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Classification and assessment of bioclimatic conditions for tourism, health resort and some weather therapies in Vietnam

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Abstract. By using the integrated analysis and quantitative method, this paper presents the results of classification and assessment of bioclimatic conditions for tourism, health resort, and weather therapies, based on 1,826 weather combinations of 19 meteorological stations of Vietnam in the period of 2001-2005.

1. In the territory of Vietnam, the number of good weather days for tourism and human health varies in a wide range: from 308.4 days per year in Vung Tau to 109.6 days per year in Sa Pa.

For tourism, excursion, sea vacation in the lowland area: Vung Tau, Con Dao and Nha Trang have about 300 good weather days per year; Phan Thiet, Hanoi, Dong Hoi, Hue, Rach Gia have 250-280 days per year; Co To, Tay Ninh, Ho Chi Minh City,... have about 200 days per year.

For health resort and some weather therapies in the highland area: Moc Chau has 207.7 days per year; Da Lat - 183.7 days per year; Tam Dao - 129 days per year; and Sa Pa - 109 days per year.

2. In Vietnam, the good weather period varies across regions:

For tourism, excursion, and sea vacation in the lowland area: In the Northeast Region, the good tourism period lasts from April to the end of November. In the Northern Region, this period lasts longer, it is just interrupted in February, when the weather is damp by mild drizzle. In the Central and Southern regions, this period is not only around year, but also distributed evenly during a year.

For health resort and some weather therapeutic medical treatment in the highland area: In the Northern Region, the good weather period for health resort and some weather therapies is shorter then in the South and it is concentrated mainly in the summer time. In Central Plateau such as Da Lat this period lasts around year.

Keywords: Bioclimatic condition; Weather combination; Good weather days; Good weather period.

1. Introduction

Solar energy is very abundant in the tropic region. However, because of winter monsoonal circulation and the characteristic of relief conditions, this plentiful energy was redistributed significantly in Vietnam. By estimating the weather and tropical bioclimatic conditions for human health, this study is one of the attempts to clarify the difference between them.

Located in the Southeast Asia, Vietnam has a high tourism potential in term of climatic conditions resources. There are a lot of nice tourism areas in the mountainous regions, which are suitable for health resort or some weather therapies. In other hand, with more

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than 3,200 km coastal line, there are a lot of beautiful beaches in the sea shore, which are suitable for sea vacation or different kinds of sea sports.

However, in winter, cold and wet or storm weather of northeast monsoonal synoptic situation cause different affects on seasonal characteristic of tourism activities. In summer, the western hot and dry wind makes considerable harm for human health in lowland area and especially in coastal zone of the Central Region.

Since the end of the 20th century, the "tourism industry" of Vietnam has been remarkably growing up, with many kinds of the tourism activities in the whole country. By using the integrated analysis and quantitative method, this paper presents the results of classification and assessment of bioclimatic conditions for two ultimate purposes: (i) for the development of tourism, excursion and sea vacation activities in lowland areas; and (ii) for health resort and some weather therapies in highland areas.

Furthermore, based on the classification, some good weather periods for tourism activities and therapeutic medical treatment are found.

2. The study area, method and database

Inside of the tropical region, spreading nearly 15 geographical latitudes (from 8° to 23°N), the territory of Vietnam covers different climatic zones, from monsoonal typical tropical climate in the South to monsoonal tropical climate with cold winter in the North. That is why bioclimatic condition for tourism, health resort and some weather therapies are significantly varied.

In this paper, combinations of some meteorological elements – symbolizing the everyday weather conditions are being classified. In order to form weather combinations, daily meteorological data are collected at 19 meteorological stations in the period of 2001-2005. These stations are distributed evenly over the country, and their geographical location is presented in Table 1 and Fig. 1. Note that within the framework of this paper, the term "Highland" is known as mountainous regions in Vietnam, including mountainous regions in the North and Central highland. The term "Lowland" is defined as deltas, hilly areas and coastal zone as well as islands.

Table 1. Meteorological stations used for weather combination classification

N°	Stations	Longitude	Latitude	Height (m)
	Lowland			
1	Mong Cai	107°58'	21°31'	7
2	Co To	107°46'	20°59'	70
3	Ha Noi	105°51'	20°01'	5
4	Sam Son	105°46'	19°49'	5
5	Dong Hoi	106°37'	17°28'	7
6	Hue	107°35'	16°26'	17
7	Nha Trang	109°12'	12°15'	5
8	Phan Thiet	108°06'	10°56'	9
9	Phu Quy	108°56'	10°31'	5
10	Vung Tau	107°05'	10°20'	4
11	Tay Ninh	106°04'	11°19'	10
12	Ho Chi Minh	106°40'	10°49'	9
13	Con Dao	106°36'	08°41'	3
14	Rach Gia	105°05'	10°00'	2
15	Phu Quoc	103°58'	10°13'	2
	Highland			
16	Moc Chau	104°38'	20°51'	958
17	Sa Pa	103°50'	22°20'	1570
18	Tam Dao	105°38'	21°27'	897
19	Da Lat	108°26'	11°57'	1513

