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BIOCLIMATOLOGY STUDY IN MODERN GEOGRAPHY

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БИОКЛИМАТОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ В СОВРЕМЕННОЙ ГЕОГРАФИИ
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Биоклиматология изучает воздействие погодных, климатических условий на живые организмы (растения, животных, микроорганизмы и особенно человека) в экосистемах в разных природных географических условиях. В последнее десятилетие XX века и в начале XXI века вопросы природных ресурсов, охраны окружающей среды становятся все более актуальными, и не только на государственном уровне. Поэтому географические исследования, а также биоклиматологические в общей оценке экологических возможностей алаптации природных ландшафтов для целей социально-экономического развития, предложения обоснованных мер по использованию природных ресурсов, организации территории, охране окружающей среды становятся все более необходимыми.

В настоящее время биоклиматологические иследования направлены на определение влияния климата на био-компоненты экосистем и компоненты, образующие ландшафты, а также на оценку экологической адаптации орга-низмов на разных территориях, конкретизацию этой оценки, отображение на карте в определенных соотношениях. Проводимые в Институте Географии исследования в этом направлении служат для одной из основных задач института - созданию географический основы планирования экономики, социального развития, организации территории в различных областях страны.

В этой статье представлены некоторые основные направления биоклиматологических наработок с тенденцией экологизации географических исследований, успешно выполненные в Институте Географии, а именно по биоклиматологии типов растительности, биоклиматологии человека, а также результаты биоклиматологических исследований, применяемые в современной географии.

Ключевые слова: *биоклиматические условия; биоклиматические критерии; погодная терипия в медицине.*

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Bioclimatology is to study the effects of weather, climate conditions on the living entities in the ecosystems, in different natural geographical conditions, those are vegetation, animal communities, microorganism and especially human being.

In the last decade of the 20th century and early of the 21st century, when the natural resources, environment issues are increasingly urgent, and it is the survival for not only a state. Application of researches of geographical, among which the study of Bioclimatology in general evaluation, evaluation of the ecological adaptability of natural landscape for the purpose of socio-economical development, proposal of reasonable measures to use the natural resources, territory organization, environment protection are becoming necessity.

At present, Bioclimatology study will not stay at the basic study (determination of the role of climate on biological components of ecosystem, and the components forming the landscape) but also to evaluate the ecological adaptation to of the bioclimatology conditions on a group of organisms, on different territories, concretize this evaluation on the map at a certain ratios. In this manner, the results of bioclimatology at the Institute of Geography has become a direction of research for adaptation, practically serving for one of the main targets of the Institute – establish the geographical foundation of the planning for economics-social developments, organizing the territory organization in different areas of the whole country.

With the trend of ecologializing the geographical studies, this articles will present some major directions of bioclimatology studies, that have been implemented very successful at the Institute of Geography, The Vietnam Academy of Science and Technology, they are bioclimatology of vegetation types, bioclimatology of human being, as well as the results of study of bioclimatology that are applied in the modern geography.

Keywords: *bioclimatic conditions; bioclimatic criterion; medical weather therapies.*

1. PREFACE

In the early years of the 21st century, the exploitation, usage of natural resources and environment are becoming urgent, the scope of study and applications of modern geography has been enlarged and more changes that are more adaptable. With the principle of "sustainable development" and "environment protection", the establishment of projects on planning of economic and social developments, organizing the territory for the welfare of human being, planning the tourism areas, recreation… adaptable bioclimatology studies are indispensable.

Bioclimatology is a scientific subject connecting the climatology, meteorology with ecology. Bioclimatology studies the effects of climatology, meteorology conditions on the living organism in different ecosystems. In particular, bioclimatology study the impacts of climate, weather on the living organism, the living process of vegetation communities, zoology communities, microorganism communities and especially the human being.

As for the natural combination – the general landscape, as well as the natural ecosystem, climate always one of the main forming components. In order

to exploited and use the natural environment, these ecosystems for the different purposes of development, the conditions of eco balance in the natural conditions, are needed to be understand clearly, among them are the knowledge on bioclimatic conditions, the relationship between the bioclimatic conditions with living organism, as well as non-living components. Reasonable exploitation those components, environment protection are the major tasks of modern geography.

As an indispensable result of progresses, achievements in study on climatology, ecology, bioclimatology research will not only aim at the basic studies, determination of the climate role on biological components in general but also evaluate those weather conditions on a group of living components on different territorial areas, and concretize those evaluations on the map to certain ratios. In this approach, bioclimatology has become a direction of research that can be applicable, practical serving the planning the socio-economic development, organizing the territory.

In Vietnam, in recent 20 years, together with the trend ecolozise the geographical study, it is shown that there are two major trends in study of bioclimatology that are strongly developed. Those are the study of bioclimatology of the natural vegetation cover and bioclimatology of human being.

2. BIOCLIMATOLOGY ON VEGETATIONAL COVER

2.1. Overview of basic studies and application of vegetation cover bioclimatology

In Geography, since the old days, the organic relationship between the climate and the natural vegetation cover had been paid attention to, and vegetation was considered as the indications of climate. The Scientists A. Griesebach (1872), De Candolle (1974), A.F.W. Schimper (1915) (15) believed that The impact of climate on natural conditions was most clearly on the vegetarian ecology. The vegetarian communities were lack of mobility, they were able to find the way to adjust ecologically to different weather conditions. Because of that, the ecological signs of vegetarian can be used as the basics for standards to classify climatic conditions.

