural land among the lowest in the world. Over

the past few decades, Vietnam’s food system has undergone landmark development stages since starting as one of the poorest countries in the late 1980s - early 1990s with 60% of the population living below the poverty line. Thanks to the “Doi Moi” - Renovation decision of the Party and State in 1986, Vietnam has basically escaped poverty and ensured a

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balance in terms of food in 2000. In 2020, the population of Vietnam reached 97.7 million people and with each year the population has increased by about 1 million people. Vietnam's agriculture plays a particularly important role in ensuring food security, social stability, and livelihoods for over 60% of the population living in rural areas contributing 14.85% of the country's GDP and about 35% of the workforce.

Up to now, Vietnam has become one of the most important food exporting countries that contribute to ensuring world food security. Over the past ten years, Vietnam has always been one of the top four rice exporting countries in the world. Not only stopping at essential food items, Vietnam has risen to become one of the two leading coffee exporting countries in the world. Vietnam is also a large and important exporter of seafood, cashews, and vegetables. It is estimated that 50% of food production in Vietnam is for export. Despite the impact of the COVID-19 pandemic, climate change, and natural disasters, Vietnam's agriculture has maintained a positive growth rate of 2.68% in 2020 and 2.9% in 2021. In addition to firmly ensuring food security, domestic food, and export of 6.15 million tons of rice in 2020, Vietnam's agricultural export turnover reached 41.53 billion USD. Particularly, in 2021, agricultural exports have established the record with 48.6 billion USD, contributing to national and world food security [1].

Although Vietnam has made great progress in reducing poverty, ensuring food security, and promoting economic growth as well as socio-economic development over the past

30 years, agricultural and rural communities continue to be among the poorest and most vulnerable, especially in the face of climate change, emerging diseases, and market fluctuations. The agriculture and food sectors, by far the most important source of livelihood for the people of Vietnam, urgently need continued efforts to reduce poverty and address the growing challenges facing agricultural development villages. Despite an overproduction of food, the challenges of child malnutrition and food accessibility remain high in some mountainous areas and ethnic minorities.

The impressive growth rate of the agricultural sector in recent decades with the strategy of high intensification has caused impacts on the environment, especially the pollution of soil and water resources due to the overuse of various agrochemicals, antibiotics, non-biodegradable waste generation, deforestation, biodiversity loss, erosion of native plant materials, soil and ecosystem degradation, and greenhouse gas emissions, which are all leading to large scale rural-to-urban migration. Vietnam's agricultural industry consists of mainly small-scale farmers with typical characteristics of limited labour productivity, fragmentation and consumption of products through intermediaries, few job opportunities, low wages for workers, and low agricultural movement. In addition, agricultural products are mainly raw, with only a very small amount of value-added content, which has not yet met food safety standards partly due to limitations in technological innovation and governance institutions.

Farmers have few conditions to access markets or learn market information. Although they participate in value chains - often it is only at the stage of providing raw materials and only a small role in adding value to agricultural products. A new form of Agricultural Cooperatives (according to the Cooperative Law 2012) has just been established thus the capacity to support farmers in market participation is still limited. Meanwhile, processing and exporting enterprises continue to dominate a number of key agricultural products and especially export markets.

In order to have integrated review of interlinkages between sectors such as agriculture, trade, health, and environment related food systems with an improved capacity to leverage changes, it is necessary to have a food system approach. Therefore, this article will address the following main questions: What are the problems of Vietnam's current food system? What are the solutions to achieve a sustainable food system? And finally, what are the roles of agroecology?

2. Method and research context

This article uses a review method based on desk study of scientific and grey literatures such as published guidelines of the Food and Agriculture Organization of the United Nations (FAO) and other UN agencies, Vietnam policy documents such as Vietnam's National Food System Action Plan: Food System Transition to Transparent, Responsible, and Sustainable Food Systems by 2030; Plan to Restructure Vietnam's Agriculture Sector for the period 2021-2025; National Target Program on

Sustainable Poverty Reduction for the period 2021-2025; One commune - One product (OCOP) Program, National Action Program Zero Hunger by 2025; National Target Program for Socioeconomic Development in Ethnic Minority and Mountainous Areas to 2030; the Construction of new rural development to 2030, and the National Nutrition Strategy to 2030. It also benefits from an insider view into the United Nations Food System Dialogue process that took place globally and in Vietnam in 2021.

The UNFSS 2021 was an event called by the UN Secretary - General to World Leaders. In order to prepare for participation in the dialogue, the leaders of the participating countries have to form a consensus to promote collective action on food system transformation in order to achieve the 17 SDGs by 2030. In preparation for participation in the dialogue during the 2021 UNFSS, Vietnam organised National Dialogues including 2 rounds of National Dialogue and 3 Regional Dialogues at the northern, central and southern levels in June and July 2021. The National and Regional Dialogues have the following common goal: "Through open dialogue with stakeholders, identify the most important strengths, weaknesses and opportunities in the Vietnamese Food System in order to achieve Zero Hunger and Poverty Reduction objectives by 2030 and the 17 SDGs of the 2030 Agenda". The National Dialogues, with an interdisciplinary approach guided by the UN, were a great opportunity to evaluate Vietnam's recent achievements in agricultural production as well as poverty reduction and

nutrition improvement with multi-stakeholder participation.

3. Results and discussion

3.1. *Diagnosis regarding Vietnam agriculture's changes since the Renovation*

Over the past 30 years of Renovation, the state has had a number of policies to recommend technical advances with characteristics of agroecology, but there still exists a gap in integrated solutions including socio-economic interventions in order to support the connection between agroecological production and markets for agroecological products. Besides, up to now, Vietnam did not have a policy on the orientation of agroecology in general, but only a policy to encourage specific agroecological practices. Moreover, support policies have been inconsistent such that the impact on the output of the agricultural products has not been significant.

Vietnam needs to take drastic action to make progress in smartly adapting to the increasingly severe impacts of natural disasters and climate change, using natural resources efficiently and sustainably, increasing national capacity in the volatile commercial environment, and significantly improving and diversifying the sources of livelihood and income for farmers with the implementation of safeguards for residents and the environment in a sustainable way.

The COVID-19 pandemic has revealed some serious weaknesses and instabilities in global food supply chains. The pandemic has

resulted in major disruptions to established supply chains as well as bottlenecks in the labour market, input material supply, agricultural production, agricultural processing, transportation, and logistics. The pandemic has severely affected human health, economies, trade, and social security on a global scale. It has also resulted in increasing rates of food and nutrition insecurity and poverty to re-emerge in many countries.

It is now clear that increasing scarcity of resources for agricultural production, combined with the global shocks of the COVID-19 pandemic and the impacts of climate change, are now the biggest challenges to food security not only in Vietnam but also for the world [2].

In Vietnam, the Prime Minister has issued a National Action Plan to implement the 2030 Agenda for Sustainable Development (Decision No. 622/QĐ-TTg dated May 10, 2017), including 115 specific goals corresponding to 17 SDGs. Vietnam is also the first country in Southeast Asia to commit to implementing the National Action Program Zero Hunger by 2025 to realise the SDG2 to eliminate hunger, ensure food security, improve nutrition, and develop sustainable agriculture in line with the National Target Program on Sustainable Poverty Reduction being implemented in Vietnam.

Currently, Vietnam is in the process of restructuring the agricultural industry towards increasing added value and sustainable development, optimising production costs, taking into account emerging factors such as liberalization trade, climate change,

disease risk, smart agriculture, and food loss control. The National Target Programs of New Rural Development, Sustainable Poverty Reduction, Socio-economic Development in ethnic minority and mountainous areas and many other programs and projects of the Government in the coming period have been implemented. There are new orientations to the development of highly local and indigenous food production systems such as the OCOP Program and attention to food safety and disease combined with the development of agricultural and rural tourism. These are expected to contribute to promoting the improvement of the food system in the intermediate term.

In order to promote the collective actions and integration of different activities related to the food system, a series of dialogues about food system transformation proposed by FAO (2018) [3] were organised. The theme of the dialogue was Vietnam's Food System Roadmaps to More Transparent, Responsible, and Sustainable Food Systems by 2030. Contents of the Food System Dialogues of Vietnam were taken from a national and regional perspective, which focused on five main action tracks to point out challenges, opportunities, and priority solutions that need to be selected in the current context: (1) Ensuring everyone has access to safe and nutritious food; (2) Shifting to sustainable consumption; (3) Promotion of sustainable food production; (4) Forming a competitive, inclusive, and equitable value chain; and (5) Increasing resilience to shocks, stress, and vulnerability.

Through the dialogues, the Government of Vietnam has become very aware that there must be close cooperation among nations and actors in the food industry to jointly create widespread and lasting changes across the whole system. These changes will also contribute to poverty reduction and ensure food and nutrition security in rural, remote and ethnic minority areas and for vulnerable groups like women and children. In addition, this is also an opportunity to connect and develop the key agricultural value chains of Vietnam in a transparent, responsible, and sustainable manner. Therefore, Vietnam welcomes and highly appreciates the call of the UN Secretary General for the UN Food Systems Summit in 2021 and this bold direction for food systems and joint efforts to achieve the SDGs by 2030.

3.2. Food system issues that Vietnam should tackle today

Vietnam's food system is diverse and faces many challenges. The dialogue also pointed to the potential for dual effects, which arise when multiple impacts occur together, especially for vulnerable communities. These are complex and interrelated issues that require multi-sectoral, multi-level, and multi-partner cooperation as well as appropriate policy tools and communication.

Forecasts and realities of climate change and global disaster risks in recent years show that Vietnam is one of the nation's most heavily affected by climate change. Floods, droughts, saltwater intrusion, pests, and diseases often occur causing a loss equivalent to 2% of the

annual GDP. The COVID-19 pandemic has caused fundamental breaks in the global food supply chain, and Vietnam is no exception. Indeed, the recent global pandemic poses a challenge to strengthen the resilience capacity of the food production and supply system.

Vietnam's food productivity and output over the past three decades has steadily grown. It is the result of the goal-oriented strategy to increase productivity and output. This also leads to the consequence that natural resources are reduced and accompanied by concerns about quality deterioration (nutrients and micronutrients), food hygiene, and safety. Excessive use of chemicals and inputs in production (herbicides, pesticides, antibiotics, fertilizers and irrigation) pollutes the environment and affects food quality and safety and causes an increase in the production cost of agricultural products thereby reducing the income of producers. Intensified production systems, inadequately controlled pollution and increased greenhouse gas emissions have degraded land, water, aquatic resources, and biodiversity while contributing to climate change. The inefficient, undiversified, and unsustainable production and use of natural resources have increased the vulnerability of food systems to markets, diseases, climate change, natural disasters, shocks, and risk pressures outside of the system. The rate of food loss and waste in Vietnam remains high. The less use and reuse of agricultural by-products leads to inefficient use of natural resources and increasing negative impacts on the environment. Meanwhile, financial incentives, skills, and the information

needed to apply sustainable good production practices, climate-smart agriculture (CSA), and agroecological farming methods are limited.

There are still many problems in the production value chain and the market. The small, intensive, and fragmented food production system and the lack of economies of scale in value chains make it difficult to expand the adoption of advanced technologies, agroecological practices, and industrial processing systems in the country. Small scale producers, cooperatives, and small and medium-sized enterprises are often unable to meet the requirements of higher quality and value products for the domestic and export markets. This is due to restrictions on innovation such as weak access to market information, new technologies, technical support and training, as well as a lack of innovative financial services (especially technological and digital solutions) to provide credit, financing/borrowing, savings, insurance, and payment systems. The performance of new cooperatives and associations by industry is limited due to weak financial governance and weak linkages to the market and the private sector [4].

Limited investment in the management of stages from harvesting, post-harvest, food preservation, storage, and food processing, as well as limited investments into functional systems for traceability, increasing food loss and waste products, reducing options for value-adding and producing safe and nutritious food that limits access to higher-value markets domestically and internationally. Lack of

cooperation in production leads to low quality and added value, unequal distribution of benefits and responsibilities, and fragile supply chains. In addition, the rapid shift of the young workforce to other economic sectors not only leads to the risk of losing motivation to produce, create, apply technology, and digitise to transform the system, but also requires capital investment and mechanization to replace human labour forces. The gap of incentive policies for private sector investment in transport, logistics, storage, distribution and cold storage/transportation infrastructure limits the ability to connect to the market, increases transaction costs and reduces post-harvest quality. The capacity to implement and enforce international trade agreements and negotiations is still limited [5].

The rate of malnutrition in Vietnam is still high, especially for some regions with difficult natural and economic conditions such as the northern mountainous region and the Central Highlands due to limited access and availability of nutritious and affordable food for the poor and vulnerable [6]. In contrast, obesity rates in urban areas are rapidly increasing. Malnutrition of children, micro-nutrient deficits, and obesity create a triple burden on national nutrition security. This is because the majority of the population is not fully aware of and has not fully formed nutritionally balanced eating habits, especially for micronutrients [7]. Similarly, citizens are not paying enough attention to nutrition and health; not to mention changing awareness, habits, and trends of responsible consumption and green consumption, which

aim to support and protect the livelihoods of the poor, fight against loss and waste, protect the environment, and diversify biology, and emission reduction. Further, they have not yet paid attention to the development, production, and use of local healthy foods rich in nutrients and micronutrients. There remains a large gap of information on nutrition and food safety causing difficulties for consumers due to weak systems of quality control, safety, traceability, and food integrity [1].

3.3. The strategy of Vietnam to tackle food system issues

In the political report, the Communist Party emphasised the orientation toward agroecology and a circular and green economy by 2030 [8]. In response to the food system issues, Vietnam needs bold and urgent collective actions to achieve progress in smart adaptation to increasingly serious impacts of disasters and climate changes, effective and sustainable use of natural resources, national capacity building in an unpredictable business environment, considerable improvement and diversification of livelihoods and income of farmers - together with implementation of sustainable social and environmental safeguards.

Agriculture is a key component in the Vietnamese food system. The development of Vietnam's agricultural sector towards a multi-purpose approach aims to: (a) continue to transform into an increasingly powerful supplier of agricultural commodities that serve the needs of volume and quality growing of domestic market as well as export;

(b) climate-smart adaptation, protection of resources, ecosystems and biodiversity; and (c) provide a sustainable source of livelihood while ensuring social security, especially for the poor in rural areas. This is demonstrated in many programs/action plans and strategies. The national strategy has been issued by the Government and the Ministry of Agriculture and Rural Development with the goal of Vietnam's agricultural brand being known as a "food supplier that is responsible, transparent and sustainable" [6].

Besides the Government's activities, there are many programs, projects, and investments in place such as the investments and initiatives being carried out in the food sector by the private sector, many multilateral and bilateral donors, national and international research and development organizations, as well as non-governmental organizations, industry associations and civil society groups.

In what follows, we discuss the specific groups of solutions that were proposed based on the results of National Food System Dialogues to address these challenging issues [9].

3.4. Solutions to promote food production towards agroecology and sustainability

The theoretical framework of agroecology:

According to M.A. Altieri (1995) [10], agroecology is a method of farming that is based as much as possible on the best use of nature's functions. Agroecology is the main content of sustainable agriculture and food system. According to FAO (2019) [11], a new agroecological concept is an integrated

approach that simultaneously applies both ecological and social concepts and principles to the management of agro-food and agricultural systems. Agroecology seeks to optimise the interactions between plants, animals, humans, and the environment while paying attention to social aspects that need to be addressed in order to achieve a sustainable and inclusive food system [12]. The world tends to implement green economic strategies, circular economy, sharing economy, and knowledge economy to achieve sustainable development goals. Essentially, these strategies are aligned with agroecological principles.

Modern agriculture of the 21st century is a possible mix of agroecology and smart agriculture based on the application of digital agricultural tools. Agroecology, when combined with accurate intelligent management methods applying digital technology, can produce more products, more diversity, and better quality in parallel with the goal of sustainable agricultural production and environmental conservation.

Agroecology considers the environmental, social, and economic features, favourable environmental factors and processes, as well as their interactions that characterize diverse agricultural systems, which are guided by the principles and practices of agroecology. One can also recognise the great potential of collective action processes in agroecology to promote knowledge sharing and increase understanding, which enable behavioural change in agroforestry systems needed for sustainable agriculture to become a reality [13].

To guide countries in transforming food and agriculture systems, bringing sustainable agriculture on a large scale into the mainstream, and achieving Zero Hunger and many other SDGs, the FAO on agroecology has proposed the following 10 Elements [11]:

Diversity; integration; effective; resistance; recycling; co-creation and knowledge sharing (describing common features of agroecological systems, basic practices and innovative approaches); human and social values; culinary culture and traditions (situational characteristics); responsible governance; circular economy and mutual support (favourable environment).

The ten elements of agroecology are closely related and interdependent and have been further elaborated into 13 principles (or guides for action) as proposed by the High-Level Panel of Experts on Food Security [14].

Basically, agroecology is flexible in terms of scale (small-large) and nature (partially or fully integrated) thus helping to provide context-appropriate solutions and problem solving of local and regional issues. On the basis of the goal of protecting and exploiting the functional activities of the ecosystem (ecological services), agroecology will, therefore, have the advantage of succeeding on a larger scale. This agriculture is often based on knowledge co-creation, which combines science with the traditional knowledge and local practices of producers. By strengthening producer autonomy and adaptive capacity, agroecology empowers producers and communities to act as agents of change.

Technically, agroecology applies ecological principles in the design of production systems to enhance ecological benefits such as biological control, pollination, nutrient regeneration, soil and water conservation, etc., on different scales. Ecological processes will be promoted on the basis of technology application. Therefore, modern agroecological intensification can be combined with precision agriculture and the application of digital technology [15].

Agroecology is not new from a technical point of views. Agroecology can be seen in the scientific literature since the 1920s and has been embodied in the practices of family farmers, in grassroots social movements for sustainability, and in politics and public books of many countries around the world. Recently, agroecology has been discussed by international organizations and the UN as a strategic tool to achieve the 2030 goal of sustainable development. An interdisciplinary approach to agroecology will receive more attention. However, technological interventions will help agroecology to operate stronger and meet the increasing demand for food/high quality food increase of the people.

The agroecological transition approach proposed by FAO, and more globally the UN agencies, is considered as a solution for Vietnam's food system transformation [6].

How can agroecology be applied in Vietnam?

In Vietnam, in terms of the agricultural sector's goals and in addition to having the potential to ensure the goal of stabilizing

national food security and employment for the majority of the rural population, the agroecology transition can also meet the requirement of a buffer zone to help maintain the quality of the food, environmental quality, and support other economic and productive activities (including supplying production materials, receiving organic and inorganic waste sources, mitigating extreme weather events such as floods or natural disasters; and landscape, environment, cultural characteristics, etc.). By focusing on transitioning to agroecology, the agricultural restructuring program will contribute to crop diversification, improve farmers' capacity to ensure food security, provide safe products and food, enhance agricultural biodiversity, improve the resilience of production systems to climate change, and help Vietnam fulfil its international commitments on climate change adaptation and mitigation. Ensuring this transition implies paying attention to and support of the transformation of agricultural economic thinking to an ecological and green economy.

