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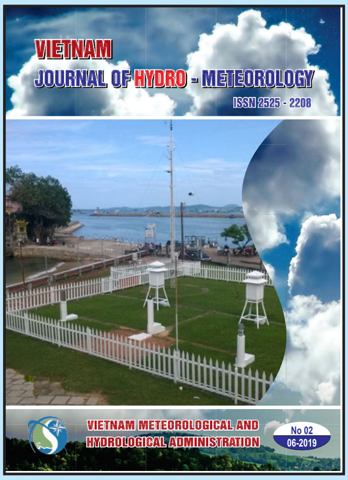

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Research Paper

THE CLEAN DEVELOPMENT MECHANISM (CDM) PROCEDURE AND IMPLEMENTATION IN VIETNAM

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ABSTRACT

The Clean Development Mechanism (CDM) allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction or limitation targets. Under the CDM, there are various benefits, enormous potential to promote sustainable development and increase foreign investment flows for developing countries. With thoughtful planning and the development of a national CDM strategy, it can also assist in addressing local and regional environmental problems and in advancing social goals. With the support of developed countries, Vietnam not only can achieve long-term sustainable development but also be able to play a role in climate protection.

Keywords*: Clean Development Mechanism (CDM), United Nations Framework Convention on Climate Change (UNFCCC), The Kyoto Protocol.*

1. Introduction

The Clean Development Mechanism (CDM), a cooperative mechanism established under the Kyoto Protocol, has the potential to assist developing countries in achieving sustainable development by promoting environmentally friendly investment from industrialized country governments and businesses. While the basic rules have been established, the CDM is a work in progress by participating governments.

The 1997 Kyoto Protocol, a milestone in global efforts to protect the environment and achieve sustainable development, marked the first time that governments accepted legally-binding constraints on their greenhouse gas emissions. The Protocol also broke new ground with its innovative "cooperative mechanisms" aimed at cutting the cost of curbing these emissions. The Protocol includes three market-based mechanisms aimed at achieving cost-effective reductions - International Emissions Trading (IET), Joint Implementation (JI), and the CDM.

The CDM, contained in Article 12 of the Kyoto Protocol, allows governments or private entities in industrialized countries to implement emission reduction projects in developing countries and receive credit in the form of "certified emission reductions" or CERs (UNEP, 2017).

1.1. International agreement

1.1.1. The UNFCCC& the Kyoto Protocol

The United Nations General Assembly published by formally launching negotiations on a framework convention on climate change and establishing an "Intergovernmental Negotiating Committee" to develop the treaty. Negotiations

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to formulate an international treaty on global climate protection began in 1991 and resulted in the completion, by May 1992, of the United Nations Framework Convention on Climate Change (UNFCCC) (Hoang et al., 2014).

1.1.2. The United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC was opened for signature at the UN Conference on Environment and Development (the Earth Summit) in Rio de Janeiro, Brazil, in June 1992, and entered into force in March 1994. The Convention sets an "ultimate objective" of stabilizing atmospheric concentrations of greenhouse gases at safe levels. To achieve this objective, all countries have a general commitment to address climate change, adapt to its effects, and report their actions to implement the Convention. As of December 2001, the Convention currently has received 186 instruments of ratification (UNEP, 2017).

More than 150 countries signed in June 1992 in Rio de Janeiro (Brazil) (Hoang et al., 2014). The Convention divides countries into two groups: Annex I Parties, the industrialized countries who have historically contributed the most to climate change, and non-Annex I Parties, which includes primarily the developing countries (UN, 2009).

1.1.3. The Kyoto Protocol

The Kyoto Protocol was adopted in December 1997. The Protocol creates legally binding obligations for 38 industrialized countries, including 11 countries in Central and Eastern Europe, to return their emissions of GHGs to an average of approximately 5.2 percent below their 1990 levels as an average over the period 2008-2012.

The targets cover the six main greenhouse gases: carbon dioxide, methane, nitrous oxide; hydrofluoro-carbons (HFCs); perfluoro-carbons (PFCs); and sulphur hexafluoride (Hoang et al., 2014). The Protocol also allows these countries the option of deciding which of the six gases will form a part of their national emissions reduction strategy. Some activities in the land-use change and forestry sector, such as deforestation and reforestation, that emit or absorb carbon dioxide from the atmosphere, are also covered (Hieu, 2003).

1.1.4. The Clean Development Mechanism (CDM) and the Cooperative Mechanisms

The Protocol establishes three cooperative mechanisms designed to help industrialized countries (Annex I Parties) reduce the costs of meeting their emissions targets by achieving emission reductions at lower costs in other countries than they could domestically International Emission Trading permits countries to transfer parts of their "allowed emissions" ("assigned amount units").

Joint Implementation (JI) allows countries to claim credit for emission reductions that arise from investment in other industrialized countries, which result in a transfer of equivalent "emission reduction units" between the countries (UNEP, 2017).

The Clean Development Mechanism (CDM) allows emission reduction projects that assist in creating sustainable development in developing countries to generate "certified emission reductions" for use by the investor.

The mechanisms give countries and private sector companies the opportunity to reduce emissions anywhere in the world wherever the cost is lowest and they can then count these reductions towards their own targets.

Through emission reduction projects, the mechanisms could stimulate international investment and provide the essential resources for cleaner economic growth in all parts of the world. The CDM, in particular, aims to assist developing countries in achieving sustainable development by promoting environmentally friendly investment from industrialized country governments and businesses.

The funding channelled through the CDM should assist developing countries in reaching some of their economic, social, environmental, and sustainable development objectives, such as cleaner air and water, improved land use, accompanied by social benefits such as rural development, employment, and poverty alleviation and in many cases, reduced dependence on imported fossil fuels. In addition to catalyzing green investment priorities in developing countries, the CDM offers an opportunity to make progress simultaneously on climate, development, and local environmental issues. For developing countries that might otherwise be preoccupied with immediate economic and social needs, the prospect of such benefits should provide a strong incentive to participate in the CDM.

1.2. Overview of CDM

1.2.1. Participation

The CDM allows an Annex I Party to implement a project that reduces greenhouse gas emissions or, subject to constraints, removes greenhouse gases by carbon sequestration, or "sinks," in the territory of a non-Annex I Party. The resulting certified emission reductions, known as CERs, can then be used by the Annex I Party to help meet its emission reduction target. CDM projects must be approved by all Parties involved, lead to sustainable development in the host countries, and result in real, measurable and long-term benefits in terms of climate change mitigation. The reductions must also be additional to any that would have occurred without the project (UNEP, 2017).

In order to participate in the CDM, there are certain eligibility criteria that countries must meet. All Parties must meet three basic requirements: voluntary participation in the CDM, the establishment of a National CDM Authority, and ratification of the Kyoto Protocol. In addition, industrialized countries must meet several further stipulations: establishment of the assigned amount under Article 3 of the Protocol, a national system for the estimation of greenhouse gases, a national registry, an annual inventory, and an accounting system for the sale and purchase of emission reductions.

1.2.2. Eligible Projects

The CDM will include projects in the following sectors: End-use energy efficiency improvements, Supply-side energy efficiency improvement, Renewable energy, Fuel switching, Agriculture (reduction of CH_4 and N_2O emissions), Industrial processes (CO_2 from Cement etc., HFC_s, PFC_s, SF_6), Sinks projects (only afforestation and reforestation).

In order to make small projects competitive with larger ones, the Marrakech Accords establish a fast track for small-scale projects with simpler eligibility rules-renewables up to 15 MW, energy efficiency with a reduction of consumption either on the supply or the demand side of up to 15 giga watt hours/yr, and other projects that both reduce emissions and emit less than 15 kilotons of CO_2 equivalent annually.

1.2.3. Financing

Public funding for CDM projects must not result in the diversion of funds for official development assistance. In addition, the CERs generated by CDM projects will be subject to a levy-known as the "share of the proceeds" of 2%, which will be paid into a newly-created adaptation fund to help particularly vulnerable developing countries adapt to the adverse effects of climate change.

Another levy on CERs will contribute to the CDM's administrative costs. To promote the equitable distribution of projects among developing countries, CDM projects in least developed countries are exempt from the levy for adaptation and administrative costs.

1.2.4. The Executive Board

The CDM is supervised by an Executive Board, which itself operates under the authority of the Parties. The Executive Board is composed of10 members, including one representative from each of the five official UN regions (Africa, Asia, Latin America and the Caribbean, Central and Eastern Europe, and OECD), one from the small island developing states, and two each from Annex I and non-Annex I Parties.

The Executive Board will accredit independent organizations–known as operational entities that will validate proposed CDM projects, verify the resulting emission reductions, and certify those emission reductions as CERs. Another key task is the maintenance of a CDM registry, which will issue new CERs, manage an account for CERs levied for adaptation and administrative expenses, and maintain a CER account for each non-Annex I Party hosting a CDM project.

1.2.5. Project Identification and Formulation

The first step in the CDM project cycle is the identification and formulation of potential CDM projects. A CDM project must be real, measurable and additional. To establish additionality, the project emissions must be compared to the emissions of a reasonable reference case, identified as the baseline. The baseline is established by the project participants according to approved methodologies on a project specific basis. These baseline methodologies are being developed based on the three approaches in the Marrakech Accord.

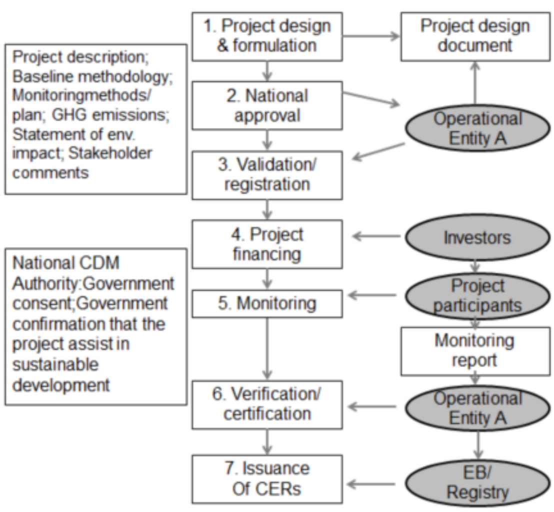

Fig. 1. Viet Nam - Key Country Indicators (UNEP, 2017)

The CDM project cycle as shown on the figure has seven basic stages: project design and formulation, national approval, validation and registration, project finance, monitoring, verification/certification and issuance of CERs. The first four are performed prior to the implementation of the project, while the latter three are performed during the lifetime of the project.

CDM projects must also have a monitoring plan to collect accurate emissions data. The monitoring plan, which constitutes the basis of future verification, should provide confidence that the emission reductions and other project objectives are being achieved and should be able to monitor the risks inherent to baseline and project emissions. The monitoring plan can be established either by the project developer, or by a specialized agent. The baseline and monitoring plan must be devised according to an approved methodology.

1.2.6. National Approval

All countries wishing to participate in the CDM must designate a National CDM Authority to evaluate and approve the projects, and serve as a point of contact. Although the international process has given general guidelines on baselines and additionality, each developing country has the responsibility to determine the national criteria for project approval. Together with the investor, the host country must prepare a project design document with the following structure: General description of the project; Description of the baseline methodology; Timeline and crediting period; Monitoring methodology and plan; Calculation of GHG emissions by sources; Statement of environmental impacts; Stakeholder comments.

1.2.7. Validation and Registration

A designated operational entity will then review the project design document and, after public comment, decide whether or not it should be validated. These operational entities will typically be private companies such as auditing and accounting firms, consulting companies and law firms capable of conducting credible, independent assessments of emission reductions. If validated, the operational entity will forward it to the Executive Board for formal registration.

1.2.8. Monitoring, Verification and Certification

The carbon component of a mitigation project cannot acquire value in the international carbon market unless submitted to a verification process designed specifically to measure and audit the carbon component. Therefore, once the project is operational, participants prepare a monitoring report, including an estimate of CER_s generated, and submit it for verification by an operational entity. Verification is the independent ex-post determination by an operational entity of the monitored reductions in emissions.

1.3. National Value and Benefits

The basic principle of the CDM is simple: developed countries can invest in low-cost abatement opportunities in developing countries and receive credit for the resulting emissions reductions, thus reducing the cutbacks needed within their borders. While the CDM lowers the cost of compliance with the Protocol for developed countries, developing countries will benefit as well, not just from the increased investment flows, but also from the requirement that these investments advance sustainable development goals. The CDM encourages developing countries to participate by promising that development priorities and initiatives will be addressed as part of the package. This recognizes that only through long-term development will all countries be able to play a role in protecting the climate (UNEP, 2017).

From the developing country perspective, the CDM can: Attract capital for projects that assist in the shift to a more prosperous but less carbon-intensive economy; Encourage and permit the active participation of both private and public sectors; Provide a tool of technology transfer, if investment is channelled into projects that replace old and inefficient fossil fuel technology, or create new industries in environmentally sustainable technologies; and, Help define investment priorities in projects that meet sustainable development goals.

Specifically, the CDM can contribute to a developing country's sustainable development objectives through: Transfer of technology and financial resources; Sustainable ways of energy production; Increasing energy efficiency & conservation; Poverty alleviation through income and employment generation; and Local environmental side benefits.

The drive for economic growth presents both threats and opportunities for sustainable development. While environmental quality is an essential element of the development process, in practice, there is considerable tension between economic and environmental objectives. Increased access to energy and provision of basic economic services, if developed along conventional paths, could cause long-lasting environmental degradation both locally and globally. But by charting a different course and providing the technological and financial assistance to follow it, many potential problems could be avoided.

1.4. Developing a National CDM Strategy

1.4.1. Evaluation of National Interests and Priorities

The CDM presents an opportunity to channel resources towards the projects that are most likely to further national sustainable development. Criteria for CDM projects should therefore be based on a country's sustainable development objectives, which may be identified by the goals and policies already established for social and economic development in related areas, such as energy, land-use change and transportation. At the national level, sustainable development programs or environmental plans may already be in place in related areas, such as policies on forests, renewable energy and clean technologies (MFAD, 2009).

1.4.2. Building Support for CDM - A Participatory Approach

One of the most challenging aspects of building a national CDM strategy is enlisting the active support from all sectors of society (civil, NGOs, private and public sector) and different sectors of the economy (industry, energy, agriculture, forestry). A successful CDM strategy will require official governmental support, both in terms of ratification of the UNFCCC and the Kyoto Protocol, but also in designating a National Authority to approve CDM projects. However, governments will also play a key role in cooperating with the private sector to market the CDM proposals to prospective investors.

The private sector can help ensure an emphasis on efficiency and the development of clear and simple rules. Including the participation of the private sector in the institutional building process encourages a less bureaucratic and more results-oriented approach in the procedure. The private sector is essential for driving the CDM, as investors seek cost-efficient means of mitigating their emissions.

Non-governmental organizations (NGOs) should also be incorporated in the development and implementation of the strategy, since they bring an environmental and social focus to the institutional agenda. NGOs can be repositories of valuable scientific expertise and technical know-how in developing and evaluating projects.

1.4.3. National Institutional Structure to Implement CDM Projects

The National CDM Authority is the host country entity or body that evaluates potential CDM projects and provides written approval confirming that the project activity is voluntary, complies with national and international criteria, and assists in achieving sustainable development of the host country (UNEP, 2017).

The National CDM Authority needs to have open communication with the government agencies of the sectors relevant to the CDM. The technical review of projects can often involve the ministries or bureaus of the relevant sector (energy, natural resources, environment, etc.).The approval of CDM projects could also involve foreign affairs ministries, since they often serve as the UNFCCC focal point.

1.4.4. Evaluation and Approval

The process will increase the probability of having projects successfully validated and certified as CDM projects, and reduce the perceived and real risks of national and foreign investors in developing and implementing carbon mitigation projects. It can also create incentives for specific project types or for priority sectors. The evaluation process also provides the main filter for ensuring that projects pursue CDM objectives consistent with relevant national policies, strategies and priorities.

International criteria: As a starting point in the evaluation process, a CDM project must first satisfy the internationally agreed criteria. Article 12 of the Kyoto Protocol stipulates three principal eligibility criteria for CDM projects:

- Projects must assist Non-Annex I Parties “in achieving sustainable development and contributing to the ultimate objective of the Convention”.
- Projects must result in “real, measurable and long-term benefits related to the mitigation of climate change”.
- Projects must result in “reductions in emissions that are additional to any that would occur in the absence of the certified project activity”.

1.4.5. Project Supply, Identification and Formulation

To promote CDM investment, host countries can hold training sessions for project developers, during which they are shown how to identify potential projects, understand the context of the UNFCCC and the carbon market, and familiarize themselves with the PDD (UNEP, 2017). Training sessions may also be necessary to understand the more complex aspects of CDM projects, such as generating proper documentation for the establishment of baselines (including assumptions and methodologies used), as well as calculating project emissions, reductions and leakage; that is, the indirect effect of emission reduction projects that lead to arise in emissions elsewhere (UNFCCC, 2018).

2. The clean development mechanism implementation in Vietnam

2.1. Introduction of policy and strategy of implementing CDM in Vietnam

Vietnam ratified UNFCCC on 16 November 1994 and signed Kyoto Protocol (KP) on 3 December 1998 and ratified on 25 September 2002. Ministry of Natural Resources and Environment (MONRE) is assigned by the Government as a

National Authority to implement UNFCCC and KP (MONRE, 2019). Submitted first national communication to UNFCCC in November 2003. The project: "Capacity Development for the Clean Development Mechanism in Viet Nam", phase 2 was carried out in Viet Nam in 2003 with 6 main tasks. International Cooperation Department, MONRE is a Executing Agency to coordinate and carry out the project (Hoang et al., 2014).

Vietnam government set up several objectives: Task 1: Public information for raising CDM awareness; Task 2: Capacity development on CDM for policy makers; Task 3: Establishment and capacity development for CDM National Authority (CNA); Task 4: Capacity development for stakeholders relevant to CDM projects; Task 5: Capacity building on CDM research and education; Task 6: Creating a pipeline of CDM eligible projects.

2.1.1. Legal Framework

Legal documents issued by Prime Minister: Directive No. 35/2005/CT-TTg dated 17 October 2005 on the implementation of KP to the UNFCCC; Decision No. 47/2007/QD-TTg dated 06 April 2007 on approving KP implementing plan to the UNFCCC; Decision No. 130/2007/QD-TTg dated 02 August 2007 on a number financial mechanisms and policies for CDM projects (Financial Policy Circular, 2007).

Legal documents issued by MONRE and MOF: Joint-Circulars No. 58/2008/TTLT-BTC-BTNMT dated 04 July 2008 for guiding the implementation of some articles in Decision 130/2007/QD-TTg dated 02 August 2007 (Financial Policy Circular, 2007). Joint-Circulars No.204/2010/TTLT-BTC-BTN&MT dated 15/12/2010 to complement for Joint-Circulars No. 58/2008/TTLT-BTC-BTNMT.

Legal documents issued by MONRE: MONRE has issued Circulars No. 12/2010/TT-BTNMT dated 26 July 2010 (replacing Circular No. 10/2006/TT-BTNMT dated 12 December 2006) and Circulars No. 15/2011/TT-BTNMT dated 28 April 2011 on guiding the development of CDM projects under KP in Viet Nam. Circulars No. 15/2014/TT-BTNMT dated 24 March 2014 on guiding the development of CDM projects underKP in Viet Nam (replacing Circulars No. 15/2011/TT-BTNMT dated 28 April 2011).

2.1.2. CDM's Institutional Arrangement

In order to govern and manage efficiently, CDM's Institutional Arrangement is set up to create good CDM plan and help project developers in development.

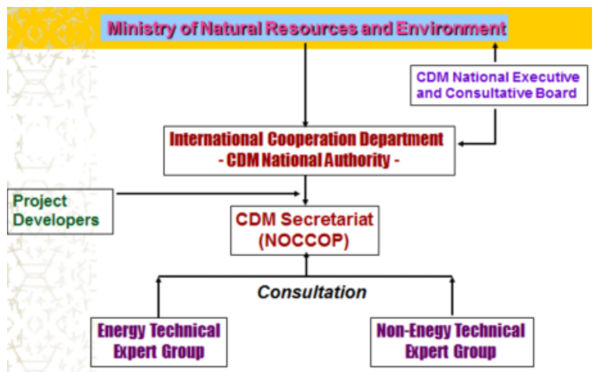

Fig. 2. CDM's Institutional Arrangement (Hieu, 2003)

2.1.3. Approval Procedure for CDM Project

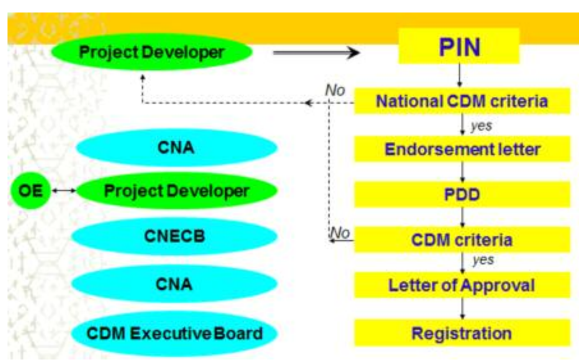

Fig. 3. Approval Procedure for CDM Project (Hieu, 2003)

According to the Circulars issued by MONRE, a document application for LoA of PDD/ PoA-DD in Viet Nam has to include (Tuan, 2012): 1) PDD, PoA-DD, CPA-DD developed by project participants; 2) Letter submitted by CDM project developers to Viet Nam DNA for LoA; 3) Comments of stakeholders directly affected by project activities; 4) The approved environmental impact assessment report;

5) The other related licenses (if any) provided by competent authorities for projects in specific fields under current regulations; 6) Technical report for PDD or PoA-DD validation report of a DoE; 7) The authorization letter of foreign investor to domestic investor for executing the obligations on registration and CER fee payment if foreign investors did not have representative office in Viet Nam.

Moreover, Preparation for CDM projects are also presented in legal official circulars such as CDM project developers shall formulate CDM project documents on the basis of investor's requirements by either of the following methods: Formulate PIN, submit it to a competent authority for grant of letter of endorsement, and then continue to formulate PDD or PoA-DD together with general CPA-DD and practical CPA-DD. Formulate PDD or PoA-DD together with general CPA-DD and practical CPA-DD, then submit them to a competent authority for grant of letter of approval.

2.1.4. Remarks

For electricity generation projects, the emission factor for electricity published by DMHCC is used in PDD/PoA-DD. If the project connects to the national power grid, it needs the support letter from Electricity of Viet Nam (EVN). For the hydropower project, it needs the license for using water surface; For the wastewater treatment project, it needs the license for releasing wastewater into the river. For multi-country PoA, it needs the LoA of the host country.

2.2. CDM potential projects, Implementation CDM in Vietnam and Current affairs

2.2.1. CDM project cycle

Requirements for CDM projects in Viet Nam: CDM project investors and developers implement and develop CDM project based on voluntary and have to follow current regulations; GHG emission reduction; Appropriate with national and local socio-economic development programmes and strategies; Contribute to sustainable development of Viet Nam; Ensure the feasibility with advance technology and have suitable financial sources; The amount of GHG emission is reality, have additionality, is calculated and verified directly or indirectly; Have environmental impact assessment; Have support from stakeholders; Have approval of host country; Register with EB and have its approval; The implementation of CDM projects do not lead to arise any new responsibilities for Vietnamese Government to KP content.