In Vietnam, in recent 30 years back, basic studies on bioclimatology of vegetarian covers comprised of the following studies:

- Study the bioclimatic classification for the landscape classification in the Northern Vietnam (Vu Tu Lap, 1976 [3]).
- Bioclimatic classification for the purpose of classification of natural vegetation types (Thai Van Trung, 1978 [7]).
- Bioclimatic classification for the purpose of forestry by Lam Cong Dinh, 1992 [1]
- Climatic classification as the basics for determination of plantation in agriculture and forestry (Dao The Tuan, 1977 [8]).
- Bioclimatic classification of vegetation for the purpose of the evaluation of bioclimatic resources in Vietnam (Nguyen Khanh Van, Nguyen Thi Hien, 1999 [11]).

In general, in bioclimatic study of vegetation, all the authors agreed that the climatic regime plays an important role in the establishment and development of tropical monsoon vegetation cover in our country, and the very devident of the bioclimatology factors, characteristics and season's rhythm of the factors will bed one of the major factors in the distributions of tree, the formation of different types of forests, the alterations of the look of vegetation. However, on the concrete case, in order to "create" the climatic regimes that are typical for one natural unit (one general natural unit, one ecology system, one vegetation type…), those studies based on the selection of different combination of temperature and humidity.

In order to classify the Northern Vietnam landscape, Vu Tu Lap used the indications of temperature-humidity. As for temperature, they are the total temperature in the year $\sum t$ (above 0°C), improved Xelianinov hydrothermal coefficient - k_N (with total annual temperature above 0°C), the number of months with the average temperature below certain major threshold (related to the growth of tropical vegetation, temperature below 18, 15, 10 and below 5°C), monthly average temperature of the hottest months below 15, 20, 25°C and above or equal to 25°C. As for humidity, Vu Tu Lap believed that as for natural landscape, the length of the raining season, dry season, and drought season will be used to classify type of bioclimatic. He used the length of raining season, dry season as criteria with thresholds as below: long rainy season (7-8 months), average rainy season (3-4 months), short rainy season ($\leq$ 2 months); very long dry season ($\geq$ 6 months), long dry season 4-5 months), average dry season (2-3 months), short dry season (0-1 month). For the Northern only, these combinations (based on temperature and humidity) bring to 206 bioclimates and after combining process, the author created 97 different groups of bioclimates.

Among the five factors creating the natural vegetation cover, Thai Van Trung believed that the group of climate-hydrography factors is the major factor that determines the appearance, structure of different vegetation types. The climatic factor has been established by Thai Van Trung through different combination of temperature, dry-humidity regimes [7]. Using the average annual temperature (T_N), temperature will be divided into 4 levels, corresponding to with major geographical altitude bands. The dry-humidity regime has been combined from two characterizes, they are total yearly rainfall (R_N) and index of drought X (X = S.A.D). Here S is the number of dry months, A is the number of drought months, and D is the number of

exhausted months. The dry months will be determined by the hydrothermal formula of H.Gaussen $P_S < 2t$ [7], used for humidity tropical latitude as Vietnam. He believed that the temperature of the low tropical area were approximately 25°C, therefore the rainfall of a drought month normally equal or less than 25mm/month, (equal "ecological drought month") that the nature has the concrete indications of the living rhythm of vegetation (such as the leave falling in a vegetation community, the faded top of young tree in the planted forest). Based on bioclimatic classification above, Thai Van Trung could classify 14 natural vegetation types with the specific bioclimatic characteristics of their own [7].

In Forestry, Lam Cong Dinh believed that the climate is the key factor to the allocation of trees, to the formation, the distribution of different types of forests on a territory. In order to determine climate regime of each location, he constract formula "temperature-humidity-lighting", among those, each factors will be characterized by three dimensions: background, distribution in a year and fluctuation.

As for *temperature background*, the author selects the specific characteristics: total annual temperature - $\sum_N$, annual temperature - T_N, indexes of annual temperature Δ_n (the ratio average annual temperature/amplitude of annual temperature) and amplitude of average daily temperature. *Temperature distribution* was displaced by the author by biological temperature (the temperature of the months in the years was classified by the following threshold: very cold, cold, cool, warm, and hot). *Temperature fluctuation* included the extreme values (temperature in the hottest month and coldest month, absolute maximum and minimum temperatures in the year). *Rainfall and humidity regime* consists of: *humidity background* (R_N, number of rainy days in the year - N_N, the annual dampness indexes - k_N, the relative average annual humidity - U_N). *Humidity distribution* will be indexed by monthly dampness indexes- I_{th}, with consideration of their influence to the vegetation (very dry, dry, rather dry, rather humidity, very humidity, wet). Thresholds of *fluctuation in rainfall, humidity* also consists of the extreme values (minimum I_{th} and maximum I_{th}). As for lighting, *background of lighting* will consist of total the annual sunshine hours, the average number of daily sunshine hours, and the lighting ratio k (the ratio of number of sunshine hours and nebulosity). The distribution of lighting in a year mainly for the biological sense, in particular the distribution of lighting month - k_{th}. The optical fluctuation will comprise of the extend of lighting (the extreme lowest and highest values). Based in the results from 140 meteorological stations in the whole country, he can establish 78 formulas based on "temperature-humidity- lighting" and then combined them in 10 groups of bioclimatic types [1].