Since the Doi Moi period, Vietnam has applied several measures related to agroecology. Indeed, agroecology has evolved over the years with various types of engineering practices and is considered as a technological advancement [16]. The agroecological production models that have been developed in production and have supportive policies in Vietnam can be divided into 6 groups of methods: (1) Agroforestry, (2) Integrated Pest Management (IPM)/Integrated Pest and Human Management (IPHM), (3) Sustainable

Rice Intensification (SRI)/Sustainable Rice Platform standard (SRP) and Vietnam Good Agricultural Practices (VietGAP)/ GlobalGAP, (4) Organic Farming, (5) Integrated Crop-Livestock System and Garden-Pond-Cage (GPC), and (6) Conservation Agriculture and Landscape Agriculture. However, corresponding pilot models in the context of Vietnam are often small in scale and lack effective connection with other systems like markets, industries, or services. Therefore, agroecological developments so far have not created a breakthrough motivation nor a widespread influence of the system.

The development of some specific agroecological schools are as follows:

1. Many models of agroforestry in Vietnam according to each ecological region have been developed in recent times. According to statistics of the International Agroforestry Organization, the area of agroforestry in Vietnam reached about 900000 hectares nationwide during 2013-2014 [17]. Currently, projects related to agroforestry are expanding in the northwest, north central, and central highlands.

2. For rice production, several systems of advanced farming practices have been recognised for technical progress, i.e., IPM, SRP, SRI, VietGAP and equivalent, climate-smart rice farming, and organic agriculture. Rice production currently accounts for less than 50% of the area. Currently, GIZ and World Bank projects in the Mekong delta and Korea in Thai Binh are continuing to expand these practices.

3. Regarding organic agriculture, according to the Ministry of Agriculture and Rural Development, the area of organic farming in Vietnam has increased from 53,350 hectares in 2016 to about 237,693 hectares in 2019. The whole country has 46/63 provinces/cities carrying out organic production. The number of farmers involved in organic production is 17,168. The number of organic production enterprises is 97 with 60 enterprises participating in exporting at a turnover of about 335 million USD/year [18]. The movement of PGS-certified organic production was developed in 2008 in a number of localities such as Hanoi, Ha Nam, Hoa Binh, and Ben Tre, which is suitable for smallholder farmers and has potential for expansion.

4. The integrated crop-livestock system has been incorporated into the concept of a GPC system, which is a system with a long history especially in the rural and mountainous areas of Vietnam. The integrated production system includes Crops - Gardens + Aquaculture - Ponds + Barns. There are some other similar concepts such as Forest - Garden - Pond - Cage system and Forest - Garden - Pond - Cage - Rice, which are considered agroforestry models. Due to the trend of intensive and specialised farming, these GPC systems have decreased in the delta, but this system is developing in mountainous or difficult areas due to the ability to diversify products and reduce risks.

5. Conservation agriculture, which is a sustainable farming method suitable for sloping land in mountainous areas, uses

ground cover with vegetation and plant waste. CIRAD's ADAM project (France) ended in Son La, stopping in the form of technical models.

6. Landscape agriculture is a new approach that applies ecological principles to the whole sub-region (such as valley, communes, district...) to achieve sustainability goals. Currently, projects of the World Bank and Sustainable Trade Initiative for Coffee and Pepper in the Central Highlands are applying this method.

Vietnam's modern agricultural production in the coming period will have to promote smart agroecology based on the application of innovations of agroecological systems combined with innovative management methods. In order to achieve this outcome, an incentive policy needs to be built. At the same time, focus should be placed on collecting, preserving, and developing genetic resources of indigenous precious plants and animals as breeding materials both in the form of farmer households and gene banks. It's necessary to support farmers to preserve precious plant varieties and animals by encouraging the development of local varieties into specialty products, improving production economic value, and helping people live with agricultural production. Research and technical assistance policies need to focus on encouraging the adoption of more sustainable agroecological production systems (e.g., agroecological practices, agroforestry, etc.) and afforestation, especially on infertile and coastal areas.

Production systems in diverse

agroecological regions with harsh conditions require investment in combination with associated industries (e.g., storage, processing, purchasing and distribution of products, etc.). It is necessary to pilot and to scale up climate-smart models to reduce greenhouse gas emissions from agriculture and contribute to increased carbon storage. Government should have incentives for the expansion of the model of nutrition sensitive agriculture in mountainous and difficult areas in order to overcome child malnutrition. It is also necessary to encourage the model of urban agriculture in the direction of agroecology combined with rural tourism to contribute to ensuring urban food security and improving the environment. Enterprises and producers must also apply agricultural economic thinking, apply agroecological technologies that possibly combine with precision agricultural production to optimise production costs and ensure income for producers.

3.5. Solutions to increasing resilience to vulnerability, shocks, and pressures of risks

Vietnam's agriculture has had an important strategic change from thinking about agricultural production to developing the agricultural economy, i.e., moving from high-yield agriculture to high-tech, ecological, responsible, sustainable agriculture and by initiating digital transformation, moving from single-sector development to multi-sectoral integration, from single-value to multi-value integration, and output connection and multi-agent connection. Vietnam has been and continues to improve mechanisms and

policies to promote actions that transform agroecological product value chains with "favourable nature" as the basis, people-centred, and responsible for climate change. This activity should adhere to the principle of the 3 P's (People, Planet, and Prosperity or people, protect the green and prosperous planet) to unlock all potentials to transform the food system from production to distribution and consumption to contribute to implementing the SDGs and contribute to the global fight against climate change.

Agriculture is the livelihood of the majority of the population in rural and mountainous areas who are vulnerable to natural disasters and epidemics. Investments in broad-based education and technical assistance are therefore needed to help vulnerable farmers, new cooperatives and small enterprises adopt good agricultural practices (GAP) and increase resilience (e.g., Climate Smart, Agricultural and Landscape management, Integrated Pest Management...), which integrates the indigenous knowledge of all farmers to reduce emissions, reduce soil erosion and increase biodiversity agricultural studies. In addition, policies and regulations should be reviewed that help enable farmers to diversify into more resilient and sustainable crops and systems and accelerate the development and adoption of improved varieties that are better adapted to the impacts of climate change and natural disasters. Also, government should support the training in basic business management and risk planning, and adoption of digital tools to strengthen the financial resilience of vulnerable male and female farmers, new

cooperatives, and small enterprises in the food system [6].

Government should be interested in increasing systematic data collection using digital and geospatial information to learn and develop better land use plans.

The development of mechanisms and policies is sorely needed to help strengthen the coordination of the agricultural sector and the hydro-meteorological forecasting bloc at all levels in co-developing and disseminating agricultural recommendations to producers through the application of information on weather and climate (climate data, season term forecast, month, and 10 days). At the same time, support should be given to training and guidance on applying weather and climate information to agricultural production and disseminating production recommendations through existing digital technology platforms. In addition, digital application like channels for aggregating, analysing, and sharing information about weather forecast according to local characteristics should exist so that farmers have contingency plans with predictable shocks. It is necessary to promote research, mechanisms, and policies to implement agricultural insurance based on weather indicators and expand insurance coverage to help vulnerable farmers transfer production risks. At the same time, a communication campaign should be built to raise awareness about the benefits, rights, and obligations of buying agricultural insurance so that producers can choose the right product.

The One Health approach with

multidisciplinary collaboration ensures synergies and cost-benefits that need to be scaled up when building, developing, and implementing innovations [6].

3.6. Solutions to improve the competitiveness and inclusiveness of the agroecological food value chain

In order to upgrade agroecological food value chains for a better connection between agroecology production and consumers, different policies should be reviewed.

Firstly, the agricultural land use policy is the most discussed. Accumulating and concentrating land into medium-sized farms is one solution to create a premise for larger-scale production, forming a generation of professional farmers who own family businesses, and applying innovative production techniques to increase productivity and efficiency while saving resources. Farms are supported by links, cooperation within the framework of agricultural cooperatives, and by digital transformation services to increase efficiency. Agricultural land-use policies and regulations need to be improved to make it easier for farmers to diversify to create more sustainable and agroecological diversified production systems such as shifting from intensive rice or maize farming to more sustainable systems with mixed crops (e.g., rice-shrimp, organic fruits and vegetables, agroforestry systems, livestock farming systems, conservation agriculture, VAC, etc.). These transformation systems need long-term development strategies, systematic management interdisciplinary,

and integration of scientific and local knowledge to avoid the risk of spontaneous transformation that could cause an imbalance in food supply and demand or an inefficient use of land resources.

Secondly, it is necessary to promote a sustainable production and to increase market access with high quality requirements through the application of mechanisation and precision farming to increase efficiency and reduce post-harvest losses. The government should issue incentives to promote research, development, and adoption of improved varieties that are better adapted to the impacts of climate change and disasters in collaboration with the private sector.

Cooperatives, trade associations and other associations play an important role in the value chain; however, their activities are not commensurate to their role due to resource and governance constraints. Policies and investments need to be updated to provide technical assistance and encourage cooperatives and professional associations to enhance skills, capacity, innovation, governance, and market linkages with the private sector.

Vietnam is a country with a relatively high rate of food loss and waste. Therefore, it is necessary to develop innovative food preservation, processing, and supplementing processes. These processes are needed to improve the availability of safe, healthy, nutritious food. Government policies should encourage Public-Private Partnership (PPP) and private sector investment in critical food system

infrastructures (roads, transport, distribution and cold chain systems, transportation, etc.), digital systems (transformation, logistics systems), traceability systems, and finance to improve the competitiveness of the value chain.

Public policy should enhance manufacturing compliance, innovative product traceability and insurance systems, use digital technology to help manufacturers and businesses better meet customer requirements, and provide market specific parameters in terms of food quality and safety. Policies and education programs should be developed to strengthen the financial resilience of vulnerable groups, youth, new cooperatives, and small enterprises in the food system to create opportunities for young people in food systems, especially in innovation and use of digital technology. Further, the development and implementation of risk strategies, insurance products and services, and business management plans are essential.

Promoting digital transformation will create opportunities for digital economic activities that help manage value chains more effectively and sustainably. According to recent research, digitalisation can actively support the agroecology transition [19]. The first concrete benefit is that farmers can access more information to make more accurate production decisions, reduce production costs, increase labour productivity, increase production efficiency, and reduce environmental pollution [20]. Through digital platforms provided by enterprises or by the state, the connection with production input

services such as seeds, fertilisers, pesticides, mechanisation services, credit loans, access to digital agricultural extension, weather and climate forecasting services, plant protection services, storage, transportation, harvesting services, access to information on buyer demand, market standards, and price information will be improved [21]. These information sources are collected, stored, updated and aggregated in the form of an open database that is centrally managed and provided by the Ministry of Agriculture and Rural Development together with businesses for all people. Farm households, large farms, cooperatives, or production enterprises can also apply the production technologies of precision agriculture to apply automation technology to optimise each part of the production process with fertilising, watering, pesticide treatment, etc., to ensure food safety and reduce environmental pollution with the support of digital platforms. The next opportunities are in the post-harvest stage, value chain management, traceability, information retrieval, and sales through e-commerce with digital platforms provided by businesses. These platforms can also take care of logistics and transportation. With advanced digital technologies such as Blockchain, Internet of Things (IoT), Artificial Intelligence (AI) being developed by Vietnamese businesses, farmers can access at an affordable cost.

3.7. Solutions to ensure access to safe and nutritious food and transition to lower food loss, food waste, and sustainable consumption

Easy access to safe and good quality food, especially in rural areas and for low-

income and vulnerable groups that face many difficulties, is paramount. Therefore, it is necessary to have solutions to support access to a multi-level and multi-sector food system in order to reduce malnutrition, stunting, and persistent poverty in the northern and central mountainous regions and in the Mekong delta, especially among ethnic minorities, to increase access to healthy food at affordable prices through coordinated and innovative policies, technologies, and interventions with the private sector, applying strategic investment, policy, training and education programs especially between the Zero Hunger Program, the Agricultural Restructuring Plan, the National Nutrition Strategy, Target Program on New Rural Development and the Paris Agreement Implementation Plan on Climate and the SENDAI Framework for Action Framework Implementation Plan on Disaster Risk Reduction.

It is necessary to review and update policies, education, and communication programs, especially mass media, social media and private sector partnerships to promote safe and nutritious food production, a healthy and balanced diet, as well as limiting unhealthy foods and reducing rates of overweight and obesity especially in urban areas. Support to school meals, education programs, and school food environments will promote healthy and nutritious diets.

Market policies, regulations, and solutions need to be identified to promote agroecological production and increase demand for healthy and nutritious food. These solutions should strengthen policies, standards, and

regulations for unhealthy food marketing, nutrition labelling, and product origin labels. They should also effectively enforce policies on fortification of food and improve food safety systems with increased evidence, risk-based management, and communication about the causes, risks and impacts of food safety problems. Finally, they should develop innovative insurance and certification systems to provide transparency and information to consumers.

It is necessary to increase investment in research and application of organic food production and in food rich in nutrients (biofortification). Public policy should promote the sustainable use of safe and nutritious foods by taking advantage of the growing global demand and willingness to pay by developing research and interventions. Food safety interventions should be tailored to specific agricultural value chains. Support for better linkage and coordination among food safety actors, food safety initiatives and projects are essential. Finally, it is strongly suggested to start using technology to reduce unhealthy processed foods through the cooperation and investment of actors in food technology, government, and the private sector.

Regarding the transition strategy to sustainable consumption, one needs to take advantage of mass media and social media to promote systematic and innovative communication and education programs that themselves promote healthy and nutritious diets, educating consumer consciousness in consuming products and services that effectively meet their needs,

all while minimising negative impacts on the environment, society, and economy. Strengthening training and education programs to promote healthy, nutritious diets will benefit consumption in food systems in rural and ethnic minority communities in mountainous areas, especially women and children. In addition, improved policies, technologies and private sector interventions are needed to provide healthier, more accessible and affordable food, especially in rural areas, policies, standards and regulations on nutritional food labelling and product origin.

The Government should develop and complete legal documents on consumer protection law. Promote the business network with the role of support and responsibility to consumers. Building a transparent information environment about businesses - food - consumers is necessary. The Government should also develop a policy on consumer responsibility for the use of food in order to avoid loss, waste, and not affect the environment; all towards building a culture of sustainable food consumption.

Some cross-cutting issues can also be identified such as policies prioritising gender equality, participation, and social inclusion where special attention is given to the most vulnerable and disadvantaged groups affected by shock and risk pressures. For example, financial initiatives, especially financial technology solutions, make lending and credit, savings, insurance, and payments more efficient.

These four strategic solutions have been identified and integrated into the development of the National Action Plan. It is essential to have a roadmap for the transformation of a sustainable food system and the transition to agroecology that covers all levels. It is a tool to coordinate actions of all actors in the food and food system sectors and to mobilise investments and contributions from domestic and foreign organizations.

Beyond the National Action Plan, a monitoring tool with a set of indicators will be necessary for the realisation of the food system transformation in Vietnam to 2030 [22].

4. Conclusions

The integrated food system transformation approach promoted by UNFSS is considered as an appropriate framework to improve the sustainability of Vietnam's food system. After identifying the main challenges facing Vietnam's food system, the National and Regional Dialogues have resulted in a number of joint initiatives and solutions needed for the food system transformation. These dialogues have been critical in specifying the different solutions and orientations to help transform food system and the agricultural sector. As discussed in this article, a set of 4 strategic solutions were identified and integrated into the development of the National Action Plan of sustainable food system transformation. This plan is a tool to coordinate the actions of all actors in the food system and mobilise investments and contributions from domestic and foreign organizations. As part of it, the agroecology

transition will be a key approach to a more transparent, responsible, and sustainable food system by 2030. The agroecological approach has been demonstrated as an instrumental pillar to improve the production component of Vietnam's food system and to move from a single-sector development to multi-sectoral integration, from single-value to multi-value integration, as well as output connection and multi-agent connection in the coming years.

Credit author statement

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COMPETING INTERESTS

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Bayesvl: An R package for user-friendly Bayesian regression modelling

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Abstract:

Compared with traditional statistics, only a few social scientists employ Bayesian analyses. The existing software programs for implementing Bayesian analyses such as OpenBUGS, WinBUGS, JAGS, and rstanarm can be daunting given that their complex computer codes involve a steep learning curve. In contrast, this paper introduces a new open software for implementing Bayesian network modelling and analysis: the bayesvl R package. The package aims at providing an intuitive gateway for beginners of Bayesian statistics to construct and analyse mathematical models in social sciences. To achieve this aim, the bayesvl package integrates three core functions seamlessly: (i) designing Bayesian network models using directed acyclic graphs (DAGs) of bnlearn, (ii) generating attractive visualization of ggplot2, and (iii) simulating data and computing posterior distribution using the Markov chain Monte Carlo (MCMC) algorithms of rstan and rethinking. A case example illustrates how the bayesvl package helps leverage users' intuition in creating and evaluating mathematical models of their social scientific problems while minimizing the daunting aspect of writing complex computer codes.

Keywords: Bayesian network, bayesvl, ggplot2, mathematical model, MCMC.

Classification number: 7

1. Introduction

While there are many straightforward philosophical reasons for the greater widespread use of Bayesian statistics, it appears that, in practice, Bayesian statistical analysis is still limited to only a minority of social and behavioural scientists. The Bayesian approach is methodologically similar to the way one's intuition works [1]. There are several factors that provide Bayesian statistics with strengths over

traditional statistics, especially in the realm of social sciences and humanities. Firstly, the Bayesian inference process incorporates both mathematics and background knowledge in the model [2, 3]. Secondly, actual observations are the primary concern when checking the strength of evidence, unlike the assumption of an infinite number of observations in conventional statistics. Moreover, even when background knowledge is incorporated, the final results can still be computed appropriately

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with one model able to be quantitatively compared with other models [3, 4]. Here, the Bayesian approach enables researchers to utilise mathematical tools with intuition and common sense [5]. In essence, when using Bayesian statistics, a researcher will use prior distributions to reflect their initial beliefs (informed background knowledge, sometimes even intuition), then update their initial beliefs with new data to form posterior distributions [6-8]. However, social scientists are still more familiar with the conventional statistics [9]. For instance, studies in top sociology journals using Bayesian statistics are virtually non-existent [10].

One of the factors that contribute to this issue is the availability of friendly software for conventional statistics such as SPSS, Stata, or SAS. As for the lack of intuitive software, the current software packages for Bayesian analysis such as require OpenBUGS [11], JAGS [12], MCMCglmm [13], Stan [14], brms [15], rethinking [16], and rstanarm [17] require users to be highly familiar with a command-line interface. The users must code the model from scratch, which can entail a steep learning curve for many statistical novices. Thus, we created an R package called bayesvl to help social scientists focus on their research problems without being caught up in computational details. With relative ease-of-use and minimal coding, the bayesvl R package can help create Bayesian network models and automatically generate stan codes of the graphical structure of Bayesian networks to perform sampling and parameter learning. It can also perform the Hamiltonian MCMC simulations and provide multiple visualization

tools such as a Bayesian network graph, a bar chart for conditional probabilities, a trace plot, a Gelman shrink factor plot, an autocorrelation effect plot, a highest posterior distribution intervals plot, a density plot, a pairwise parameter comparison plot, etc. Moreover, it can produce a number of statistical and computational checks such as calculating conditional probabilities, the effective sample size, or r-hat statistics. Finally, it supports a detailed model comparison process with the Pareto-smoothed importance sampling leave-one-out cross-validation approach (PSIS-LOO-CV) [18], the widely applicable information criterion (WAIC) [19], and the Bayesian stacking weights [4, 20]. In this paper, we will briefly introduce the core functions of bayesvl and demonstrate its functions with a real-life example.