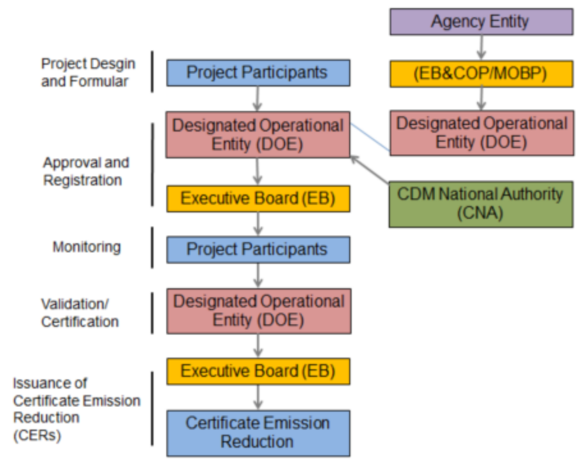

Fig. 4. CDM project cycle (Hieu, 2003)

Main activities and results of implementation of UNFCCC

Vietnam has carried out the following climate change projects (Hoang et al., 2014): 1) Asian: Study on global impacts of climate change; 2) "Asian Least Cost GHG Abatement Strategy" (ALGAS); 3) Vietnam coastal zone vulnerability assessment; 4) Economic of GHG Limitation (Phase 1): "Formulization of methodology to assess GHG limitation"; 5) Reduction of electricity consumption in Cement Ha Tien 2 Plant by using surplus thermal for additional generation; 6) Implementation of UNFCCC in Quang Ninh Province; 7) "Enabling Activities for the Preparation of Initial National Communication Related to UNFCCC"; 8) "Vietnam National Strategy Study on Clean Development Mechanism" (NSS); 9) Use of biogas; 10) Increasing carbon sequestration in planted forest in Vietnam through use of genetically improved species; 11) Energy efficient in Public Lighting sector.

2.2.2. Formulation and development of climate change, CDM/PCF projects portfolio:

Improve energy efficiency in Small Medium Scale Enterprises (SME); Reducing CH4 emission by managing water level on rice fields. Fuel switching oil to gas (Thu Duc Plant); Recover CH4 from landfills (Ho Chi Minh City, Ha Noi, Hai Phong City). Capacity Development for CDM; Development of renewable energies (wind, biogas, solar, geothermal power); Cogeneration of electricity (Nghe An Tate & Lyle Company); Establishment of Protection Forest (Central Regional).

The project has launched by UNEP with the support from Dutch Government. Vietnam is one of the three countries in Asia has been selected to participate in the project. The project will assist Viet Nam to take advantages to joint CDM market through establishing GHG emission reduction projects that are consistent with national sustainable development goals.

Expected Outcomes: Define and improve a regulatory framework to support CDM activities; Enhance CDM capacity building and skills for related organizations; Identify prospective CDM projects; Operational information and guidelines for raising awareness and capacity building on CDM that can be applied in the project (Laurie, 2018).

Project Preparation Phase: Review national experiences on AIJ / CDM projects; Organize and participate in CDM national workshop with participation of main national stakeholders involved on CDM; Establish a country specific strategy approach in order to obtain the highest degree of political support; Designate an appropriate focal point agency that will coordinate national CDM activities and investments; Develop a multi-year work plan for promoting nationals CDM activities and investments in Vietnam.

2.2.3. CDM projects under consideration

It is witnessed a gradually rise number of registration of CDM projects in Vietnam, especially hydropower projects.

Table 1. Potential CDM projects under consideration

No	Name of Project	Project site	Emission reduction potential (Gg CO_2)	Status
1	Rang Dong oil field associated gas recovery utilization	Vung Tau City	6,740	Approval letter
2	Thuong Ly landfill closure and gas recovery and utilization	Hai Phong City	64	Endorsement letter
3	Ho Chi Minh /Hanoi Cities landfill gas for electricity generation	HCM/Hanoi Cities	3,100	Endorsement letter
4	Reforestation of newly allocated land in A Luoi-North Central Vietnam	Thua Thien Hue Province	192	
5	Increasing the efficient use of energy in brewery	Thanh Hoa province	11	Under consideration
6	Thu Duc power plant unit 3 fuel switch from oil to gas	HCM City	664	Under consideration
7	Wind+ Diesel hybrid electricity supply system	Binh Thuan City	106	Under consideration

Vietnam is transitioning to renewable energy sources to maintain competitive electricity generation and to deliver increased capacity quickly. Several renewable energy projects have been developed through the clean development machanism as rooftop solar project, large-scale solar project, on-shore wind power project (DEHSt, 2017).

Challenges: The awareness and knowledge of CDM issues among managers, policy markers, experts, enterprises, general public, private sector, NGOs are still limited; The financial sources for CDM activities in country are limited; The CER price in the world is dropping; The domestic carbon trading market is still under development (UNDP Vietnam, 2018) (Nhan et al, 2010).

Table 2. Preliminary porfolio of CDM project

No	Name of project	Developer	Capacity	Expected GHG reduction (KT CO_2)
1	Upgrading existing coal fired thermal of Pha Lai power plant	Electricity of Vietnam (EVN)	440 MW	378/y
2	Wind power plant in Quang Tri Province	QuangTri Electricity Company	20 MW	129/y
3	Geothermal power plant in QuangNgai Province	ORMAT private	50 MW	310/y
4	Dak Pone hydro power	RCEE	14 MW	40/y
5	Cogeneration for PhongKhe paper village	RCEE	6.4 MW	74/y
6	Rice husk power plant in TienGiang Area	Institute of Energy	3 MW	56/y
7	Improvement of oil fired boilers in DongNai pulp and paper factory	Dong Nai paper factory	25,000t paper/y	4.3/y
8	Improvement of energy efficiency in Song Da cement factory	Song Da cement factory	85,000 t/y	18.2/y
9	Efficiency of public lighting system in big city	Institute of Material Science	100,000 units	190/y
10	Advanced sedimentary brick kiln in BacNinh province	Institute of Thermal Engineering	400 mill.pieces/y	49/y
11	Reforestation of newly allocated land in A-Luoi district	SNV Farmer Union of ALuoi	3,000 ha	28/y
12	Cam Lam KN Solar Power Project in Viet Nam	Hanwha Energy Corporation	50 MW	62/y
13	DaNhim-HamThuan Solar Power Plant	DaNhim-HamThuan-DaMi Hydropower Joint Stock Company (DHD)	47.5MW	50/y

Solutions: Revise and issue related legal documents to create a favorable legal framework for investors to develop and implement CDM in the country; Integrate CDM activities into national, sectoral, local development strategies and plans; Strengthen the cooperation between ministries, agencies, organizations and localities in development of CDM projects in Viet Nam; Increase the public awareness, capacity building activities on CDM; Actively assist project participants in developing the CDM projects. Create close co-operations with EB, DOE and project developers (Nhan et al, 2010) (UNDP, 2003).

3. Conclusion

The full extent of potential benefits available to developing countries under the CDM is difficult to forecast, but its enormous potential to promote sustainable development and increase foreign investment flows is clear. With thoughtful planning and the development of a national CDM strategy, it can also assist in addressing local and regional environmental problems and in advancing social goals. The CDM allows developing countries to participate in the global effort to combat climate change at a time when other development priorities may limit the funding available for GHG emission reduction activities. The CDM's objective of advancing the development goals of developing countries recognizes that only through long-term sustainable development will all countries be able to play a role in climate protection.

Vietnam has interested in climate change activities. Vietnam signed and ratified UNFCCC in 1994. Vietnam signed KP in 1997 and ratified it on 25 September 2002. In 1994, Vietnam issued Environment Law and Decree of Government guiding implementation of environment protection law. Vietnam would implement its commitment in International Convention on environment protection which it signed.

The UNEP Project: "Capacity Development for CDM" will contribute an important part to facilitating CDM activities and sustainable development in Vietnam in the future.

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Research Paper

OVERVIEW OF INVESTIGATIONS IN ECONOMIC LOSS BY ECOSYSTEM DEGRADATION RELATING TO CLIMATE CHANGE

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ABSTRACT

Typical ecosystems of islands and coastal areas of our country such as natural forests, corals, seagrasses and mangroves play an important role in local and social socio-economic development. Coastal ecosystems provided many uses such as energy (firewood, wood, ...), exploitation and aquaculture, food and medicine, transportation, tourism, disaster prevention, habitat of plants and animals, CO_2 absorption, etc. and non-use (biodiversity, learning cultures,...). However, the impacts of climate change and sea level rise (CC, SLR) and the increase in natural disasters will change the composition of sediments, salinity and pollution levels of water, leading to degradation and threaten the survival of these ecosystems. These are the most productive ecosystems, and also the most threatened in the world. In recently, researchers around the world have built scientific methods to evaluate economic value as well as increasingly complete economic losses. A number of studies have studied the economic loss due to ecosystem degradation related to climate change in Vietnam and in the world but it is still limited. This study mainly assesses the real situation of economic losses due to ecosystem degradation under the impact of climate change in recent studies.

Keywords: *Economic loss, ecosystem degradation, climate change.*

1. Introduction

Climate change is a phenomenon of warming of the Earth's surface due to increasing concentrations of greenhouse gases (CO_2, CH_4, NO_x, CFC, HFC ...), causing environmental fluctuations and sea level rise (SLR). According to the IPCC report (2007a), the average temperature increase of the Earth is about 0.8°C compared to 1850 and it is expected to increase to 1.4-6.4°C by 2100, compared to previous 50 years, the rate of increase in temperature in the last 50 years has nearly doubled (IPCC, 2007). Lots of research by scientists around the world has confirmed that climate change and SLR are one of the main causes of degradation of typical natural ecosystems such as natural forests, corals, seagrasses and mangroves (An et al., 2015). Along with re-

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search on ecosystem degradation, scientists have also conducted studies on the estimation of value of economic losses for typical ecosystems with evaluation methods.

Vietnam is amongst countries being mostly affected by climate change and SLR. That is a threat to Vietnam's coastal island ecosystems. In fact, Vietnam's sea and island ecosystems are now being degraded at a very fast rate. The areas with high biodiversity are gradually shrinking, the number of species and wild species is declining sharply, many genetic resources are degraded and lost and many factors show ecological imbalance. Population of plants and animals tend to move farther from shore due to changes in the structure of coastal circulation, changes in river-sea interaction in coastal estuaries and due to loss of up to 60% of natural habitats (http://www.vasi.gov.vn/).

Investigations on loss assessment (damage) in Vietnam have started since the late 20th century and till early 21st century. The assessment of economic value of natural resources and environmental impacts on the 1990s together with the Law of Environmental Protection (in 1993) required the identification of damage caused by pollution from environmental degradation. Studies were carried out on various projects at different levels with the common goal to determine the economic value of environmental, ecosystem and public health factors under the operation of factories, industrial zones,... in particular and environmental pollution factors due to economic development activities of each region and locality in general. However, the number of studies on economic losses due to ecosystem degradation is limited. An overview of the study of economic losses due to ecosystem degradation in the context of climate change will synthesize the methods, techniques applied and the results of relevant domestic and international studies.

2. Studies on degradation of typical ecosystems due to climate change impacts in the world and Vietnam

2.1. Typical ecosystem degradation in the context of climate change in the world

In the world, researches on ecosystem degradation due to climate change impacts are quite popular, especially regarding coral reef, seagrass, and mangrove ecosystems.

When seawater temperature increases rapidly, it will stimulate symbiotic algae growth, these algae almost cover the sunlight, making corals unable to photosynthesize, causing "white death" (https://www.cbd.int/). Coral reef ecosystems that were prone to degradation due to climate change, as shown by the fact that aa series of dead coral in the last two decades in the research area. Selective methods to manage marine protected areas included limiting the current degradation, protecting resilient areas, integrating climate change into marine conservation plans, management and evaluation (Brain et al., 2009). A research has shown that climate change trends such as temperature, sea level rise and increasing CO_2 content would put pressure on many species of seagrasses. The surface of the water is covered, increasing turbidity and reducing light penetration to the bottom, thereby reducing the photosynthesis of seagrasses, causing seagrasses to die (Short and Neckles, 1999). Mireia et al. (2014) identified the negative effects of global warming and sea level rise on seagrass ecosystems in general and especially Zosteranoltii seagrass. Determination of the change in the distribution of this seagrass to the end of the 21st century will begradual development towards the North about 888km in appropriate habitat conditions, and will gradually disappear in the South (Mireia et al., 2014). Global changes such as sea level rise affected mangrove degradation. The sedimentation rate in the mangroves might be large enough to compensate for the current sea level rise (Field, 1995). Four mangrove response scenarios in response to sea level rise offered by Gilman et al., (2007): A. There is no relative change in sea level. There is no change in mangrove location; B. Changes in mangrove area under the impact of climate change. Mangroves enter land and the sea encroachment strongly; C. Changes in mangrove area under the impact of climate change, in case there are no obstacles to the mainland. Mangroves enter the mainland, mangroves encroach upon the sea but the coast is eroded; D. Changes in mangrove area under the impact of SLR and stuck between irrigation infrastructures. Mangroves encroach upon sea but erode, land encroachment is stuck between dykes. Eventually mangroves shrink or disappear (Gilman et al., 2007). Besides, forest ecosystem is vulnerable in the context of climate change. The change in temperature, precipitation, and CO_2 concentration negatively affects the photosynthesis and metabolism of plants. Climate change increases the risk of extinction of rare animals and genetic resources, increases the risk of wildfires, and spreads of diseases more widely and widely (Charlotte et al., 2007). Tropical forests are more vulnerable to the impacts of climate change, especially, young trees. Climate change can have impacts on forest health (growth, regeneration, species composition and diversity) leading to degradation and vice versa (Inkyin and Su, 2014).

2.2. Typical ecosystem degradation in the context of climate change in Vietnam

In Vietnam, degradations of coral reefs, seagrasses, mangroves have been investigated from 2010. Studies evaluated the causes of degradation of ecosystems in which climate change is one of main reason. However, research on degradation of natural forest due to climate change has not been focused, mainly due to human impacts.

Yet (2010) developed a set of criteria to assess the degradation of coral, seagrass and mangrove ecosystems. Assessments of the causes and extent of degradation of coral ecosystems, seagrasses, coastal mangroves were conducted in Vietnam and their changing trends (Yet, 2010). A study completed the database of current state of primary ecosystems such ascoral reefs and mangroves of 14 research areas focusing on 5 key areas: Ha Long Bay, Ba Lat, Tam Giang - Cau Hai and Con Dao, Truong Sa Islands. This assessed and forecasted the level of degradation of the ecosystems (coral reefsand mangroves) in these study areas. The level of degradation varied foreach region. The self-recovery abilities of typical marine ecosystems were assessedin some study areas (Cuong and Thung, 2011). The project pointed out the characteristics of the distribution of ecosystems of coral reefs, seagrasses, mangroves and forecasted the extent of degradation according to scenarios of sea level rise of 50cm and 100cm in key island areas of Vietnam: Bach Long Vi, Ly Son, Con Dao and Phu Quoc (An et al., 2015). The study by Tiến (2015) evaluated the natural environment fluctuations and socio-economic vulnerability in Nhon Hoi economic zone and surrounding areas. Especially, the study forecasted the fluctuations of ecosystems (coral reefs, seagrasses and mangroves) in the study area with the scenarios of climate change, sea-level-rise (B_2) for 2030, 2050, and 2100. Thereby, it was proposed spatial planning and solutions to cope with and adapt to climate change and SLR (Tien, 2015).

3. Principle for estimating economic losses due to ecosystem degradation

3.1. The total economic value of typical ecosystems

The ecosystems' functions include providing people goods and services and the use of such goods and services bring economic value to people. According to Tietenberg (2003), use values refer to the ecological goods and services that the environment provides to people and economic systems, non-use values are intrinsic, intrinsic values of the ecosystem, as shown in Fig. 1.

Direct use value includes goods and services provided by natural resources and environment and can be directly consumed such as shrimp, fish, firewood, wood, seafood, recreational tourism, medicine…

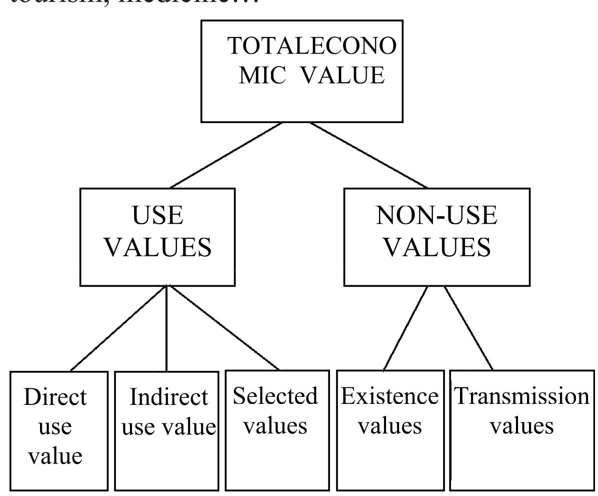

Fig. 1. The total economic value of natural resources and the environment

Indirect use value are values and benefits from ecological services provided by the system of natural resources and environment and ecological functions such as CO_2 absorption, climate control, storm prevention floods and natural disaster mitigation, filtration and regulation,...

Selected values are the values used directly or indirectly, although they can be used in the present but have not been used for some reason, leaving them for future consumption as value: tourism landscape, genetic resources, other resources...

Existence values are the values in the perception, feeling and satisfaction of individuals when knowing the properties of resources & environment existing in a certain state. These valuesare measured by an individual's willingness to pay to obtain that status.

Transmission values are direct or indirect values that can be used by future generations. This value is also often measured by an individual's willingness to pay to conserve resources and the environment for generations to come.

Based on the above analysis, a summary of the economic value of some typical ecosystems (natural forests, corals, seagrasses and mangroves) is in Table 1.

Table 1. Total economic value of some typical ecosystems (natural forests, corals, seagrasses and mangroves)

Direct use values	Indirect use values	Selected values	Transmission values
-Natural forests & mangroves: providing energy: wood, firewood, ... -Mangroves, corals & sea grasses: Exploiting and raising aquatic products; Providing products such as food, medicine, medicine, construction materials ... Traffic; Tourism, entertainment	-Preventing floods, storm barriers, storm surges, erosion and accretion. -Providing shelter for animals and plants. - CO_2 absorption, environmental conditioning. -Preventing saline water intrusion. -Gathering, expanding land	- Potential sources of medicinal herbs - Potential landscape for tourism	-Preserving biodiversity Cultural, historical, religious and political values -Transmission values for future generations

3.2 Methods of estimating economic losses

Dixon (1993) developed an approach to assess pollution/degradation/incident impacts on economic values (Fig. 1). Accordingly, economic losses will be calculated based on the difference of expenses and benefits at the two points: the baseline state (before the incident) and the state after the incident

The baseline state appears when no breakdown or degradation of the ecosystem occurs, the environmental system provides natural ecological goods and services to the economic system. When an incident/degradation occurs, the structure and function of the ecosystem's environment system will change, thereby leading to decrease or complete cutoff in the quantity and quality of goods and services provided in comparison with the baseline state. This leads to changes in the benefits and costs of individuals and society - these are the economic losses of incidents/pollution/environmental degradation and ecosystems.

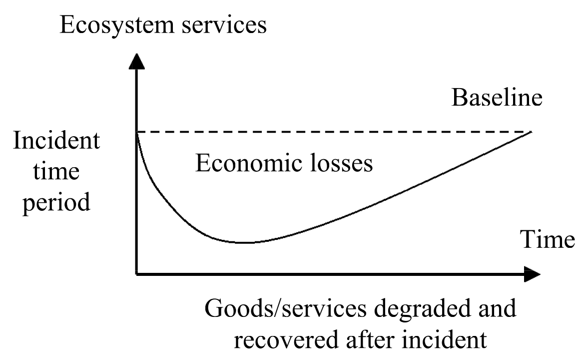

Fig. 2. Environmental economic damage due to natural and human impacts (Dixon, 1993)

To measure the economic value at the two points before and after the incident, Dixon and Sherman (1993) proposed three groups of methods: the market price method,revealed preference method, state preference method. Assessment method based on state preference method. The methods and specific objects applied are summarized and presented in Table 2

Table 2. Methods of estimating economic losses due to environmental incidents degradation

List	Methods	Applications
I	***Methods of costmeasurement based on the real market***	
1.1	Market price	Assessing the change in quantity and quality of ecosystem goods and services exchanged or traded on the market such as aquatic products, timber, pharmaceuticals, etc.
1.2	Production change	Values are measured, and market prices are used to calculate inputs and outputs in production and to assess physical changes in the process when there are damage factors such as: ecosystem degradation reduction of biological resources (aquatic products: shrimp, crabs, fish ...) living in such environment entails the influence of fishermen©s income
1.3	Health costs	Assessing the cost of illness caused by environmental pollution or damage agents such as paper factory affects the health of people around the area
1.4	Recovery and replaceme-nt costs	Determining the value of the change in the quality of environment/resources and ecosystem services is determined by the cost of restoring/replacing the lost resource assets. For example: calculating economic losses due to oil pollution incidents.
1.5	Protection or prevention costs	Investigating the costs that people actually have to pay or are willing to pay to avoid the damage that can be caused by environmental degradation such as the value of mangroves in coastal erosion prevention.
II	***Methods of damage assessment based on the replacement market***	
2.1	Travelling costs	Assessing the value of outdoor recreation such as fishing, hunting, yachting and sightseeing ... or assess the pollution damage by observing the change in the number of visitors to a recreational destination
2.2	Value of enjoyment	Estimating the value of the hidden environment in the market price of some common goods and services (real estate market, ...)
2.3	Production function	Applicable to indirectly used values when they are in the production function of an economic activity and have significant effects on the output of that economic process. For example, the influence of production inputs on fishing industry and aquaculture
III	***Methods of cost measurements based on the hypothetical market***	
3.1	Contingent valuation	By developing a hypothetical scenario and market with information collected about individual consumption behavior and choices in the hypothetical market, it is possible to changes in fish welfare. Due to changes in environmental quality,factors such as biodiversity damage when natural ecosystems are degraded
3.2	Choice modelling	Estimating the non use value of resources by building two or more hypothetical scenarios, each with many different attributes such as developing ecosystem resource use scenarios to evaluate the values / benefits of each scenario for resource and environment management

4. Studies on economic costs due to ecosystem degradation in the context of climate change

Coral reef ecosystems have been studied by many scientists in the world to measure the economic costs due to climate change than other ecosystems (natural forests, seagrasses and mangroves). Despite, the number of studies that estimate the economic value of these ecosystems is significant. Economic values of coral reefs, mangroves, and seagrasses for global compilation were summarized (WRI, CI, NOAA, 2008), which contains a number of researches in the world on the economic values as well as economic losses due to degradation of ecosystems, especially by the impact of climate change. The deterioration of the Caribbean reefs could lead to revenue losses from fisheries, tourism and reduced coastal protection over the next 50 years.Economic losses amount in fishery from $95 to $140 million, tourism: 100 - 300 million $, coastal protection 140 - 420 million$ (Burkeand Maidens, 2004). Anderson (2007) investigated losses of benefits from Zanzibar coral ecosystem damage in Tanzania (the country on the east coast of Africa) by estimation of the tourist cost method before and after the coral bleaching incident. The annual loss due to the coral bleaching was estimated up to 15.04 million$, or $254 to $1,780 per guest (Anderson, 2007). The damage caused by the destruction of coral reefs in Sri Lanka to induce erosion on the south and west coasts estimated at an average of 40 cm per year. This study used alternative cost method of coastal protection provided by coral reefs. 30.0 million$ has been used for structures to reduce damage of coral reefs. Average cost was from 246,000 to 836,000 dollars per kilometer (Berg et al., 1998). The economic value of the mangrove ecosystem in Malasia was measured by the market price method to calculate the value of fishing and logging. Fishery value was 70 billion Rupiah/year and traditional non-commercial use value is 20 billion Rupiah/year, logging value (selective felling) is 40 billion Rupiah/year (Ruitenbeek, 1994). The economic value of mangrove ecosystems was assessed in Tha Po Village in Surat Thani Province - Southern Thailand used market price method by estimated value of firewood, timber, fisheries and replacement value method by estimated value of sea protection function. The economic value of the study area obtained from the mangrove ecosystem ranges from 27,263 USD to 35,921 USD for 1 ha (Sathirathai and Barbier, 2001). Desvousges (1998) studied the option of using the Canyon mountain (USA) between hydropower construction and tourism development. Market price method was used to calculate the net economic value of electricity production and tourism cost method was used to calculate the tourism value of the cliff. Electricity production value was 80 million USD/year but the tourist value for the result was 900 million USD/year. So this study preserved the Canyon cliff for tourism development (Desvousges, 1998). Recreation and tourism of forested areas in Europe and North America were calculated using a random measurement method through a willingness to pay mechanism. The price paid for the use of recreational and travel services by people in Europe and North America ranged from 1-3USD/person/time (David and Corin, 2001). In general, studies on the measurement of economic losses and economic values of typical natural ecosystems (natural forests, corals, seagrasses and mangroves) have been conducted by scientists and organizations around the world. Scientific research has contributed significantly to the management of ecosystem resources and environment in countries. In particular, the flexible use of economic evaluation methods creates a diverse reference source for further studies.