In a specifically bioclimatology study, as study in agricultural climate, Dao The Tuan in his "Scientific foundation for determination of vegetation structure of plantation", 1977 [8] accessed the agricultural climate conditions for groups of different agricultural and industrial plants. On the bioclimatology basics, such as temperature indexes ($\sum_t$, number of months with the temperature below 20°C, threshold of temperature fluctuation), as for humidity (R_N, time and duration of rainy, dry seasons, humidity indexes, drought indexes , type of humidity by Ivanov), Dao The Tuan divided Vietnam territory into 23 agricultural climate areas as a basics for arrangement of plantation framework, arrangement of harvests for vegetables, industrial plants, short day crops, perennial plants originated in tropical, subtropical regions.

The study of classification of bioclimatology conditions for the purpose of evaluate the climate resources was implemented in the project "Establishment of Vietnam bioclimatology map, ratio 1/100000" (Nguyen Khanh Van, Nguyen Thi Hien, 1999), [11]. For the purpose of planning of agricultural and forestry productions, a series of research on bioclimatology conditions, establishment of bioclimatology map in different areas in Vietnam territory such as Tay Nguyen, 1988; North West, 1993; Northern Centre (ratio 1/250000), 1991; North East, 1996; South East (ratio 1/500000), 1996 has been conducted [12].

Normally, in those researches, the authors of Institute of Geography to employ the combination of temperature-humidity established from the values of temperature and humidity background and some specific characterizes that manifest the split in the year of the temperature, rainfall as the thresholds for the classification, categorization of bioclimatology.

In addition to the usage of numeric value of the above-mentioned factors, the maintaining duration of the factors (the length of the cold season, dry season) were studied very carefully, because these also the characteristics of important bioclimatology that determining the splitation of the natural vegetation covers. On the basics of clearly determination of bioclimatology conditions that forming these vegetation types, the proposals for using the natural monsoon tropical bioclimatology in Vietnam will be more useful, more appropriate to the natural laws.

In some particular regions, when the conditions are acceptable, frequency, the spoliation of some extreme weather phenomenon, that affect greatly on the production in agriculture, forestry (hoarfrost, dry hot wind, icy rain…) will be considered. In those conditions, the concept of resistant limits of organism to environment factors has been applied completely. This is one of the new points of bioclimatology study applied in modern geographic science.

The vital implication of establishing the bioclimatology maps in the study of modern geographical research can be found. Bioclimatic map is one of the important component maps for the

mapping of vegetation types, landscape mapping, landscape evaluation map.

If the study, classification of traditional bioclimatology give us the "general picture" on the territorial bioclimatology conditions, the directions for the long-term strategy in using the national bioclimatology resources, the forming the bioclimatology map in different regions will assist us in more concrete proposals. These research results will be the scientific basics for the evaluation of the favorable of climate conditions in different territories on the plantation cover, from the perennial industrial plants to afforest, planting to cover the bare hills and mountains, afforesting in the sand land near the seaside (the places greatly impacted by wind and waves). These results will assist the managers to select, determine the suitable structure of cultivated crops for agriculture, forestry or industry, construct strategy for social-economic development in the region. In order to clarify the practical usage of bioclimatology maps, Ha Tay bioclimatology maps can be used as an example, as a base for generalized evaluation of natural conditions, natural resources, socio-economic development of the province.

2.2. Vegetation cover bioclimatology maps and their real applications

Ha Tay is a province laid on the western side of the Northern delta with the monsoon tropical climate, with a cold season. For the province's socio-economic development, in the agriculture-forestry development planning, Ha Tay's bioclimatology map of vegetation, ratio 1:100000 has been constructed. Based on the experience from study and construction of national and regional bioclimatology maps, a system of indexes of HaTay's bioclimatology map will be established based on a combination of temperature-humidity as follows:

Temperature indices: Regional temperature background will be exhibited through the air average annual temperature T_N, that will be divided into 3 levels:

I. Hot: $T_N \geq 22°C$, equal to $\sum_N$ above 8000°C, in Ha Tay the arears with the altitude of terrain less than 300m are characterized by this temperature.

II. Humidity: $22°C < T_N \leq 20°C$, equivalent to $\sum_N$ in the range of 8000 - 7300°C, the regions with the altitude of terrain from 300m to 700m are characterized by this temperature.

III. Cool: $T_N \leq 20°C$, equivalent to $\sum_N$ below 7300°C, the regions with the altitude of terrain above 700m are characterized by this temperature.

If the cold season is one of the specific bioclimatology of the Northern Vietnam, it limit the growth of tropical plants, to some certain extend, this character will be favorable for some the plantation, vegetable originated in subtropical region. Therefore, it is necessary to use this character to develop a reasonable plantation structure, to develop short day vegetable such as tomatoes, cabbage, beet, turnic… That why the length

of cold season (N) will be determined by the number of months that the average temperature below 18°C.

1. Short cold season: N=3 months, in the Ha Tay delta in every year there will be at least 3 cold months.

2. Average cold season: N=4-5 month, in Ha Tay that average cold season can be found in the mountainous area such as Ba Vi Mountain, in the terrain with the altitude below 700m.

Humidity index: humidity background will be illustrated by the total annual rainfall index R_N. On the basics of annual rainfall distribution in Ha Tay, combined with experience in study in other regions in the whole country, the annual rainfall can be divided into the following levels:

A. Abundant rainfall $R_N \geq 2000mm$, this rainfall can be observed at the mountainous area near Ba Vi Mountain.

B. Reasonable rainfall $2000 < R_N \leq 1500mm$, can be observed at almost of Ha Tay terrain.

C. Low rainfall : $R_N < 1500$ mm, can be observed at the North East of province.

As above analysis on the countenance and structures of natural vegetation types as well as plants in agriculture, forestry, the climatic regimes, the diversification of the rainy season, dry season on the territory are very important. Therefore index of the dry season's length (n) will be determined by the vegetation bioclimatology dry months. According to H. Gassen [7] $r_{dry\ month} < 2.t$ (in the tropical region the rainfall in dry month $r_{dry\ month} \leq 50mm$). The dry season in Ha Tay can be classified into the following levels:

a. Short dry season $n \leq 2$, observed in Bavi Mountain.

b. Average dry season: n=3-4 months as observed in most of the part of Ha Tay territory.