2. The bayesvl R package

The bayesvl project was launched in 2017 [21, 22] and the package was eventually published in CRAN [23] and Github [24] in 2019. There were several components that contributed to our conception of the software: the visualization capability of R and the causality and uncertainty inherent to Bayesian Network modelling [25]. Simulated data using the MCMC algorithm makes this package more scientific for social science research in the age of Big Data and is visually appealing and intuitive to the readers [26]. To this end, the bayesvl R package was developed referring to rethinking [16] and rstanarm [17] for MCMC simulation method; bnlearn [27, 28] for Bayesian network modelling; and ggplot2 for beautiful and flexible data visualization.

The model fitting procedure of the *bayesvl* package is relatively simple. First, it is recommended that users install version 3.5.1 or more recent versions of R software. Then, the *ggplot2*, *rstan*, and the *bayesvl* packages need to be installed. Then, a diagram needs to be built to visualize the relationship between variables.

Moreover, visualization supports four cognitive mechanisms: reinterpretation, abstraction, combination, and mapping [29, 30]. The *bayesvl* package provides simple code to help researchers build the diagram. Other packages for Bayesian statistics such as *brms*, *MCMCglmm*, *rstanarm*, and *rethinking* tend to require the user to code mathematical formulae, which can be intimidating. Thus, the simplicity of *bayesvl* code helps researchers ease into the world of Bayesian statistics. Next, the Stan code for model fitting can be created automatically with the *bayesvl* package's link to *rstan*. Finally, the *bayesvl* package allows the

MCMC results to be viewed in both numbers and charts.

3. Case example

In the following section, we will examine the model fitting procedures and graphical ability of the *bayesvl* package through a real-life example: a nested multi-level Bayesian network with varying intercept, which analyses how the satisfaction of medical patients are affected by their socioeconomic, residence, and insurance status, and the outcome of their medical treatment. The dataset for this real-life example was deposited in the Open Science Framework (OSF)'s depository and contained 1042 observations on health insurance, health care, and socioeconomic status [31, 32].

3.1. Model construction

The statistical problem at hand is to investigate the level of a patient's financial burden given their socio-residence status,

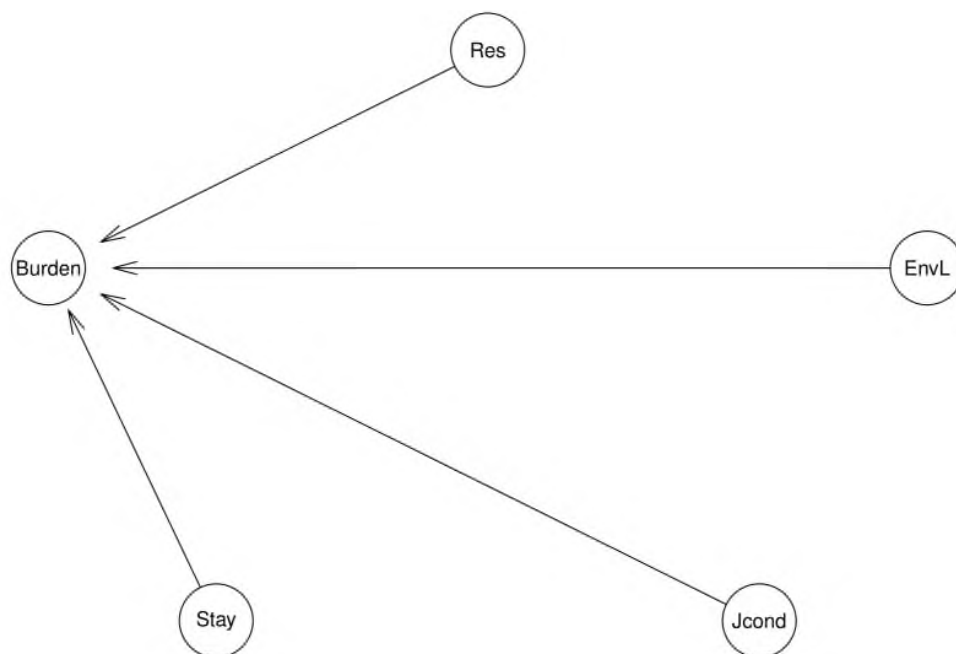


Fig. 1. A nested multi-level Bayesian network with varying intercepts analyses how a patient's financial burden is associated with their residence, length of hospital stay, employment condition, and the amount of 'thank you money'.

length of hospital stay, employment condition, and the amount of 'thank you money' included in the treatment fee. First, one can create a visual representation of the relationships among the variables, i.e., a relationship tree. Fig. 1 presents a visualization of this example.

Explanatory variables:

- *Res*: whether a patient lives in the same region as the hospital; yes=1; no=2.
- *Stay*: the amount of time a patient stays at the hospital; under 10 days (short)=0; or more than 10 days (long)=1.
- *Jcond*: the employment condition of the patient; stable=3; unstable=2; or unemployed=1.
- *Envl*: the amount of 'thank you money' that the patient must pay with the treatment fee; high (>15%)=3; medium (7-15%)=2; low (<7%)=1.

Response variable:

- *Burden*: the self-reported financial situation of the patient after the treatment; minimally affected (A)=1; adversely affected (B)=2; destitute (C)=3; adversely destitute (D)=4.

As one can see, the model is a nested multi-level Bayesian network, which enables simultaneous analyses of individual quantities to be performed [2]. This is also a direct example of how Bayesian modelling leverages the background knowledge of social science researchers [9]. It is true that data sets that pool data over multiple units are commonplace in social sciences; for example, people can

attend different schools, companies trade in different markets, and votes live in different communities. These causal structures are captured in Bayesian hierarchical models.

In a simple regression model, we have the following mathematical formula:

$$y_i = \alpha + \beta x_i + \epsilon_i \quad (1)$$

in which $\epsilon_i \sim N(0, \sigma)$.

With the varying intercept multi-level model, the mathematical formula has the following form:

$$y_i = \alpha_{[i]} + \beta x_i + \epsilon_i \quad (2)$$

Applying Eq. (2) to the model in Fig. 1, we have:

$$y_{\text{burden}[i]} = \alpha_{\text{Res}}[x_{\text{Res}[i]}] + \beta_{\text{stay}} x_{\text{stay}[i]} + \beta_{\text{Jcond}} x_{\text{Jcond}[i]} + \beta_{\text{Envl}} x_{\text{Envl}[i]} + \epsilon_{\text{burden}[i]} \quad (3)$$

In the model, β_{stay} , β_{Jcond} and β_{Envl} are three regression coefficients indicating the slopes of regression lines or the rate of change in y_{burden} as x_{stay} , x_{Jcond} and x_{Envl} change, respectively, while α_{Res} stands for a varying intercept.

Once the user has a clear picture of the causal and correlational structure of the variables, the next step is to code the Bayesian network model. The following box presents how the nodes and arcs are added to the model.

```
# Add nodes to model
model <- bayesvl()
model <- bvl_addNode(model, "Burden", "norm")
model <- bvl_addNode(model, "Stay", "binom")
model <- bvl_addNode(model, "Jcond", "norm")
model <- bvl_addNode(model, "EnvL", "norm")
model <- bvl_addNode(model, "Res", "cat")
# Add arcs to model
model <- bvl_addArc(model, "Stay", "Burden", "slope")
model <- bvl_addArc(model, "Jcond", "Burden", "slope")
model <- bvl_addArc(model, "EnvL", "Burden", "slope")
model <- bvl_addArc(model, "Res", "Burden", "varint")
```

A relational diagram is constructed with two commands: `bvl_addNode` and `bvl_addArc`. When using `bvl_addNode`, the statistical distribution of any variable is chosen with "norm" for normal distribution, "binom" for binominal distribution, or "cat" categorical distribution. Meanwhile, the code `bvl_addArc` is used for setting the mathematical relationship between two nodes, for example, with a fixed-effect model ("slope"), varying slope model ("varint"), varying intercept model ("varslope"), or a mixed-effect model ("varpars"). For multilevel modelling, random-intercept ("varslope") and mixed-effect models ("varpars") are used.

3.2. Automatic generation of stan codes

The `bayesvl` package allows the users to easily generate the stan codes for the model using the following commands:

```
# Generate the stan code for model
model_string <- bvl_model2Stan(model)
cat(model_string)
```

As a result, we have the following stan codes automatically generated from building the graphical structure of the Bayesian network.

```
functions{
  int numLevels(int[] m) {
    int sorted[num_elements(m)];
    int count = 1;
    sorted = sort_asc(m);
    for (i in 2:num_elements(sorted)) {
      if (sorted[i] != sorted[i-1])
        count = count + 1;
    }
    return(count);
  }
}

data{
  // Define variables in data
  int<lower=1> Nobs; // Number of observations (an
integer)
  real Burden[Nobs]; // outcome variable
  int<lower=0,upper=1> Stay[Nobs];
  real Jcond[Nobs];
  real EnvL[Nobs];
  int NRes;
  int<lower=1,upper=NRes> Res[Nobs];
}

transformed data{
  // Define transformed data
}

parameters{
  // Define parameters to estimate
  real<lower=0> sigma_Burden;
  real b_Stay_Burden;
  real b_Jcond_Burden;
  real b_EnvL_Burden;
  real a0_Res;
  real<lower=0> sigma_Res;
  vector[NRes] u_Res;
}

transformed parameters{
  // Transform parameters
  real mu_Burden[Nobs];
  vector[NRes] a_Res;
  // Varying intercepts definition
  for(k in 1:NRes) {
    a_Res[k] = a0_Res + u_Res[k];
  }
}

for (i in 1:Nobs) {
```

3.3. MCMC simulation and convergence diagnostics

Next, using the following commands, we can fit the model and execute the MCMC estimation for the model.

```
# Fit the model
model <- bvl_modelFit(model, dat, warmup = 2000,
iter = 5000, chains = 4, cores = 4)
summary(model)
```

The summary of the model is given in Table 1.

Table 1. Simulation result.

	Mean	SD	n_eff	Rhat
b_Stay_Burden	0.22	0.05	8933	1
b_Jcond_Burden	-0.50	0.04	8173	1
b_EnvL_Burden	-0.06	0.03	8613	1
a_Res[Yes]	2.76	0.12	7895	1
a_Res[No]	3.58	0.11	7846	1
a0_Res	2.79	3.13	1563	1.01
sigma_Res	3.66	3.82	2151	1

Two values were used to diagnose the convergence of the model: n_eff (effective sample size) and Rhat value. In standard practice, n_eff is good when it reaches above 1000 samples. Rhat is roughly 1, which means all chains have the same distribution. Meanwhile, the model should be checked again when Rhat is greater than 1.1. In Table 1, n_eff is greater than 1400 and Rhat equals 1,

which suggests that the model is successfully converged.

A fundamental aspect of the MCMC approach is to visually diagnose the convergence key indicators such as Markov chains, the Shrink factor, and the autocorrelation phenomenon. The following examples help us understand this visual diagnostics process.

Figure 2 presents the trace plots for all

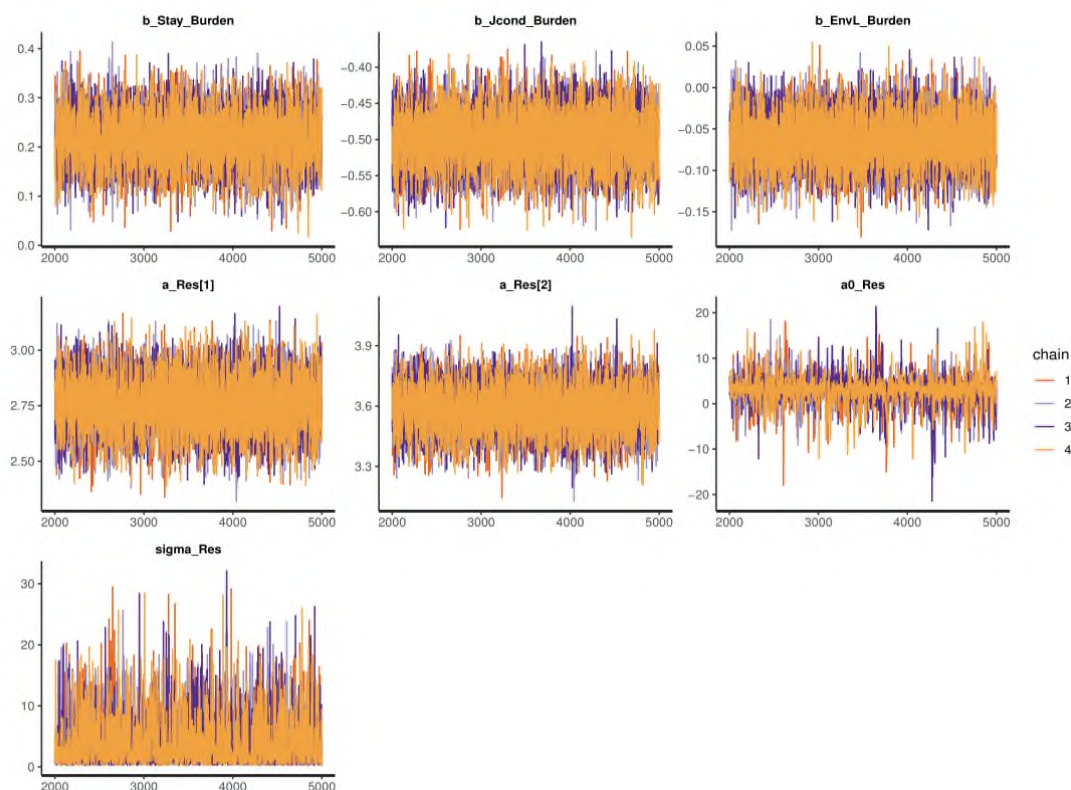


Fig. 2. The trace plot for each variable of the Bayesian regression model.

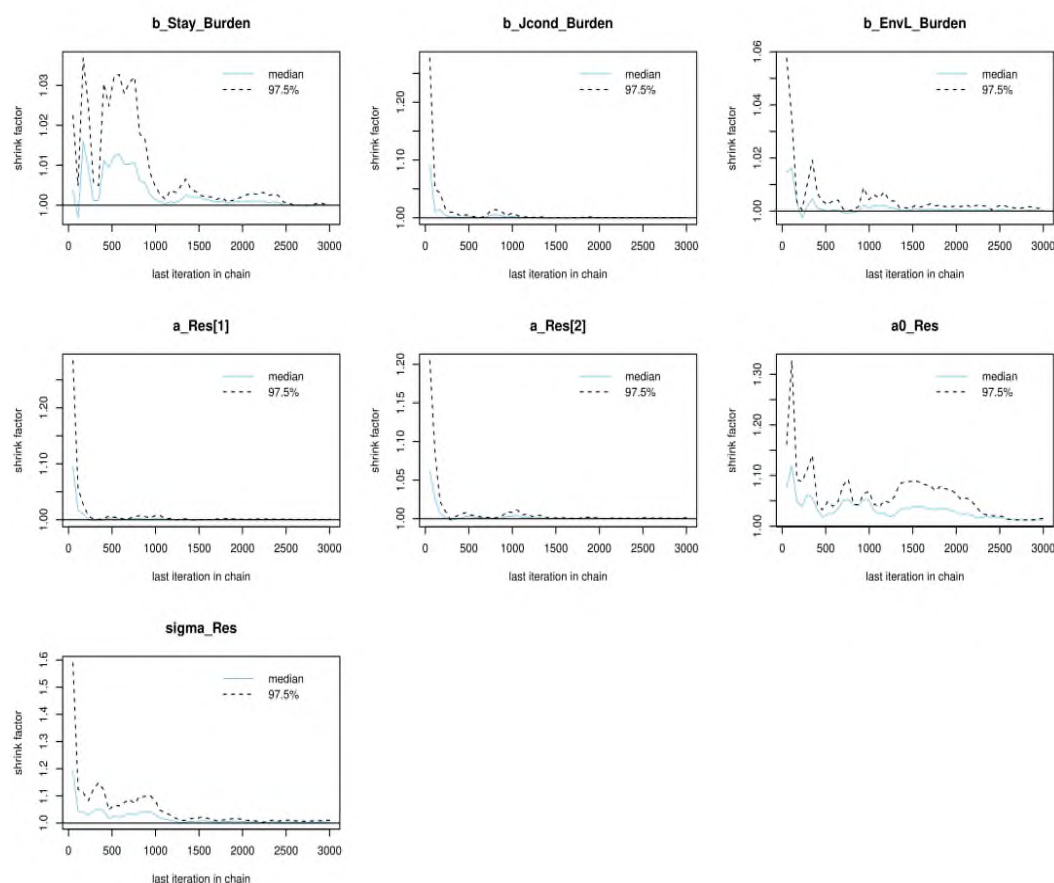


Fig. 3. The Gelman plot for each variable of the Bayesian regression model.

model variables, which show no divergent chains. The figure can be generated with the command `bvl_plotTrace`.

Figure 3 shows the convergence of all variables in the model according to the Gelman shrink factor (or potential scale reduction factor). To generate the visualization, the command `bvl_plotGelmans` is used. Similarly, Figs. 4 and 5 also illustrate different values for technical validation.

Figure 4 presents the autocorrelation factor (ACF) for each variable in the model (using the command `bvl_plotAcfs`). Technically, the MCMC algorithm produces samples that correlate with each other but are not independent. Therefore, the ACF plot allows researchers to check whether autocorrelation eventually stops.

Figure 5 provides technical validation for the posterior distribution of each variable in the model. The illustration can be generated using `bvl_plotParams`.