In Vietnam, research on cost assessment (losses) has started from the late 20th century and early 21st century. The measurement of economic value of natural resources and environmental impacts on the 1990s with the introduction of the 1993 Law on Environmental Protection required the identification of damage caused by pollution from environmental degradation. Lots of research was carried out on various topics and projects at various levels sharing the common goal of determining the economic value of environmental, ecosystem and public health factors under the operation of factories, industrial zones,... in particular and environmental pollution factors, due to economic development activities of each region and locality in general. A number of studies evaluated the value or economic losses due to ecosystem incidents / degradation in the context of climate change in Vietnam. Thanh (2015) conducted a research on Economic evaluation due to climate change for Northern fishery and propose solutions to minimize damage caused by climate change used method with production function (the impact model of climate change through variables of rainfall, storm, temperature, ... to the annual fishing output) and market price. Results showedthe estimated annual economic loss due to climate change to the national aquaculture is about 584 (billion VND), annual aquaculture was about 568 (billion VND) (Thanh, 2015). The loss of typical ecosystems (coral reef, seagrassand mangrove ecosystems) due to natural and human impacts applied incase study of 4 areas: Cua Ba Lat, Tam Giang - CauHai, Con Dao and Ha Long Bay. Measurement method used random measurement (economic loss valuation of non use values); market prices (calculation of economic losses of direct use values of fisheries) and travel costs methods (costcalculation of tourism values), cost of avoided losses (estimated value loss coastal protection), benefit transfer (economic losses, reduction of sediment accumulation, expansion of mangroves). Results of this study showed thatthe loss of economic value due to ecosystem degradation in the four pilot sites were respectively 5.06, 6.32, 11.05 and 6.20 billion VND (Chinh and Truong, 2011). Economic valuation of typical sea - island ecosystems for the sustainable development of a number of frontal islands in Vietnam's coastal areas.Three key research islands are Bach Long Vi (Hai Phong province), Con Co (Quang Tri province) and Tho Chu (Kien Giang province). The method used such as market price (for the value of mineral exploitation), travel expenses (for travel and sightseeing values), replacement cost (for nutritional filtration value), cost of avoided damage (protection value, erosion control), random assessment of CVM (for biodiversity values, habitats, nursery grounds for marine biomes and non-use value) and inherit the results of other relevant studies. The economic value of ecosystems in 1 year in the 3 pilot sites was 599.05, 267.52, 565.24 billion VND, respectively (Lan, 2015). On another hand, a study estimated the recreational value of Cuc Phuong National Park (National Park) for domestic tourists to assess by apply method travel expenses to calculate the recreational value of tourists visiting Cuc Phuong National Park. The total tourism benefit was 1,502 billion VND and the consumer surplus of visiting tourists was 105,415 millionVND (Thanh and Hai, 1997).

5. Conclusion

Based on the summary of investigations on ecosystem degradation due to climate changes, it has shown that studies in the world and in Vietnam on ecosystem degradation, especially coastal ecosystem degradations (corals, seagrasses, mangroves) are quite popular. Studies have established a set of criteria to assess the degradation of coral, seagrass and mangrove ecosystems. The main cause of degradation of these ecosystems was human impact and natural disasters such as climate change and SLR. A number of studies have selected degradation research methods and evaluated the impact of climate change on ecosystems, forecasting the degradation of ecosystems of mangroves, coral reefs and seagrasses under the scenario of climate change and offered solutions to cope with climate change as Yet (2010), Cuong and Thung (2011), An (2015), Tien et al. (2015).

In terms of research on measuring economic costs as well as evaluating the economic value of ecosystems in the world and in Vietnam, there has been a certain stage of development according to the social management requirements. The system of methods and techniques applied to measure economic costshave been increasingly addedand improved. Studies have also selected the flexible use of multiple cost measurement methods and the calculation of monetary damages. However, studies measuring economic losses due to ecosystem degradation in the world and in Vietnam are still limited. An equally important factor causing economic damage to ecosystems is climate change, which is rarely mentioned.

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Research Paper

APPLICATION OF MOBILE DUST MONITORING SYSTEM TO EVALUATE DUST CONCENTRATION IN SEVERAL STREETS OF HANOI CITY

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ABSTRACT

This study attempted to design an intelligent, portable device as hardware for dust measurement by IMHEN. The device is able to collect a specific dust level, the time and location of various measurements, and environment parameters such as temperature, relative humidity, atmosphere pressure, etc. The device's design used the programmable Arduino Mega 2560 board as the main processing unit. The device is small, portable, battery-operated which makes it to be suitable for mobile measurement of environment parameters. Additionally, the device has been applied to monitor dust concentration at different time scale in some main routes of Hanoi city. The analysis of monitoring results showed that there were differences of dust concentrations at off-peak hours among different routes. The total dust concentration (TSP) observed that some roads such as La Thanh, Lang Ha, surounding Road No.3, Tran Duy Hung, Nguyen Chi Thanh were higher 1.5 to 2 times than the permissible limit value according to QCVN 05:2013/BTNMT

Keywords*: Mobile dust monitoring device, Dust pollution, Hanoi city.*

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1. Introduction

In the present, the growing trend and air pollution were intensively tracked through the environment paramters to have a better monitoring solution. Instead of using big and static measuring stations, human developed the compact, multi-functional and intelligent device (Devarakonda, 2013; Mead et al., 2012; Yu et al., 2013). With the development of integrated circuits, one modern device can integrate many functions inside that is very nessessary .

In big cities, air pollution was more and more serious along with the significant increase of urbanization. The monitoring of air quality, especially the dust concentration in the air, was a essential requirement to improve the efficiency of environmental quality monitoring. The mobile dust monitoring device might assist in monitoring dust pollution in real time and space in cities. The main objective of this study was to design, install and integrate a set of compact, multifunctional and intelligent dust and meteorological element monitoring device.

The device was designed and assembled for mobile monitoring of dust, temperature, humidity, pressure and GPS navigation parameters. The data from the device was utilized to develop a current pollution map of the TSP dust concentration on some main streets of Hanoi City.

2. Methodology

2.1. The design and installation of mobile dust monitoring device

The mobile dust monitoring equipment is configured as follows: a sensor, timer, GPS receiver, LCD touch screen, central processor unit, GPS navigation, sensor of temperature and humidity, time reader, and memory card that are connected to the central processor unit through different interfaces. The central processor unit has a function to control the operation of these parts. When the device starts working, the sensors collect data on dust concentration and other meteorological parameters such as humidity, temperature, air pressure, coordinates and time; and record these parameters in memory cards.

The research team has summarized and designed based on a number of similar mobile monitoring methods implemented in other studies (Table 1). In this study, a dust monitoring device in the environment was concerned. The main requirements for the device are: 1) Collecting the dust level measurement from an external professional instrument device; 2) The location, time and other parameters (temperature, humidity, atmospheric pressure, etc) to associate with the dust measuring point; 3) The device should be portable and battery-operated; 4) It has a built-in LCD screen to display various parameters and the dust level itself; 5) It also has built-in memory storage to exchange the data.

Table 1. A number of mobile dust measurement methodologies in the world

Author	Means of observation	Device	Parameter	Time
Kaur *et. al* (2007)	Walk	TSI P-Trak 8525 A high-flow personal sampler (HFPS)	Dust (superfine particle counting) $PM_{2.5}$	1s
Isakov *et. al* (2007)	Minivan	Mobility analyzer TSI 3071 and Particle counting equipment TSI 3010	Dust (superfine particle)	30s
Airparif (2009)	Tricycle for carrying goods	P-Trak Thermo Scientific 42i	Dust (superfine particle) NO; NO_2; NO_x	1s 60s
Wallace *et. al* (2009)	Van	Thermo Scientific 42i	NO; NO_2; NO_x	10s
Dionisio *et. al* (2010)	Walk	Dust-Trak 8520	PM_{10}; $PM_{2.5}$	60s
Vogel *et. al* (2011)	Put in Backpacks (walking or going by bicycle)	GRIMM OPC and GRIMM Nano check	Dust (superfine particle); PM_{10}; $PM_{2.5}$; PM_1	60s for superfine particle and 6s for dust
Dons *et. al* (2011)	Put in Backpacks	AethLabs AE51	BC	300s
Adams *et. al* (2012)	Van	GRIMM 1.107 Monitor Lab 8850 Thermo Scientific 48	$PM_{2.5}$ SO_2 CO	1s 1s 1s

The general schematic of the device is presented on the Fig. 1.

On this schematic, there are following main functional blocks:

(1) Dust sensor

The dust measuring device (Haz-Dust HD 1100) was selected for this study. This is a modern dust equipment using the scattering imaging method so that it ensures high accuracy and reliability. Furthermore, the device also has external memory to store data (https://www.skcinc.com/catalog/). The specifications are described as below:Measuring range: 0.01 - 200 mg/m^3 (1 to 20,000 µg/m^3); Particle size: 0.01 - 120µm; Accuracy: ± 0.02 mg/m^3; Sensitivity is less than 0.01 mg/m^3; Alarm system setting feature; Battery: Ni-Cad rechargeable battery; Continuous operating time is more than 8 hours; Battery charging time is from 10~12 hours; Output signal (analogue): 0~2V; Operating conditions: Humidity is less than 95% (without steam condensation); Dimension: 9x3x1.5.

- Weight: 0.9kg

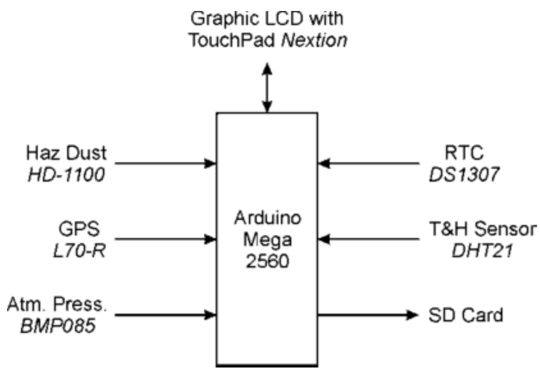

Fig. 1. The general principle diagram of mobile dust monitoring device

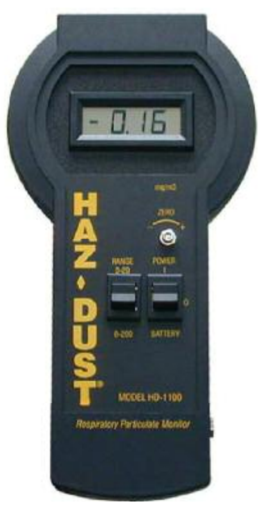

Fig. 2. The dust measuring device HD-1100

(2) Central processor unit

This paper selected the Arduino Mega 2560 as the main microcontroller board. The board is based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button (https://www.arduino.cc/en/Guide/).

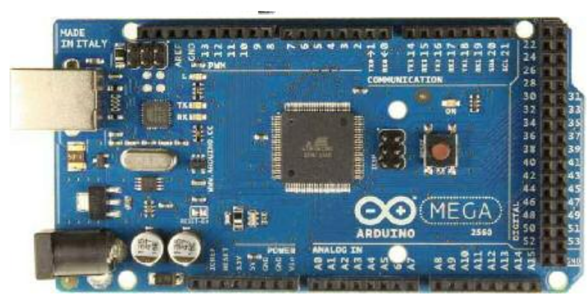

Fig. 3. The Arduino Mega 2560 Board

(3) Display screen

The graphical LCD screen Nextion NX4832K035 was selected in order to increase the display capability. It has also a built-in touchpad to interact with the user so that we do not need to provide an additional keypad for inputting commands (https://nextion.tech/).

Fig. 4. The GLCD with TouchPad from Nextion

(4) Memory card

A flash memory card with capacity around 4GB is sufficient for general purposes of this device (Youngblood, 2015). It could be used to continuously record and store data for a period of 12 months.

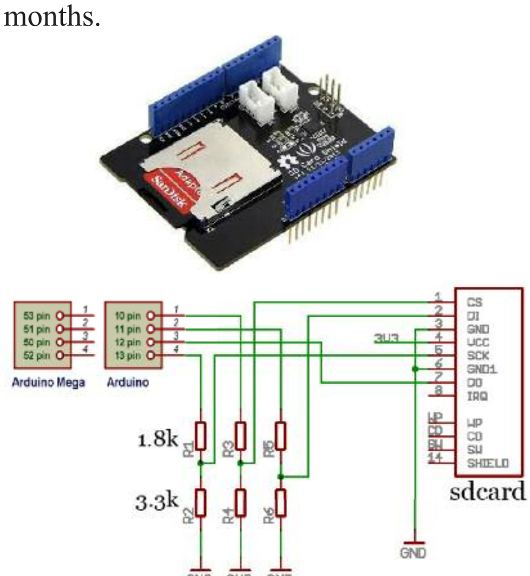

Fig. 5. The SD card and its connection with Arduino Mega 2560 Board

(5) GPS navigation

GPS L70-R: For GPS location of the measuring points, we use the very popular IC L70-R from Quectel (https://www.quectel.com/).

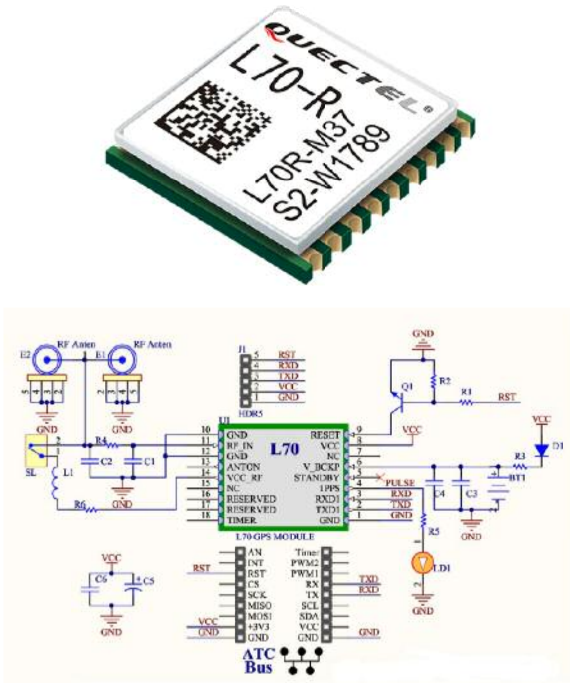

Fig. 6. The GPS L70-R and its connection schematic

(6) Pressure sensor

BMP085: To measure the atmospheric pressure, we use the sensor BMP085 made by Bosch as shown in following figure (http://wiring.org.co/learning/libraries/).

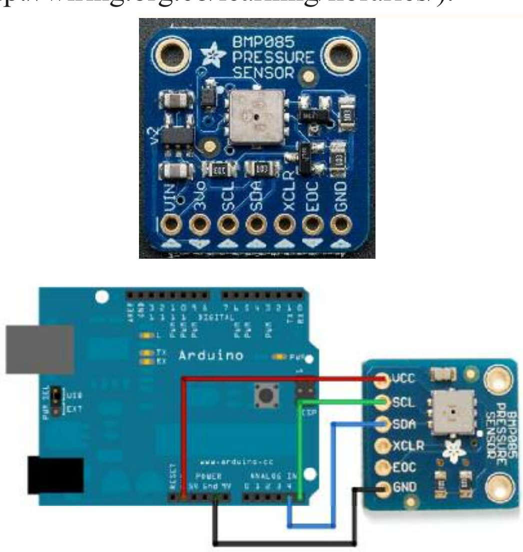

Fig. 7. The atmospheric pressure sensor BMP085 and its schematic connection with Arduino Mega 2560

(7) Temperature and humidity sensor

DHT21: In this paper, this study uses the DHT21/AM2301 temperature and relative sensor from AOSONG (Aosong Electronics Co., Ltd.). The specifications as below: Power supply: 1.8 - 3.6V; Power consumption: 0.5uA at 1Hz; Communication: I2C standard; I2C Speed max: 3.5MHz; Noise level: 0.02hPa (17cm); Measuring range: 300hPa ~ 1100hPa (9000m to -500m); Response time: 7.5ms; Weight: 1.18g; Size: 21mm x 18mm; Operating temperature: -40 to 85°C.

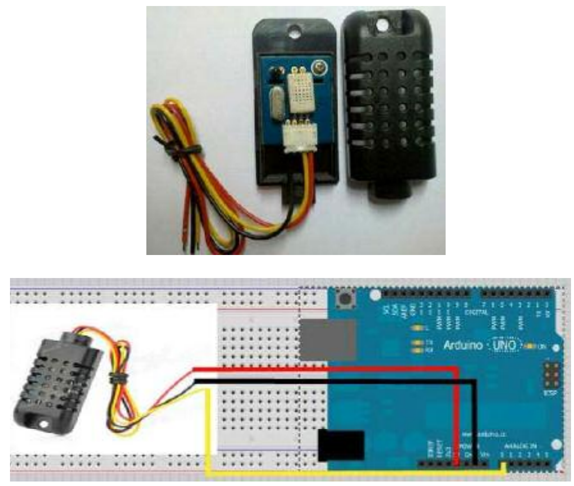

Fig. 8. The atmospheric pressure sensor BMP085 and its connection schematic with Arduino Board

(8) IC timer

DS1307: To have correct time of the measurements, the device uses a RTC (Real Time Clock) IC DS1307.

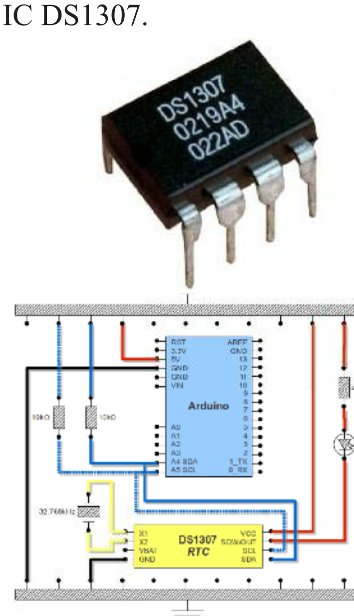

Fig. 9. The RTC DS1307 and its connection schematic with Arduino Board

(9) The results of design and installation

The device is powered by 5V battery. The above designs and descriptions was fully implemented and successfully tested. The resulted device is very light and compact (with the dimensions of 12cm x 7cm x 4cm). The main board of the device is shown in the Fig. 10.

Fig. 10. The designed product

The tests have confirmed all the design requirements are fulfilled; all the signals are collected successfully and correctly. The data can be easily copy into the PC since the file is in FAT32 format. The monitoring data from the mobile device is in the excel file format with parameters namely ID, time, date, temperature, humidity, pressure, dust concentration, longitude and latitude. The data is continuously recorded after each step within 5 seconds.

(10) The equipment calibration

To ensure the accuracy of monitoring data, the mobile dust measuring device has been calibrated and certified by the Vietnam Metrology Institute (the registration number of DK 05).

2.2. Mobile dust monitoring

The scope of monitoring was the traffic roads (La Thanh, Lang Ha, Ring Road No. 3, Tran Duy Hung, Nguyen Chi Thanh) in the urban districts of Hanoi City.The monitoring time period was the implementation of mobile TSP dust monitoring has been conducted from December 26, 2018 to January 5, 2019 with two time frames as peak hour (from 6 to 9 hours and from 17:00 to 20:00), and off-peak hour (the remaining time frames)

Fig. 11. Mobile dust monitoring by motorcycles

The monitoring data from the mobile device was added to the excel file format with parameters namely ID, time, date, temperature, humidity, pressure, dust concentration, longitude and latitude. The data were continuously recorded after each step within 5 seconds.

Thereafter, the ArcGIS software (the latest version of ArcGIS 10) has been utilized to develop dust pollution maps for the monitoring routes.

Fig. 12. The monitoring route: La Thanh - Lang Ha - Le Van Luong - surrounding Road No.3 (Khuat Duy Tien) - Tran Duy Hung - Nguyen Chi Thanh road

3. Results and discussions

To evaluate the monitoring results from the device, the survey team conducted a parallel monitoring of Haz Dust 1100 and Met one GT-521. Monitoring time was 8-9 hours on May 1, 2017. Observing route was in Nguyen Xien Street, start-point coordinates (20.97252, 105.8195), end-point coordinates (20.99149, 105.8032). The recording time of Haz Dust 1100 was 5 seconds. The recording time of Met one GT-521 device was 10 seconds. The results presented the current situation of TSP dust concentration according to peak and off-peak hours in some traffic routes in Hanoi City from mobile monitoring data.

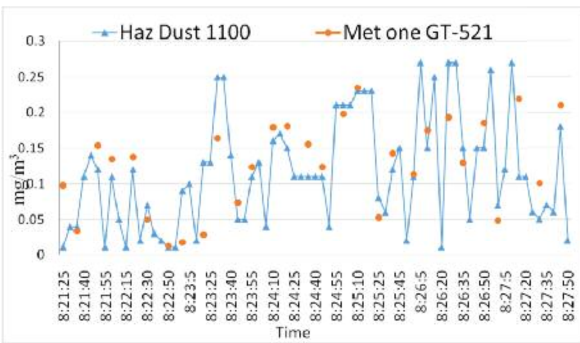

Fig. 13. The results of TSP dust concentration

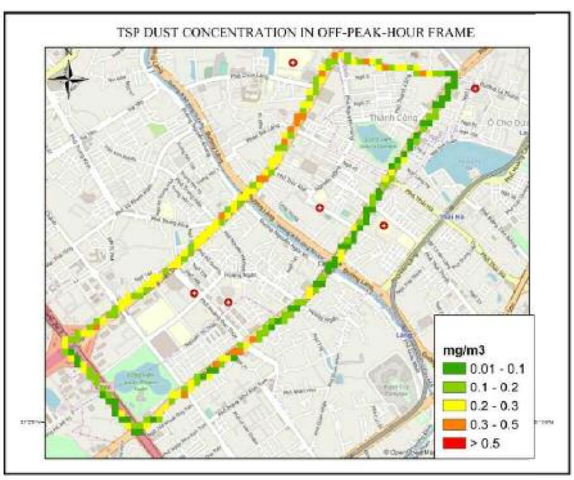

Fig. 14. The TSP dust concentration during off-peak hours at some traffic routes

The TSP dust concentration on traffic routes depended upon the density of vehicles, the amount of dust on roadbeds and surrounding construction activities. It was seen that even in off-peak hours, the TSP dust concentration was also fairly high on the route of La Thanh, Tran Duy Hung and Nguyen Chi Thanh. The monitored value was from 0.2-0.3mg/m^3. Furthermore, many monitoring locations such as Nguyen Chi Thanh - La Thanh crossroad, Nguyen Chi Thanh - Chua Lang crossroad have been monitoring value of 0.3-0.5mg/m^3 that exceeded the National Technical Regulation 05:2013/BTNMT (average 1 hour).

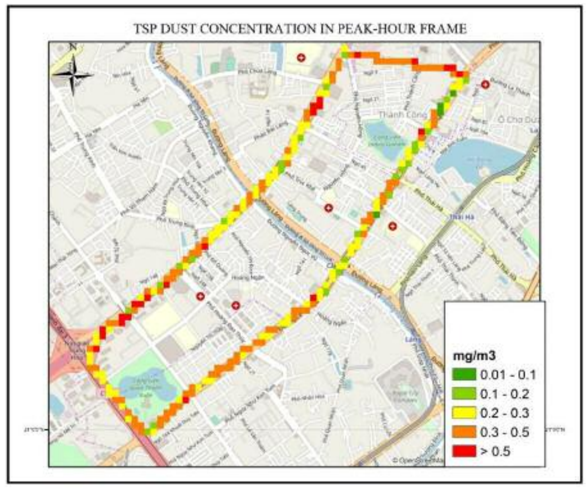

Fig. 15. The TSP dust concentration during off-peak hours at some traffic routes

The Fig.15 indicates the concentration of TSP dust during off-peak hours in La Thanh, Lang Ha, Le Van Luong, Khuat Duy Tien, Tran Duy Hung and Nguyen Chi Thanh road. The dust level during off-peak hours was much higher than off-peak hours (from 1.2 to 1.5 times). Additionally, most of the monitoring positions exceeded the permissible standard. The areas of high TSP dust concentration consisted of La Thanh street, Nguyen Chi Thanh - Lang intersection and Lang Ha - Lang intersection. The observed value ranged from 0.5 to 0.6mg/m^3 and exceeded the permitted value by 1.5 - 2 times.