In addition, due to the studied region observed some special climate phenomena, that greatly impact on the vegetation life in general, and on the p[productivity of plantation in particular, the system of criteria to be use to classify Ha Tay bioclimatology will be added another two secondary criteria, that is the degree of dry and hot and the frequency of hoarfrost appearance.

* *The hot-dry degree* (k) will be determined by the number of average dry and hot day (dry and hot day is a day of with the indexes at 13.00: temperature $\geq$ 35°C, relative humidity $\leq$ 65%).

k_0: without dry and hot

k_1: very little dry hot: 1-5 days/year

k_2: little dry hot: 5-10 days/year

k_3: rather many hot and dry days: 10-20 days/year

* *The frequency of hoarfrost appearance* (s) will be determined:

s_1: very little hoarfrost: 1-10 days/10 years

s_2: average hoarfrost: 5-10 days/10 years

s_3: much hoarfrost: occur every year.

In conclusion, on Ha Tay bioclimatology map ratio 1/100000 with 6 tropical monsoon units as follows:

• $IC1bk_3s_1$: hot bioclimatology type, short cold

season, little rainfall, average dry season, rather many dry and hot days, less hoarfrost appearance. This type of bioclimatology will be observed in the North East of Ha Tay.

- IB1bk$_3$s$_1$:this type of bioclimatology is hot, short cold season, average rainfall, average dry season, rather many days of hot and dry, less appearance of hoarfrost, can be observed at almost of the target area.

- IA1bk$_2$s$_1$: this type of bioclimatology is hot, short cold season, much rainfall, less hoarfrost, can be observed at the South West of Ha Tay

- IIB1bk$_1$s$_2$: this type of bioclimatology is warm, short cold season, average dry season, less hot and dry days, average hoarfrost, can be observed at the terrain with altitude less than 700m at the West side of Ba Vi mountain.

- IIA1bk$_1$s$_2$: this type of bioclimatology is warm, short cold season, much rainfall, average dry season, very little dry and hot days, average hoarfrost, can be observed at the terrain with altitude less than 700m at the East side of Ba Vi mountain.

- IIIA2ak$_0$s$_3$: this bioclimatology is cool, average cold season, much rainfall, short dry season, without dry and hot days, many hoarfrost frequency.

Ha Tay's bioclimatology map ratio 1/100000 (figure 1) will be used as the foundation for the formation of vegetation type map, landscape map and the map evaluating the landscape of Hatay Province. Those results and observances will support the planners to determine the plant and vet getable framework in agriculture-forestry in their strategy of socio-economic development.

3. STUDY HUMAN BEING BIOCLIMATOLOGY

3.1. Some major trends in study of human being bioclimatology in Vietnam

In the world, human being bioclimatology strongly develops in the old Russia, Poland, Bulgaria… In Vietnam, at the initial human being bioclimatology concentrated on *the effects of some major climate, weather factors on human being sence organisms* (skin, eyes), on the heart rate… in the concrete climate condition. Those are the projects "Weather and diseases", physiological threadholds of Vietnamese", "some major bio-meteorological issues", "On the biological parameters of Vietnamese"… of Dao Ngoc Phong, Trinh Binh Di… The above researches are the foundation for the determination of biological parameters and the threadholds of sensation of human being in the conditions of monsoon tropical weather and climate in Vietnam.

There was classification, categorization of human being bioclimatology on Vietnam territory as follows:

- Classification of weather types and biological implication of those weather on human body and life, author Phan Tat Dac, Pham Ngoc Toan [2].

- Classification of weather based on the quantitative indices of heat - cold, the duration of cold period, total daily temperature converted to the altitude of 0-25m, Tran Viet Lien [4].

- Classification of temperature humidity on the basics of major temperature humidity factors: 3 major characteristics of temperature, 1 characteristics of rain by Nong Thi Loc [12].

- Classification of human being bioclimatology on the basics of some typical weather characteristics: efficiency radiantion temperature, black-globe temperature, the heat-cold parameter by Dang Kim Nhung [5].

- Classification of human being bioclimatology of the Da river valley for the purpose of human being welfare, tourism, recreation (Nguyen Khanh Van, Nguyen Thi Hien) in the Hoa Binh Lake [9].

In addition to that, there are other researches, evaluation of human being bioclimatology in some regions for some concrete purpose. The evaluation of weather, climate regimes (evaluation of radiation, cloud, wind, temperature, rain-humidity regimes and frequency of some special weather phenomena…) for development of some tourism activities, such as natural research, festivals, to climb up a mountain, water-skiing, building of some medical weather therapies…

Study human being bioclimatology in housing construction design, public projects

Some examples of study human bioclimatology for the purpose of welfare, tourism and organize recreation areas "weather therapy".

3.2. Evaluate the human bioclimatology for the human welfare, tourism in Hoa Binh Lake.

Though the impacts of weather on human being is very collectively, but to some certain extend, basic climate characteristics will have impact on the human life and health. Human being bioclimatology map for the purpose of welfare, tourism in Hoa Binh Lake were constructed based on the splitation of major climate factors (T$_N$, the number of rainy days per year) and some major typical supplementary weather characteristics (total sunny hours in a year, the duration of the period of appropriate temperature, equivalent effective temperature Webb, special weather phenomena such as the hot and dry days, the number of hailstone days, number of the frost days).