The Pareto-smoothed importance sampling (PSIS) diagnostic plot in Fig. 6 illustrates the model's goodness-of-fit given the underlying data. The PSIS diagnostic plot is used together with the leave-one-out cross-validation (LOO) technique to validate the model's performance. In the `bayesvl` package, the LOO-PSIS diagnostic can be used with the following command:

```
loo<-bvl_stanLoo(model)
plot(loo)
```

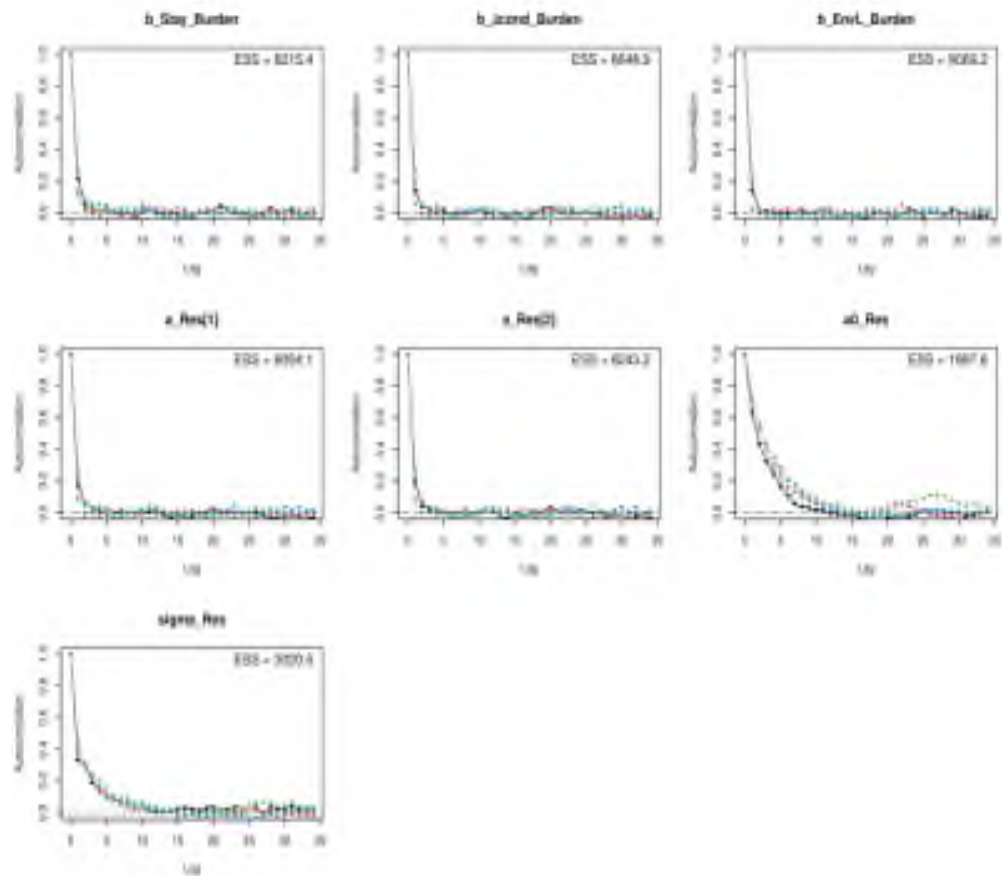


Fig. 4. The autocorrelation factor plot for each variable of the Bayesian regression model.

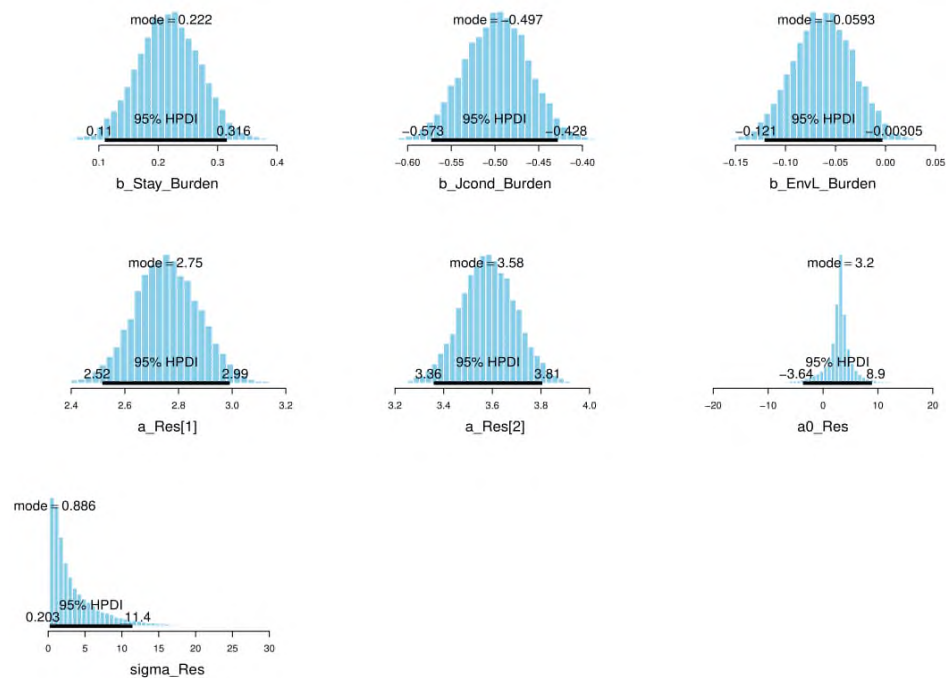


Fig. 5. The parameter plot for each variable of the Bayesian regression model.

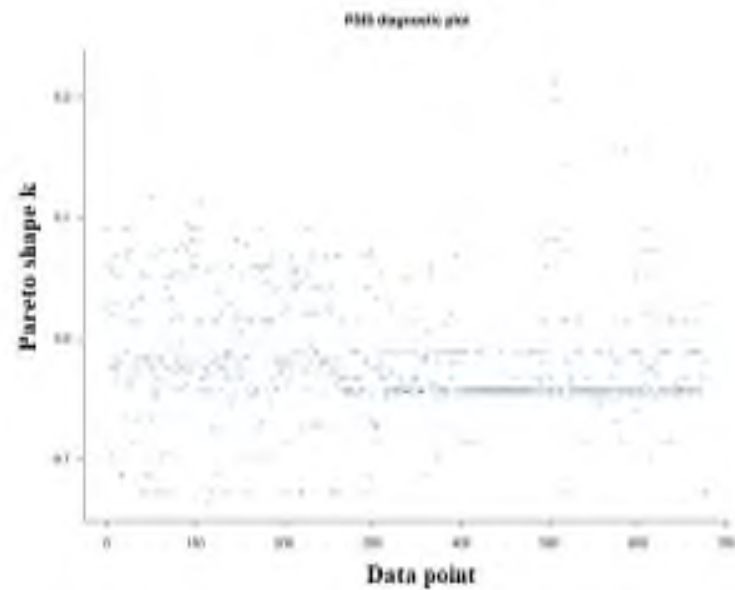


Fig. 6. The LOO plot for each variable of the Bayesian regression model.

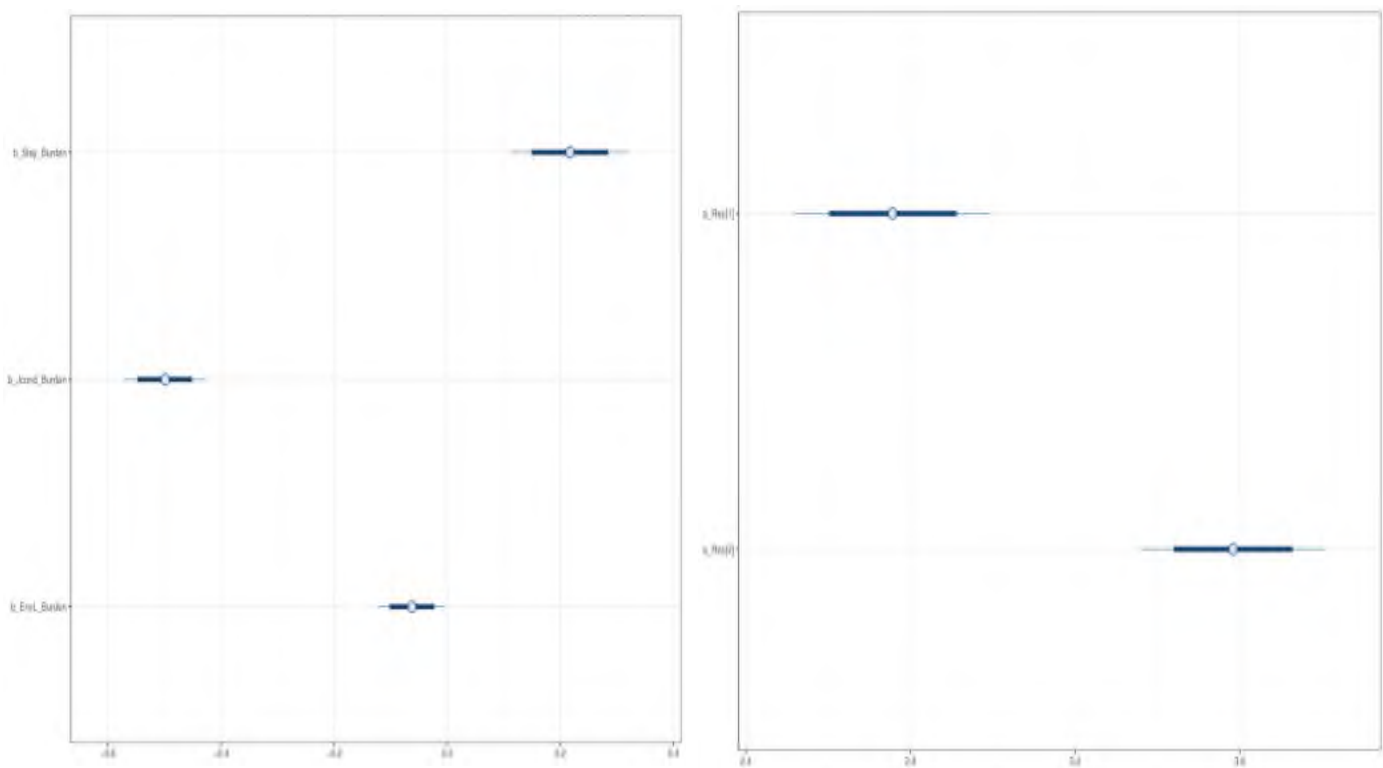


Fig. 7. The interval plot of the coefficients' posterior distribution.

3.4. Regression results

The range of posterior distribution (Fig. 7) can be visualized using the command `bvl_plotIntervals`.

Or we can view the coefficients in a different style using the command `bvl_plotDensity` (Fig. 8).

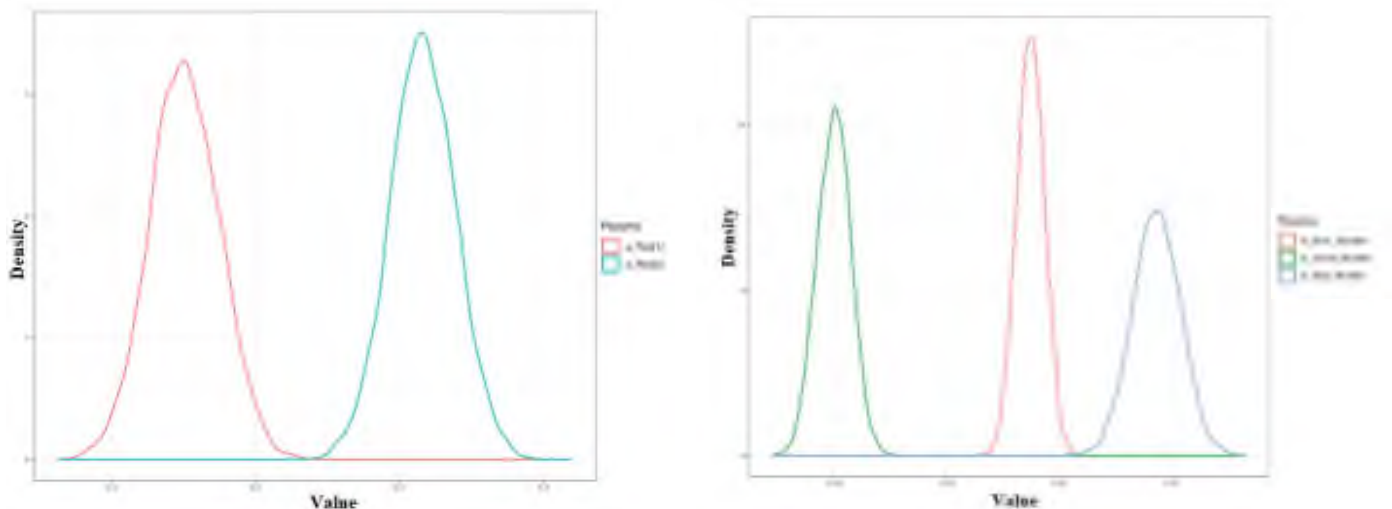


Fig. 8. Plotting the coefficients' posterior distribution.

4. Discussion

As demonstrated in the example above, the bayesvl R package can be useful for social sciences and humanities researchers to gain familiarity with Bayesian statistics. First, the bayesvl R package allows users to visualize their model in the form of a Bayesian network, and makes it relatively easy to code the graphical structures of any Bayesian network with only two commands: `bvl_addNode` and `bvl_addArc`. Bayesian network modelling is suitable for handling problems due to the veracity of data [25] as well as ensuring the examination of the models. As a visual presentation, researchers can visually inspect the formulated correlational structures [33, 34]. With the link to `ggplot2`, bayesvl allows quick and easy visualization of the data as well as of the posterior distribution. Good data visualization can help researchers quickly identify errors in the data [35] and point them toward possible causal/correlational structures in the data. Moreover, bayesvl can help researchers with the Stan code, especially new learners who are not familiar with the coding language of Stan.

B. Aczel, et al. (2020) [3] observed that selecting from a wide variety of inference tools in Bayesian analysis can be confusing and D. Spiegelhalter (2020) [2] also noted the daunting computational nature of modern Bayesian analysis, its lack of established and widely accepted criteria for significance, and its lack of user-friendly software. However, there have been many attempts to analyse the practice and philosophy of Bayesian data analysis to point toward a more established framework of Bayesian inference. For example, J. Gabry, et al. (2019) [36] argued that Bayesian data analysis, in practice, is an iterative process of model building, inference, model checking and evaluation, and finally model expansion. In each stage, visualization is indispensable. However, A. Gelman, et al. (2013) [37] argued that the most successful forms of Bayesian statistics do not support that particular philosophy but align more with a form of 'hypothetico-deductivism'. Similarly, S.E. Lazic, et al. (2020) [38] argued how a Bayesian approach can deal with the problem of pseudo-replication.

5. Conclusions

In building this software package, we hope to contribute to the growing spread of Bayesian statistics applications in the social sciences and humanities. We believe that an appreciation for testing and trying new methodologies will make social sciences and humanities studies more scientific and reproducible [39, 40]. Compared with the conventional frequentist regression, Bayesian regression modelling is better at dataset analysis of small sample sizes [41]. Moreover, the Bayesian approach offers a wide range of tools to construct, compare, and choose models based on their predictability performance [8]. In this new era of AI and Big Data, reproducibility and transparency are two values one must uphold, which will greatly reduce the cost of science [42].

CRedit author statement

Quan-Hoang Vuong: Conceptualisation, Editing and Reviewing; Minh-Hoang Nguyen: Writing - Original draft preparation, Data curation; Manh-Toan Ho: Editing and Reviewing.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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Land system and agricultural economy during the Tran dynasty: New approaches

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Abstract:

In Vietnamese history, the Tran dynasty was peculiar in that its military triumphs and literati rule formed a spirit that could hardly be found in other monarchical ages. There is thoughtful research being conducted on military arts during the wars against the Mongol-Yuan invasions as well as a considerable number of studies on the Tran culture and civilisation. However, the view from economic and social studies is likely thin. The land system and agricultural economy, among key foundations of all medieval institutions including the Tran dynasty, remain unclear with several unanswered questions. Through new approaches, this paper attempts to demonstrate a new scientific understanding and fill the knowledge gap. In summary, historical studies often mention two prominent socio-economic features of the Tran, including *dien trang*, *thai ap* ownership, and slavery system. However, further studies show that the “serf” was not as heavily exploited as in medieval Europe. With pro-agricultural and lowering taxation policies based on the idea of “relaxed ruler-ship as the root”, the Tran relied on village units as the foundation for the harmonious relationship between the state and its people and the model of a welfare centralised state.

Keywords: agricultural economy, land system, military arts, Tran dynasty.

Classification number: 8.1

1. Introduction

The Tran occupies a significant position in the history of Vietnam with its incomparable socio-political achievements. However, most dedicated research has concentrated primarily on tactical shrewdness during battles against Yuan’s invasions while some others extracted sophisticated cultural and civilisational manifestations of the dynasty. These studies lacked an appropriate socio-economic perspective in explaining much of these achievements. More analytically, the land management and agricultural economy, some of the core components of medieval politics that encompassed the Tran, need further

critical investigations. From several alternative approaches, this article aims to introduce a fresh look at this complex and hopes to bridge the gap in the literature.

2. Research results

2.1. Natural and human impacts on the topography of the Red river delta

According to recent bioclimatic findings¹, during the first three-to-four centuries of the second millennium AD that is, the same

¹Bioclimatic is an interdisciplinary field investigating natural impacts on biological forms to identify the main ecological conditions in the past. One of the principal methods is to investigate old trees’ rings.

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time period of Ly - Tran era (1009-1400) in Vietnam's history, southeast Asia unexpectedly became much warmer [1]. This development increased rainfall and effectively raised water levels in the rivers that created more and more distributary channels. The topography of the Red river delta was thus also restructured. Floods caused transient damages while speeding up the process of alluvial deposits that began to extend towards the southeast of the delta. By the thirteenth and fourteenth centuries, new habitat areas were formed along the coast, which makes up today's provinces of Nam Dinh, Thai Binh and Ninh Binh. The acceleration of alluvium deposit was also uneven with vestiges of scattering depressions and swamps sandwiched between the Red and Day rivers, especially in the low sections. More water resources and increasing cultivated landmass created favourable conditions for rice farming. Even wetlands were used for agricultural activities. For example, a large depression at the south of the delta became paddy fields for summer crops (*lua Chiem*).

The Nam Dinh province, at the end of the Ly and the beginning of the Tran, also suffered from this uneven topographical restructuring. Its districts, like today's Vu Ban and Y Yen, were filled with ponds, swamps, and lagoons. Rising tides along the Red river still regularly reached Co Le pagoda, which was originally named Keo (Giao Thuy) meaning the intersection of salt water and fresh water at high tide. Therefore, although Tuc Mac village (Loc Vuong, Nam Dinh) was the homeland of the Tran, it was not until 1262, forty years after the establishment of the dynasty, that the court built Thien Truong Palace². Most likely at the beginning of the thirteenth century, when the

Tran was founded, residency was still sparse. Thien Truong Palace was only built with the arrival of Tran Nhan Tong in 1270 who was also the first retired emperor to live there after ceding the throne to Anh Tong in 1293. Despite having close political associations with the Tran, vibrant social developments in the low sections to the south of the Red river from the end of the thirteenth century to the next were mainly because of economic factors, with the first being agriculture.

A Vietnamese historic solution to a dense geography of rivers was levee and dike construction. It prevented floods and expanded the area for rice cultivation on riverside spillways during rainy seasons. However, it was also dike and levee constructions that separated paddy fields from annual fertile alluvial deposits, causing the soil to quickly exhaust. Meanwhile, most of the silt in the hundreds of billions of cubic meters of water of the Red river system that flows into the sea each year was settled to the bottom, which caused the flow to rise and threatened the levee lines. Levee breaches occurred whenever there was an extensive flood and causing severe damage to local communities was an inevitable consequence of this solution. River bottoms became fuller over time, and more silt rushed to the sea mouths effectively creating dunes and mudflats at the river mouth and slowing down flood escape. Many depressions in the delta, formed by the rapid rate of alluvial deposits, still exist after thousands of years despite not receiving more alluvium. Maintaining dikes and levees became important administrative works as they became higher and bigger. Officials in charge also gained more significant roles.