Through the monitoring results, it could be noticed that dust pollution sources on the inner roads mainly come from the rolling dust from road surface and transportation.

The mobile dust monitoring equipment was designed and assembled on some main roads of Hanoi city. In the process of monitoring, the research team has found that the device has some advantages and disadvantages as follows: 1) It is a mobile monitoring device which easily installed on traffic vehicles such as electric bicycles, motorcycles, cars, etc; 2) The sensor head has a firm structure; 3) Many parameters including as measurement time, dust concentration, temperature, humidity, pressure and location (GPS) could be monitored; 4) The display unit (LCD screen) has a small size, compact; and could display many types of data at the same time; 5) The equipment operates continuously and stably; 6) The equipment is easy to use and operate; 7) The device automatically records data after a period of 5 seconds and could store statistic for long periods (about 12 months); 8) The device records data as a .csv file (compatible with excel), therefore, it is easy to extract and process data; 9) It is the suitable monitoring equipment for electric bicycles or motorcycles; 10) The device could easily replaces the sensors once a problem or failure occurs; 11) Sensors are supplied by reputable manufacturers, it is therefore easily obtained in case of requiring replacement; 12) It has competitive price compared to mobile monitoring systems with the same function.

Besides, there are some disadvantages in this equipment such as: 1) The device only indirectly monitors TSP dust, and the PM10 dust could be observed through the percentage of TSP dust; 2) The threshold dust concentration (or allowed monitoring limits) of the device: 0.01 mg/m3; 3) The device could not be utilized in rainy conditions; 4) The monitoring results are written directly to memory cards, the device has no online data port; 5) The data shows error when moving in complex terrains that leads to fluctuations in vehicles (electric bicycles, motorcycles, cars, etc.) installed the mobile dust monitoring equipment; 6) The device does not monitor the wind speed and wind direction; whereas, wind parameters considered as the main factors, directly affect the monitoring results of dust concentration on traffic routes.

4. Conclusion

The study has presented about the design of a portable dust measurement device. By using programmable Arduino board, the device is compact, accurate and well-connected with the Haz Dust device as expected. The further upgrades may include as wireless connection between the device and the host computer, or other environmental parameters to be measured.

The device has been applied for mobile dust monitoring in some main streets of Hanoi city. The observation process has shown that the device operates stably with high accuracy.

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Research Paper

INVESTIGATION OF SELECTING DROUGHT INDEX FOR AGRICULTURAL DROUGHT REZONING IN GIA LAI PROVINCE

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ARTICLE HISTORY

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ABSTRACT

Based on the data from hydro-meteorological stations, combined with the soil-specific data of Gia Lai province, the study selected the Palmer index to describe the drought. It was suitable with growing season to develop a monthly agricultural rezoning map for Gia Lai province. The study also showed that the number of days over years and the total number of days in the growing season tended to increase from the northern districts to the southern districts of the province and decreased from the eastern districts to the western districts. According to the time distribution from November to April, drought in Gia Lai province tended to increase from November to January, February and gradually decreases to April. According to spatial distribution, drought might decrease from west to east and from north to south. Through this study, it was shown that the areas suffered from agricultural drought were mostly the northwestern districts of the province in January.

Keywords*: Agricultural drought, Agricultural rezoning, Palmer index.*

1. Introduction

Many studies published more than 150 definitions of drought from early 1980s. The definitions reflect regional differences, needs and regulatory issues, but generally, drought is divided into four categories: meteorological, hydrological, agricultural, and socio-economic (Wilhite and Glantz, 1985; Wilhite, 2000). Agricultural drought is the different characteristics of meteorological or hydrological drought affecting agriculture, focusing on the lack of rainfall, the difference between actual evaporation and potential evapotranspiration, lack of water, reduction of underground water level or reservoirs (FAO, 2013; Sabău et al., 2015; Vicente-Serrano et al., 2015; Abhishek and Dodamani, 2018). Agricultural drought often occurs in areas where the soil moisture does not meet the needs of a specific crop in a certain period of time. Agricultural drought may explain the susceptibility of crop changes during different stages of growth during growth period (Allen et al., 1998; Potopová et al., 2015; Anderson et al., 2016; Ma'rufah et al., 2017).

In recent years, Gia Lai province as well as Vietnam has been conducting many practical studies, monitoring and assessments of natural conditions and natural resources in order to im-

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prove living standards, boosting agricultural production, serving the goal of restructuring the provincial agricultural sector. However, the main topics using the meteorology and hydrological resources in the most general method have not had detailed studies and assessments for each locality in the province. In particular, the rezoning of agricultural drought will help minimize the enormous losses caused by this phenomenon every year.

This study focused on selecting the most suitable new drought index to serve the agricultural drought rezoning in Gia Lai province. This is an urgent scientific research, contributing to mitigating natural disasters in order to develop socio-economic development in Gia Lai province in the direction of being sustainable and adapting to the current climate change conditions. These assessments can help regulators as well as manufacturers to actively adjust production plans, in order to increase the system's resilience in drought conditions, and adjust usage rationally groundwater and surface water resources, overcoming the effects that may be caused by drought phenomenon. These issues can be solved to mitigate impacts of natural disasters affected the development of economy and society of Gia Lai province.

2. Methodologies

2.1. Data sources

Meteorological data

Important monitoring data was used to calculate, evaluate, compare and verify data from the model or calculation methods in order to give an accurate assessment of applicability, the practicality of the selected model or calculation method. In the study area, data sources were collected from 7 meteorological stations in Gia Lai province and surrounding areas in Table 1.

Drought data and soil characteristics

The composition of the main soil group in Gia Lai is quite similar including: 1) Yellow red soil (Ferralsols - F): This group of soil has many different types, which are typically soil types: red yellow soil on magma acid (Fa) rock, yellow red soil on clay and metamorphic rocks. (Fs), sepia on magma baze and neutral rocks (Fk); 2) Gray soil (Acrisols - X): the typical soil type for this group of soil is gray soil on magma acid rock (Xa); 3) Alluvial soil (Fluvisols - P): There are 2 typical soil types for this soil group: glay alluvial soil (Pg) and stream alluvial soil (Py); 4) Humus soil (H): There are 2 typical types of soil: red yellow humus soil on magma acid rock (Ha) and yellow red humus soil on clay and metamorphic rocks (Hs).

We has carried out a survey on drought characteristics in all districts throughout the province through the collection of documents and reports of damage caused by natural disasters of the districts in the last 10 years.

Table 1. List of meteorological stations to collect data

No.	Name	Latitude (°)	Longitude (°)	Factor	Time period
1	Kon Tum	14.36	108	Temperature, precipitation, humidity, wind speed, evaporation and sunny time	1994-2018
2	Dak To	14.65	107.85	Temperature, precipitation, humidity, wind speed, evaporation and sunny time	1994-2018
3	Pleiku	13.97	108.02	Temperature, precipitation, humidity, wind speed, evaporation and sunny time	1994-2018
4	An Khe	13.95	108.65	Temperature, precipitation, humidity, wind speed, evaporation and sunny time	1994-2018
5	Yaly	14.22	107.84	Temperature, precipitation, humidity, wind speed, evaporation and sunny time	1994-2018
6	Ayunpa	13.4	108.45	Temperature, precipitation, humidity, wind speed, evaporation and sunny time	1994-2018
7	EaHleo	13.22	108.2	Temperature, precipitation, humidity, wind speed, evaporation and sunny time	1994-2018

In addition, the research also conducted an assessment of the current status of information on soil moisture survey points implemented through the project: “Developing drought maps and the lack of domestic water in the South Central and Highland” (Thuc, 2008). The results showed that the recent information on the status quo has little change compared to the result of the previous soil moisture survey. This research inherited all information about the soil profile characteristics of the previous project.

2.2. Applied Method

There are many methods and indices for calculating drought in the world in general and in Vietnam in particular, but the most used indicators with high accurate, computational and appropriate are the Palmer, SPI and Ped indices.

In the calculation process, the evaluation study determined the period and the drought level from the three indicators mentioned above were then compared with actual survey data. The results shown that the Palmer index includes the Z and PDSI, which was the best optimization for drought simulation and suitable for the growing season of crop. Therefore, this study used the Palmer index to develop an agricultural drought map in Gia Lai province.

2.2.1. Palmer drought index

The Palmer drought index (Palmer, 1965) is one of the first index to explain evaporation and soil moisture conditions, which are widely used for drought analysis and monitoring. The necessary input conditions are weekly or monthly data of precipitation and temperature. PDSI is the water based on moisture balance equation of the upper and lower soil layers. At each time step, additional rainfall and transpiration (ET) is deducted from the calculation area. Based on these calculations, the precipitation value of CAFEC (Climatically Appropriate For Existing Conditions) is determined for each time step. The difference of d (mm/month) between actual rainfall and CAFEC in a given month was shown by starting from the original water supply.

To ensure uniformity between different months and locations, Palmer determined the weighting empirical Kj for each month j of the year. The result of d and Kj is called Z - anomalous index of humidity compared to long-term climate. Palmer used an empirical relationship to turn Z into PDSI - an extreme (or extremely wet) limit index. PDSI is a cumulative index meaning that the value in each month depends on the value in the previous months. The PDSI algorithm contains several experimental constants estimated by Palmer based on data from only two locations. A limitation of the Palmer index is that the calculations are complex, the data must be continuous.

Z - Palmer drought index

Z - Palmer is an anomaly moisture index that meets short-term conditions better than PDSI and is usually calculated for a much shorter period of time to allow the identification of fast-growing drought conditions built by Palmer in the beginning in 1960, the Z - Palmer was usually calculated by month.

Z is calculated using the formula: $Z = Kd$

$$d = P - \hat{P} = P - (\alpha PE + \beta PR + \gamma PRO + \delta PL) \quad (1)$$

The value of d is considered as the moisture standard deviation. Four potential values should also be identified: (1) Input potential evapotranspiration (PE) determined by the Thornthwaite method; (2) Potential recharge of soil moisture (PR) is maximum amount of moisture that can be stored; (3) Potential runoff (PRO) is the difference between rain and PR; (4) Potential loss of soil moisture (PL) is the maximum amount of moisture that can be lost.

Table 2. Drought decentralization according to Z index

Z indicator	Drought level
≥ 3.50	Extremely wet
+2.50 ÷ +3.49	Very wet
+1.00 ÷ +2.49	Moderately wet
-1.24 ÷ +0.99	Normal
-1.25 ÷ -1.99	Moderate Drought
-2.00 ÷ -2.74	Severe Drought
≤-2.75	Extreme Drought

The Z-Palmer index provides a measure of moisture anomalies in an area on both levels: dry and moist. This index is used to compare current periods with known drought periods or can be used to determine the end of periods. Basing on land using data and the water balance method, the Z-Palmer index is quite strong for drought determination.

PDSI drought index

Developed by Wayne Palmer in 1965, this index has now become a common index and a background for many other indices. The Palmer index is based on a supply and demand model for soil moisture, using monthly temperature and precipitation information. In addition, the index is dependent on more difficult-to-calibrate factors including evapotranspiration and recharge rate. Palmer tried to overcome these difficulties by developing an approximation algorithm based on precipitation and temperature data.

$$PDSI_i = 0.897PDSI_{i-1} + \frac{1}{3}Z_i \qquad (2)$$

where PDSI of the first month in the series calculated by 1/3Zi and Z is the humidity anomaly index

Table 3. Drought decentralization according to PDSI index

PDSI	Condition
≤ 4.0	Extremely wet
3.0 ÷ 3.99	Very wet
2.0 ÷2.99	Moderately wet
1.0 ÷ 1.99	Slightly wet
0.5 ÷ 0.99	Incipient wet spell
0.49 ÷ -0.49	Near normal
-0.5 ÷ -0.99	Incipient Drought
-1.0 ÷ -1.99	Mild Drought
-2.0 ÷ -2.99	Moderate Drought
-3.0 ÷ -3.99	Severe Drought
≥ -4.0	Extreme Drought

PDSI is the drought index and widely used. PDSI is very effective to evaluate agricultural drought because of its moisture content.

2.2.2. Growth season of crop

A growing season is defined as equal rainfall and potential evapotranspiration in which ETo or PET potential evapotranspiration is calculated by FAO Penman-Monteith method (Allen, 1998).

ET_o is calculated using the formula

$$ETo = \left(\frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}\right) \quad \text{(mm/day)} \quad (3)$$

where ET_o is reference evapotranspiration (mm/day^1); Rn is net radiation at crop surface (MJ/m^2/day); G is soil heat flux density (MJ/m^2/day); T is mean daily air temperature at 2m height (°C); u_2 is wind speed at 2m height (m/s); e_s is saturation vapour pressure (kPa); ea is actual vapour pressure (kPa); e_s - e_a saturation vapour pressure deficit (kPa); Δ is slope vapour pressure curve (kPa/°C) and γ is psychrometric constant (kPa/°C).

3. Results and discussions

3.1. Determination of growing season of crop

Based on the characteristics of the growing season, it will give a better overview of the drought occurring in the study area, helping to determine the year of the heaviest drought and the least drought occurrence in the calculation period. Start time and end time as well as length of time of growing season varied from year to year and from region to region. The short growing season leaded to a low soil moisture level in that year and a high possibility of agricultural drought. In contrast to the long growing season, the moisture content was high in the soil, the agricultural drought was rare.

At Pleiku station, the growing season ranges from 154 days to 233 days, the average for many years was 198 days starting from April 25 and ending on November 9. The year of severe drought was in 2015 and 2010, with the growing seasons of 167 and 154 days, respectively. Amplitude was around 25 days. At An Khe station, the growing season ranges from 183 days to 284 days, the average growing season was 266 days starting from April 28 and ending on January 19 of the following year. The year of severe drought was in 2014 and 2015 with 183 and 206 days. Amplitude is around 31 days. At Ayunpa station, the growing season ranged from 157 days to 250 days, with an average of 194 days starting from May 3and ending on December 4. The heaviest drought years were in 2015 and 2012 with 119 and 157 days, respectively. Amplitude is around 45 days. At Yaly station, the growing season ranged from 155 days to 213 days, the average values over many years were 195 days starting from April 21 and ending on November 2. The heaviest drought periods were in 2015 and 2016, with ranges of 155 days and 168 days, respectively. Amplitude was around 19 days.

Thereby it could be seen that the fluctuations in days over years and the total number of days in the growing season tended to increase gradually from the northern districts of the province to the southern districts of the province, and tended to decrease from the eastern districts to the western districts of the province. Spatial distribution of agricultural drought was most likely to occur in the north-western part of Gia Lai province, with a tendency to decrease from north to south and from east to west. The whole province in each region has different drought characteristics. The worst drought year and less frequent drought was uneven throughout the province over the years. Therefore, it is necessary to determine the growing season each year so that the seasons can be changed appropriately to minimize damage caused by drought.

3.2. Map of agricultural drought rezoning in Gia Lai province

After determining the growing season, it can be seen that drought occurs in Gia Lai province from December to April. Thereby, this study focuses on analyzing and developing drought maps from the set of data calculations from the Palmer index for these months.

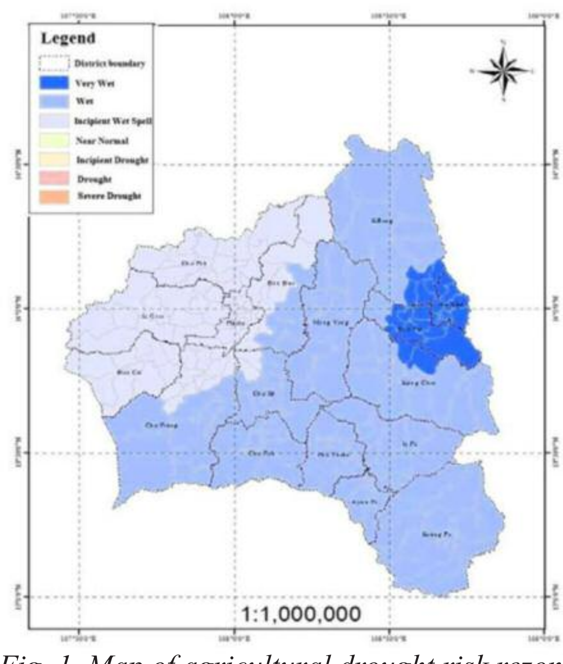

Fig. 1. Map of agricultural drought risk rezoning in Gia Lai province in November

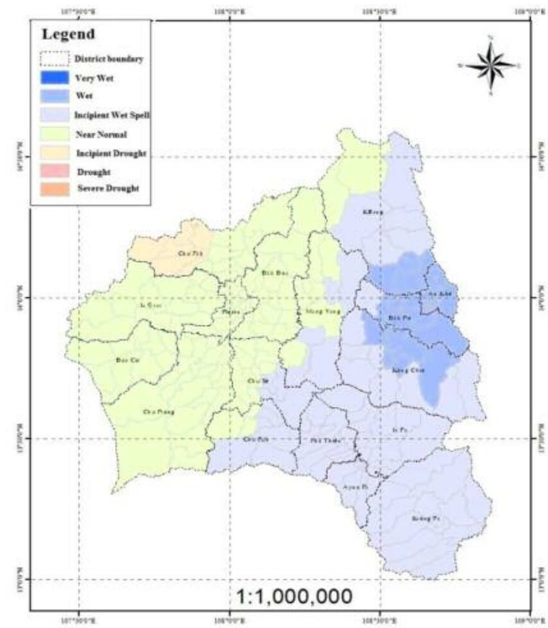

Fig. 2. Map of agricultural drought risk rezoning in Gia Lai province in December

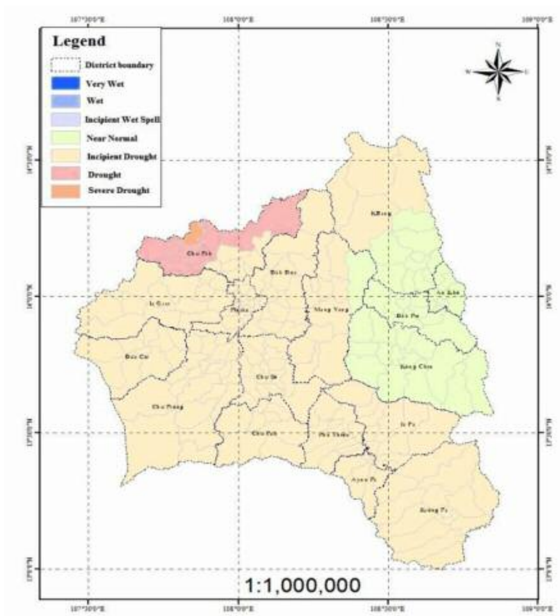

Fig. 3. Map of agricultural drought risk rezoning in Gia Lai province in January

Based on the agricultural drought-specific zoning of Gia Lai province, it could be seen that there is almost no risk of drought happening throughout the province (November, December). The moisture content in soil is from wet to very wet in November (Fig. 1). In December, there was a gradual decline and the area of Chu Pah district happened drought (Fig. 2). According to space, soil moisture content decreases from East to West and from South to North of the province. Drought has begun to occur in the northwest region of the province.

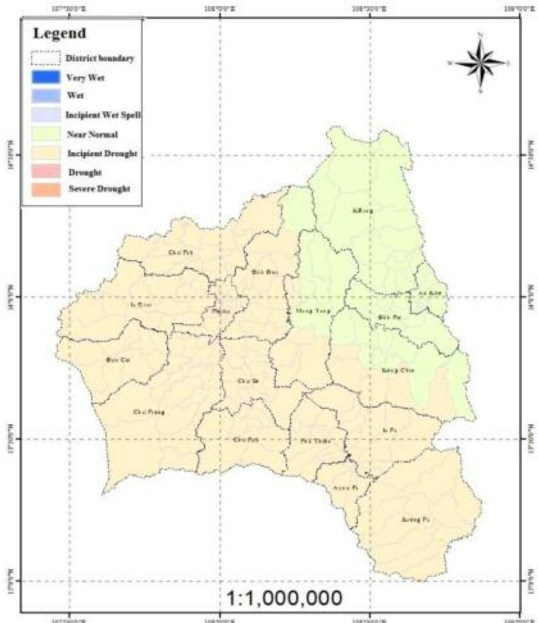

Fig. 4. Map of agricultural drought risk rezoning in Gia Lai province in February

In January, drought began to occur in most of Gia Lai province, except An Khe, Dak Po and Krong Chro districts, the northern part of Kbang district, and the northeastern part of Mang Yang district. Severe drought occurred in Chu Pah district, a district located in the Northwest of Gia Lai province (Fig. 3). In February, drought was reduced in Chu Pah district. Districts like Mang Yang and Kbang have terminated (Figs. 3-4). In terms of spatial distribution, severe drought occurred in the northwestern region of the province. Drought gradually decreases from north to south and from east to west.

Labedzki and Kanecka-Geszke (2009) studied standardized evapotranspiration as an agricultural drought index based on 40 meteorological stations located in various agro-climatic regions of Poland. A great spatial differentiation of the frequency of droughts depending on drought category and soils were determined (Labedzki and Kanecka-Geszke, 2009; Labedzki and Bak, 2014). Drought index can be used to implement an early warning system for drought and to operate adrought monitoring service. Water supply is calculated by the cumulatively effective precipitation with the application of the weight to the precipitation. Water demand was derived from the actual evapotranspiration, which was calculated applying a crop-coefficient to the reference evapotranspiration (Kim et al., 2014; Sun et al., 2012).

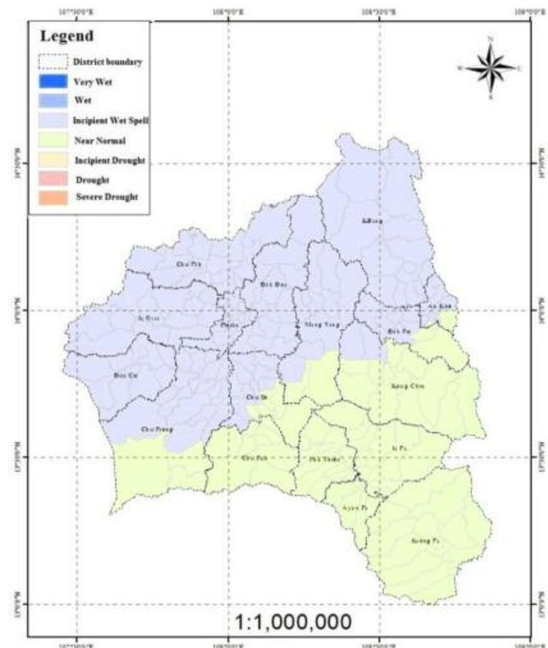

Fig. 5. Map of agricultural drought risk rezoning in Gia Lai province in March

From March to April the entire Gia Lai province has almost terminated drought season. Most of the areas were wet enough for the next growing season (Figs. 5-6). Therefore, the map of drought risk distribution in Gia Lai province, it showed that drought tended to increase from November to January, and decreasefrom February to April. Spacially, drought could decrease from west to east and from north to south. Thereby the most likely area for drought occurrence was in the northwestern region of the province.

A study conducted by Kamruzzaman et al. (2019) to assess the spatiotemporal characteristics of agricultural droughts inBangladesh during 1981-2015 using the Effective Drought Index (EDI). The study identified that thecharacteristics (severity and duration) of drought were also analyzed in terms of the spatiotemporalevolution of the frequency of drought events. They found that the western and central regions ofthe country are comparatively more vulnerable to drought. Moreover, the southwestern region was more prone to extreme drought, whereas the central region is more prone to severe droughts (Kamruzzaman et al., 2019). However, agricultural drought is often characterized by current water demand-supply conditions, without considering the rarity of drought event in the historical period. Agricultural drought caused by soil water deficit exerts great influence on ecosystems and growth of crops. Accurate monitoring and detection of spatio-temporal characteristics of agricultural drought are meaningful for food security. In order to overcome the limitations of using crop water deficit indicator or dryness anomaly indicator only, an integrated evapotranspiration deficit index combining water deficit and dryness probability was proposed (Zhao et al., 2017).