Based in the researches on the adaptability of human being to the different temperature conditions, consideration of splitation of temperature in Hoa Binh lake, temperature criteria will be selected with two bands:

I.   Rather (little bit) hot-cool weather, T$_N$: 24-18°C, these the "appropriate temperature" interval, rather favorable for living, health of human being. In Hoa Binh lake, the terrain with altitude below 100-1100m the annual average temperature will be like that.

II.   Rather cold temperature: T$_N$: < 18°C, can be

observed at the highland area with the altitude from 1000-1100m above, the temperature values will be considered as "rather appropriate" for human being.

In the tropical region, the number of rainy days will impact direct on human living, health. In the region with many rainy days, air humidity is high, it badly affects the human health. In the region with very low rainfall, very low humidity is also not good for human health. In addition to the tourism, ecological tours, recreation, the high number of rainy days is also unfavorable. The number of rainy days/year (N) in Hoa Binh lake will be divided into 3 levels:

A. High rainy, N ≥ 180 rainy days/year, popular at the mountainous area.

B. Reasonable rainy, 120 rainy days/year ≤ N < 180 rainy days/year

C. Less rainy, N < 120 rainy days/year, usually observed at the low areas at the valley with less wind, dry and hot climate of the research areas

Like many places in the North West Region, in Hoa Binh Lake during summer, due to the effect of "Laos wind" - hot and dry wind occurs often. In the hot and dry day, when the wind rate about 5-10m/s, the air temperature reach 35-37°C (sometimes may be 40°C), the air humidity reduces to only 65% (particularly may be below 45°C), human body will faced with water losses through sweat. Is this phenomena lasts for several days, the nerve, cardiovascular, endocrine will be affected, especially in aging people, children and illness patients. The dry and hot days in Hoa Binh Lake can be divided into 4 levels as follows:

1. No dry and hot
2. Insignificant dry and hot $1 \leq n < 9$ days/year
3. Much dry and hot $10 \leq n < 29$ days/year
4. Significant dry and hot $n \geq 30$ days/year.

"The length of the period with appropriate temperature" for human health in the year will be determined by the total days with the average day temperature less than 24°C and more than 18°C, minus the number of hot and dry days/year.

Equivalent effective temperature - EET, considering the total effect of temperature, air humidity and wind speed will be determined by the formula:

$$\tau = 0.5\,(t_k + t_u) - 1.94\,\sqrt{v}$$

Here t_k and t_u are the "dry" and "wet" temperature (°C), v is the wind speed (m/s).
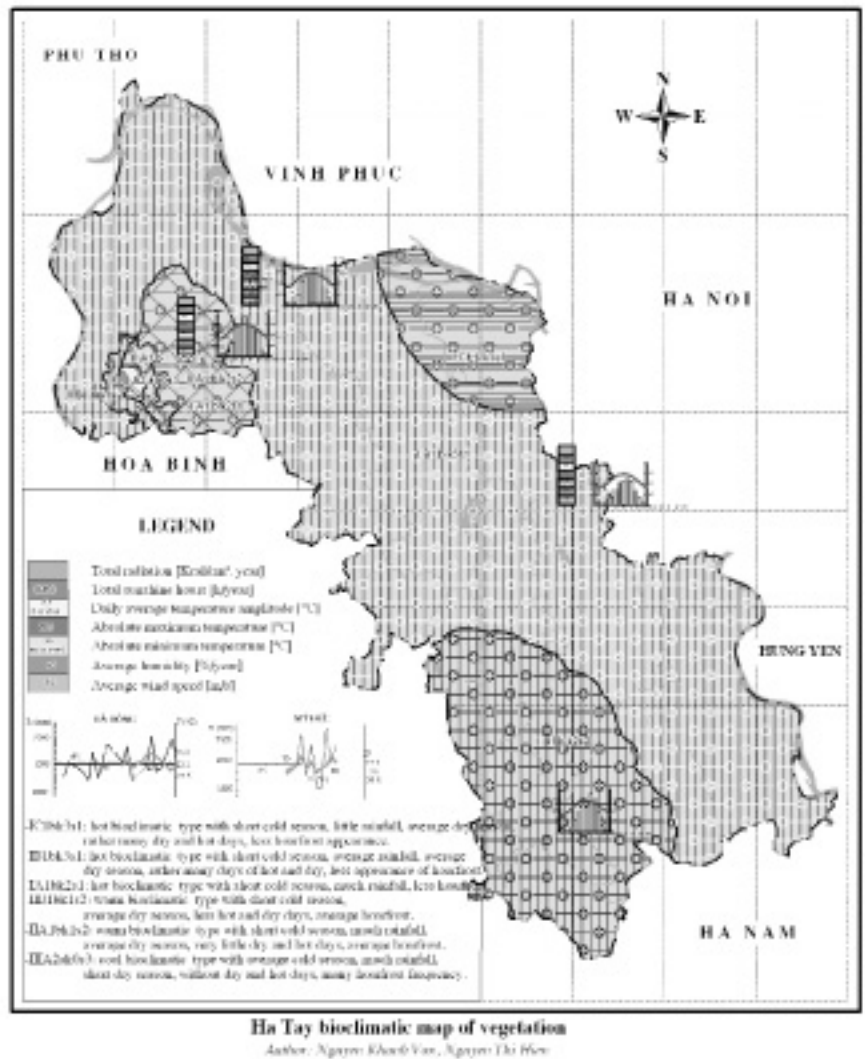