Carrying the flood preventive methods of the Ly (1009-1225), the Tran attached special

²This differs from the circumstance under the Ly. Chau Co Phap was elevated to Thien Duc palace in 1009, right after the establishment of the Ly.

importance to dike and levee constructions. According to the record of March 1248 (imperial year *Mau Than*) in the Complete Annals of Dai Viet (*Dai Viet su ky toan thu*), the court “ordered constructing dikes, called cauldron dike (*de quai vac*), from upstream to the coast, to prevent floods. Setting up dike and levee construction supervisors (*Ha de chanh pho su*) to oversee... [the] construction of cauldron dike started from then on” [2]. This record also shows that the Tran had assigned the work of building flood preventive systems to specific *lo*³ (with rivers flowing through) in order to have an extended dike and levee system from upstream to the river mouth. According to experts, by the end of the fourteenth century, dike and levee constructions on the Red river delta were completed. Along with the construction, the Tran established supervisors who were responsible for managing, speeding up the construction, and maintaining the dikes. In the *lo* with dikes, each *phu*⁴ were to have two supervisors and deputy supervisors (*Ha De Su*)⁵. This local official position was carried forward into later eras.

2.2. Types of land ownership

Land ownership is the key to understanding socio-economic foundations. One of the notable types of land management in Vietnam’s history is village public ownership of land. This type of ownership appeared very early and existed until the mid-twentieth century. Under the Tran, public ownership in villages held an important position as it was the economic foundation for harmonious village-state relationships and the

basis for a welfare centralized state (*tap quyen than dan*).

Public land ownership in villages: under the general progress of land ownership and the historical reality in Vietnam, the size of land under the village public ownership dwindled over time and gave way to land privatization.

There is not enough historical evidence to fully restore the image of village public ownership under the Tran, but we can be quite certain that it was no smaller than that under the early Le (1428-1527) era when public ownership of land remained an economic pedestal for the centralised government. From the Le to the Nguyen, from official historical records as well as other types of historical documents like stele (*bi ky*), genealogy (*gia pha*), and land registration (*dia ba*), village public ownership was often called *cong dien* (公田) or “public arable land”. Under the Tran, this usage was still very rare. The term appeared mostly in oft-cited *An Nam chi nguyen* (安南志原)⁶ by Cao Hung Trung. In *Cong Phu* (貢賦, on tribute and tax), it is noted that the “Ly - Tran period had two types of public land ownership”⁷. One of those was recorded as *Quoc kho dien* (国库田) or “national treasure land”, which is a type of *cong dien*. In various studies about Ly - Tran’s land management, authors often categorise this as *state-ownership* and argue that it was actually *Cao Dien* (晁田), a type of land specifically cultivated by prisoners [3]. This is, in fact, a conflation.

³*Lo* is an administrative unit. The Tran Dynasty divided the country into 12 *lo* to manage.

⁴The lower level of *lo* was *phu*.

⁵*Ha De Su* (河堤使) is often mistaken as a court official. This was only a minor administrative position in each *phu*, *lo* with levee cutting through. However, the role was highly important in supervising overall levee constructions and maintenances.

⁶The original title could be *An Nam Chi* (安南志), however, there are also different titles. Here, we use the version that was referenced by Emile Gaspardone in his work in 2017, which has been translated and published by the Publisher of Hanoi National University of Education.

⁷“李陳之時公田有二名”, see Cao Hung Trung (2017), *An Nam chi nguyen*, Hanoi National University of Education, Hanoi, p.485 (for original kanji, see p.82).

Quoc kho (国库) in *Quoc kho dien*, as an official terminology, appeared very early in China's history and up until now it is still used with much of its original meaning: "national treasury" or *kho dun quoc gia*. The term is often used to refer to important national resources, assets, or incomes. There are no Chinese classics nor historical documents that saw "land" itself as part of "national treasure". *Quoc kho dien* so far only appeared in Cao Hung Trung's *An Nam chi nguyen*. It is likely that the author used the word *Quoc kho* to mean tax collected from a popular type of land ownership during the Ly - Tran period, which was also the primary source of state income. Under the Tran, this type of land was exactly public village ownership. Profits from the tiny *Cao Dien* could not be the major source of income of Dai Viet. With all the detailed tax rate recorded by Cao Hung Trung, it is hard to see "national treasure" merely represented an income from a small proportion of land with little economic significance. *Quoc kho dien* should be matched with something worth calling "national treasure land". It must be the vast area of public ownership in villages. When discussing Vietnam's history during the Tran, Chinese authors, who have sufficient semantic awareness, have already considered *Quoc kho dien* as lands that were publicly owned and as the main source of national income⁸. It is also quite clear that they do not see *Quoc kho dien* as state-ownership.

State-ownership of land: lands owned by the Tran are often referred to as, *quan dien*, *quan dia* (官田, 官地) or "official lands".

⁸郭振鐸, 張笑梅 (2001), 越南通史, 中國人民大學出版社 (Quach Chan Dac, Truong Tieu Mai (2001), *Vietnam thong su*, People's University Publisher (China), p.23.

State ownership of land appeared very early in China⁹ and can be used as a reference for understanding Vietnam's circumstances. State-owned lands came from different origins but were directly managed by the state. Under the Tran, official lands were largely inherited from the previous dynasty and were partly formed through reclamations and plantation building with the labours of prisoners, civilians, and soldiers. According to the Complete Annals of Dai Viet, Emperor Tran Thai Tong (1218-1277) captured many of Champa's soldiers and prisoners and brought them back to Dai Viet after the battle in 1252 [2]. Most of them were sent to wastelands for reclamation and then established Cham villages. The land, however, was put under state direct management [4]. This was the aforementioned *Cao Dien*, which located near the capital¹⁰ and served as a place for exiles. After five years of its establishment, in 1230, the Tran issued the legal document *Quoc trieu thong che* and accordingly, "prisoners who are sent to *Cao Dien* will have their faces inscribed with six

⁹*Quan dien*, *quan dia* (官田, 官地) are the types of ownership that appeared very early in China. By Sung era (960-1127), with the needs for a centralised economic and military forces, the court extended these types of ownership and since then, *quan dien*, *quan dia* gradually were separated from other types of public ownership, *cong dien* (公田). *Quan dien*, *quan dia* were extended in four directions: 1) Reclamation of low depressions; 2) Compulsory acquisition of private lands; 3) Set up management system over deserted lands and confiscate those belonged to run away; 4) Confiscating lands of criminals. Together with various methods of development, central courts also sold *quan dien* to private owners. By the time of the Ming (1368-1644) and Qing (1644-1911), these types of ownership were scaled down significantly. They only existed as assets of royal members, such as *Hoang trang* (皇莊) under the Ming, *noi vu phu quan trang* (內務府官莊) under the Qing, lands granted to public schools (官立學校), and plantation (屯田) in the frontiers. See 辭海 (1989), 縮印本, 上海辭書出版社, Shanghai Dictionary Publisher, p.1143.

¹⁰*Cao Dien* (梟田) is an area belonging to today's Dong Ngac, North Tu Liem district, Hanoi.

characters, live in Cao commune, work on public land, each has 3 *mau*¹¹, and pay 300 *thang*¹² of rice annually” [2]. This equalled the amount collected from mid-range types of land, like *Chuoc dao dien*.

Lands under state ownership during the Tran were utilised for various purposes. They could be used for building palaces or *hanh cung* (行宮). Several palaces were erected outside the capital Thang Long, including Thien Truong, Vu Lam, and the recently discovered Lo Giang palaces (today's Thai Binh). Besides, the Tran continued using those that were constructed under the Ly such as Ly Nhan (today's Ha Nam) and Ung Phong (today's Nam Dinh). Except for the Thien Truong palace, which was considered the “second capital” and was the residence of retired emperors, other palaces were relatively small and equalled the size of one or two communes. The lands for palace constructions were considered court private property. The people living there (and possibly the surrounding areas) were granted special privileges in order to serve the royal families, princes, and nobles.

Another important type of land that was state-owned was *son lang* (山陵) or “mausoleum”. By the time of monarchical absolutism, almost every dynasty attached great importance to the constructions of mausoleums and organizations of rituals practices. Tran's mausoleums were available in many places but were mainly concentrated in two major districts: Thai Duong, Long Hung (today's Hung Ha, Thai Binh), and An Sinh (today's Dong Trieu,

Quang Ninh). The area of *son lang* in Thai Duong equalled only to the area of a village and the land was primarily cultivated by the Thai Duong villagers. They were granted the same rights and duties as others who were exempt from taxation and forced labour (*dan tao le*) in order to serve the monarch. Profits from these lands were mainly used for annual rituals and as a stable source of income for the communities who helped organise the events.

In 1344, the Tran established the positions of plantation chief and deputy chief (*Don dien chanh su* and *pho su*) at *ty Khuyen Nong* (Agricultural Encouragement Office). This was an administrative decision aiming at specialising the management of *don dien* (屯田) or “plantation”¹³, another type of land that was state owned. Tran's plantations came from different origins, but the most common were production concentrated areas that were reclaimed and maintained by prisoners. There was no record of the Tran using military forces for labours on plantations. Most likely with the policy of *ngu binh u nong* (the rotation between army service and agricultural production), the standing army was not large enough to be deployed in economic activities.

Additionally, “official lands” or *quan dien*, *quan dia* also included lands that were temporarily awarded or distributed to royal members, nobles, and court officials with public achievements. This type of land was also included by Cao Hung Trung in

¹¹One *mau* was equal to ten *sao*. One *sao* was equal to 360 square metres.

¹²One *thang* was equal to 0.6 kg rice.

¹³*Don dien* (屯田) or “plantation” appeared first during the era of Three Kingdoms (220-248). Believing the words of a servant named Cuc De (枣祗), Cao Cao deployed his army into land reclamations and agricultural production. This was then extended by later monarchs. There were two types of plantation: *quan don* (军屯) which was used for military purpose and *dan don* (民屯) for civil purpose.

quoc kho dien, hence, a type of *cong dien*. Awarded lands were called *Chuoc dao dien* (斫刀田¹⁴). Etymologically, the name derives from Le Phung Hieu (982-1059), a court official with public achievements under Ly Thai Tong (1000-1054). He was mythologised as a brave general who could throw a blade as far as 10 miles, hence “*chuoc dao*” or “cutting blade” emerged. The court then rewarded him with the title of land magistrate, or *quan dia* (官地), and the land remained state-owned.

In principle, other than tax obligations, the state had the right to demand further profits from the cultivators living on awarded lands. However, many local documents (folktales, steles, or *minh van*...) recorded only a small amount (estimated from the total income of *quoc kho dien*) needed to be paid to the state. This shows that the court paid great attention to people’s livelihood, as Hung Dao Vuong (1229-1300) told Tran Anh Tong in 1300. Many documents also show that awarded lands were not permanent.

There were other types of awarded lands such as *Thai ap* and *Thang Moc ap*. The first written document referring to *Thai ap* is Hung Dao Vuong’s “*Hich Tuong Si*” (proclamation to the army) which was recorded in the Complete Annals of Dai Viet by the time of his death in 1300. The word *Thai ap* is mentioned twice in the document for symbolic purposes as my *Thai ap* (余之采邑) [2]. In reality, *Thai ap* mainly functioned as a temporal residence for royal members and nobles outside the capital. Owners of *Thai ap* were granted lands and several households for tax collection and

services. According to Ngo Si Lien, the Tran ordered “royal members [to] stay in their *Huong ap* [*Thai ap*], when they have an audience with the king, they come to the capital, and then return to their own palaces; Quoc Tuan in Van Kiep, Thu Do in Quac Huong, Quoc Tran in Chi Linh are all like that” [2].

If *Thai ap* was awarded according to position and title, *Thang Moc ap* was largely used either as a reward or compensation to defuse conflicts among royal members and nobles. *Thang Moc ap* had no uniform regulations and was granted and regulated on an ad hoc basis. Like *Thai ap*, the receivers were not given full control. Other than a small area for palace construction, they could only collect taxes and mobilise service workers. Ownership still belonged to the state. Thus, this type of land management is not much different from the system under the Ly. Beside *Thai ap* and *Thang Moc ap*, there was *Thuc ap* (食邑). This was the type of land that the state granted to royal members and nobles so that the latter could reap some needed profits from collecting taxes or mobilising labour forces. Normally, such profits would belong to the state.

Depending on the nature of public ownership or state ownership, the court may allow turning a portion into private ownership or grant permission to collect tax. On this occasion, *Thai ap* and *Thang Moc ap* were not privately owned by royal families and nobles. This practice differed completely from European enfeoffment¹⁵.

Because the Tran did not have a consistent system for land management, it is quite

¹⁴In the historical accounts of the Ly - Tran era, authors often cited a passage translated from *Dai Viet su ky toan thu* and explained this as *Thac dao dien* (lands gained by throwing blade). In fact, *Dai Viet su ky toan thu*, *An Nam chi nguyen* and *Nam ong mong luc* (by Ho Nguyen Trung) all recorded this as *Chuoc dao* (斫刀), which is a type of weapon.

¹⁵Several research have categorised *Thai ap* and *Thang Moc ap* together *dien trang* as types of private ownership. For example, T.H. Quynh, D.X. Lam, L.M. Han (1998), *Overview of Vietnamese History*, Hanoi Education Publisher, 487pp (in Vietnamese).

difficult to gather comprehensive information about *Thai ap* and *Thang Moc ap*. Based on scattered records in ancient texts¹⁶, fieldwork collections¹⁷, private ownership of land can be summarised as follows.

Private land ownership: Private land ownership had already gained significance under the Ly. By the time of the Tran, this form of ownership developed even further. Private land was recorded in historical documents as *dan dien dia* (民田地) or *danh dien* (名田) [2]. Private ownership led to the expansion of the land market. Since the Ly, land trading activities were already vibrant. The court had to issue many decrees and regulations to settle ownership disputes or land-related conflicts. The Tran also paid attention to the format of official documents. In 1227, the court decreed that all applications and documents must be signed by having a handprint on half of a paper sheet (押手半紙法) [2]. After ten years, the regulations were tightened yet again and according to which testaments, land purchase documents, or money borrowing must have witnesses. Witnesses hand-printed (押手) on the first three lines followed by seller's handprint on the next four [2].

A distinctive aspect of land trading was that the Tran were also involved in these activities. In 1254, the court sold *quan dien* (鬻官田) to villagers at a price of five “strings”

of money (*xau* or *quan*, 五鎰) per *dien*¹⁸. There is not enough historical evidence to gain a deeper understanding of the court's selling prices in comparison with market prices, but some documentation may allow us to have an estimation of the monetary value of a *mau*. From the inscriptions on steles at the The An pagoda built in 1209 (the 5th year of Tri Binh Long Ung), there is some information about a Nguyen family who donated more than a hundred *mau*. To buy this land, he originally paid a thousand *quan*. Thus, each *mau* costed about ten *quan* (double the court's price of five ‘strings’ or *quan*). In 1291, when Dai Viet suffered from a famine, rice became expensive and one *quan* could only buy three *thang* of rice. The price of a *mau* of land in the middle of the thirteenth century thus only equalled fifteen *thang* of rice¹⁹.

Private ownership also includes the public land that was subjected to various encroachments and reclaimed areas along riverbanks. This was a major policy of the Tran as the court encouraged nobles to take part in reclamations. Lands that were privately owned in Dai Viet thus existed in various forms and scales. Based on varying local documents such as steles or genealogy, we can notice that small and medium-sized owners make up a significant proportion of private land ownership. What is quite special,

¹⁶Mainly from documents like *Dai Viet su ky toan thu*, *Lich trieu hien chuong loi chi* (by Phan Huy Chu), *Kien van tieu luc* (by Le Quy Don), *Nam ong mong luc* (Ho Nguyen Trung) (in Vietnamese).

¹⁷This was mentioned in *Land Regime and Some Historical Issues in Vietnam* by T.H. Quynh and *Thai ap - Dien trang of the Tran Dynasty (XIII-XIV centuries)* by N.T.P. Chi (in Vietnamese).

¹⁸The character *cuong* (鎰) means “string” of money. Most research has translated this as “quan”. Under the Tran, one *quan* was worth 10 *tien*, each *tien* worth 60 *dong*. To exchange, people stringed together 600 *dong* which was equivalent to a *quan*. The character *quan* (貫) means a string of money.

¹⁹Fifteen *thang* was equal to over ten kg of rice, at the same time, a servant was only worth one *quan*, *Dai Viet su ky toan thu* (1993), 2, p.202 (in Vietnamese).

unlike in other East Asian countries, is that women owning private land was a common phenomenon. The documents also show that, under the Tran, measuring units were quite arbitrary. Besides standard units such as *mau* (*dien*), *sao*, and *thuoc*²⁰, there were also unconventional units based on popular usages such as a *khom*, *bon khom*, *thua*, and *phan* [3]. This shows that land management and control were not entirely centralised. Most likely, state data on arable lands was based primarily on local informants. Lands that were privately owned were often small and their whereabouts were estimated using nearby locations. We often encounter descriptions such as the (private) land “near the east of Dao Thu” (*Dong can Dao Thu*), “near the west of Dang Tinh” (*Tay can Dang Tinh*), or “near the south of Chang Tu” (*Nam can Chang Tu*). They were all relatively small ownership such as “1 *sao* 9 *thuoc* near the east of Vu Mai”, or “4 *sao* 5 *thuoc* near the west of Nguyen Lanh”.

The development of private ownership of land inevitably led to land accumulations, which effectively produced large-scale landowners. Among them, ordinary landowners (without titles) who owned up to hundreds of *mau* were not rare. There were wealthy owners who donated large areas of land to pagodas such as Nguyen Truong Le, from Van Dong village who contributed 75 *mau*, or a dancer from Hoa Lu who offered 20 *mau* to Quynh Lam pagoda.

The most notable example of large-scale private landownership under the Tran was

dien trang, which are the private estates of royal members, nobles and court officials. *Dien trang* emerged after 1266 when the court encouraged nobles to reclaim riverside and coastal lands and set up private estates there. Ngo Si Lien made a detailed comment that “royal members often send their servants to build coastal levee to prevent saltwater, and to reclaim the land after two to three years, let them marry each other and stay there, and set up many private lands” [2]. By the end of the Tran, Ho Quy Ly implemented a series of reforms including the policy of *han danh dien*, and, according to which, except for the emperor and the chief princess, all landowners could own a maximum of 10 *mau*. Surplus lands must be submitted to the state and become *quan dien* (官田). Ngo Si Lien explained that it was because royal members and nobles had accumulated too much private land [2]. The policy of *han danh dien* thus was a political move to restraint emerging economic forces among nobles by extinguishing *dien trang*, a type of private ownership and at the same time to increase the size of state ownership.

Pagoda ownership: this was also a type of ownership with lands came from many origins. First, it was the property donated by Buddhist devotees, which was a very common practice. Almost every pagoda under the Tran had land donated by Buddhist followers. The size of the land was also very diverse. Usually, each land donation ranged from a few *sao* to a few *mau*. For example, Van Hue Vuong Tran Quang Trieu alone contributed 4,000 *quan* of money and 300 *mau* to the aforementioned Quynh Lam pagoda, while Bao Tu Hoang Thai Huong offered more than 50 *mau*. These lands were

²⁰One *thuoc* was equal to 24 square metres.

all privately owned and distributed differently across locals. Pagoda lands, most times, were also granted by the court or donated by emperors, queens, royal members, or high-ranking court officials. Despite not having coherent regulations, it was quite common for the court and court officials to donate land to pagodas. Although pagoda land ownership was quite large, it had little impact on Tran's land management. The size of land ownership was more of an expression of Buddhist socio-political influences in the contemporary society rather than an economic foundation for ecclesiastical power as in Europe.