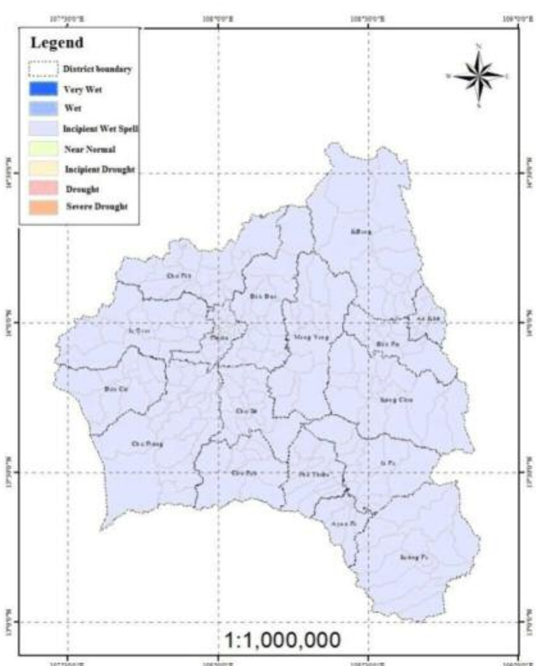

Fig. 6. Map of agricultural drought risk rezoning in Gia Lai province in April

4. Conclusion

This study has important implications for assessing drought and particularly agricultural drought that can occur in Gia Lai province, which is subject to many impacts and changes under current conditions. The fluctuations in days over years and the total number of days in the growing season tended to increase gradually from the northern districts to the southern districts of the province, and tended to decrease from the eastern districts to the western districts of the province.

The agricultural drought rezoning is new results for the province in the Central Highlands in this study. A detailed district-level drought maps for the months in Gia Lai province, has been developed, reflecting spatial-specific densities for each month; drought tended to increase from November to January, and decrease from February to April. Basing on space, drought could decrease from west to east and from north to south. Thereby, the drought area happens in the districts of the northwest region of the province. The research results can contribute as a scientific background for the locality to refer to the agricultural development orientations. Orientations in agriculture need to study carefully the mechanism of weather and the impacts of natural disasters, especially the drought in agriculture.

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Research Paper

RESEARCH ON URBAN SPRAWL TRENDS AND LANDSCAPE CHANGE IN PLEIKU CITY, GIA LAI PROVINCE

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ABSTRACT

Urban sprawl is an international phenomenon happening principally in quickly developing areas. A study on the spatiotemporal features of urban sprawl is useful for the sustainable land management, landscape and urban land planning. The present research explores the trends, types and changes of landscape of urban sprawl in the context of a rapid urbanization process in Pleiku city and in the Central Highland of Viet Nam from 2000 to 2019. The results show the expansion of the Pleiku city has witnessed a fluctuation in its land uses through two decades. The rate of land use in residential areas has been increasing by 0.22 percent, infrastructures (0.61 percent), and other land (0.41 percent). This assertion is further supported by the rapid reduction of the vacant land (1.14 percent) and agriculture land (0.21%). Moreover, three types of urban sprawl are distinguished by analyzing covered urban area maps from the analysis of Satellite data images and current land use maps. Firstly, it is the outlying type with the area of 3.97 km^2, almost 62.72 percent of the total newly increased urban area. Secondly, the area of the infilling type is 1.11 km^2, which makes up 17.54 percent, and the figure for the edge-expansion area is 1.25 km^2, accounting for 19.75% of the total urban sprawl area. Studying trends and types of urban sprawl are useful to manage and properly allocate for sustainable land resource as well as urban land use planning.

Keywords: *Urban sprawl, urban planning, urbanization, Pleiku, sustainable management, landscape.*

1. Introduction

The term "sprawl" was first used by Earle Draper of the Tennessee Valley Authority in the context of a national conference of planners in 1937 (Maier et al., 2006). Sprawl was referred to as an unaesthetic and uneconomic settlement form. The term of "urban sprawl" was first used in the opening paragraph of an article by the sociologist William Whyte in Fortune magazine in 1958 (Robert, 2002). Planners have since then used the term to categorize an urban development, generating undesired social effects. Urban Economists also adopted the term and added to the debate terms like scatter, leapfrogging and ribbon development.

Urban sprawl is a form of spatial expansion, characterized by low densities, scattered and discontinuous "leapfrog" growth, and isolation of land uses, encouraging the massive use of private vehicles and strip-malls; the form of development is found mainly in open, rural lands on

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the edge of metropolitan areas (Richard, 1989; Ewing, 1997; Burchell et al., 1998; Hadly, 2000). The phenomenon of urban sprawl, often known as suburbanization, started at the end of the industrial era, and it has continued since throughout the world, especially in Western countries (Robert and Clark, 1965; Real Estate Research Corporation, 1974; Edwin and Bruce, 1990). Many new urban patches have emerged from the previous agricultural land and tremendous changes of landscape pattern have taken place within the study period (Lv et al., 2011).

In terms of different urban form, Wilson et al. (2003) have identified three categories of urban growth: infill, expansion, and outlying, with outlying urban growth further separated into isolated, linear branch, and clustered branch growth. The relation to existing developed areas is important when determining what kind of urban growth has occurred. An infill growth is characterized by a non-developed pixel being converted to urban use and surrounded by at least 40% existing developed pixels. It can be defined as the development of a small tract of land mostly surrounded by urban land-cover (Wilson et al., 2003). Ellman (1997) defines infill policies as the encouragement to develop vacant land in already built-up areas. Infill development usually occurs where public facilities such as sewer, water, and roads has already existed (Wilson et al., 2003). Forman (1995) describes infill attrition as the disappearance of objects such as patches and corridors (Richard, 1995). An expansion growth is characterized by a non-developed pixel being converted to developed and surrounded by no more than 40% existing developed pixels. This conversion represents an expansion of the existing urban patch (Wilson et al., 2003). Expansion-type development has been called metropolitan fringe development or urban fringe development (Anderson, 2001). Forman (1995) discusses it as edge development, defined as a land type spreading unidirectional in more or less parallel strips from an edge. The analogous land transformation is shrinkage, defined as the decrease in size of objects, such as patches (Richard, 1995). Outlying growth is characterized by a change from non-developed to developed land-cover occurring beyond existing developed areas (Wilson et al., 2003). This type of growth has been called development beyond the urban fringe (Anderson, 2001). The outlying growth designation is divided into the following three classes: isolated, linear branch, and clustered branch (Wilson et al., 2003).

Vietnam is entering into an important stage of urbanization, space and population in urban areas have increased rapidly (World Bank, 2011), beyond the control of the government, causing several consequences on national land resources, imbalance of environmental ecosystems, imbalance in architectural space, depletion of cultural and historical architectural, and reduction of urban land rapidly, putting great pressure on technical infrastructure (Nguyen Van Hieu, 2017).

Since the 2000s, Vietnam's urban areas have developed in three main trends: (1) The trend of scaling up by the merging of peri-urban areas, urbanized agricultural communes, which are shifting from agriculture to services and handicraft production, the agricultural production part is declining; (2) The trend of expanding urban space by investing in synchronous urban infrastructure, building new modern urban areas creates favorable conditions for expanded urban development; (3) The tendency to extension and encroach on the beaches to construct the new urban areas, both as a means of increasing the urban area, facilitating the development of new modern urban centers and developing an attractive new urban image (Ha Dao, 2019).

A study showed an expansion of Hanoi urban areas from nearly 1000 ha to 6000 ha in the period of 30 years. This trend illustrated Hanoi's urban starts diffusing sprawl development from 1984 to 1992 (Pham and Yasushi, 2008). Meanwhile, another study in Central Highland, the unstable urbanization process has been taking place among 5 provinces of this zone, both the volume of urban and the level of urbanization (Hoang, 2014).

In Pleiku city, the study of urbanization trends is as a basis for urban planners and managers to propose the appropriate planning policies, which has not implemented yet. Moreover, the rational land use helps promote the land potential as well as simultaneously achieve the socio-economic development goals of municipal in the coming years. Therefore, there is a need to assess trends and the type of urban expansion and landscape, which is the scientific basis for solving the conflicts on the relationship between urban development and land use, as a basis for proposing future urban development policies. Hence, the study on trends and types of urban expansion in Pleiku City, Gia Lai province is really necessary and towards sustainable urban development. The study in Pleiku city is a representative case study for small and medium-sized cities in Vietnam.

2. Methodology

2.1. The study area

Pleiku city of Gia Lai province, a small urban area, is located in the North's of Highland area of Viet Nam (Fig.1), between 13°50'00" to 14°04'44" North, 107°49'30" to 108°06'22" West. The study area covers 9 communes and 14 wards, which together, cover an area of approximately 260 km^2. The current population figure is estimated to be 230.489 inhabitants, with an annual growth rate of 1.4 percent (Pleiku Statistics Office, 2019).

Pleiku city plays a significant role in the Central Highland area of Viet Nam and the whole Indochina area by special location lies on the crucial gird of National Road No. 14, No. 19 and Ho Chi Minh boulevard, which are lifeblood roads to connect the whole country and Indochina area (Tran, 2019). In addition, the city is nearly to both Le Thanh (between Viet Nam and Cambodia) and Ngoc Hoi (between Viet Nam, Laos and Cambodia) international border gates, significant routes to transport products from Laos and Cambodia to maritime ports of Viet Nam.

Pleiku city is one of the most economically dynamic city in Gia Lai province since the start of the economic reform in 1986. Socio-economic development and rapid urbanization have led to a significant transformation in the pattern of land use. The growing need for housing to accommodate the increasing population has led to an ever-growing urban expansion through the encroachment of non-urban land, especially agricultural land. During this period, a large amount of fertile agricultural land was transformed into other purposes in Pleiku because of rapid urbanization and weak land management.

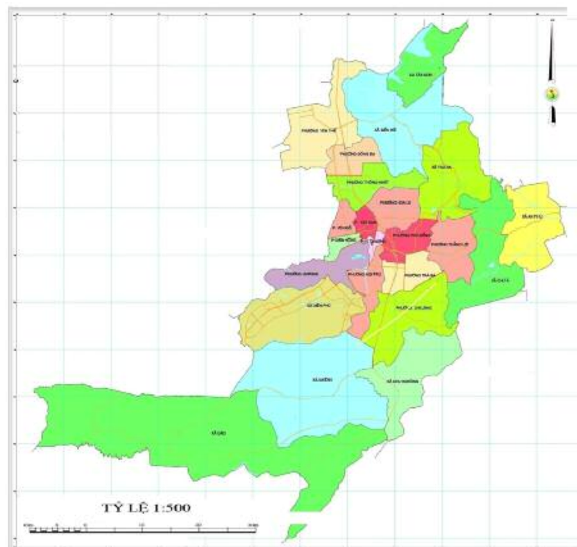

Fig. 1. Location of study area

2.2. Research methodology

2.2.1. Data collection method

The data were collected into two datasets, one for from primary and secondary data. Primary data were collected by observation and aerial photographs including the Satellite data via website http://.www.earthexplorer.usgs.gov. A satellite image of 2019 was created to cover the study area. Moreover, the study carried out a ground observation in study areas on October 13-26, 2019, and recorded for 130 images. These locations determined in place of urban sprawl.

Secondary data were collected from local authorities within Pleiku city and Gia Lai province, such as Land use status quo map (LUSM) from the Department of Natural Resource and Environment (DONRE), a map that demonstrated the distribution of various types of land at a specified time, and was made according to each administrative unit (The National Assembly, 2013). A map of LUSM at scale 1:10.000 was covering the city in 2019 to determine the residential areas, produced by the DONRE and converted into a digital format. Similarly, demographic data were obtained from the People's Community of Pleiku city. Population data from Statistical Yearbook of 2000, 2005, 2010, 2015 and 2019 were used. In addition, the documents showed the patterns of physical and socioeconomic change of the municipal such as population and density, sectors of economy growth, infrastructures, transportation, recreation, urban open were gained from Department of Agricultural and Rural development (DARD), Department of Plan and Invest (DPI), Department of Transportation (DOT) and was aggregated by authors.

2.3.2. Data analysis

A free software environment for statistical computing and graphics supported by the R Foundation for Statistical Computing was used to analyses data and to illustrates several graphical of figures. In addition, a free and open source cross platform desktop geographic information system (QGIS) application that supports viewing, editing and exporting graphical map of Pleiku urban sprawl.

In order to figure out the number of land use trends and the occupied land scale, Microsoft Excel was employed to carry out.

2.3.3. Approach and methods

This study is a first attempt to determine land use trends types in Pleiku urban during the past two decades from a landscape perspective. The local review studied documents such as the Land use status quo map in 2000 and 2019 (Pleiku Department of Natural Resources and Environment, 2019).

In term of the approach and methodology, to classify the types of urban sprawl in Pleiku town, the study used the method of literature review and based on the framework of Wilson et al. (2003) and Jun et al. (2011). A metric T was defined for calculating the ration between the length of common edge of newly developed urban patches and existing urban patches as:

$$T = Lc/l \quad (1)$$

where Lc (km) is the length of the common edge between a newly developed urban patch and an existing urban patch, l (km) is the perimeter of the newly developed urban patch. The value of T is between 0 and 1. If $T > 0.5$, it means that at least 50% of the new urban patches is surrounded by the old urban square, and it represents the infilling type (Fig. 2a); if $0 < T$ the new urban patches develop from the edge of the old urban covers, and the common length is less than 50% of its frontier. This type is edge expansion (Fig. 2b) or shrinkage (Richard, 1995); if $T = 0$, it means that the new urban areas have no spatial association with the old urban patches, and this is outlying type (Fig. 1c) with outlying urban growth further separated into isolated, linear branch, and clustered branch growth (Fig. 3) (Richard, 1989; Wilson et al., 2003). The distance to existing developed areas is important when determining what kind of urban growth has occurred (Karen and Michail, 2005; Basudeb, 2010).

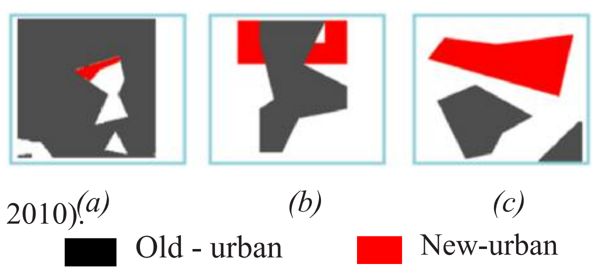

Fig 2. The three types of urban sprawl (a) Infilling type, (b) Edge expansion, (c) Outlying type

In addition, other documents reviewed include the sectors of socio-economic development, infrastructural, residential, commercial, industrial, transportation, recreation, urban open and so forth to identify the major stakeholders

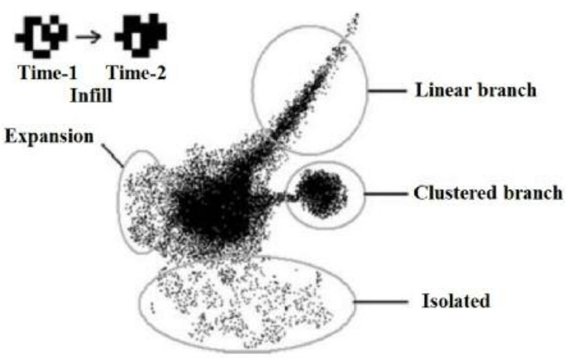

Fig. 3. Schematic diagram of outlying urban growth pattern (Basudeb, 2010)

3. Results and discussion

3.1. Trends of physical growth of Pleiku city

Land use analysis in Table 1 shows that between 2000 and 2019, the development of Pleiku city has witnessed changes in land uses. The significance of the change in the land uses as a result of urban sprawl has been discussed and it has significantly affected farming lands in the area.

Firstly, the residential land area increased quickly and continuously during the period shown, enlarged by nearly 12.17 km^2, equivalent to 8.29% (in 2000, it was only 2.47%, of course, it reached 10.76% in 2019), an average increase of 0.64 km^2/year. The main reason was determined by the rapid increase in the population of the nuclear family process as well as free migration to find agricultural production materials of ethnic minorities in the North and migration from rural to urban (Katherine, 2010) in the region over two decades (from 135,000 in 2000 to 254.802 people in 2018), an increase of 119,802 people.

Secondly, land use of infrastructure increased rapidly and continuously throughout the study period, accounting for only 4.64% in 2000 but reaching 11.20% in 2019, an increase of 2.5 times (equivalent to 14.43 km^2) within 19 years, an average increase of 0.76 km^2/year. This transformation is still a trend up to now, with the reason for developing infrastructure for the transition of economy from agriculture to industry and services according to the city's development orientation (Gia Lai Government, 2005 and 2018), typical projects such as roads systems of Ho Chi Minh (phase 2); bypasses of Pleiku city; school system (branch of Nong Lam University; Chau A - Thai Binh Duong school; Nguyen Chi Thanh school); service systems likes HAGL hotel, Duc Long hotel, etc.).

Thirdly, service and commercial land increased by 1.09% in the period of 19 years, in 2000 it accounted for only 0.08% but reached 1.17% in 2019, an increase of 15 times (equivalent to 2.13 km^2), and equivalent to an average increase of 0.12 km^2/year. The main force to increase commercial land was the factor of population, combining with policies in investment and development of infrastructural and housing, which requires investors to continuing in expanding and upgrading their business systems. For example, household furniture, office equipment on Pham Van Dong street; interior decoration materials on Tran Phu and Phan Dinh Phung; beauty services, cosmetics business, clothes, fashion shoes on Thong Nhat, Cu Chinh Lan streets; markets in Chu A commune, Hoa Lu ward on Cach Mang Thang Tam street.

Looking at land use trends, the research illustrates that increased land area was mainly transferred from agricultural land and vacant land. On the one hand, the land for agriculture (Land of forests and other agriculture) contributed significantly more to infrastructural and residential land in Pleiku city than the others. For example, land of forests decreased gradually, with 3.07%, equivalent to 5.66 km^2, an average reduction of 0.30 km^2/year). In addition, the rate of decrease of the other farming land was 25.81 percent of total conversion area through 19 years, equivalent to 63.08 km^2, an average reduction of 3.32 km^2/year).

On the other hand, over the time period in question the amount of reduction of vacant land was steadily become more important, actually having a change of 17.49 percent, respectively 33.89 km^2, an average reduction of 1.78 km^2/year, which was about 0.6 times lower than the rate of cultivated parcel (28.88%). This is due to the transformation from vacant land to annual crops and perennial trees.

Table 1. Land use inventory of the Pleiku city

ID	Land Use Types	Years					Change 2019/2000	
		2000	2005	2010	2015	2019	Area (km^2)	%
A	Agricultural land uses categories	175.46	174.51	178.42	189.36	188.81	14.30	5.49
1	Land for cultivation of annual crops	33.37	35.79	49.05	54.57	53.30	17.51	7.64
2	Land for cultivation of perennial trees	39.64	42.84	96.47	111.53	108.08	65.24	26.25
3	Land of forests	34.84	32.50	32.19	22.69	26.84	-5.66	-3.07
4	Aquaculture land	0.20	0.20	0.35	0.49	0.49	0.29	0.11
5	Other agricultural land	67.41	63.18	0.36	0.08	0.10	-63.08	-25.81
B	Other land uses categories	37.84	50.51	56.51	66.45	70.10	19.59	12.37
1	Residential	6.43	15.88	24.51	27.48	28.05	12.17	8.29
2	Office land	0.23	0.89	1.17	1.63	2.13	1.24	0.73
3	Commercial land	0.20	0.72	1.15	1.80	3.05	2.33	1.09
4	Green and sport areas (open spaces)	0.10	0.41	0.57	0.69	0.72	0.31	0.24
5	Industrial land	0.72	1.61	1.61	1.43	1.43	-0.18	0.27
6	Infrastructures land	12.10	14.78	20.25	27.62	29.21	14.43	6.56
7	Others land	18.06	16.22	7.25	5.80	5.51	-10.71	-4.81
C	Vacant land (unused land)	47.48	35.75	25.84	4.96	1.86	-33.89	-17.49

These fluctuations in the structure of the land use are consistent with the socio-economic development in Pleiku city. The rapid physical expansion of the city explains the current peri-urban status of these peripheral settlements, and increasing in infrastructures of roads, schools, hospitals and so forth, resulting in increasing consumption of sub-urban land.

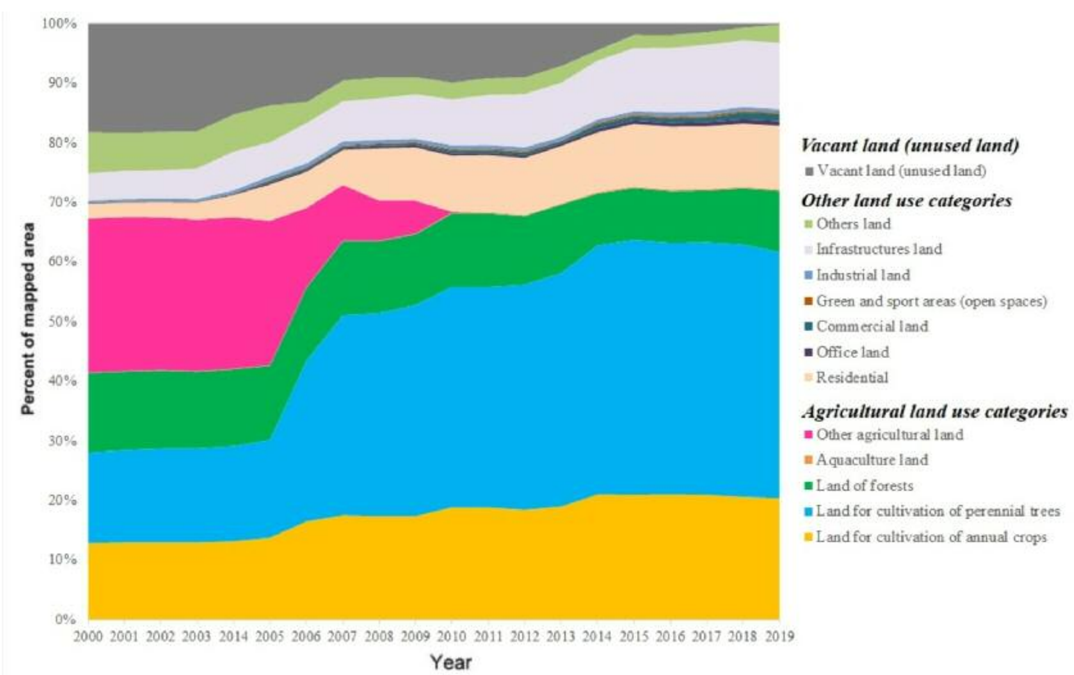

Fig. 4. Land use trends in Pleiku city

Landscape Characteristics in 2019

The term landscape characteristic equally to land use type in urban areas. Pleiku city landscape is concerns on the degraded and loss of agriculture land in area. It is not concerned with what landscape makes one landscape better or worse than another.

Agricultural land declined to 0.21% of the total area and was typically isolated on the peripheries of the study zone, which had a very patchy and scattered configuration (Fig. 5). The built-up areas became the most predominant land-use type in the urban landscape of Pleiku 28.88% of the total (Table 2).

In the larger context, built-up areas expanded primarily along the National Road No.19 and National Road No. 14 parallel to the development of the transportation network. In particular, the urban spread in a linear pattern toward the Tan Son, Bien Ho, Dien Phu and Phu An communes. In this process, the low-density residential character of the study area was mostly

replaced with high-density mixed uses and was mainly situated on the slopes of hills in the northern part of the study area.