Figure 1. Ha Tay bioclimatic map of vegetation

The map of allocation of human bioclimatology for human and tourism development in Hoa Binh Lake can be seen in figure 2. This maps shows that in Hoa Binh Lake, there will be 7 human bioclimatology as follows:

- IC4. This bioclimatology is little bit hot-cool, less rain, a lot of dry and hot, located in Yen Chau Valley.
- IC3. This bioclimatology is little bit hot-cool, less rain, much dry and hot days, located Da river valley from Van Yen to the North of Ta Bu and near Tu Ly.
- IC2. This bioclimatology is a little bit hot-cool, less rain, insignificant dry and hot, observed on the right band (along the current) of Da river.
- IB3. This bioclimatology is a little bit hot-cool, reasonable rain, much dry and hot, observed on the whole South valley of Da river.
- IB2. This bioclimatology is a little bit hot-cool, reasonable rain, insignificant dry and hot, observed on the left band (along the current) of Da river, in Muong Chien – Bac Yen – Phu Yen area.
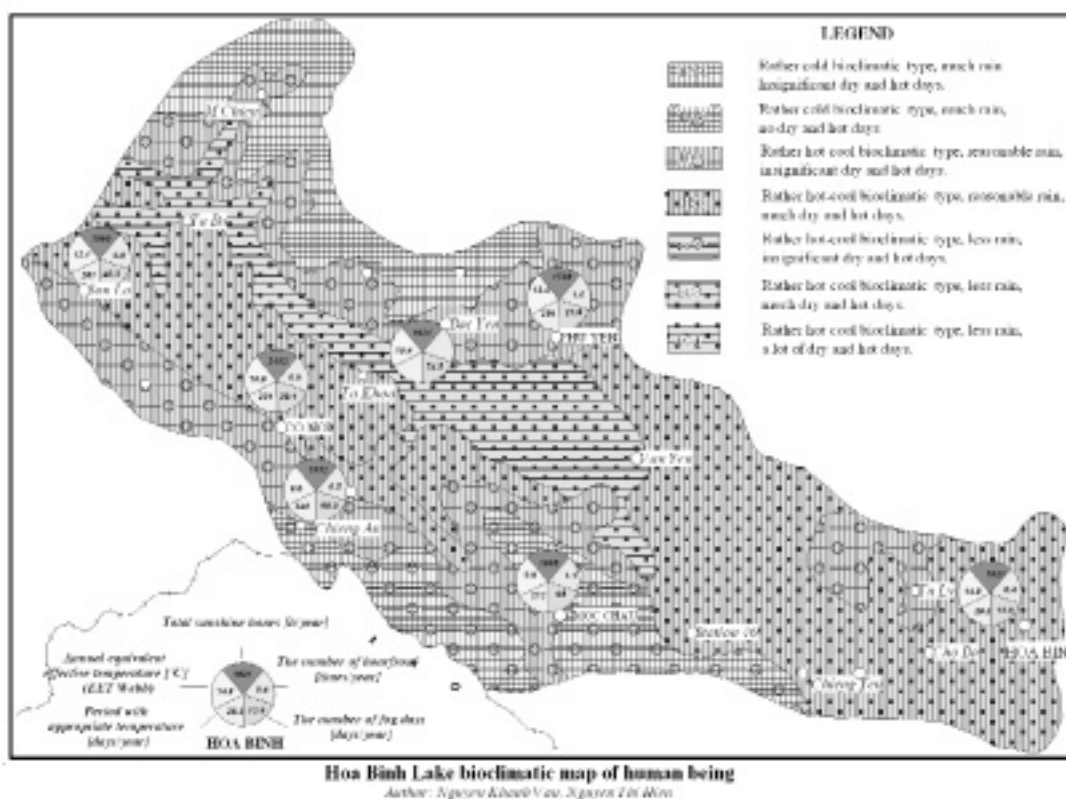- IIA1, IIA2. These type of bioclimatology is

Figure 2. Hoabinh Lake bioclimatic map of human being

rather cold, much rain with the degree of dry and hot from zero to insignificant hot and dry, located in the high terrain with altitude more than 700m of Da River valley [9].

3.3. Evaluation of human bioclimatology for tourism, recreation, sightseeing, seaside recreation in the low terrain and convalescence, weather therapy in the highland of Vietnam.

On the classification of 1826 weather combinations, for the period from 2001-2005, from 19 weather observing stations, the evaluation of bioclimatology for the purpose of tourist development, recreation, sightseeing, seaside recreation in the low terrain and convalescence, weather therapy in the major tourist centers of Vietnam have been conducted as follows:

The bioclimatology criteria to be selected to establish "weather combinations" are: air temperature t_{13h} (°C), relative humidity U_{13h} (%), wind speed v_{13h} (m/s) at 13.00 everyday, combined with the total rainfall in the daytime (from 07.00 to 19.00) in the low terrain in order to evaluate for development of different types of tourism; when combining with the data on the occurrence of fog during the daytime hours will be used to evaluate the opportunities for recreation and "weather therapy".

• *Air temperature:* air temperature affects direct the human health, too hot or too cold normally unfavorably affect health as well as temperature balance. Based on the site researches on the human health [4, 5, 6], some thresholds for adaptable

temperatures are as follows: favorable: *: $t_{13h} \approx$ 22 - 30°C; unfavorable *: $t_{13h} > 30$°C or < 22°C.