2.3. Land policy and agricultural economy

Under monarchical absolutism, in many countries, especially eastern countries, the central court had a special power allowing it to assume the supreme ownership of the land²¹. Unlike territorial sovereignty, which is the sovereign rights of the state over an entire territory that any country would have with the formation of the modern state, the supreme ownership of the land is a concept used to refer to state supremacy over the entire land as a means of production, an important type of asset that evolved together with an increasing role of the state in managing agricultural economic activities. In various eastern countries, the necessity for constructing and maintaining irrigation systems was an important factor that contributed directly to this power evolution [5].

²¹The supreme land ownership (最高土地所有权, Верховная Собственность на землю) was a complex historical process. In Vietnam's medieval history, not until the early Le when this type of ownership was fully established.

In Vietnam, until the early Le (1428-1527) when the state was powerful enough to put all lands under its command, the state could promulgate *quan dien*²², taking away from villages the rights to manage and distribute land. With that, the supreme ownership of the state over land was officially established²³.

Under the Tran, taxes collected from public ownership which occupied much of the entire arable land were the major source of state income. The tax rates were defined according to land qualities (upper, middle, and lower land) and calculated based on *mau* as the measuring unit. However, from various historical documents, under the Tran, calculations of land area were not standardised. *Dien* as a measuring unit was also annotated as *mau*, but it did not have consistent dimensions²⁴. Thus, until the end of the Tran, the court had not conducted a national land measurement. Most of the figures for tax purpose may have been submitted by local self-governing apparatuses.

²²Perhaps, the adage "land of the king, pagoda of the village" (*dat vua, chua lang*) came from this.

²³Inherited the socio-political legitimacy of the Tran which had been accumulated through various achievements such as fending off foreign invasions, organising irrigation systems and general development of Dai Viet, in 1397, Ho Quy Ly ordered "each landowner has to report the amount of land they own, with his name put on the land. Lands without report or commitment will be confiscated as *quan dien*", *Dai Viet su ky toan thu* (1993), 2, p.293. This was one of the key steps in establishing the supreme ownership. The Ho was defeated against Ming invasions, and thus it was until the early Le, when this authority was fully established.

²⁴Stiles at Long Dau Pagoda erected in the twelfth year of Hung Long (1304) noted: "an arable land of 63 *dien* 83 *sao* in Dong Ha, Da Ly. Used 31 *dien*, 91 *sao*... for traffic... used 15 *dien* 95 *sao* 10 *thuoc* 7 *tac* for *sa mon*". The milestone at Da Boi also recorded: 12 *dien* 11 *sao*... however, this information does not allow an exact estimation of how many *sao* per *mau*.

The Complete Annals of Dai Viet recorded in 1242 that:

“[the court] divide the country into twelve *lo*. Set up [the administrative positions of] *An Phu*, *Tran Phu* with a chief and deputy officer. In communes, set up *dai* and *tieu tu xa*. [Court officials] from fifth rank up is *dai tu xa* and from sixth rank down is *tieu tu xa*. There are people who are simultaneously in charge of 2, 3, 4 communes, together with *xa chinh*, *xa su*, *xa giam*, and *xa quan*”.

Based on this record, official historical accounts under the Tran assumed that the court had set up heads for each commune by that time. They were *xa quan*. The state intervened in village politics, however, further research showed that this initial assessment may not be accurate. First, with the position of fifth rank and sixth rank, *dai tu xa* and *tieu tu xa* were unlikely the heads of a village. Under the Tran, they were equal to *Luc Bo Lang Trung* (the head of a Ministry Office), *Thiem su* or *Tri Phu*, and *Tri Chau*, which were positions much higher than that of a village head. It is likely that the above passage only implies certain court positions in charge of managing village-related affairs. There was an equivalent unit of “*xa*” named “*huong*” with administrative tasks that were all undertaken by local self-governing apparatuses. Thus, by now, the rights to manage and distribute lands that were publicly owned remained within village politics.

Even though the Tran did not have a strict land management system as that under the Le, the court could still infiltrate village politics. First, it did so by controlling the number of males in the populations. Immediately after it

was found, the Tran set up local census records to manage the male population. According to Phan Huy Chu, soldiers had no salary. They performed their duties and once finished they went back to self-sufficient cultivation. These soldiers were given some portion of public land as a reward. Sometimes, the court may even intervene directly in the distribution of arable land. The Complete Annals of Dai Viet recorded a typical example of this. In 1337, when mentioning the merits of the servants, retired emperor Tran Minh Tong did not agree to award a title to Hung Hieu Vuong’s boat keeper Pham Ngai, but later granted him 5 *phan* of a *suat* of arable land [2]. *Phan* and *suat* were some of the measuring units back then. As it required an official decree to grant a mere portion of arable land to a servant, we can argue that land ownership still largely belonged to villages, not the court.

The ability of the central court to control villages also manifested in the practice of rewarding court officials with a tax portion. In *Lich trieu hien chuong loai chi*, when discussing salaries of court officials in 1244, Phan Huy Chu commented: “Perhaps [we should base on] public land tax rate, set up standards, just like recent practice of *ngu loc*?” [6]. According to this policy, the court used *quoc kho dien*, the income from taxing public land, as a reference to determine reward and pay scale. Phan Huy Chu’s comments can be substantiated by historical evidence of official tax collectors who “relaxed taxation... people are all grateful” (according to the myth of Tran Nhat Hao, Tran Khanh Du). Similarly, to show their benevolence, royal members and nobles also lowered both tax and service requirements thresholds. Thus, under the Tran, the public

land owned by villagers still accounted for a large proportion of the entire arable land of Dai Viet and its tax contributed significantly to state income. The court did not interfere in the management and distribution of village public land but had a certain level of control over these affairs.

With such importance, the tax rate stipulated in *Quoc kho dien* was highly detailed, clear, and coherent. According to Cao Hung Trung (2017) [7], it was divided into three levels:

- Best quality type (*thuong dang*): sixteen *thach*, eighty *thang* each *mau*
- Medium quality type (*trung dang*): four *thach* each *mau*
- Poor quality type (*ha dang*): three *thach* each *mau*

It is difficult to estimate with these measuring units. According to several calculations, a *thach* (石) is equivalent to nearly 40 kg of grain. Hence, the corresponding tax rate for each *mau* of the best quality is about 650 kg, the medium quality is about 160 kg and the poor quality is about 120 kg. Applying traditional methods, average yields of the best quality type could reach 600-800 kg per *mau*; for the medium type, it was 400-500 kg per *mau*; and for the poor quality type, it was about 300-350 kg per *mau*. The first two types allowed two crops per year²⁵. Thus, with the above tax rate, villagers only had to pay roughly 25-30% of the total harvest [8].

As a reward, the court could temporarily

grant rights to collect taxes and mobilise labour to royal members, mandarins, and those with public achievements. Grantees were responsible for a “relaxed rulership” (*khoan thai suc dan*) in order to create a harmonious society (*tren duoi dong long, an hem hoa muc, ca nuoc chung suc*) in the times of hardship.

Quan dien and *quan dia*, state-owned lands, were utilised for various state activities such as ritual ceremonies, building mausoleums (the land of Son Lang), exiling criminals (*Cao Dien*), and settling prisoners (plantations). Yields from these lands were fully owned by the state and mainly spent on on-site expenditure. These types of land were also used as rewards to royal families, mandarins, those with public achievements, and pagodas. The aforementioned *Chuoc Dao Dien* was still part of public ownership. In fact, the recipients of the land could pass it on to the next generation, but not entirely as a private property because the court could retrieve it in case descendants committed a crime and were thus not entitled to transferring or trading rights. This can be understood as a conditional type of land distributions and rewards. According to Cao Hung Trung, the nature and tax rate of rewarded lands under the Tran was similar to *Chuoc Dao Dien* under the Ly. Taxes collected from this type of land are prescribed as follows:

- Best quality type (*thuong dang*): a *thach* each *mau*.
- Medium quality type (*trung dang*): a *thach* each three *mau*
- Poor quality type (*ha dang*): a *thach* each four *mau*.

As mentioned above, a *thach* weighed approximately 40 kg. Accordingly, medium

²⁵According to several *Bi ky* and Le Quy Don's *Van Dai loi ngu*: a *mau* of land of good quality (in the eighteenth century) could yield 25-30 *ganh lua*, which is roughly one ton or 600-800 kg of grain.

and poor quality types were taxed, respectively, at 13.3 kg and 10 kg each *mau*. This may be because of productivity issue, but this tax rate was significantly lower than those imposed on other items of *quoc kho dien*. It can also be understood that this tax rate was the portion that awardees had to give back to the state (exemptions were often stated beforehand) and this low tax rate was in fact a preferential policy towards royal families and nobles. The court selling lands to private owners in 1254 was evidence of state-ownership, and it also shows that *quan dien* was still abundant and the state was not seriously interested in preserving this type of ownership.

While considering the public ownership of land in villages to be the major source of national income, the Tran respected village autonomies. Like other monarchs in medieval Vietnam, it was a type of hydraulic state. The state contributed to organising, constructing, and maintaining irrigation systems while playing an important role in fending off foreign invasions. For this reason, the state gained tremendous support from villagers. Along with the consolidations of political and economic strength, the Tran also came close to full domination over the entire public land, especially the public land owned by villages. The first to claim the supreme ownership of public land was Ho Quy Ly who was then followed later by early Le emperors.

During the Tran, private ownership was also encouraged. The state protected both private ownership of lands and paddy fields. There was a rare event in the history of Vietnam's monarchical absolutism when the state had to

compensate when taking land from villagers for levee constructions. Normally, to carry out welfare projects such as levee constructions, the state could requisite all necessary resources. But in this case, the institution of private land ownership was preserved. In 1248, the court ordered each *lo* to construct flood preventive levees from headwaters to the coast and to "measure how much land needed to be taken from villagers" to compensate according to market rate" [2]. Thus, not only were villagers compensated for the land taken for levee constructions but also reimbursed at market prices. This shows a rather favourable attitude in the court's policy towards private owners. This also shows that, under the Tran, supreme ownership of the state over land had not yet formed.

To encourage the development of large-scale private land ownership, the Tran also mobilised royal families and nobles in the reclamation of riverside and coastal areas to set up manors (*trang vien*). Politically, allowing "royal members, princes, princesses, concubines" to set up private estates was a solution to unite royal forces and sustain their loyalties. This was quite a unique policy under the Tran. However, over time, corruptions among nobles exposed various shortcomings of the system, which eventually intensified oppositions against the court.

In terms of tax policy, many researchers have argued that it was not until the eighteenth century that monarchies in Vietnam began to tax private land, however, our primary sources show that taxing private land began from the Ly. The Complete Annals of Dai Viet notes

that: “In August of the first year of Hoi Phong [1092], there was a bumper crop. Establish land record, collect three *thang* per *mau* to provide food for the army” [2]. In the *Cong phu* section, when mentioning tax rate during the Ly - Tran era, Cao Hung Trung wrote: “[with] people’s land, collect three *thang* per *mau*” [7]. In 1402, Ho Han Thuong raised the tax rate from three up to five *thang* per *mau* [2]. This was accompanied with a tax regulation imposed on male owners based on their volume of private land. This regulation is similar to the tax rate during the early Tran era, according to which “male landowners pay by grain, people without land are exempt. [The rate is] a *quan* per one or two *mau*, two *quan* per three *mau*, three *quan* per five *mau* or more” [2].

The above information, which was collected from different historical periods and primary sources, shows that three *thang* per *mau* was a very low tax rate and it was the rate imposed exclusively on private ownership. Describing the method of tax collection, the Complete Annals of Dai Viet and *An Nam chi nguyen* all identified *trung to* or ‘attendant taxation’ (徵租), and this was to show some kind of leniency on landowner rather than exercising absolute power. Compiling land registrations at the end of the eleventh century was also recorded as *dinh dien tich* (定田籍) or “written record of the land registration”. This implies that low first tax collection was only symbolic. This was the first step towards the establishment of the supreme ownership of land by monarchies in Vietnam.

Pagoda owned land was a relatively special type of ownership. Pagodas had a huge amount

of land, but they hardly had any economic influence under the Tran. Lands were gained primarily from political and religious reasons. The court also used lands that could be taken from state-own to support Buddhism. Buddhist devotees, including court officials and nobles, donated their lands to show their respects and to wish for future blessings. All these lands had private origins. Pagodas had many types of ownership, but they only mirrored existing land management with little actual impact on the system of land ownership.

According to many calculations, in between the thirteenth century and mid-fourteenth century, the population of the Red river delta had doubled and the density of residence in the region could be up to 150-180 people per square kilometer [9]. The relatively open land policy created opportunities for many village landowners. A consistent policy of the Tran (until Ho Quy Ly’s reform) was to encourage the process of land accumulation. With this, there were emergencies of landowners who owned hundreds of *mau* [3]. The number of wealthy landlords was quite large during the battles against Mong - Nguyen and Tran Hung Dao as they had to count on them to support his armies. During the Bach Dang campaign, a unit of the imperial army had already marched to the battlefield, but the military supplies and provisions did not arrive in time. Some wealthy villagers in Thuy Nguyen (today’s Hai Phong) were willing to contribute their own rice stocks. Many of the large landowners were nobles and court officials especially since the court encouraged the reclamation and establishment of private estates.

The development of the sub-agricultural economy and the relatively large-scale landownership conditioned the development of the commodity economy. Vibrant market systems created a vivid economic picture in rural areas. In 1293, Yuan emissary Tran Cuong Trung (Tran Phu) after returning from the mission, wrote a book entitled *An Nam tuc su* (contemporary An Nam), which provided many vivid vignettes of everyday lives under the Tran. Describing commodity markets, he observed markets had two sessions every day with hundreds of commodities on display [10].

Originating from the idea of “relaxed rulership as the root” (*khoan thu suc dan lam ke sau re, ben goc*), the Tran regularly implemented welfare policies to support people during times of hardship. Responding to droughts and floods, the court often exempted or reduced taxes. Large-scale exemptions were recorded in 1290, 1307, 1343, and 1362. The high-ranking court official Tran Khac Chung asserted that when floods occurred, the king must come to rescue his subjects and that was truly the kingly ethics. However, these policies only lasted until the mid-fourteenth century. After that, Tran nobles moved away from their people. Private estates gradually lost the character of a dynamic economic model and became a place of labour exploitation. During the late Tran, Dai Viet entered a period of turmoil.

3. Conclusions

The land management under the Tran differed significantly from both previous and subsequent eras. The changing topography

of the Red river delta and agricultural circumstances were results of both natural evolutions and human activities, including the unusual rainfall in the thirteenth century and the attempts to construct levees on most major rivers. Controlling floods was a critical task, hence the state set up supervising positions of *Ha de chanh su* and *pho su* in the *lo* with rivers passing through. These local officials had a very important role. By this time, the state, however, had not assumed supreme control over lands. The public land ownership in villages remained the main source of national income. The *quoc kho dien* mentioned in Chinese national archives included this type of land. Because of this, the court set up *dai tu xa* and *tieu tu xa* to infiltrate and oversee village affairs.

A special feature of land ownership under the Tran was that it quickly evolved thanks to various court’s incentives. Private ownership contributed significantly to Dai Viet’s economic strength. Pagoda ownership was also not insignificant. However, this development was conditioned by enormous Buddhist socio-political influences. It was not at all the same as in Europe, where land ownership made up the economic power of the church.

Historical studies often mention two prominent socio-economic features of the Tran, including *dien trang*, *thai ap* ownership and slavery system. However, further studies show that the “serf” was not heavily exploited as in medieval Europe. With pro-agricultural and lowering taxation policies based on the idea of “relaxed rulership as the root”, the

Tran relied on village units as the foundation for the harmonious relationship between the state and its people and the model of a welfare centralised state.

COMPETING INTERESTS

The author declares that there is no conflict of interest regarding the publication of this article.

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Vietnam's Middle and Late Neolithic marine cultures

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Abstract:

This article presents the basic content of the prehistoric marine cultures in Vietnam in the Middle Neolithic including Cai Beo culture, Trang An relic complex, Da But culture, and Quynh Van culture as well as Late Neolithic marine cultures including Ha Long, Hoa Loc, Bau Tro, and Xom Con. This study clarifies human adaptation to changes in the ecological environment in each region, the cultural achievements of inhabitant groups in these localities, and the position of communities in the coastal plains during the formulation and development of Vietnam's prehistoric marine culture. Today, Vietnam's marine region has been under the influence of rising sea levels. Rising sea levels would lead to the disappearance of archaeological sites as it did in the late Pleistocene. In the future, the sea will extend, while mountains are being destroyed, hills are being levelled and the sea being filled, all of which will result in the permanent destruction of a number of sites. Each individual archaeological site not only serves as an annal, but also an identity card of the country in an integrated world. Evidently, the prehistoric sites of the marine cultures of Vietnam have been playing a particularly important role in the socio-economic development of Vietnam and it needs to be studied, protected, and brought into play.

Keywords: East Sea, marine culture, Neolithic, Prehistoric cultures, sea level fluctuation.

Classification number: 8.2

1. Introduction

Vietnam is located in Southeast Asia between 23°22'-8°30'N and 102°-109°24'E (mainland) or 117°E (islands). The mainland covers an area of 331,688 km² and its continental shelf connected to Southwest Pacific Ocean extends more than 1 million km². With such a location, Vietnam demonstrates an apparent advantage as a bridge that links its mainland to islands in Southeast Asia. The coastline of Vietnam is 3,260 km long with every 100 km² of land owning 1 km of coast (the world average is every 600 km² of land has 1 km of coast). In Vietnamese waters, there are thousands of islands and archipelagos connected to the mainland via an extensive continental shelf.

The East Sea extends over an area of 3,537,000 km², is 1,400 m in average depth, and pertaining to the tropical and equatorial climate pattern. The Vietnam sea accounts for almost one-third of the East Sea's area. An outstanding characteristic of the East Sea is that it is a closed sea; it is enclosed by the Asian continent and archipelagos of the Philippines and Indonesia, and only such narrow marine straits as the Taiwanese, the Luzon, the Malay and the Palawan are open to the Pacific Ocean. The nature of a closed sea influences the features of sea currents, tides, and creatures.

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The East Sea is of a particularly important position in Asia based on three categories: natural position, geo-economy, and geo-politics. It possesses a great deal of resources for surrounding countries, a life-line nautical route for a number of countries around the world, a place of contact of multiple cultures, and a geo-military position on the global scale. At present, Vietnam has 26 coastal provinces and cities that make up over 42% of the area and over 45% of the total population of the country. About 15.5 million people are living on the shoreline and 160,000 people on the islands. This is a human force that directly protects and sustainably exploits resources in the country's marine sovereignty, which includes marine cultural resources.

2. Paleoclimatology and environment from Late Pleistocene to Early Holocene

2.1. Geological divergence and prehistoric cultures in Vietnam

During the times of geological divergence, the Late Pleistocene is dated from 40,000 to 12,000 BP, while the Holocene is from 12,000 BP to present. Holocene consists of 3 periods: Early Holocene (from 12,000 to 7,000 BP), Middle Pleistocene (7,000 to 4,000 BP), and Late Pleistocene from 4,000 BP to present [1].