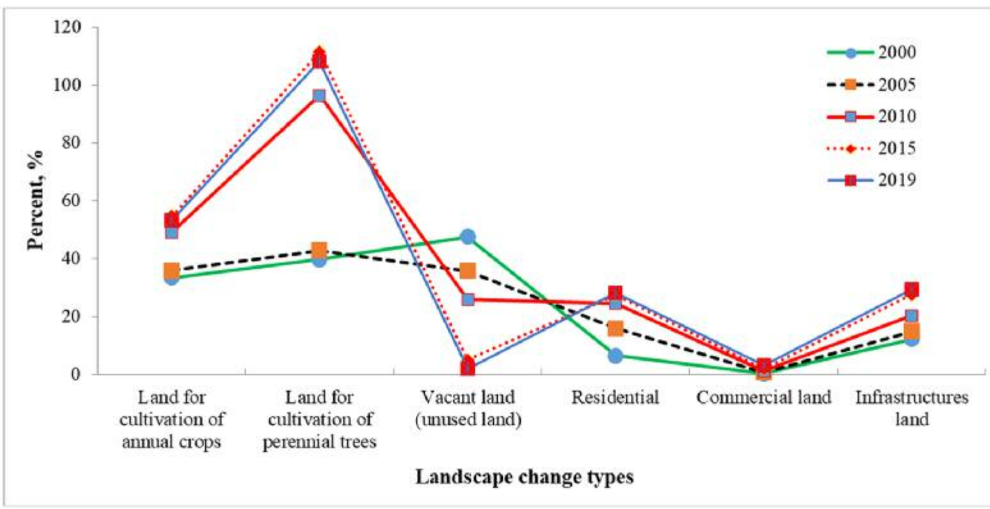

Fig. 5. Landscape change types in Pleiku city

3.2. Types of urban sprawl and areas affected in Pleiku city

Detailed analysis of the newly expanded urban areas revealed the general trends of urbanization process and pointed out the configuration of the different urban sprawl types in Pleiku city between 2000 and 2019. The types of three kind of urban growths are illustrated in Fig. 6 and Table 2.

The Fig. 6 shows that the types of urban sprawl in Pleiku are similar to framework of Wilson et al. (2003) and Jun et al. (2011). These three types of urban growth have been visualized in this study including infilling type, edge expansion and outlying type.

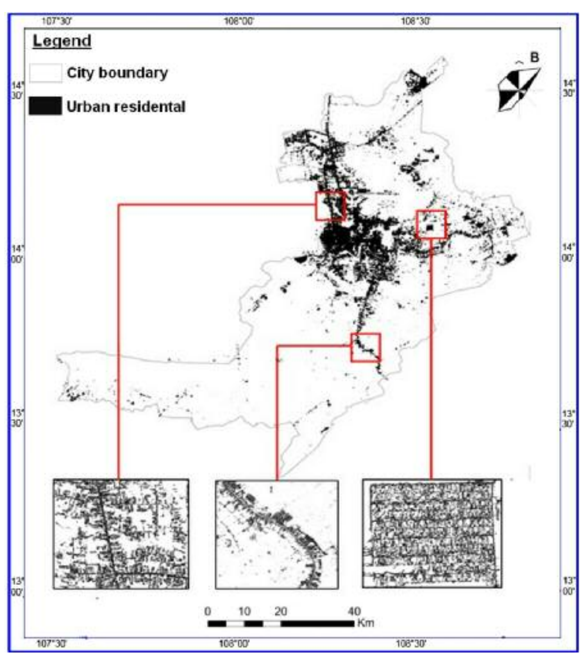

Fig. 6. Spatial distribution of three urban growth types in study area in Pleiku city

Table 2. Land areas of urban sprawl

Types of urban sprawl	Zones	Area (km^2)	(%)	Communes/ Wards
Infilling type	I1	0.56	8.85	Thong Nhat
	I2	0.3	4.74	Dong Da
	I3	0.25	3.95	Ia Kring
Sum		*1.11*	17.54	
Edge expansion	E1	0.35	5.53	Thong Nhat
	E2	0.35	5.53	Dien Phu
	E3	0.55	8.69	Hoa Lu
Sum		*1.25*	19.75	
Outlying	In1	0.46	7.27	Bien Ho
	In2	0.46	7.27	Yen The
	In3	0.31	4.90	Tra Da
	L1	0.52	8.21	Tan Son
	L2	0.41	6.48	Bien Ho
	L3	0.33	5.21	Dien Phu
	L4	0.42	6.64	Phu An
	L5	0.27	4.27	Chu Hdrong
	N1	0.36	5.69	Phu Dong
	N2	0.43	6.79	Phu Dong
Sum		*3.97*	62.72	
Total		6.33	100.0	

From Table 2, it can be seen that the whole city has 6.33 km^2 and divided into 16 urban sprawl zones, accounting for 2.43 percent of total land area and 22.57 percent of total residential areas.

The comparison among the three sprawl types, as the majority sprawl - outlying sprawl reach at 3.97 km^2 and became the main sprawl type, which makes up 62.72 percent of urban sprawl areas. In term of edge expansion, the second type of urban sprawl is 1.25 km^2, which makes up 19.75 percent. With regard to the infilling type, this type is 1.11 km^2, which are the smallest one with only 17.54 percent.

3.2.1. Infilling type

As for the infilling type, its area was smallest in urban sprawl. It was prominent where expansion occurred in the infilling of the remaining open spaces within urban areas.

This study has revealed that the infilling urban sprawl regions consist of Thong Nhat, Dong Da and Ia Kring wards with three locations (from I1 to I3), as shown in Fig. 7, which were transformed non-urban lands (Lands of Perennial trees and Annual crops) within the urban region, made them more compact, and also slightly changed urban boundaries between Pleiku city and neighboring districts (Chu Pah and Ia Grai).

In conclusion, in terms of infilling sprawl, the relatively corresponded to sustainable sprawl types (Roberto et al., 2002). The alternation of dominative sprawl types indicated that urban expansion was becoming "relative" and "sustainable" when we consider the previous "waste" character in land use.

Fig. 7. Infilling type in Thong Nhat and Dong Da wards

3.2.2. Edge expansion

Fig. 8. . Edge type in Hoa Lu ward

The edge enlargement sprawl, which was practically saturated and compact, was the second major sprawl type as shown in Fig. 8. Edge-expansion emerged mostly in the adjacent urban fringe (Nick et al., 2006). The most sprawl type, which accounted for 19.75 percent of the total sprawl areas, was the edge expansion sprawl in Thong Nhat ward, and Dien Phu, Chu Hdrong communes (from E1 to E3), where land was ready to develop from the edge of the pre-developed area (Duong et al., 2018).

3.2.3. Outlying type

The outlying sprawl, which includes insolated type, linear branch and nucleated branch, has been the summing almost 62.72 percent of the whole study area, which was considered to be the majority sprawl type. Development outside the main urban region was a reflection of rural towns adopting strategies to establish development or industrial zones (Karen and Michail, 2005). Outlying characterized the newly scattered development that was far away from the pre-developed urban zone which is described below:

(a) (b) (c)

Fig. 9. Outlying types in Pleiku city (a) Insolated expansion type, (b) Linear spreading out type, (c) Nucleated type

a) Isolated type

The whole city has 1.23 km^2 isolated areas, which accounted for 20.34 percent of urban sprawl in Bien Ho commune, Yen The and Tra Da wards (from I1 to I3), as shown in Fig. 9a. Dispersed settlements are ones where the houses are spread out over a wide area. They are often the homes of farmers and can be found in peri-urban areas of Pleiku city.

b) Linear branch

As far as the other types of urban growth are concerned, linear settlements in study area, the buildings are constructed in lines shape, often next to a geographical feature in a lake shore, a stream or following a road in Tan Son, Bien Ho, Dien Phu, Phu An and Chu Hdrong communes, as shown in Fig. 9b. The number of liner settlements has 1.95 km2, 30.81 percent of total urban sprawl area, is considerably more common than insolated type, which makes up 20.34 percent.

Most urban sprawl sites are located around the sub-urban areas of Pleiku city, within or near villages of ethnic minorities.

c) Nucleated or Clustered branch

The nucleated sprawl, where buildings are close together, often clustered around a central point, was the third sprawl type in outlying which as shown in Fig. 9c. The area of the sprawl type is 0.79 km2, which accounts for 12.48 percent of the total sprawl areas, was the development sprawl in Hoa Lu ward (N1 and N2). The location of nucleated settlement can be determined by a range of factors, including being easy to defend, close to a water supply or located at main routes. This proximity makes communication quicker and easier than in linear and dispersed settlements. Because people are closer together, it is also easier to do daily tasks such as buying and selling of goods and services.

4. Conclusions and recommendations

Spatial and temporal studies on urban sprawl or urban areas expansion are necessary for land planning and urban planning in Viet Nam, which is experiencing a rapid increase of land demand for construction in the context of economic development and population growth. Understanding the change in the spatial configuration of urban areas over time is essential for identifying the effects of urban sprawl and landscape.

In term of land use, the results of the assessment of land use trends in the period of 2000-2019 show that the land use and landscape of Pleiku city has changed rapidly and significantly. Perhaps the biggest change has been in the overall of settlement and infrastructures plots. Accompanying this shift in the composition of land use trends has been a changing in its type, most notably a reduction outside of agriculture in term of land for cultivation of annual crops, perennial trees and vacant land. In general, the trend of land use fluctuations in the region is consistent with socio-economic development of Pleiku city.

Besides, the results revealed a remarkable expansion of urban areas between 2000 and 2019. The different types of urban sprawl showed a tendency of leading the shape of the whole landscape composed by the three different sprawl types to become regular in outline in distribution. According to the sprawl quantifying mechanism, outlying sprawl was often appearing at outside the chief inner-city area, that extended urban coverage, have accelerated the increase of urban size significantly. The expanse of infilling was gradually transformed non-urban parcels within the urban region for municipal use, the urban patches gather gradually to be more compact. The edge expansion was to develop from the edge of the pre-developed area, the pre-constructed urban areas or far from the core areas.

Finally, because of the inadequate analysis of urban sprawl and its effects, the mechanism and manifestation of urban sprawl was not explained in this study, thereby needing further consideration. The continuing study on urban sprawl in rapidly developing regions should concentrate on the effects of the different sprawl types on sustainable land use and urbanization, distribution of the different sprawl types. The links between socioeconomic driving forces and urban sprawl configuration with social, economic, and environmental effects have to be clearly understood, which may play an important role in urban planning in Pleiku city.

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Research Paper

APPLICATION OF ECOSYSTEM MODELING OF PHYTOPLANKTON SIZE STRUCTURE USING STELLA TO ANALYZE ASAN BAY COATAL ESTUARY

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ARTICLE HISTORY

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ABSTRACT

The phytoplankton dynamics considering size structures were investigated in Asan Bay. The contribution of netphytoplankton (>20μm) was high in spring, whereas contributions of nanoplankton (2<20μm) increased from summer to winter. The enrichment of PO_4^{3-} in winter and the increase of radiance in spring often appeared to control phytoplankton community structure in spring. Water runoff might bring NO_2^-+NO_3^- and NH_4^+ into Asan Bay in summer. However, phytoplankton biomass didn't increase in summer season. Based on these results, the variations of phytoplankton size structures might be determined by different light and nutrient availability. Application of dynamical estuarine ecosystem modeling for phytoplankton size structure using STELLA with state variables of the model included major inorganic nutrients (NO_2^-+NO_3^-, NH_4^+, PO_4^{3-}, S_i), size classes of phytoplankton (netphytoplankton, nanophytoplankton, two classes of zooplankton (mesozooplankton, microzooplankton), and organic matters (POC, DOC). The results suggest that understanding of phytoplankton size structure is necessary to investigate phytoplankton dynamics and to better manage water quality in Asan Bay. .

Keywords: *Applied ecosystem model, Phytoplankton dynamic, STELLA.*

1. Introduction

The different size phytoplankton can be affected differently by nutrients and light uptakes as well as grazing in water column. Depending on season the growth of each phytoplankton size class is different. In coastal estuaries, phytoplankton dynamics and production are controlled by physical, chemical and biological factors (Sin et al., 2000). Estuarine ecosystems became a key issue in environmental research for coastal waters as well as freshwater environments. Size-structured phytoplankton dynamics were incorporated in estuarine coastal ecosystem model developed by Sin and Wetzel (2002).

In shallow coastal ecosystems, the combination of mixing and nutrient inputs due to wind, tides, river discharges and benthic fluxes is known to influence the phytoplankton community structure and primary production (Dube and Jayaraman, 2008; Kiorboe, 1993; Schwing-

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hamer, 1981; Wen et al., 2008). The coastal ecosystem at transition zone affected from unusual nutrient inputs, together with other environmental conditions (salinity, temperature), bringing continuous nutrient availability for phytoplankton and consequently food supply for marine and estuarine organisms. The systems close to the coastal area have shown to be the main N, P, and Si nutrient source to the water body due to the use of soils for farming and their continental runoff (De Marco et al., 2005). Benthic faunal activity and density play an important role in determining the rates of benthic nutrient fluxes, which enrich the water column and contribute to phytoplankton growth. Even low benthic fluxes can allow diatoms to dominate the phytoplankton community (Claquin et al., 2010).

The spring blooms were observed by many studies in coastal estuaries. Gemmell et al. (2016) applied high-resolution optical techniques, individual-based observations of phytoplankton sinking and a recently developed method of flow visualization around freely sinking cells. Netphytoplankton such as diatoms are an abundant and ecologically important group of silicified eukaryotic phytoplankton. They are estimated to account for 20–40% of the oceanic primary production. Phytoplankton sinking rates are independent of cell size across a range of greater than 106μm3 in rapidly growing cells (Nelson et al., 1995; Waite et al., 1997; Gemmell et al., 2016).

STELLA was also applied for germination and vertical transport of cyst forming dinoflagellate model by Anderson (1998) and reservoir plankton system model by Angelini and Petrere (2000). STELLA was developed as tool for ecological and economic system modeling (Costanza et al., 1998; Costanza and Gottlieb, 1998; Costanza and Voinov, 2001). Bach (2019) applied STELLA to model phytoplankton size structure dynamic in coastal ecosystem (Bach, 2019).

The investigation of phytoplankton structure can examine spatial and temporal variations in chlorophyll a of various phytoplankton size classes and provide more knowledge of phytoplankton dynamic characteristics in coastal estuarine.

2. Methodologies

2.1 Study location

The Sapgyo, Asan, Daeho, Seokmoon and Namyang embankments were constructed in the upper region of the Asan Bay since 1970s (Fig. 1). The large scaled industrial complex was constructed along the coastal of the Asan Bay. The freshwater from embankments interacts with seawater when the gates of embankments are open. Water samples were collected 1m below surface by using Niskin water sampler for more than 5 years at 1 station as Fig.1 in the Asan Bay.

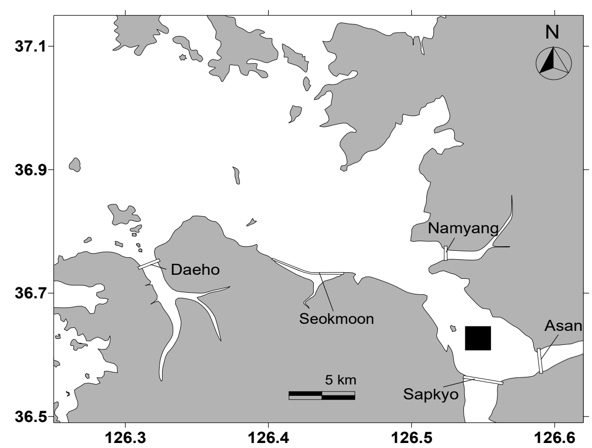

Fig. 1. The study and modeling site in the Asan Bay, South Korea.

2.2 Measurement of environmental properties and chlorophyll a

Water sampling was collected at study site in Fig. 1. For determinations of chlorophyll a, 200 mL of sampled water filtrate was filtered through Whatman® 25mm GF/F glass microfibre filters (0.7 μm) under minimal vacuum (<100 mm Hg). The filters were placed in dark test tubes pre-filled with 8 mL extraction solution (90% acetone and 10% distilled water). After storage for 12 h in chilly condition (4^{o}C), chlorophyll a was measured on a Turner Designs® 10-AU Fluorometer. Nano phytoplankton (< 20μm) and netphytoplankton (> 20μm) were sized by mesh and analyzed in Microbial Ecology Laboratory, Mokpo National Maritime University.

Ambient nutrients (NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}, dissolved Si) were analyzed by using Bran Luebbe autoanalyzer (Parsons et al., 1984). DOC, POC, microzooplankton (> 200 μm and < 330 μm) and mesozooplankton (> 330 μm) were analyzed and identified in Laboratory of Department of Environmental Engineering, Kwangju University. Nutrient loadings from freshwater were estimated by multiply of monthly nutrient concentrations at the stations near dikes of Asan and Sapgyo lakes with monthly water discharge amount of each lake through dike.

2.3 Model description

Dynamical estuarine ecosystem modeling of phytoplankton size structure using STELLA has developed in Bach (2019). The model was applied for site in Fig. 1. The ecosystem model includes 10 state variables (Bach, 2019): nano- (< 20 μm), net- (> 20 μm) phytoplankton; microzooplankton (> 200 μm and < 330 μm), mesozooplankton (> 330 μm); nutrients NO_2^-+ NO_3^-, NH_4^+, PO_4^{3-}, dissolved S_i, and non-living organic materials, DOC and POC. Large and small phytoplankton are differentiated in their ability for nutrients, light limitations, temperature dependent metabolism and assimilation rate. Germination of netphytoplankton was considered together with wind forcing effect.

Grazer variables were differentiated by the size structure of potential prey, as well as their half-saturation foods and assimilation rates (at 10^{o}C) and affected by temperature response factor. POC, DOC were released from phytoplankton accumulation and zooplankton excretion and mortality. Nutrients were enriched by bacterial degradation of organic matter and grazer excretion. The ecosystem model was integrated with STELLA 7.0 using the function (a numerical variable time step differential equation solver using a 4th order Runge-Kutta method).

3. Results and discussions

Temperature was not significant controlling factor for phytoplankton, however, increase of temperature in spring contributed for the growth of phytoplankton. Salinity could be affected by annual precipitation. Especially, water runoff from land have decreased salinity significantly in summer. Radiance increased in spring. It could create increasing of light attenuation coefficients in water. However, depending on stations with different factors such as turbidity light attenuation coefficients were nonlinear on radiance. Generally, the contribution of large cells (netphytoplankton, >20μm) to total concentrations of chlorophyll a was high from February to April and then it decreased until early May. However, the contribution increased again during late May to early June with small peak. In contrast, abundance of nanophytoplankton and were dominant from May to November. In summary, the contribution of micro-sized class was evident in spring whereas nano-sized classes were more significant from summer to winter in Asan Bay. Annually, total chlorophyll a peaked in spring and decreased from spring to winter. The total chlorophyll a have trended high concentration at studied station in spring. The difference among different season suggest that temperature, light and water runoff can affect to spatial variations of chlorophyll a. Water runoff from farms as well as industrial zones flowed into Asan Bay that peaked NO_2^-+NO_3^- and NH_4^+ in summer. Besides, NH_4^+ and PO_4^{3-} had small peaks in winter, therefore, they contributed for growths of phytoplankton in spring. Silicate appeared no significant evidence for phytoplankton controlling factor. These results indicate that phytoplankton size structures in Asan Bay depend on not only nutrients but also light as well as temperature. The investigation of spatial and temporal variations in chlorophyll a of various phytoplankton size classes may evaluate precisely phytoplankton dynamics.

The calibration of ecosystem model was applied by adjusting values of parameters which were not observed by the field study or the literature for the Asan Bay. These parameters included optimal light intensity for net-, nanophytoplankton, respiration rate of phytoplankton, mortality rate of phytoplankton, mortality rate of zooplankton, respiration rate of zooplankton, excretion rate of zooplankton, hydrolysis rate of POC, degradation rate of DOC, fraction of DOC in sinking

The field measurement and model state variables of phytoplankton classes, zooplankton classes, organic matters and nutrients were shown in Figs. 2 and 3. The model output data were compared to field measurements of state variables. Simulated netphytoplankton approached very closely field observations (Fig. 2A). Simulation output of nanophytoplankton was similar to field concentrations although seasonal peaks were not simulated accurately (Fig. 2B). Especially, large cells contributed about 80% to the total chlorophyll a during spring. However, the contribution increased again during late May to early June with small peak. In contrast, abundance of small cells (nanophytoplankton, 2~20μm) were dominant from May to November. In summary, the contribution of netphytonplankton was evident in spring whereas nanophytoplankton was more significant from summer to fall in Asan Bay. Under low nutrient concentration conditions such as in May or September, phytoplankton can reduce cell size to nanophytoplankton to adapt to these conditions. Mesozooplankton and microzooplankton were expressed in Figs. 2C-2D.

Variation of measured POC was similar to simulated variation, however DOC was difficult to validate since few data were observed (Figs. 2A-3B). Ammonium showed good agreement with field data except for the peak observed in July 2004 (Fig. 3C). The great simulation was observed for nitrite+nitrate outputs (Fig. 3D). For orthophosphate and dissolved silicate, the simulations were similar to field data except the peak of orthophosphate (Figs. 3E-3F).

The prediction of the long-term planktonic evolution studied the global stability for the coexistent equilibrium of phytoplankton-zooplankton system by Zhao et al. (2018). The numerical simulations were investigated that increasing the cell size, the system goes into oscillation. Cell size was qualitatively similar to the result of the experimental analysis. Cell size affected the growth and reproduction of phytoplankton, evolutionary interactions between phytoplankton and zooplankton were closely related to the cell size of phytoplankton (Zhao et al., 2018). Physical features of the area strongly influenced phytoplankton biomass distributions, composition and size structure after high volumes of river discharge occurred during February. The dynamic circulation of February resulted in high photosynthetic capacity of the abundant phytoplankton population (Mangoni et al., 2008). Macedo and Duarte (2006) developed three one-dimensional vertically resolved models to investigate differences between static and dynamic phytoplankton productivity in three marine ecosystems: a turbid estuary, a coastal area and an open ocean ecosystem. The quantitative importance of these differences varied with the type of ecosystem and it was more important in coastal areas and estuaries (from 21 to 72%) than in oceanic waters (10%).

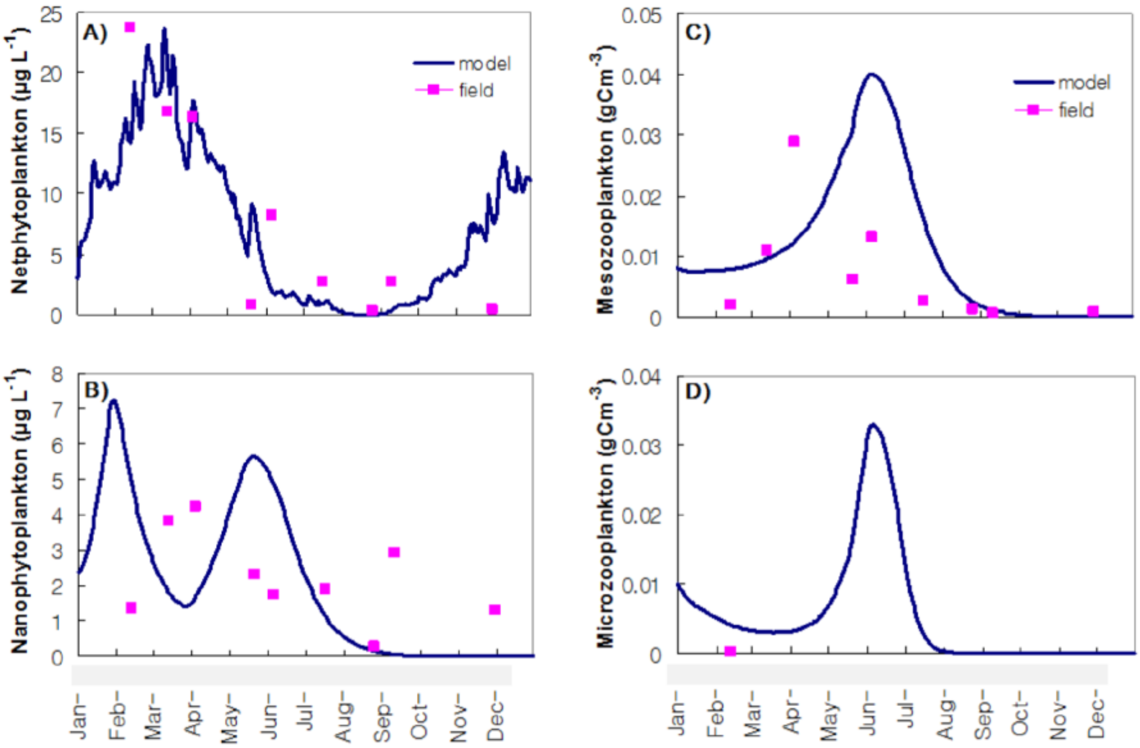

Fig. 2. Results for size classes chlorophyll a (net- and nano-), meso- and microzooplankton in the polyhaline zone of the Asan bay system. Field data for chlorophyll a size classes.