• *Relative humidity:* air humidity play an important role in human temperature balance in order to adaptable to the environment. For human health, the air humidity can be divided into the following thresholds: *favorable:* $U_{13h} \approx$ 50-80%, *unfavorable :* $U_{13h} > 80$% or < 50%.

• *Wind speed:* Wind enhance the process of temperature exchange through the body skin. Site research results show that there will be wind thresholds that can impact on human health: *favorable* $v_{13h} \approx$ 1-3 m/s, *unfavorable :* $v_{13h} > 3$ m/s or < 1 m/s.

• *Total rainfall:* rain will affect direct on tourism activities, especially outdoor activities such as sports, swimming, water –skiing, boating, parachute. On practice, the rain fall of 5mm during the day time hours (from 07 am to 19 pm) will affect less on tourism activities [14]. Therefore, the rainfall of 5mm can be used as a threshold to evaluate: favorable: daytime rainfall ≤ 5mm, *unfavorable:* daytime rainfall > 5m.

• *Fog:* as for activities, recreation or weather therapy in the mountainous region, fog clearly affects the temperature exchange, evaporation, sweat. Fog occurrences clearly affect the convalescence in the mountainous recreation [13]. Fog can be divided as follows: *favorable* days that have no fog, *unfavorable*: days with fog.

On practice, those climate factors affect the human health generally. On the other hand, Vietnam weather is not completely stable. In a season, there

Table 1. Total days that favorable for tourism, sightseeing, and "weather therapy" in Vietnam
(2001-2005)

N°	Stations	Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Lowland															
1	Mong Cai	NE	15.0	13.4	18.2	23.0	23.0	18.0	20.0	20.8	21.2	26.4	24.8	17.4	241.2
2	Co To	I-NE	10.8	9.4	14.0	23.0	20.6	12.2	14.4	17.8	19.2	26.8	21.0	12.4	201.6
3	Ha Noi	BB	20.4	18.2	22.2	24.4	27.2	21.4	22.8	23.6	25.8	26.8	26.0	21.2	280.0
4	Sam Son	BB	18.8	12.2	19.4	23.2	22.2	20.0	19.0	19.4	20.0	24.8	24.2	18.0	241.0
5	Dong Hoi	C	21.6	19.0	22.0	23.8	22.8	18.8	21.8	21.8	22.0	22.2	22.4	18.2	256.4
6	Hue	C	20.6	20.8	24.2	26.6	23.4	18.4	18.0	20.0	22.4	22.6	19.8	15.6	252.4
7	Nha Trang	C	29.0	27.6	28.2	23.6	23.6	23.4	24.4	22.6	22.4	24.8	22.8	25.2	297.6
8	Phan Thiet	C	30.6	26.6	24.8	18.6	19.6	21.8	20.6	21.6	21.8	24.4	22.8	26.8	280.0
9	Phu Quy	I-C	28.0	26.4	27.6	19.0	11.8	7.4	9.6	5.2	7.4	23.6	23.4	23.2	212.6
10	Vung Tau	NB	30.8	27.0	29.0	22.0	21.8	24.8	24.6	21.0	23.8	25.8	28.2	29.6	308.4
11	Tay Ninh	NB	23.4	17.8	18.6	14.4	20.0	16.8	21.0	20.4	18.4	17.2	22.0	23.8	233.8
12	HoChiMinh	NB	18.6	12.6	15.4	15.2	15.6	19.2	21.2	18.0	19.4	19.0	21.2	24.6	220.0
13	Con Dao	I-NB	30.0	28.2	30.8	26.2	23.0	20.6	22.4	22.8	23.4	22.6	27.0	29.0	306.0
14	Rach Gia	NB	30.4	26.4	21.8	21.8	16.8	15.8	14.8	11.8	17.2	21.8	25.0	28.8	252.4
15	Phu Quoc	I-NB	26.6	24.2	24.0	21.2	17.0	15.2	17.4	12.6	15.4	17.0	20.2	23.0	233.8
Highland															
16	Moc Chau	M-NW	8.5	6.4	8.5	15.5	22.0	25.5	26.8	25.1	23.4	18.8	15.2	12.1	207.7
17	Sa Pa	M-NE	3.9	2.1	3.3	5.3	10.5	14.9	13.8	15.8	14.4	10.6	8.2	6.8	109.6
18	Tam Dao	M-NE	3.6	3.1	4.3	5.4	12.6	16.4	18.1	18.3	18.2	13.6	9.4	7.0	129.5
19	Da Lat	M-CP	14.2	12.4	14.8	18.8	22.3	18.2	14.7	14.7	15.4	14.8	12.3	11.2	183.7

may be several types of weather (in a few days) that completely opposite: dry hot, cold dry, cold humidity plus wind... Therefore, in order to evaluate the daily weather, different "weather combinations" have been established with the following concepts:

The days that favorable for tourism, sightseeing, and "weather therapy" are those days with the above four factors in the range of favorable.

The days that rather favorable for tourism, sightseeing, and "weather therapy" are those days that one of the above four factors are in the range of unfavorable . In these days, human body needs a little adjustment to the weather environment. In general, the above two types are considered as days with favorable conditions for human health in tourism, sightseeing, as well as "weather therapy"

The days that rather unfavorable for tourism, sightseeing, and "weather therapy" are those days with two of the above four factors lay in the unfavorable range.

Statistic data of the day with the average good weather conditions for tourism, sightseeing, and "weather therapy" are those days will be presented in the Table 1.