The beginning is the presence of An Khe Palaeolithic, dating from the Middle Pleistocene, with a Kalium-Argon (K^{38}/A^{40}) radioactive isotope age between $782,000 \pm 20,000$ BP and $800,000 \pm 22,000$ BP [2], and a *Homo erectus* fossil from Tham Khuyen cave, which was dated by Electron Spin Resonance to be from $401,000 \pm 51,000$ BP to $534,000 \pm 87,000$ BP [3]. The end of the primitive period and the beginning of the

Protohistoric period occurs when the State of Van Lang appeared dated at 2,700 BP [4].

Basically, the dates of geological periods correspond to the existing time frame of prehistoric archaeological cultures in Vietnam¹. During the Late Pleistocene, there existed two archaeological cultures belonging to the Late Palaeolithic period, namely, the Nguom culture (or Nguom industry) (from 41,000 and 34,000 BP to $23,100 \pm 300$ BP) [5, 6], Son Vi culture ($32,100 \pm 150$ BP and $28,139 \pm 200$ BP to $11,500 \pm 120$ and $11,330 \pm 150$ BP) [7].

Early Neolithic Vietnam has identified two Archaeological cultures named Hoa Binh culture (or Hoabinhian) and Bac Son culture (or Bacsonian), which date from the Early Holocene and both ending together in 7,000 years BP [8, 9]. The Bacsonian date is $11,000 \pm 200$ BP (Doi cave), $10,295 \pm 100$ BP (Bo Lum cave), while the Hoabinhian lies across from the end of Pleistocene to the beginning of Holocene, from $21,560 \pm 220$ BP, $21,300 \pm 300$ BP, $20,170 \pm 160$ BP to $13,980 \pm 200$ BP and $10,430 \pm 180$ BP (Cho cave). The inhabitants of the Hoa Binh and Bac Son cultures resided in the karst valleys where they hunted and gathered animals and plants from the continent. These two cultures belong to the continental culture, but did know the gifts of the sea by exchanging items such as jewellery made of sea shells with other inhabitants living by the sea.

The prehistoric marine culture of Vietnam is known to the inhabitants of the Middle Neolithic period as people lived in the marine

¹Archaeological culture is a term to refer to archaeological sites that have stable and unified characteristics of relics and artifacts, and distinguish it from other archeological cultures of the same line.

environment, exploited marine resources, had extensive relations with the surrounding area, and created a new culture imbued with elements of the sea [10, 11]. These cultures are the Cai Beo culture (dating from 6,475±170 BP from the Cai Beo site to 4,100±40BP from the Ba Vung site after adjusting 4,520 BP); the Da But culture (from 8.7040±85 BP at the Hang Sao cave to 6,430±60BP at the Da But site

and 4,790±50BP at the Go Trung site), and finally the Quynh Van culture (4,785±100 BP or 2,835 BC to 3,450±70BC) (Fig. 1).

The marine cultures of the Later Neolithic period include archaeological cultures such as Ha Long (Quang Ninh province - Hai Phong city), Hoa Loc (Thanh Hoa province), Bau Tro culture (Nghe An, Ha Tinh, and Quang Binh provinces), Xom Con (Khanh Hoa and Phu



a. Pointed tools



b. Discoid tools



c. Fully sharpened axes



d. Fully sharpened axes



e. Stone with round holes



f. Pottery pot

Fig. 1. Stone artifacts of Cai Beo Culture. Source: Nguyen Khac Su (2009), *Cai Beo Prehistoric Site, Cat Ba Island*, Social Sciences Publishing House, Hanoi, p.308, 313, 326.

Yen provinces), group of relics of Long Thanh - Binh Chau (coastal of South Central Vietnam), and a group of relics of An Son - Giong Ca Vo (coastal of Southern Vietnam). These cultures are dated ranging from 4,500 to 3,000 BP.

2.2. Paleo-environment in Vietnam's sea area

The study of Vietnam's prehistoric marine culture cannot be separated from the study of the paleo-environment, especially the fluctuations in ocean levels since the Late Pleistocene to Holocene and their impacts on the waters of Vietnam. In Earth's history, there were at least 20 glacial and interglacial cycles representing the same number of phases of marine transgression and regression, but excluding the negligible fluctuations of sea level between phases or those caused by neotectonic movements varying from region to region. According to G. Kukla, the Pacific level had various fluctuant phases between 300,000 and 20,000 BP. It lowered to -140 m from 150,000 to 20,000 BP [12]. Several recent studies have also confirmed that Southeast Asian sea levels lowered to -130 m and -120 m bringing about floating bridges that humans and animals used to migrate across the region between most islands and the mainland [13].

According to recent geological and geomorphological research, the East Sea's water level fluctuates from -120 m to water levels of -100, -30, -20 and -5 m, respectively. These stages of transgression are approximately dated to c 15,000; 10,000; 9,000; and 8,000 BP, respectively. Sea levels reached its current position c 7,000 BP, while from c 6,000-4,000 BP, it was approximately 2-3 m higher than

today's levels, but dropped relatively rapidly after c 4,000 BP [14]. According to Boyd and Doan Dinh Lam's analysis of sediment core data from Tam Coc, sea level from c 5,500-2,600 BP was approximately 5.4-40 m higher than current national standards [10, 15]. This means that around c 5,500 BP, it was 3.25 m higher than the current average sea level.

3. Late Pleistocene - Early Holocene cultures

3.1. Late Paleolithic cultures

The Late Pleistocene marine transgression is still evidenced through a presence of a water notch on Hang Dinh at 7.05-7.85 m high dated from $32,960 \pm 689$ to 41,000 BP. The sea at that time inundated the present coastal zone and encroached deeply onto the mainland fully covering most of the area of the current plain of Red river. During this time, the northern part of Vietnam was represented by the Nguom Industry (Thai Nguyen province) and the Son Vi culture (Phu Tho province). The Nguom Industry is between 41,000 and 34,000 BP to $23,100 \pm 300$ BP [5, 6], while the Son Vi culture is from $32,100 \pm 150$ BP and $28,139 \pm 200$ to $11,500 \pm 120$ BP and $11,330 \pm 150$ BP [7]. The pollen composition found in sediment from this period includes species prone to hot temperature such as *Polypodiaceae*, *Palmae*, *Quercus*, and so on, while some species prone to cold climate like *Juglams*, *Pinus*, and so on, which are characteristic of primarily broad-leaved forest vegetation, some coniferous trees, and altogether being year-round evergreen forests; monsoon tropical climate with a humid hot summer, elevated rainfall and a cold dry winter, low precipitation [16].

Regarding climate and environmental changes at the end of Pleistocene, Ha Van Tan said that there was a cold dry period of about 30,000 BP over the entire Southeast Asian continent. Corresponding to this period is the appearance of fine industries and small stripping. After that, the climate gradually warmed up, which can be divided into two periods: a hot but relatively dry period and a hot and humid period. This period of warming is marked by the emergence of Son Vi and Hoa Binh Cobblestone Industries [17].

3.2. Early Neolithic cultures

The prehistoric residents who resided in limestone caves inland like the Hoabinhian (20,000-7,000 BP) or the Bac Son people (11,000-7,000 BP) were still ignorant of sea products. Only some pierced cowries serving as ornaments or grave goods were found to be resulting from exchanges. It seems that traditional cave colonization, pebble tool manufacture, and freshwater mollusc exploitation kept these people away from marine contacts and integration.

The analytic results using the method of magnetic susceptibility on cave sediments extracted from Con Moong cave (Thanh Hoa province), Cho cave (Hoa Binh province), and Lan Mo (Son La province) have indicated that between 20,000 and 7,000 BP in North Vietnam, there were humid and hot cycles intervening with cooler or cold ones. Cave sedimentation was 10 times faster in the period of 11,400-8,800 BP than that of 11,400-20,500 BP. That is, the precipitation of the later period was 10 times more elevated than that of the previous one [18]. There was a cold period evident in North Vietnam from 11,400

to 8,800 BP, which was also accompanied with a high rainfall giving rise to a reduction of mountain snail species (*Cyclophorus*) in the case of Mai Da Dieu (Thanh Hoa) and an extremely prosperous expansion of stream snails (*Antimelania costula*) seen in all Hoabinhian cave sites. These research results are proven to be partly in line with Bellwood's comments that from 18,000 to 6,000 BP, the increased rainfall and expanded rainforest fundamentally changed the paleo-geography and profoundly affected the humane ecosystem of Southeast Asia [19]. Not until 7,000 BP did almost all prehistoric cave inhabitants move out to the open air for settlement and systematic exploitation of resources in the coastal plains. From that point, the prehistoric marine cultures were officially formed.

4. The prehistoric marine cultures

4.1. Marine cultures of the Middle Neolithic

Residents of Cai Beo culture: the group of Hoabinhian inhabitants who resided in the northeastern coastal region of Vietnam currently encompasses 12 sites of the Soi Nhu site group with Soi Nhu cave being the most well-known [11]. In the Early Neolithic era, this inhabitant group dates back 25,000 to 12,000 years corresponding to the pre-Hoabinhian period. Typically, inhabitants in Soi Nhu cave dated back to $12,460 \pm 60$ BP to $15,560 \pm 180$ BP; those in Ong Bay Rockshelter dated back to $16,630 \pm 120$ BP, and inhabitants of Ang Ma cave dated back to $25,510 \pm 220$ BP. All the cultural findings in these caves were the remains of terrestrial animals and stone tools that mostly stemmed from the Hoabinhian including blade-sharpened axes and tools

made of limestone. In the period from 12,000 to 7,000 BP, the living area of the Soi Nhu inhabitants had expanded but remained along the edge of the mainland despite the increasing proximity of the rise in the sea level called Flandrian elevation [20].

After 7,000 BP, the sea began to rise submerging some low-lying northeastern coastal areas. The inhabitants at this time extended their residential space, but some remained living in caves such as the Eo Bua, Ba Thom, Ha Giat, Dong Dang, Dong Cau (or Ha Long cave) and Tien Ong (or Duc cave) caves, while others occupied coastal plains such as Thoi Gieng (lower layer), shelf seas such as Cai Beo (lower layer), and Ao Coi, or tidal flats, such as Hon Ngo-Nui Hua. These sites formed an archaeological culture named the Cai Beo culture, which dates from 7,000 to 4,000 BP in the Middle Neolithic period. Notably, Ha Long cave dates from $6,480 \pm 40$ BP and Cai Beo (lower layer) from $6,475 \pm 170$ BP [21].

In order to adapt to their new surroundings, the Cai Beo people made and used tools such as points, triangular axes, oval axes, discoidal implements, shouldered axe for edge-ground polishing, squid shell-shaped completely polished axes, along with percussion stones, anvil stones, pestles, grinding tables, and pebbles with round holes like Hoabinhian artefacts. In particular, clay, sand-mixed, thick-walled, and hand-shaped pottery items were also evident during this period. After 5,000 BP, thin-walled pottery made of a sand-clay mixture bearing different decorations such as knitted patterns, coarse cord-marked patterns, crushed patterns, and printed patterns began to appear.

The Cai Beo people developed ways to exploit marine resources. Over 90% of the animal bones found here belonged to marine animals such as dolphins, catfish, pomadasys hasta, arias leiotetocephalus, stingrays, sharks, a number of unidentified species of fish, crabs, squid, sea turtles, mussels, scallops, and sea oysters. Over 200 kg of fish bones were found in the Cai Beo site and the vertebrae of one fish unearthed even measured up to 10 cm in diameter [21]. In addition, the bones of some terrestrial animals such as deer, elk, goat, and wild boar were excavated. The Cai Beo cultural sites show that the Cai Beo people quickly adapted to changes in the marine environment, mastered marine exploitation activities, and established the prehistoric marine culture in the country's Northeast.

Some skeletal remains of the Cai Beo people show characteristics of the *Australo-Melanesien* ethnic. Such elements were unearthed in this region such as *Australo-Melanesien* in Ang Giua cave and *Australo-Negritoid* in Soi Nhu cave [22]. The above anthropological and archaeological documentations suggest that inhabitants of the Cai Beo culture descended from inhabitants of the Hoabinhian. Many archaeological papers testify to the development path from the Cai Beo to the Ha Long cultures [11]. In short, the existence of a prehistoric coastal plain exploration route from the Hoabinhian through the Cai Beo to the Ha Long cultures along the north-eastern coast is beyond dispute.

Trang An inhabitants: another direction of coastal plain occupation and exploration taken by post-Hoabinhian inhabitants was to the southwest of the Red river delta to the region of the Trang An landscape complex, Ninh

Binh province. This is home to 25 prehistoric archaeological sites of which nine have been excavated, namely, Trong, Boi, Moi, Thung Binh 1, Thung Binh 3, and Thung Binh 4 caves, and the Ong Hay, Vang, and Oc rockshelters. The sites are scattered over an area covering 6,000 ha in the core zone of the Trang An heritage site, which is a lowland and swampy region with an average elevation of 2 m above sea level.

The prehistoric inhabitants here, dating from 30,000 to 4,000 BP, witnessed fluctuations in the natural environment shifting from the continental environment (30,000 to 7,000 BP) to a marine one (7,000 to 4,000 BP). They then returned to the mainland after 4,000 years due to the impact of the rise and fall of sea levels in the Middle Holocene period. Cultural sites before the rising waters are the Ong Hay rockshelter 27,750±100 BP, 9,535±30 BP; Trong cave 24,438±93 BP, Boi cave 12,447±72 BP, 10,620±64, Moi cave (lower layer) 12,640±35 BP, 9,555±30 BP, and Thung Binh 1: 12,880±420 BP to 12,980±390 BP [23].

The inhabitants of this period made tools mainly from dolomite limestone, which they used to hunt terrestrial animals such as buffalo, gaur, deer, roe deer, pigs, badgers, bears, leopards, monkeys, porcupines, birds, tortoises, and freshwater fish. They also caught mountain and stream snails, *Lanceolaria fruhstorferis*, clams, and freshwater mussels. Cultural remains, which are mainly mollusc shells compacted into layers ranging from 2 m to over 3 m thick in the caves, indicate that man's temporary and seasonal habitation at the time was linked to the mollusc breeding season.

The inhabitants of this period had not yet exploited the marine resources although, through their trading activities, they were aware of the seawater products. In the layers dating back to 9,000 BP in the Boi and the Trong caves, small, thick, and bright white shells of the *Neritina undata* species were found perforated with a bead-like thread, as well as round clam shells pierced with strap holes. At a later stage, jewellery was made from the shells of *Neritina pulligera* and *Cypraea* with beautifully-shaped mouths, punctured at the back and dyed with ochre to make jewellery beads.

During the rise in sea level, the ancient inhabitants of Trang An landscape complex continued to live typically in the Moi cave (upper layer) dating from 8,550±30 to 4,705±25 BP, Oc rockshelter from 8,790±210 BP to 5,120±315 BP, and the Vang rockshelter from 8,720±235 to 5,130±310 BP. Inhabitants of this period began to exploit what the sea had to offer. They collected molluscs such as *Geloina coaxans*, estuarine oysters, undata sp snails, black-spotted tritons, yellow-rimmed snails, apple snails, blood cockles, *Cyclina sinensis*, asiatic hard clams, and caught sea fish. However, they continued, as normal, hunting terrestrial animals such as deer, boar, monkeys, hedgehogs, and turtles.

Due to the marine environment, the Trang An complex no longer had a source of pebbles from rivers and streams. Therefore, it was important to produce tools made from limestone, which the people exchanged with traders for andesite to make blade-sharpened axes and sandstone-ground tables. They made use of large-sized oyster shells and *Geloina*

coaxan shells to make knives, scrapers, and pickaxes, and they used Asiatic hard clam and cowrie shells to create jewellery, and, in particular, they produced pottery. The earliest pottery remains found in layer 6A of the Moi cave dates from 7,381 to 7,186 years BC; the pottery recovered from the Vang rockshelter dates from $8,720 \pm 235$ BP, and that found in the Oc rockshelter from $8,410 \pm 295$ BP. The pottery is a clay type, unrefined, and filled with gravel. The pottery was handmade and fired at low temperatures to shape it into products such as the brown or greyish brown round-bottomed vase with a vertical, flat mouth lip, an 8 to 12-mm thick edge, and the outer surface marked with deep fault grooves 5 to 8 mm in width. The creation of pottery in this area may have been associated with the need for freshwater storage and microbiological processing of marine products [24].

Five thousand years after the sea level fell, the continental characteristics of the Trang An complex gradually returned. It took 4,000 years for this region to basically revert to a continental environment. During this period, people were less interested in living in caves and moved to occupy outside spaces, and they practised fixed agricultural activities in the low plains of today's Nho Quan and Gia Vien districts. In exploring the marine environment, the ancient inhabitants of the Trang An complex gradually adapted to the changed environment from the mainland to the sea and back to the mainland, and they made new types of tools. They soon developed grinding techniques and pottery, and deployed mixed economic activities to exploit the resources of the limestone forests surrounded by the sea and picturesque areas, thereby

creating a unique cultural nuance of the Trang An landscape.

Residents of Da But culture: the inhabitants of this region are proud to have 10 sites belonging to the Da But culture of which five are located in Vinh Loc district (Thanh Hoa province). Specifically, the ages of the following sites are $6,430 \pm 60$ BP at the Da But site, and $6,390 \pm 60$ BP, $6,095 \pm 60$ BP, and $5,710 \pm 60$ BP; the Ban Thuy site $5,860 \pm 95$ BP; the Con Co Ngua site $5,520 \pm 95$ BP, $5,140 \pm 95$ BP and $5,560 \pm 95$ BP; and the Lang Cong and Con Trung sites $4,790 \pm 50$ BP [25]. They also inherited five sites located in Tam Diep city and Yen Mo district (Ninh Binh province), which are the Sao cave dating back to $9,170 \pm 105$ BP and $8,740 \pm 85$ BP, Co cave, Mo cave, Oc cave, and Dong Vuon over 4,000 BP [26].

When the Thanh Hoa plains were first occupied, and when the sea had not yet encroached upon this region, the inhabitants of the Da But culture hunted animals, collected river clams and made clam dunes from their shells, as well as carried out cultivation and domestication. In the period of 5,500 to 5,000 BP, most of the Vinh Loc plain lowlands were under water. The inhabitants of Lang Thuy and Con Co Ngua at this time exploited the sea, collected marine molluscs, and dumped waste into high mounds. Some people ventured further afield to explore the coastal plains and settled in Con Trung (Hau Loc district, Thanh Hoa province), or the Sao, Co, Oc, and Mo caves (Tam Diep city, Ninh Binh province).

While the Da But inhabitants were exploring the coastal plains, they quickly developed tool-making techniques from crudely flaked

pebble tools to edge-polished ones, and completely polished implements such as oval and quadrangular axes. They also invented new tools such as hoes, chisels, saws, awls, centre-perforated stones, and weights added to fishing nets with stones bearing grooves for stringing, and they used animal bones, horns, and mollusc shells to make chisels, awls, sewing needles, and cutters.

Through this process, Da But became one of the earliest pottery centres in Vietnam. Da But pottery culture has remained mostly unchanged for thousands of years. The Da But people would still hunt animals such as deer, buffalo, pigs, dogs, chevrotains, cats, mink, and porcupines, and they collected animals from rivers, streams, swamps, and freshwater such as clams, mussels, snails, venus clams, lanceolaria fruhstorferi, crabs, fish, *trionychid* turtles, and tortoises. When the sea level was rising, the local people exploited coastal seafood resources such as sea urchins, scallops, veneridae, and they went fishing, although not as much as during the Cai Beo period.