The timing, location, and monsoon mixing or intensity of storms and associated rainfall amounts also affect nutrient makeup and discharge to coastal waters. Freshwater discharge can deliver nutrients to the coastal zone and determines the hydrologic properties of the water column, including vertical stratification, water residence time, salinity, turbidity, and clarity. Therefore, the composition, concentration, and delivery of nutrients depend on how the watershed has been modified by agricultural, urban, and industrial activities.

Coastal and estuarine ecosystems are also influenced by seasonal and multi-annual hydrologic variability. Large estuarine ecosystems are affected by multiple stressors, including nutrients and other pollutants, changes in light regime (turbidity), temperature, mixing, and circulation, they exhibit a range of biogeochemical and trophic responses to short and long term hydrologic changes, which are changing in place and time. These stressors may alter the ecological characteristics of these large systems. The delivery of anthropogenic nutrients and other pollutants to coastal waters is in a highly dynamic state, as development and accelerated loading.

Phytoplankton biomass and primary production related size-fractionated, together with net community metabolism, were measured in a coastal ecosystem (Ría de Vigo, NW-Spain) during a full annual cycle (Cermeño et al., 2006). In seasonally, this ecosystem was characterized by two distinct oceanographic conditions, upwelling and downwelling favourable seasons. The seasonal with upwelling provides a feasible explanation for the continuous dominance of large-sized phytoplankton such as netphytoplankton. Large phytoplankton during favourable conditions for growth affected to an enhancement of the ecosystem's ability to export organic matter to the sediment and to adjacent areas, as well as to sustain upper trophic levels (Cermeño et al., 2006; Garcia et al., 2008; Moloney and Field, 1991).

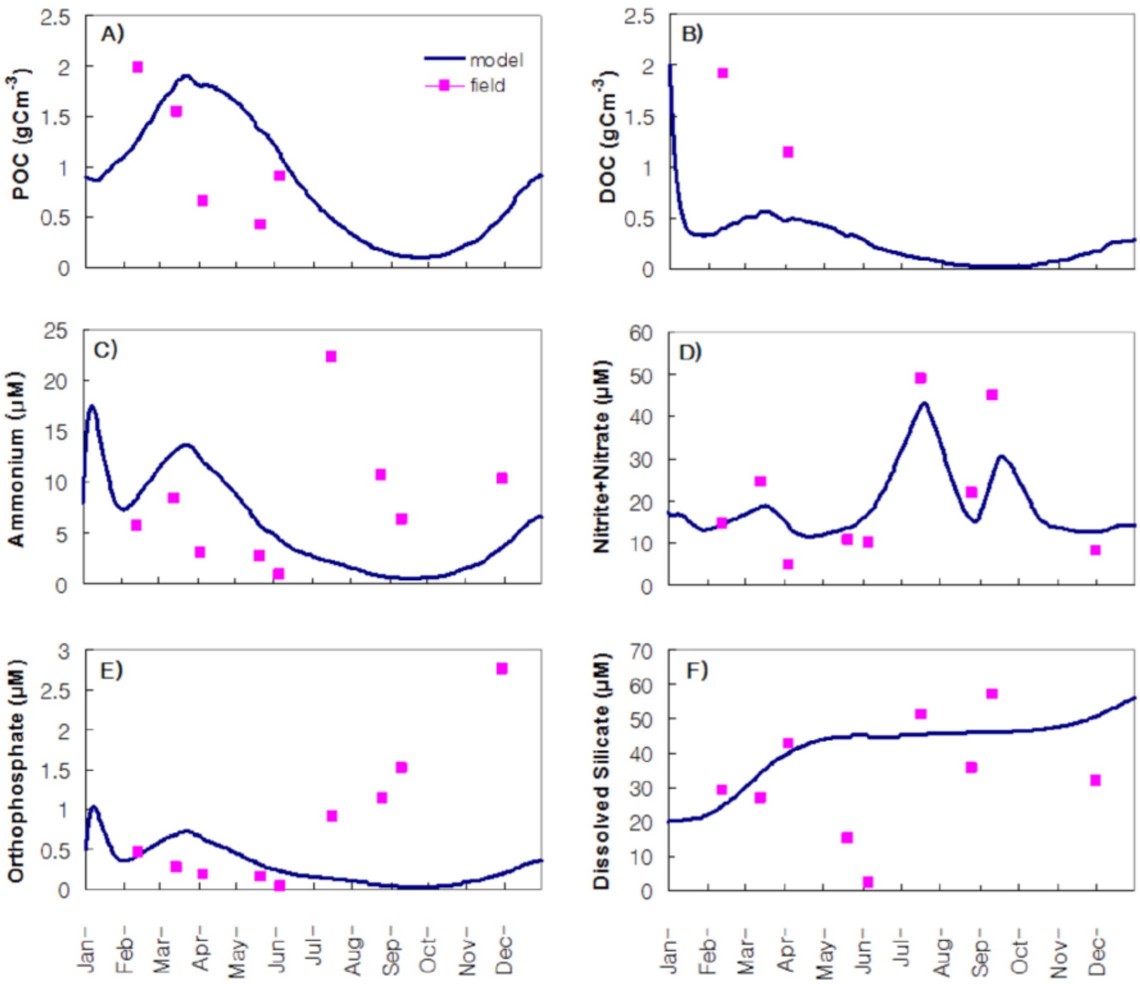

Fig. 3. Results for particulate organic matter (POC), Dissolved organic matter (DOC) and nutrients (ammonium, nitrite+nitrate, orthophosphate and dissolved silicate) in the polyhaline zone of the Asan bay system. Field data for POC, DOC and nutrients were collected.

4. Conclusion

Applied model could figure out phytoplankton growth in field study station where estuarine and coastal ecosystem suffered nutrient enrichments and change of hydrology from embankments in Asan Bay. In spring, netphytoplankton were highly abundance at the study station. Inversely, nanophytoplankton were abundant in both spring and fall. Netphytoplankton had high relationships with total chlorophyll a, as well as primary productivity at study site that demonstrated the important role of netphytoplankton in contribution for Asan Bay phytoplankton during spring. NH_4^+ and PO_4^{3-} had small peaks in winter, therefore, they contributed for growths of phytoplankton in spring. Input of freshwater into Asan Bay peaked NO_2^-+NO_3^- and NH_4^+ in summer, nevertheless, this season appeared no significant evidence for chlorophyll a increase of phytoplankton. Therefore, the size structures of phytoplankton were controlled by not only nutrients but also light exposure and temperature. The applied model also demonstrated that physical processes including wind mixing, water transparency, temperature as well as nutrients affected phytoplankton dynamics and response of phytoplankton could be related to the environmental changes in the coastal estuarine area.

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Research Paper

ANALYZING STAKEHOLDER INVOLVEMENT IN URBAN DOMESTIC WATER SUPPLY SYSTEM - CASE STUDY IN CENTRAL HIGHLAND OF VIETNAM

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ABSTRACT

Ensuring adequate and safe water supply is a top priority in human life, especially cities or residential areas. Accessibility and safety in water supply services requires good operation in the components of domestic water supply systems including water sources, water treatment plants, and distribution network systems. This means that the cooperation and coordination of stakeholders (SH) should be good to help maintain the stable system. Therefore, it is necessary to analyse stakeholder involvement, indicating their responsibilities and roles in maintaining the system. The most appropriate level of involvement is presented to clasify the roles of each stakeholder when operating the system. Analyzing the stakeholders are based on two attributes of interest-power matrix, and then classifiying three most appropriate level of involvement including co-working, co-thinking, co-knowing.

Keywords: *Water supply, Stakeholder analysis Co-working, Co-thinking, Co-knowing, Interest-power matrix*

1. Introduction

Waterborne disease remains one of the major health concerns in the world. Diarrhoeal diseases, which are largely derived from contaminated water and inadequate sanitation (WHO, 2005). Deaths of 502000 can be atributed to unsafe and insufficient drinking-water and 297000 are due to inadequate handwashing, of these deaths, 88% occur in Africa and South- East Asia (WHO, 2014).

In some cities of Vietnam, the quality of water sometimes does not meet the requirements of national standards QCVN 01:2009/BYT for drinking water and QCVN 02:2009/BYT for domestic water when water comes to consumers (MONRE, 2014). The causes were identified as poor pipelines, the high rate of leakage, polluting water sources and inadequate water quantity for meeting the demands of locals. To improve that status, water safety plan is first introduced by World Health Organization (WHO, 2005), and manual has recently published on implementing a WSP (World Health Organization and International Water Association, 2009). The aim of a WSP is to ensure that a water supply system consistently produces safe water that is acceptable to consumers. Major stakeholders that could affect or be affected by decisions or activities of the drinking-water supplier should be encouraged to coordinate their planning and manage-

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ment activities where appropriate (WHO, 2011). The WSP approach requires water utilities to work with other stakeholders to make them aware of their responsibilities and the impact that their actions have on the utility's ability to supply safe drinking-water. The WSP approach promotes dialogue, education and collaborative action to remove or minimize risks (Bartram et al., 2009). Moreover, stakeholder engagement is not separate from other management processes (Conallin et al., 2017).

A domestic water supply system will be included the processes from the water source to the users. These components are water source, water treatment plant and distribution network system, so there are many organizations and agencies involved in the system that are responsible for each part of the system (Bartram et al., 2005). Therefore, the management of the system must have the coordination of stakeholders to ensure that the system is managed and operated well (WHO, 2005).

Therefore, a stakeholder analysis plays an important role in managing water supply systems (Wang et al., 2013). First, this will help to understand the responsibilities and obligations of the parties at each stage of the process (from water sources to users) to ensure that the parties fulfill their responsibilities (Reed et al., 2009; Yawson and Greiman, 2014). Moreover, this helps to avoid overlapping and difficulties in management. Second, understanding the responsibilities will facilitate stakeholders to coordinate periodically or solving problems arising in the management process.

In 1984 Freeman wrote the seminal work Strategic Management: A Stakeholder is "any group or individual who can affect or is affected by the achievement of the organization's objectives" (Freeman, 1984). Stakeholder analysis is an approach, a tool or set of tools for generating knowledge about actors - individuals and organizations - so as to understand their behaviour, intentions, interrelations and interests; and for assessing the influence and resources they bring to bear on decision-making or implementation processes (Varvasovszky, 2000). Stakeholder analysis allows managers to identify the interests of different groups and find ways of harnessing the support of those in favour or the activity, while managing the risks posed by stakeholders who are against it (DFID, 2003). The stakeholders in drinking water supply system are identified (Wang et al., 2013) including water companies, Governement, consumers, polluting companies, communities, experts and professional institutions, media and NGOs.

This study focus on analysing the most appropriate level of involvement of stakeholders in the urban water supply system in Pleiku city, Gialai province - A case study in central highland of Vietnam. In which, there are main stakeholders related to three components of water supply system such as Water Company, Department of Natural Resource and Environment, Department of Transport Gialai, Users, Government (Anh et al., 2019).

2. Methodology

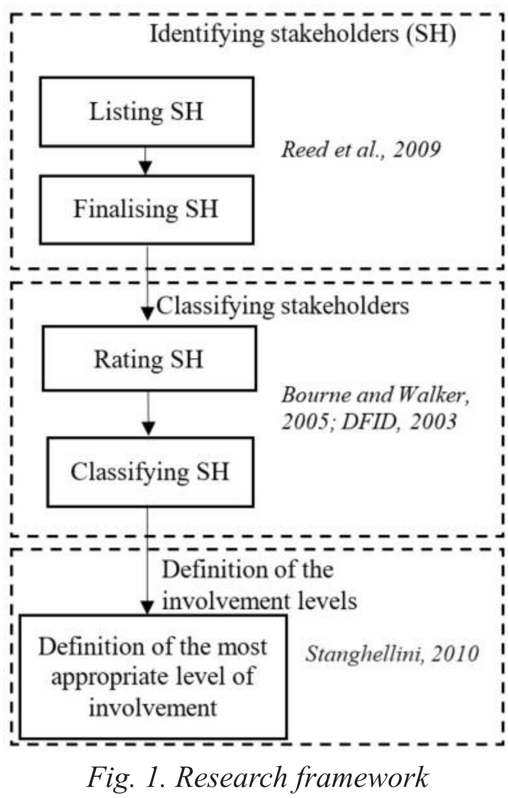

Fig. 1. Research framework

The analysis of stakeholders in the domestic water supply system will be conducted in three steps: Identifying stakeholders, Clasifying stakeholders, Definiton of the appropriate level of involvement of each stakeholder.

2.1. Identification of stakeholders

Stakeholders can be defined as actors who have an interest in the issue under consideration, who are affected by the issue, or who - because of their position - have or could have an active or passive influence on the decision-making and implementation processes. They can include individuals, organizations, different individuals within an organization, and networks of individuals and/or organizations (Suchman, 1995).

The widespread use of the term "stakeholder" was defined by Freeman as "any group or individual who can effect or is affected by the achievement of the firm's objective" (Freeman, 1984). Stakeholders in drinking water supply systems can be regarded as actors who have an interest in drinking water supply systems, who are affected by drinking water supply safety, or who have or could have an active or passive influence on decision-making and implementation processes.

Stakeholder identification needs to be done in a process with focus groups, expert opinion, semi-structured interviews, snowball sampling, or a combination of these methods (Reed et al., 2009). Based on an initial review of secondary sources (e.g., published and unpublished documents, policy statements, internal regulations of organization, etc.), potential stakeholders in this study were identified, and then conduct interviews (semi-structured interviews) representing stakeholders to conduct a review of the stakeholder list, and adding or removing any stakeholders. A final list of stakeholders is used to classify stakeholders in the next step.

After collecting all data (reports, documents, laws), a list of stakeholders is fully listed. Following the semi-structured interview method with staff, leaders involved in the domestic water supply system including water sources, water treatment plants and distribution system (leadership, installation personnel, maintenance and maintenance) to consider deciding whether to add or remove stakeholders. After interviewing the last table, the media and experts in water supply field were added to the task, the Gialai Department of Natural Resources and Environment (DONRE) has added the function to control water pollution.

2.2. Classification of stakeholders

Likert scaling may be described in the following manner. A set of items, if possible composed of approximately an equal number of favorable and unfavorable statements concerning the attitude object, is given to a group of subjects. They are asked to respond to each statement in terms of their own degree of agreement or disagreement. The specific responses to the items are combined so that individuals with the most favorable attitudes will have the highest scores while individuals with the least favorable attitudes will have the lowest scores (Likert, 1932). The interest-influence matrix is an approach for conducting a stakeholder analysis which is usually adopted as a management tool in project design (Romanelli et al., 2011; Caputo, 2013). Bourne and Walker (2005) have developed this concept in an index of interest-impact. Variables are the level of interest/likelihood of impact and the level of influence/power level, placed on a scale of 1 to 5. The ranking of interest and influence/power can be divided into 5 levels (low, low-medium, medium, medium-high, high). Apart from, the handbook of Department for International Development guides how to score each stakeholder, use a five-point scale where level 1 is very little importance or influence, and level 5 is very great importance or influence (DFID, 2003). This study uses a scale of 1 to 5 corresponding to the levels of interest - influence/power components. This research are based on the levels of ranking scores, the questionnaire of representatives of stakeholders are proposed to collect. After collecting the scores from surveys of 50 stakeholders (n = 50), datta are analysed by SPSS software 13.0.

Based on the stakeholder power-interest matrix, the stakeholders were subsequently divided into four basic groups: context setters/keep satisfied - stakeholder group with high potential; key players - stakeholder group with a high level of interest and power; crowd/minimal effort - stakeholder group with low level of interest and power; subjects/keep informed - stakeholder group with a high level of interest and low level of power (Driscoll and Starik, 2004; Wang et al., 2013; Yang et al., 2018).

2.3. Definition of the level of involvement of each stakeholder

After classifying stakeholders, it is important to decide how to involve the stakeholders. This is possible using the classification, which is very simple, clear and exhaustive: co-operating/co-working, co-thinking, co-knowing (Aggens et al., 1995; Stanghellini and Collentine, 2008).

Stanghellini (2010) identifies three different degrees of stakeholder involvement: co-working, co-thinking, and co-knowing. Co-working indicates stakeholders who actually participate in and contribute actively to the drinking water supply system. Co-thinking means stakeholders who have an input with respect to content and are sources of expert knowledge. Co-knowing means that stakeholders do not play an active role in the process but should be kept informed. After analyzing the mean score for power and interest atributes, scores of both attributes, which are higher than 3, should be classified as definitive stakeholders, while those with one attribute of higher than 3 are expectant stakeholders, while both attributes with scores of lower 3, are latent stakeholders. Corresponding to these 3 levels are co-working, co-thinking, and co-knowing stakeholders (Stanghellini, 2010).

3. Results and discussions

3.1. Identification of stakeholders in urban water supply system

Among stakeholders Gialai water supply company plays the most important role because it is responsible for treating and supplying water to users safely and adequately. The government is the one who makes the relevant policies and laws, so it plays an important role and affects the operation of the system (Wang et al., 2013). The protection of water resources is the responsibility of DONRE, but the surrounding community is a contributor to the protection of water resources. This is very important because a stable source of water with quality and reserves will help the Plant operate stably, which helps provide water to users safely and adequately. The Department of Construction is primarily responsible for the operations, general management of the pipeline network, and the water supply company will be responsible for installation, operation, maintenance and maintenance. These are important stakeholders in the system because it helps to safely transport water from the treatment plant to its users and not to be polluted. Control of water quality in the pipeline network is the responsibility of the Department of Health/Preventive Medicine Center for sampling, quality control and information disclosure (Anh et al., 2019).

Table 1. Interaction between stakeholders and urban water supply system

No.	Stakeholders	Role	Effects on the system	The system affects stakeholders
1	**Gialai Water Supply Joint Stock Company**	Producing and delivering clean water	Direct impact on the quality of treated water and adequate distribution of water	Can be affected by operating costs of systems, policies that put pressure on operations
2	**Users**	Purchasing and using clean water	Demand may affect the operation of the piping system	Affect daily needs of life and can affect health
3	**State agencies/organisations** Gialai hydraulic joint stock company Department of Health/ Gialai center for preventive medicine Environmental Police Department Gialai electricity company	Supporting and monitoring operation of system	Monitoring water quality Supervising the pollution of water sources Providing ancillary services (energy)	No significant impact
4	**Governments**	Creating the mechanism and introducing regulations, laws	May impact the treatment process (through regulations and regulations) Impact on pipeline network planning, water source protection Other preferential policies and subsidies	Direct impact by social equity and development goals
5	**Communities (living around the lake and pipeline system)**	Protecting the integrity of water supply system	May cause water pollution May cause a number of incidents (broken pipes ...)	No significant impact
6	**Key agencies** Department of Natural Resource and Environment Department of Transport Gialai	Managing the main components of water supply system	Water resource management and exploitation Pipeline network management	Impacting on development goals and ensuring social security
7	**Media**	Informing and announcing news related to the system	May affect public opinion through issues, complaints and incidents related to the system	No significant impact
8	**Experts and institutions**	Sharing and studying good practice	Indirect impact through guidance and recommendations	No significant impact

Fig. 2. Internal and external stakeholders in urban water supply system

Internal stakeholders can be defined as those who are formally connected with the project (e.g. owners, customers and employees), whereas external stakeholders are those affected by the project in some way (Gibson, 2000). Therefore, internal stakeholders can be defined as those whose actively participate in three components including water resource, water plants, distribution system. In addition, external stakeholders are any those whose support the system. Identifying internal and external stakeholders are consulted experts.

3.2. Classification of stakaholders

Table 2. Results of interest score analysis

Interest of SH	N	Range	Minimum	Maximum	Mean	Std. Deviation
I1	50	4.00	1.00	5.00	4.1200	0.79898
I2	50	4.00	1.00	5.00	3.8800	0.89989
I3	50	4.00	1.00	5.00	2.4200	1.07076
I4	50	2.00	3.00	5.00	4.0600	0.68243
I5	50	4.00	1.00	5.00	2.0800	1.22624
I6	50	3.00	2.00	5.00	3.4400	0.57711
I7	50	4.00	1.00	5.00	2.8800	1.22291
I8	50	4.00	1.00	5.00	2.7400	1.15723

Table 3. Results of power score analysis

Power of SH	N	Range	Minimum	Maximum	Mean	Std. Deviation
P1	50	4.00	1.00	5.00	3.9200	0.87691
P2	50	4.00	1.00	5.00	3.2200	0.91003
P3	50	4.00	1.00	5.00	3.1400	0.97813
P4	50	2.00	3.00	5.00	4.0400	0.69869
P5	50	4.00	1.00	5.00	2.0000	1.01015
P6	50	4.00	1.00	5.00	3.1800	0.71969
P7	50	4.00	1.00	5.00	3.0100	1.18511
P8	50	4.00	1.00	5.00	3.1800	1.01035

Stakeholders with High Interest and High Power - They are the most important stakeholder with high level of interest as well and high power, hence, they are referred to as "the key players" (Enserink et al., 2010) (Fig. 3). According to Table 1 and 2, the mean score of interest attribute is 4.1200 (SD = 0.79898), the highest score; the value of power is 3.9200 (SD = 0.87691), the second place. The water company is the most important stakeholder because they directly treat water and deliver to users, and it controls water quality to ensure safe and adequate water supply. In addition, the water company benefit highly from the production and supply of clean water (Gialai Water Company, 2018).

With the mean scores of interest and power are 4.0600 (SD = 0.68243) and 4.0400 (SD = 0.69869), the second highest scores are of governments. They enact policies and laws related to the water supply, so they are high power to create mechanisms, which helps operate water supply system, resulting in benefits from achievements of public health, social costs and tax obligations from water users and businesses.

There are three main components of the water supply system in Pleiku city, including Water Source (Bien Ho), two water supply plants (Saigon-Pleiku Plant, Bien Ho Water Plant) and pipeline network system (Anh et al., 2019). In which, the Department of Natural Resources and Environment will manage the water resource (Bien Ho), the Department of Construction will manage the pipeline network. This show why key agencies are the third place in mean score with mean value of Interest = 3.4400 (SD = 0.57711) and that of Power = 3.1800 (SD = 0.71969).

Stakeholder with High Interest but Low Power - These stakeholders need to be kept in loop by keeping them informed. They can prove to be powerful allies in influencing other powerful stakeholder (Chandraprabha, 2019). The fourth place of interest score is Users with mean =3.8800 (SD = 0.89989), the mean value of power is 3.2200 (SD = 0.91003). User who are using water supplied from the system, they have great benefits from adequate and safe water. They have to pay for water service, and have the right to appeal when the water service does not meet the requirements.

Stakeholder with Low Interest but High Power - They are an important group of stakeholders because any change in their degree of interest has huge influence on the project at hand. Hence, they are "the context setters". They just need to be monitored. All that is required from such stakeholders is feedback, cooperation and some assistance when necessary (Xue, 2018). There are also media organizations involved in posting news, writing articles about issues related to the water supply system. Experts and professional organizations will be independent critics on issues, incidents and information related to system components, in some cases they should be consulted before making decisions and policies. In addition, they carry out studies to help clarify issues, planning and warnings such as water resources, water supply systems, water treatment processes, water safety plans, and others related to water issues. For media group, the mean scores of interest and power are 2.8800 (SD = 1.22291) and 3.0100 (SD = 1.18511), and for experts and institutions these figures are 2.7400 (SD = 1.15723) and 3.1800 (SD = 1.01035). The scores are quite similar for this group. These results are consistent with the study of (Wang et al., 2013)

In addition, there are a number of organizations and related agencies in the state agencies group such as the Preventive Medical Center that will check the quality of water in pipes and at user tap water, Environmental Police (detect, treat) penalties related to water, Gialai power company supplying electricity for operating plants, and Gialai Irrigation Joint Stock Company that manage Bien Ho B (there is a dam separating Ho A and Ho B of T'Nung Lake) (Anh et al., 2019). This group has the mean value of Interest = 2.4200 (SD = 1.07076) and that of Power = 3.1400 (SD = 0.97813).