The results from analyze the human bioclimatology for seaside recreation, "weather therapy" in the highland areas show that:

* In Vietnam, the annual days good for human health in tourism activities averagely fluctuate with a high amplitude among regions, from 308.4 days in Vung Tau to 109.6 days in Sapa.

For tourism, sightseeing, and seaside recreation in the low terrain: every year, in Vung Tau, Con Dao, Nha Trang there will be 300 days with good conditions. Phan Thiet, Ha Noi, Dong Hoi, Hue, Rach Gia 250-280 days with good weather. Coto, Tay Ninh, Ho Chi Minh City... with about 200 days with good weather conditions.

For vacation, and "weather therapy" in some high terrain regions: Moc Chau 207.7 days of good

weather/year; Da Lat 183.7 days of good weather/year, Tam Dao 129 days of good weather/year, Sapa-109 days of good weather/year.

* In Vietnam, The period with good weather conditions will be different among regions:

For tourism, sightseeing, seaside vacation in the low terrain: in the North East region, the period with good weather condition for the above activities is from April to the end of November. In Bac Bo, the period of good weather condition is longer, nearly the whole year with a short split in February when the weather is saturated, high humidity due to drizzle rain. In the Center and the South, the period with good weather for tourism not only last for the whole year but also equally distributed among the months.

For recreation and "weather therapy" in some high terrain regions: in the North, the period with good weather condition for the above activities is less than that of the South, and mainly during the summer. While in Tay Nguyen Highland, the whole are good weather condition for tourism and "weather therapy".

4. CONCLUSION

Viewing the process of formation and development of the bioclimatology research in Vietnam, it is found that this research direction is of science significance and also practical applications. From the theoretical research, serving the specialized studies (climatology, vegetation type classification, landscapetology), recent bioclimatology study now becomes more practical application. If in the past, bioclimatology study was conducted separately by different fields (landscapetology, geobotany, environmental medicine…), now facing with the unreasonable exploitation of natural resources,

economic development with environment pollution, deterioration of living environment, it is required that geographical science, and applicable bioclimatology, have to reach a new approach in more general, to guarantee the ecological security for different forms of resources of the country.

The above three examples show that the methodology of approaching applicable bioclimatology research is rather abundant, precisely to service the tasks of research the modern geographical science.

The results of bioclimatology research in Vietnam show that our bioclimatic resource is very abundant and diversified. In order to use reasonably that resources, clearly understand the bioclimatology are necessity. Some characteristics of bioclimatology at first glance, seems unfavorable for tropical plants, however, under other sides, they are the favorable conditions of Vietnam tropical monsoon bioclimatology. Perhaps very little areas in the tropical band there is cold season like the north Vietnam, that make it become especially attractive. In the lowland areas, from the North of Ngang pass up (North latitude 18°), vegetable of the cold region such as kolh, cabbage, tomato, carrot, potato can be successfully grown during three months of winter.

Faced with pressing issues of current resource and environment exploitation, the research and teaching of geographical, climatology can not be separated from the bioclimatology issues. It is necessary to equip the future generation a further view, more realistic on the ability of ecology balance in the nature, more practical methods to protect the living conditions. In the future, it is necessary to have more projects on bioclimatology in general and applicable bioclimatology in particular in geographical science.

1.   *Lam Cong Dinh.* Bioclimatology application in forestry in Vietnam. – Ha Noi: Science and Technology Publishing House, 1992.
2.   *Phan Tat Dac, Pham Ngoc Toan.* Climate and life. – Ha Noi: Science and Technology Publishing House,1980.
3.   *Vu Tu Lap.* Geographical landscape in the North of Vietnam, – Ha Noi: Science and Technology Publishing House, 1976.
4.   *Tran Viet Lien.* Climate and the issues of organing working, recreation and tourism on Vietnam territory. – Ha Noi: Hydro-meteorological Directorate, 1993.
5.   *Dang Kim Nhung.* Human bioclimatic classification in Vietnam, Doctor thesis, Institute of Geography, Varsava, Poland (1990) (in Russian).
6.   *Dao Ngoc Phong.* Weather and diseases. – Ha Noi: Medicine Publishing House, 1972.
7.   *Thai Van Trung.* Vietnam vegetation types (From ecosystem perspective). Second edition, with correction. – Ha Noi: Science and Technology Publishing House, 1978.
8.   *Dao The Tuan.* Scientific basics for determination of plantation structure. – Ha Noi: Agriculture Publishing House, 1977.
9.   *Nguyen Khanh Van*, The bioclimatic conditions for rational using of utility natural resources at Hoa Binh lake region // Journal of Sciences of the Earth. – 1992. – T. 14. – P.27–32 .
10. *Nguyen Khanh Van.* Information, Series of Geography, Russian Academy of Sciences, Moscow, 6, p 114-123 (1993) (in Russian).
11. *Nguyen Khanh Van, Nguyen Thi Hien.* // Journal of Sciences of the Earth. –1999**.** – 21. P 70-79.
12. *Nguyen Khanh Van.* Bioclimatology basics. – Ha Noi: Hanoi Pedagogy College Publishing House, 2006.
13. *Nguyen Khanh Van.* Bioclimatic resource assessment for convalescence and some weather therapies in mountainous regions of Vietnam // Укр. геогр. журн. – 2005. – № 2. – С. 70 – 74.
14. *Nguyen Khanh Van.* Bioclimatic assessment for sea vacation tourism in coastal zone of Vietnam // Укр. геогр. журн. – 2007. - №2. – С. 60 - 64.
15. *Yeu Cham Sinh.* Fundamental climatology. Hydrometeorological Service (1975) (translation from Chinese into Vietnamese)