Pollen spores found in some sites dating from the Da But culture indicate the existence of a significant amount of legumes, coconuts, and herbaceous pollen suggesting the possibility that the Da But people cultivated and tended certain species of vegetables, tubers, fruit, and seeds. The stone axes and hoes accounted for a high proportion of tools. The fertile Ma river delta had favourable conditions for growing and cultivating fruit and vegetables such as tubers, gourd, squash, water potatoes, taro, and cypress. The Da But inhabitants raised various animals such as buffaloes, cows, and pigs as well as possibly dogs and elephants [27, 28].

The Da But people maintained their custom of burying the dead at their homes in a squatting position or lying on their sides according to their burial rites. Moreover, if a number of individuals passed away at the same time, they would be buried collectively in one grave. They also unanimously agreed on arrangements for the deceased. Specifically, corpses were placed in circular acupoints of 0.6 to 0.7 m in diameter and 0.5 to 0.8 m in depth. Burials were one-off affairs with no re-burial rituals performed [29].

The anthropological composition of skulls of the Da But people was predominantly *Melanesien* (*Australoid*) or *Indonesian* (*Southern Mongoloid*), which existed long before the Hoabinhian [30]. According to Marc, cranio-metric and dental non-metric analyses of the 1979-1980 in Con Co Ngua site season human material are consistent with observations of the 2013 assemblage. The people are phenotypically aligned with both Late Pleistocene Southeast Asians and modern Melanesians and Australian Aboriginal populations. They contrast with the majority of Neolithic, Metal period and modern peoples of Mainland Southeast Asia [31]. Pottery and full-body-ground axes of the Da But culture were found in the surface layer of Con Moong cave, Dang cave, Lai cave, and Doi cave (Ba Thuoc district), suggesting the migration path taken to explore the coastal plain was from the area of Cuc Phuong National Park.

However, during the late stages of the marine culture sites such as Hoa Loc (Hau Loc district) and Man Bac (Ninh Binh province), and the Le and Ho mountains (Nam Ha), new elements appeared that differed from those of the Da

But culture. There is a high likelihood that this population group arose from exposure between the native Mon-Khmer language speakers and migrants who arrived by sea. In this regard, it is important to take Peter Bellwood's point of view into consideration when he argued that there was a group of Malayo-Polynesian-speaking inhabitants in Chinese Taipei around 5,500 to 5,000 BP who migrated down to the islands in Southeast Asia through Batanes province to the islands of the Philippines, then to Borneo and the Palawan islands, and into Vietnam. During this time, the majority of people in Vietnam spoke the Mon-Khmer language. Cultural and anthropological vestiges have been found at the Man Bac site (Ninh Binh province) [32] and the An Son site (Long An province) [33].

Residents of Quynh Van culture: the 24 sites revealing scallop dunes or piles of kitchen deposits situated along the coastal plains of Quynh Luu district (Nghe An province) and Phai Nam district (Ha Tinh province) belonged to the Quynh Van culture dating from 6,000 to 3,500 BP. This period had three development stages: (i) early stage (6,000 to 5,000 BP) with a prime example being the Quynh Van sites, (ii) middle stage (5,000 to 4,500 BP) with the Quynh Hoa and Go Lap sites, and (iii) the late stage (4,500 to 3,500 BP) illustrated by Con Dat and Phai Nam sites [34].

The Quynh Van inhabitants mainly fashioned tools from bedrock. More than 95% were grinding and dressing tools made from amorphous stones. These implements include choppers, chopping tools, discoid scrapers, turtle-shell-shaped scrapers, short axes, and triangular and iron-shaped picks. The following

two artefacts are representative of the Quynh Van culture. Some cobble tools such as pestles, striking stones, and grinding tables were also excavated. Generally speaking, in the Quynh Van culture, the tool-sharpening technique developed slowly whereas the pottery-creating technique and types of pottery developed rapidly. In the early and middle stages (6,000 to 4,500 BP), the main pottery items produced were large-sized conical ceramic vases with pointed bottoms, slightly flared mouths, and patterns brushed on the inside and outside surfaces.

In the late stage (4,500 to 4,300 BP), a new small round-bottom ceramic type of pot appeared with thin sides, an average mouth diameter of 20 to 30 cm, and body height of 15 to 30 cm. This item was often decorated with check and coarse cord patterns on the outside surface and with brushed patterns on the inside surface. The Quynh Van people mainly collected marine molluscs such as scallops, sea urchins, smooth scallops, screw snails, iron snails, meretrix, veneridae, oysters, clams, mussels, and lanceolaria fruhstorferis, as well as crab, trionychid turtle, and tortoises.

These sea creatures usually lived in coastal zones, estuaries, and enclosed bays. Species of marine fish in this area were rare as each site yielded only a few small head bones or vertebrae of such fish. The early inhabitants still hunted some terrestrial animals such as rhinoceros, wild buffalo, gaur, sambar deer, roe deer, deer, and elephants. There are no signs of cultivation and domestication practice during this period.

The Quynh Van people laid burial tombs at their own residences. Thirty-one tombs were discovered in a 100 m² excavation area at the Quynh Van site. The graves had round mouths and were 60 to 70 cm in diameter and were dug into the scallop shell layer. The corpse was placed directly into the grave in a squatting posture with two hands holding the knees. There are few cases where the corpse is found lying on its side. The remains of bones are often broken, fragmented, and incomplete. Burial items include pestles, stones, chopping tools, bone-made tools, jewellery made of marine mollusc shell, and ivory fragments. The excavated skulls bear anthropological characteristics of the *Australo-Melanesian* group with some traits of the *Mongoloid* group [35].

The scallop dune sites of the Quynh Van culture are large with a layer that is 7-m thick that includes intermingled layers of scallops discarded by inhabitants at the time and scallops that had died naturally. This indicates that the people here lived a nomadic existence rather than in a permanent manner and caught seafood according to the seasons. Most archaeologists consider Middle Neolithic cultures to be derived from the Hoabinhian, even from the Dieu technique in Ba Thuoc district (Thanh Hoa province) as evidenced by the existence of iron-shaped tools, which were identical to tools typical of the Quynh Van culture [36]. The latter evolved into the Bau Tro culture through the Thach Lac culture. This development process reflected changes in population structure and ways of living, as well as the relocation of residences in order to adapt to environmental changes along the coastal plains of Nghe An and Ha Tinh provinces at

that time. Historically, the Quynh Van culture represented the post-Hoabinhian Neolithic path in central Vietnam, an approach to the shallow bay in this region.

4.2. Marine cultures of the Late Neolithic

The culture of Ha Long: this culture ranges from 5,000 to 3,000 BP and is distributed predominantly in the Ha Long bay [37]. The stone tools are typified by shouldered axes, stepped adzes, grooved grinding stones with U-shaped cross section, and porous pottery. Twenty-eight of the thirty-one habitation sites of the Ha Long people are located on sand dunes and riverine tidal areas while only 3 caves were found. Each of the “fishing villages” here had an average area of 1,500 m², which is smaller than the “agricultural villages” situated in the Red river delta, however, the population density here was also likely lower. The Ha Long people showed a very high development of stone-working technology, building pottery, planting trees for fibres and as means of transport for exploiting the marine products, as well as exchanging and trading goods with the mainland and distant islands. Stepped adzes and Ha Long marks have been found not only in the mainland of North Vietnam, but also in the coastal provinces of Guangdong, Fujian, and Hong Kong indicating the overseas relationships made by Ha Long people in the past [11]. Radiocarbon dates determined from several Ha Long “fishing villages” are as follows: Ba Vung 4,100±40 BP (calibrated from 4,820 to 4,520 BP); Bai Ben 3,380±50 BP, 3,470±55 BP, 3,180±55 BP, 3,300±55 BP, 3,900±80 BP, 4,070±50 BP, 3,090±50 BP, 3,270±55 BP.

This is a stage of forming the typical marine cultures such as Ha Long, Trang Kenh (Quang Ninh province, Hai Phong city), Man Bac (Ninh Binh province), Hoa Loc (Thanh Hoa province), Bau Tro (Quang Binh), Long Thanh, Binh Chau (Quang Ngai province) and Xom Con (Khanh Hoa province). Among them, the Trang Kenh - Man Bac sites belong to Phung Nguyen culture and they are distributed in the sea dating from 4,000-3,500 BP.

The culture of Hoa Loc: this culture was named after a site located in Lien Loc commune, Hau Loc district (Thanh Hoa), with a date of $4,050 \pm 53$ and $3,913 \pm 84$ BP [38]. The Hoa Loc inhabitant possessed a sedentary settlement pattern, a farming that used hoes, and a high growth of stone tool and pottery production. The large-sized stone hoes, large and crude quadrangular axes, stone artifacts with engraved marks in horizontal, earthen seals with geometric motifs, "leech"-shaped earrings, polygonal-rim pots, and ink-slab-shaped boxes are typical of the Hoa Loc culture. People of this culture had relationships, exchanges, and contacts with those who lived inland such as Con Chan Tien (Thanh Hoa), Ghe Da (Phu Tho), Ban Giem (Son La), and notably in the marine habitats like Ha Long (Quang Ninh), Thach Lac (Ha Tinh), Bau Tro (Quang Binh), and even in Taiwan, Fujian (China) [39].

The culture of Bau Tro: this culture was named after the site of Bau Tro excavated by E. Patte in 1923 [40], which consisted of over 20 sites distributed on the coastal plain from Nghe An to Quang Binh dated between 4,500 and 3,000 BP. The distinctive characteristics are recognized through the manufacture and use of

axes, adze, hoes, chisels, knives, saws, drills, polishing stones, pestles, saddle querns, and hammerstones. Pottery includes vessels with knobs attached to rim walls, and everted-rim pots with worm-shaped rim edges impressed by such decorative motifs as tortoise-shell shape, stave shape on the cord ground, and pigmented with red and black. The Bau Tro people practiced hunting, gathering, fishing, farming and reached a high level of stone manufacture [40]. They colonized the coastal plain and mastered the freshwater pools, had an open relationship with other contemporary tribes, and contributed to the formation of the pre-Sa Huynh and Sa Huynh in Central Vietnam as well as the pre-Dong Son and Dong Son cultures in Ca river basin.

Along with the cultures of Ha Long and Bau Tro, there are some synchronic marine ones like Hoa Loc (Thanh Hoa), Binh Chau - Long Thanh (Quang Ngai), and Xom Con (Khanh Hoa) that fundamentally belong to the Bronze Age dated between 4,000 BP and 3,000 BP.

The culture of Long Thanh - Binh Chau: this culture is represented by two stages of the early and late Bronze Age in the marine area of Quang Ngai. The site of Long Thanh, situated in Duc Pho, showed similarity to the lower layer of Xom Oc, Bai Ong, and Vuon Dinh - Khue Bac through the introduction of egg-shaped and globular burial jars accompanied with earthen and stone artifacts in residential areas with no signs of bronze artifacts dated to the early Bronze Age. The site of Binh Chau, located in Binh Son, has had similar findings to the upper layer of Xom Oc, Bau Tram with such features as: graveyards located separate from the living area, earth

burials accompanied with grave goods like spear head, arrow head, chisel, fishing hook, folded-shoulder vessel, high-footed bowl, and “leach”-shaped earrings. Of which, the pots with folded shoulders and pointed bases, as well as the bowls with cylindrical feet, are the most represented artefacts of this culture. This is a marine culture developing into the Sa Huynh culture in central Vietnam [41].

The culture of Xom Con: this culture was named after the site of Xom Con, Cam Ranh (Khanh Hoa) and is dated to 4,000-3,000 BP and comprises the coastal sites such as Xom Con, Cu Hin, or island sites like Hon Tre, Hon Mun, and Hon Tam. Stone tools are characterized by stone quadrangular axes, ornaments made from snail shells with species *Tridacnan* and *Tubo*, high-footed bowls built by a paddle technique, and had incised and pigmented decorations. Sea products gathered by Xom Con people were exported to other regions like Bien Ho (Gia Lai), Hoa Loc (Thanh Hoa), and even Japan or the Pacific islands [42].

A place belonging to the Xom Con culture is the site of Van Tu Dong. It is situated on the sea bay of Cam Ranh, Khanh Hoa, which is the farthest residential point on the south among the people living in the marine transgression habitat at about 4,000 BP. This site was excavated in 2006. The meal waste of the ancient residents here includes mainly shells of arca, scallop, barnacle, and snail that were piled up into mound called a shell-midden site. A shell examination indicated that there were 7 species of snails, 3 species of barnacles, and a few marine species of arca, scallop, oyster and mussel, which inhabited the alluvial

ground, estuary, swamp, lagoon, tidal areas, and even off-shore at a depth of a few tens of metres below the surface. They reflected a very dynamic mode of marine exploitation and had various ways of processing mollusc species suggesting a diversity of cuisines that local people had. The ancient people of Van Tu Dong were those who settled in the coastal area with primary economic activities of exploiting the marine products in the coastal zone.

The culture of Giong Phet (or the culture of Can Gio): this culture is most characterized by sites of Giong Phet, Giong Ca Vo, Long Buu, and Giong Am dated between 2,500 and 2,000 BP and located in the estuaries of Can Gio. This culture is composed of the habitation sites (in the early stage) and burial grounds (in the late stage). Giong Phet people exploited sea resources, building pottery, especially manufacturing ornaments made on semi-precious stones, glass, and sea shells. They buried the dead in big jars in a flexed position. Some of the graves were indicated as being reinterred or buried directly under the ground. The culture of Giong Phet was probably developed from the site group of Ben Do and Hoi An and transformed into the culture of Oc Eo. It had a close relationship with the Sa Huynh culture and the contemporary people in the Philippines, Cambodia, and Thailand. Radiocarbon dates were at $2,480 \pm 50$ BP as determined from Trench 1 of the Giong Ca Vo site at 1.5 m deep, and $1,665 \pm 40$ BP from Giong Am [43]. In history, it was possible that the Sa Huynh people used primitive seaports including Hoi An and Can Gio dated to the end of the first millennium BC, and that it was

those primitive seaports which witnessed a transformation from Sa Huynh to Champa and from Giong Ca Vo to Oc Eo.

5. Conclusions

The prehistoric marine cultures of Vietnam are sources of real historical material that illustrate a transitional step from the Stone Age to Bronze Age, from the prehistoric to historical time, and from the Primitive to Civilization through four generalized development stages below:

Stage of approach (10,000-7,000 BP): people of the Hoabinhian and Bac Son culture were the first ones approaching the sea as a predecessor of the prehistoric marine culture of Vietnam.

Stage of formation (7,000-4,000 BP): people of the middle Neolithic, represented by the cultures of Cai Beo, Da But, Quynh Van, and Bau Du, expanded their occupation to the coastal plains, exploiting the marine resources, and forming the centres of the prehistoric marine culture of Vietnam.

Stage of pervasion (4,000-3,000 BP): a series of late Neolithic and early Bronze Age cultures were formed and developed across the marine regions of the country including Ha Long (located in the northeastern marine region), Hoa Loc, Thach Lac, Bau Tro (in the coastal region of northern Central), Long Thanh - Binh Chau (in the middle Central), Xom Con (in Southern Central), and a number of other synchronic sites distributed on the coastal islands such as Con Co, Ly Son, Hon Do, Bau Hoe, Tho Chu, and Con Dao.

Stage of convergence (3,000-2,000 BP): the marine cultures of the late Neolithic and early

Bronze Age were integrated with those living in mountainous areas and plateaus coming from the Pacific Ocean creating three Iron Age cultures of Vietnam: the Dong Son culture in the North, the Sa Huynh culture in the Central, and the Can Gio culture in the South.

The inhabitants of the Neolithic Middle Ages dominated and exploited the coastal plains of Vietnam such as the communities of Cai Beo, Trang An, Da But, and Quynh Van, which were the most crowded due to exploitation strength of copper from the sea and islands in their area. This created a difference in economic orientation between the sub-regions and opened the way for the formation of prehistoric marine cultures in Vietnam.

Within each of these occupational zones, the internal development from the Middle Neolithic to the Late Neolithic periods in each region was evident. For example, the transition from the Cai Beo to the Ha Long cultures along the Northeastern coast, from the Da But to Hoa Loc and Man Bac cultures, and from the Quynh Van to Bau Tro cultures. The historical process of Vietnam's prehistoric marine culture from 7,000 to 4,000 BP is diverse and multi-directional. However, all developments during this period had the same starting point - a background of the Hoa Binh - Bac Son culture, converging at the pre-Dong Son to Dong Son cultures in the North, and pre-Sa Huynh to Sa Huynh cultures in Central Vietnam.

Today, Vietnam's marine region has been under the influence of rising sea levels. On 17 April 2013, the Ministry of Natural Resources and Environment issued a scenario of changing climate and rising sea levels for Vietnam

from 2012 to the end of the 21st century that included three levels. In the lowest level, the annual average temperature of Vietnam would increase by 1.6 to 2.2 degrees Celsius and sea levels would be up by 49-64 cm accordingly. In the medium level, the average temperature would increase from 2 to 3 degree Celsius and sea levels would rise 57-73 cm. In the highest one, the average temperature increase would reach to 2.5-3.7 degree Celsius, causing a rising sea level to increase by 78-95 cm and up by 105 cm in the area of Ca Mau - Kien Giang.

With respect to a flooding threat, it is estimated that until 2100, sea levels would elevate by at least 1 m. As a consequence, approximately 39% of the area of Cuu Long river plain, over 10% of the area of Red river and Quang Ninh plains, more than 2.5% of the area of the coastal provinces, and more than 20% of the area of Ho Chi Minh city would be under the inundation threat. Roughly 35% of the population of provinces of Cuu Long river plain, over 9% of the population of Red river plain and Quang Ninh, nearly 9% of the population of the coastal provinces of the central region, and about 7% of the population of Ho Chi Minh city would be directly affected.

A lesson taken from the adaptation of the prehistoric inhabitants to the marine habitat during their cultural development would be certainly valuable. Rising sea levels would lead to the disappearance of archaeological sites as it did in the late Pleistocene. In the future, the sea will extend, while mountains are being destroyed, hills being levelled and the sea being filled, all of which will result in

permanent destruction of a number of sites. Each individual archaeological site not only serves as an annal, but also an identity card of the country in an integrated world. Losing the relics can be viewed as losing one's direction in their lives and losing one's mind that is unable to come to success. Evidently, the prehistoric sites of the marine cultures of Vietnam have been playing a particularly important role in the socio-economic development of Vietnam and it needs to be studied, protected, and brought into play.

COMPETING INTERESTS

The author declares that there is no conflict of interest regarding the publication of this article.

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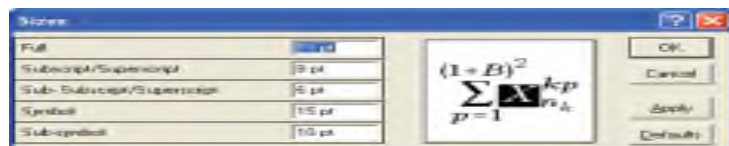


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