Stakeholders with Low Interest and Low Power - They have a low level of interest and possess little power to have significant influence. Hence, they are referred to as "the crowd". The community in the study area is also related to the system with the level of being responsible for protecting water sources and network systems. This is expressed through the mean value of interest and power are 2.0800 (SD = 1.22624) and2.0000 (SD = 1.01015).

3.3 The level of involvement of each stakeholder

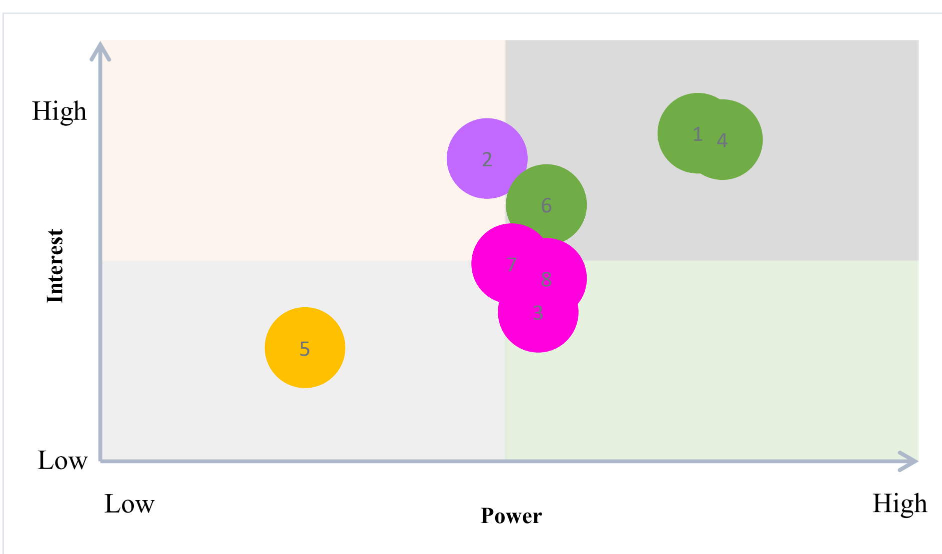

Fig. 3. Interest - Power Matrix

After analyzing the mean scores for the stakeholders, the interest-power matrix shows the positions of the stakeholders. Gorvernment and water company are the highest in the levels of power and interest points and are an active participant in the management of water supply system. Users and Key agencies in positions that have more power and interest than the rest of stakeholders in managing and operating the water system. These four stakeholders Media and experts, institutions havesimilar positions of power and interest. Regardless of their high power, they are generally not the main target for engagement, but cannot be ignored (Grimble and Wellard, 1997). With limited power and little interest in the water supply system, there is little need to extensively engage with communities. State agencies are able to participate with a minimum, with little interest in the process. The number from 1 to 8 correspond to stakeholders (SH) from 1 to 8 in Table 4.

Table 4. The involvement levels of stakeholders

SH	Interest	Power	Classification	Involvement
1	4.1200	3.9200	Definitive	Co-working
2	3.0800	3.2200	Definitive	Co-working
3	2.4200	3.1400	Expectant	Co-thinking
4	4.0600	4.0400	Definitive	Co-working
5	2.0800	2.0000	Latent	Co-knowing
6	3.4400	3.1800	Definitive	Co-working
7	2.8800	3.0100	Expectant	Co-thinking
8	2.7400	3.1800	Expectant	Co-thinking

Stakeholders who are active involvement are water company, governments, consumers, and key agencies. They are considered as co-working stakeholders. They should involve actively in the policy-making process. Expectant stakeholders (co-thinking) are experts and institutions, media,state agencies should be consulted in order to gain useful informations and opinions from various sources, which help improve the efficency of water supply system. The appropriate level of involvement for the latent stakeholders is co-knowing (Communities).

4. Conclusions

From the results of the analysis and grouping into the level of participation of stakeholders, when studying and issuing policies related to water supply systems, it is necessary to consider the appropriate level of participation of stakeholders. Making appropriate decisions, helping to operate the system well. At the same time, clearly defining responsibilities, obligations and powers for the parties to implement and coordinate the implementation is best done in reality. This helps ensure safe water delivery to users, the ultimate goal of the water supply system, which helps to ensure the health of the user community.

The review exercises power and benefits to consider the appropriate level of participation among stakeholders, from which there are solutions to adjust to improve the operation efficiency of the water supply system

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Research Paper

DISATER MANAGEMENT IN JAPAN AND EFFECTIVE USAGE OF METEOROLOGICAL INFORMATION WITH A PROMPT REPORT OF TYPHOON HAGIBIS

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ARTICLE HISTORY

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ABSTRACT

Typhoon Hagibis (T1919) hit area of Japan and 100 casualties and missing people were reported. The course, intensity, land timing were correctly forecasted in numerical weather models and lots of information issued almost properly, however, one of the severest typhoons in decades brought huge damages. Even if emergency warnings and evacuation directions were issued, most people did not evacuate. Evacuation in night-time was danger and earlier evacuations in comparison with day-time that recommended. In March of 2019, the guideline for evacuation was updated and risk levels of warning were categorized from Level 1 to Level 5.

Keywords: *Typhoon Hagibis, Evacuation, Disaster Risk Reduction.*

1. Introduction

Typhoon Hagibis (T1919) landed Japan around 7pm Japan Standard Time (JST) of 12th of October, 2019, went across Kanto/Tohoku area and passed to Pacific sea in early morning of 13th. It brought huge damage, mainly in Kanto/Tohoku area, according to the disaster report No. 35 (issued at 11th of November) (CAO, 2019), number of casualties were 95 (32 in Fukushima prefecture and 12 in Chiba prefecture) and 5 were still missing. The number of completely collapsed houses were 1,981, inundation house were 27,861 (above floor level) and 32,821 (below floor level) in 12th November 521,540 houses had electric failures at midnight, suspension of water supply were 166,149 at 12th of October, airplane cancellations at Haneda airport were 1796 (domestic) and 337 (international) at 12th and 813(domestic), 198 (international) at 13th. Washouts of embankment were 12 points of 7 rivers controlled by country and 129 points of 23 rivers controlled by prefectures. Damage of crops were 19.52 billion, agricultural facilities were 157.8 billion, forestry was 65.6 billion and fishery was 11.5 billion Japanese Yen (each statistical data is reported at 11th of November from ministries).

Forecasts of numerical weather prediction models from numerical weather prediction centers, i.e. ECMWF, JMA-GSM and so on, had forecasted its course, land timing and location correctly from the beginning of the week (7th of October). Japan Meteorological Agency (JMA) announced that the typhoon brought huge damage to Japan firstly 3 days at 9th (Wednesday) and media/public continuously informed fore-

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casts/warns precisely and frequently. On 12th (Saturday), Hagibis brought strong rain mainly in front of its trajectory and orographically at slopes faced to east and south in Kanto/Tohoku area heavy rain was recorded. At Hakono (JMA AWS station in Kanagawa prefecture) recorded 942.5mm precipitation in 24 hours until 21:00 of 12th, total precipitation was 1001.5mm, and it exceeded 3 times of monthly precipitation in October (334.3mm) (CAO, 2019).

JMA warned dangerous weather events in 3 types of information, i.e. advisory, warning. JMA issued extreme warning for Shizuoka, Kanagawa, Tokyo, Saitama, Yamanashi and Nagano at 15:30JST (JMA1, 2019) for Ibaragi, Tochigi, Niigata, Fukushima and Miyagi at 19:50JST of 12th (JMA2, 2019) and for Iwate at 0:40JST of 13th. The extreme warning were issued for 13 prefectures finally. Recently, JMA shared not only meteorological but met-related analysis/forecasting data, for example, landslide index, flood risk and inundation risk shown in Fig. 1. For the typhoon Hagibis, these information were timely issued and correctly reflected actual condition well.

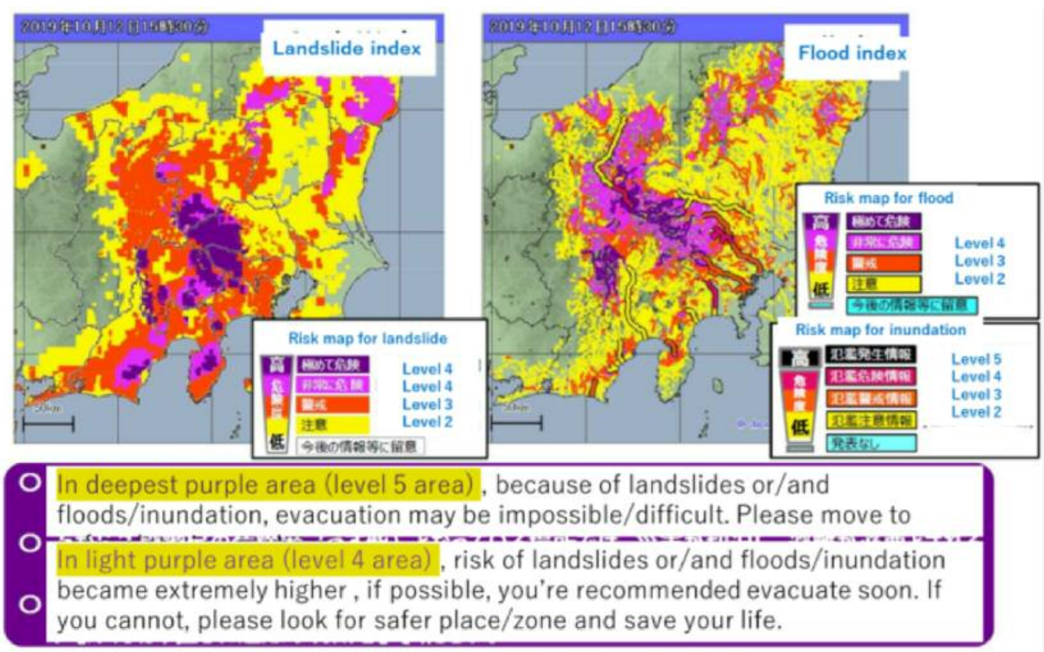

Fig. 1. An example of Risk indexes for Hagibis (captured from a JMA extreme warning report (JMA1, 2019) and translated).

JMA also managed multi language information web site for inhabitants and tourists in Japan, and information for weather warning, weather forecast, composite radar image, real-time risk map for landslide/inundation/flood, tsunami warning, earthquake information and volcano warning are shared. The web page address in Vietnamese is following (https://www.data.jma.go.jp/).

2. Evacuation during the disaster

For the typhoon Hagibis, weather forecasts were correct and directions for evacuation were issued from local municipal offices mostly earlier, however, 95 casualties were recorded by the typhoon.

In 2018, western Japan experienced heavy rain disaster in July and 237 casualties were recorded (JMA3, 2019). In Okayama, Mabi-town located confluence area of Oda-river and Takahashi-river, one forth (1/4) of the town was inundated and the deepest depth of water exceeded to 4.8m (casualties of the Kurashiki-city was 51). The flood occurred night-time and some people could not evacuate higher place/higher floor and during evacuation some was flown by water.

Table 1. Damage of heavy rain disaster in July 2018

List	Casualties	Missing	Heavily injured	Injured	Completely collapsed	Partly collapsed	Inundation houses
Okayama	66	3	9	152	4,828	4,433	7,112
Hiroshima	115	5	61	85	1,150	5,721	8,957
Ehime	31		33	2	625	3,315	2,679
Whole Japan	237	8	123	309	6,767	15,234	28,469

In Hiroshima, lots of landslides occurred in fragile and steep slopes. This area was developed as residential area near to the city central, however, the soil contained sands and relatively fragile for rains. In this area, landslide disaster happened in early morning of 20th August, 2014 and 74 casualties (73 was killed by landslides) reported. Nevertheless, landslides brought many casualties in 2018.

According to "the census for evacuation consciousness during a heavy rain event in July 2018" (Edo, 2019), 79.8 percent people (695 of totally 871) understood dangerous of heavy rain when they heard a comment "never experienced heavy rain in the extreme warning issued by JMA. 42.8% people collected in the context of disaster and rain, 37.7% did nothing, 22.8% confirmed their evacuation route, 19.1% checked stock of foods, 15.2% prepared evacuation goods. However, the ratio of evacuated people was 3.6% and 71.5% people judged they did not need to evacuate. The heavy rain started around noon of 6th of July and lasted until the morning of 7th and the heaviest rain (30 to 40mm per hour) were recorded at 6pm and 7pm. People had felt unusual heavy rain and 35.5% people evacuated from 0pm to 6pm, 38.7% evacuated during from 6pm to midnight of 6th. On the other hand, a small town Sakamachi, 45% people (48 of totally 107) evacuated to shelters or relatives houses during the disaster.

Table 2. Evacuation activity at Hiroshima during heavy rain in 2018. (Referred from "A census for evacuation consciousness during a heavy rain event in July 2018")

List	Evacuated	Consider evacuation but not evacuated	Judged evacuation unnecessary
Number	31	217	623
Ratio	3.6%	24.9%	71.5%

Mostly every year, such disasters occur and lots of papers pointed that "Normalcy Bias" brought such damages frequently. People always tend to think "someone except me encountered with an accident/disaster" and "I have never encountered with an accident/disaster for long time, at this time it would be all right for me". During the highest risk level, TV noted, "If you cannot evacuate, move to upper floor or move to opposite side from slope/river. Please choose possible way to survive", repetitively.

According to the TV interview after the disaster (5:30pm news of NHK on 16th October) (MLIT, 2019; Nippon, 2019), a woman lived in Fukushima (28 casualties recorded) said "after washout, the water level rose very fast, in 20 to 30 minutes up to few meters." Some old people could not evacuate to upper floor, some lived in plain houses and some people could not aware it, because river water rose at mid night. Nn Nagano and Tochigi, when some people tried to evacuate to evacuation facilities, their cars were flown by flooded water. In Kanagawa, after rain became weaker, on the way, some people tried to back to their home. The road collapsed with their car when they were passing riverside road which had become fragile. Previous disasters revealed that night time evacuation is more dangerous because people could not know information, heavy rain disturbs people to see road, river, mountain and to hear sounds from surroundings. As a consequence, an earlier evacuation in daytime is a good way to protect people from natural disasters.

3. Frame of Disaster Risk Reduction (DRR)

In Japan, disaster management frame is prepared in central government and preparedness frame of DRR is escalated as shown in Fig. 2.

Correspondence and activities of DRR consist from "real-time phase" and "day-to-day preparatory phase". In "a real-time phase", Local Meteorological Offices (LMOs) operate real-time dissemination network of warnings and websites dedicated to the respective local governments in order to share and exchange the information and potential risks (the number of local governments was about 1700 in July 2015). Collaboration with the prefectural governments, LMOs share real-time warning and information services on floods of specific rivers and sediment disaster and briefing/advice to prefectural governments and municipalities. LMOs implement telephone meetings/advices about countermeasures in hazardous conditions.

In "a day-to-day preparatory phase", LMOs improve operation of services through the investigation of utilizations by local governments and the public after the severe events. Clarification of warning criteria for the impact-based warnings was coordinated and the criteria was shared with local authorities and the public, through JMA Websites. In 2013, coordination of criteria for emergency warnings introduced, which was regulated in the Act to strengthen collaborations in catastrophic events.

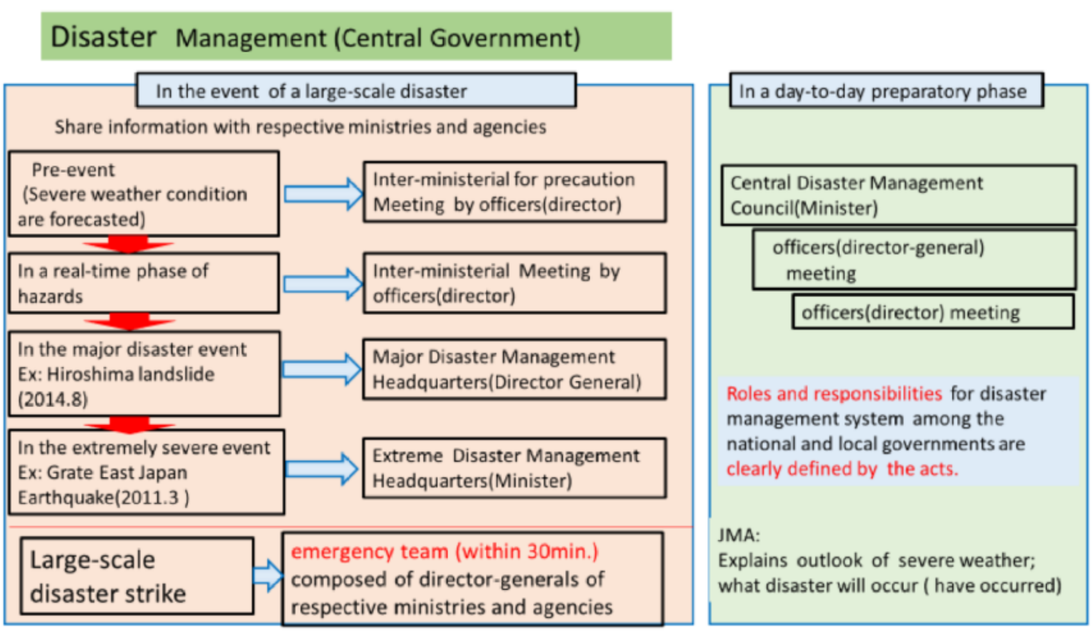

Fig. 2. Disaster management frame in central government (Hatori, 2015)

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In prefectures and municipalities level, LMOs support or exchange meteorological information with 47 prefecture governments and around 1,700 municipalities in cities, towns, villages. Regarding DRR information, LMOs issue daily weather forecasts 24/7 basis and when severe events are forecasted, bulletins for severe weather for example typhoon is successively issued. When these events start, meteorological warning is issued from each local LMO and escalated from "advisory", "warning" and then "emergency warning". Responses of municipal offices and residences are shared on JMA web site, for example as the "To-do List when Advisory, Warning or Emergency Warning is Issued" shown in Fig. 3.

	Weather Warning/Advisory type								Municipal responses	Resident responses
	Heavy rain			Storm	Storm surge	High waves	Heavy snow	Snowstorm		
		Landslides	Inundation							
Emergency Warning (Significant likelihood of catastrophe)	Landslide Alert Information **	Heavy rain Emergency Warning (risk of landslides*)	Heavy rain Emergency Warning (risk of inundation)	Storm Emergency Warning	Storm surge Emergency Warning	High wave Emergency Warning	Heavy snow Emergency Warning	Snowstorm Emergency Warning	• Immediately urge residents to take all possible steps for self-protection • Alert residents to the issuance of an Emergency Warning and highlight the exceptionally dangerous situation	• Take immediate action for self-protection (head to an evacuation center, or if it is dangerous to go outside, evacuate to a safer place within the building)
Warning (Chance of catastrophe)		Heavy rain Warning (risk of landslides*)	Heavy rain Warning (inundation)	Storm Warning	Storm surge Warning	High wave Warning	Heavy snow Warning	Snowstorm Warning	• Urge residents to evacuate • Issue evacuation advisories and orders to areas as necessary • Prepare for emergency response • Issue evacuation preparedness information to trigger evacuation of people requiring assistance • Establish evacuation centers • Disseminate Warnings to residents	• Start voluntary and early evacuation or follow evacuation advisories/orders • For Storm Warnings, evacuate to a safe place • Report abnormalities to municipalities and other authorities • Stay away from hazardous places • Prepare for evacuation
Advisory (Possible development of serious adverse conditions)	Heavy rain Advisory			Gale Advisory	Storm surge Advisory	High waves Advisory	Heavy snow Advisory	Snowstorm Advisory	• Patrol areas requiring caution • Advise residents to pay attention • Monitor weather bulletins and information on rainfall conditions • Prepare to call out relevant officials	• Check emergency supplies • Check evacuation routes and centers • Check windows and storm shutters • Monitor weather bulletins on TV, radio and JMA's website

* The term "landslides" here refers to debris flows and concentrated slope failures.
** This alert information relates to debris flows and concentrated slope failures.

Fig. 3. The To-do List when Advisory, Warning and Emergency Warning is Issued

Weather forecasts have been improved more closely and easier to the public. For example the number of forecast/warning area was increased from prefecture level around 90 in 1953 to 1,800 blocks/municipality level in 2012. For people understanding, information includes images and illustrations help us to understand the situation objectively. On the "extreme warning for heavy rain of Hagibis", the warning included "weather chart", "typhoon trajectory", "precipitation/wind distribution map of AWSs', "composite radar image", "risk index for flood/landslide/inundation" for visual usage on medias and municipal offices. Warning mentioned the similarity of historical events and media explained risks of the event using video/photo archives of historical disasters.

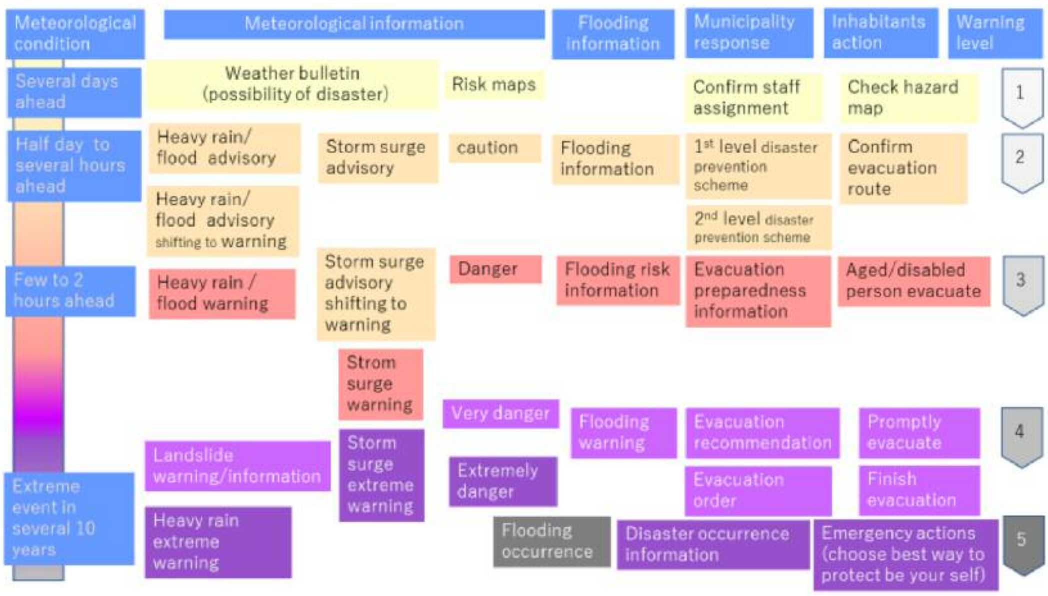

Fig. 4. Risk category of disaster information and response (Based on JMA web site: https://www.jma.go.jp/jma/)

In March of 2019, the guideline for evacuation was updated from cabinet offices, and the updated guideline, risk level of warning was categorized from Level 1 to Level 5. Meteorological condition, meteorological information, municipality response and residence response are mentioned along risk category Level 1, 2, 3, 4 and 5 shown in Fig. 4.

4. Conclusion

The Japan Meteorological Agency issued a warning 5 - the highest on the country's five-level disaster warning scale - after recording record rainfall during the 19th typhoon, internationally known as the Hagibis. This was an unprecedented level of warning in Japan for decades. The areas covered by the warning were the capital of Tokyo and six provinces including Kanagawa, Saitama, Gunma, Shizuoka, Yamanashi and Nagano. The Japan Meteorological Agency called for people living in these areas, especially those near rivers, seas and mountains, to take urgent measures to protect their lives. In the event of a move to an evacuation point where danger was encountered, it must be quickly sought to shelter in tall, well-ground houses nearby. Because natural disasters can occur at any time, Japanese have the habit of hoarding from normal living. Vietnam also needs to learn from Japan about how to respond and cope with different types of natural disasters including tropical storms.

Acknowledgement

DRR frame and process are referred from JMA web site, the World Bank Disaster Risk Management Hub report and lecture materials at Takusyoku university by Hiroshi Yokoyama and JICA training course for agricultural insurance by Koichi Kurihara (not published).

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