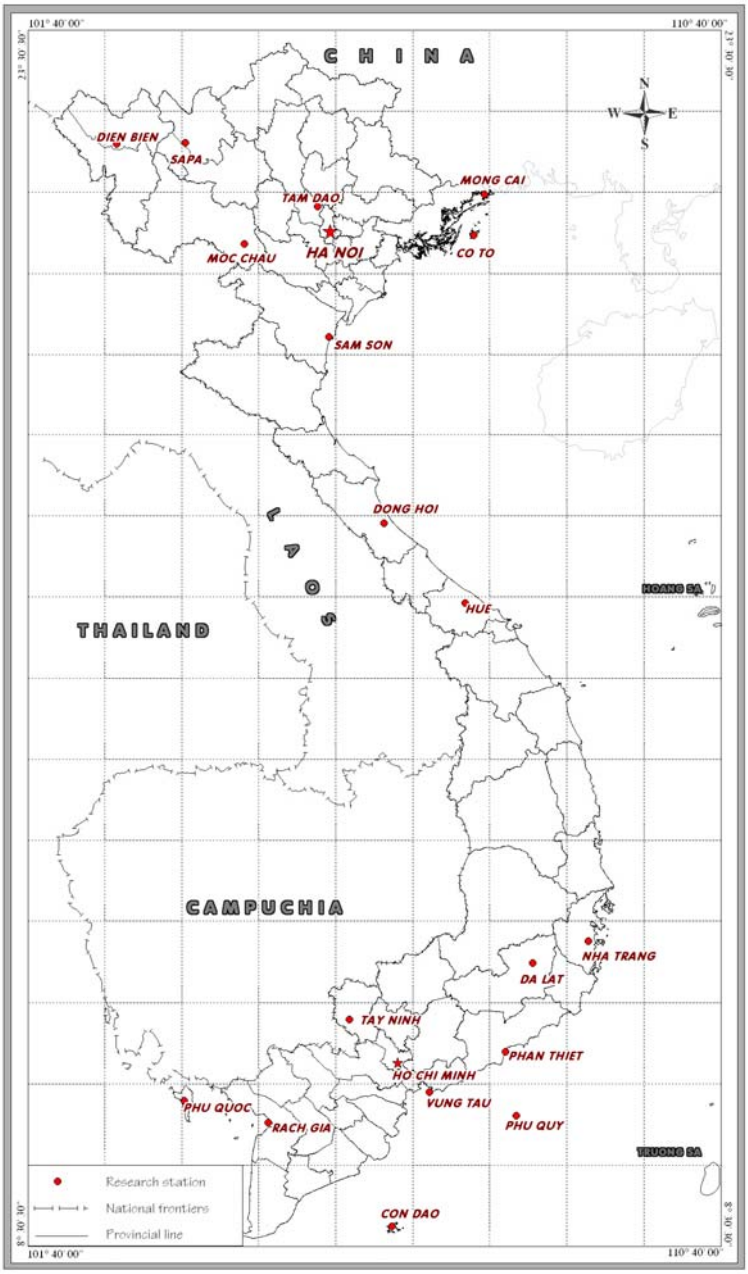

Fig. 1. Distribution of meteorological stations in Vietnam.

The criteria are chosen for bioclimatic classification such as temperature (°C), relative humidity (%), wind speed (m/s) at 13 o'clock and rainfall during the daylight in lowland area in term of assessment for development of tourism activities as well as existence of fog during the daylight in highland in term of assessment for health resort and some weather therapies.

Air temperature: Air temperature affect directly to human health, to hot or too cold weather often makes negative effect on people

in their heat regulation. People who always live in a hot climatic condition often get either cardiovascular disease, renal disease, gastrointestinal disease or other disorder such as dehydration, peripheral vasodilatation, high fever,... On the contrary, the cold weather can causes either some diseases of respiratory system or urinary tract, enteritis, arthritis,... for people. Based on the experimental results [1, 2, 3] there are thresholds of air temperature for human health: 22-30°C - *appropriate*; > 30°C - *inappropriate*; < 22°C - *inappropriate*.

Air relative humidity: Air humidity plays an important role in term of creating the heat balance and human adaptation to environmental change. Too high or too low humidity makes negative effect on human health; especially it is in connection with unfavorable heat condition. Japanese encephalitis, dengue hemorrhagic fever are often occur in the period of very hot and damp weather; very hot and dry days make human exhausted and debilitated. The thresholds of relative humanity for human health as the followings: 50-80% - *appropriate*; > 80 - *inappropriate*; < 50% - *inappropriate* [1, 2, 3].

Wind speed: Wind spreads radiate heat on the surface of human skin. In the hot season, wind makes the process of sweat evaporation from skin easy. However, strong wind in winter makes human body colder, strong and cold wind makes children and old people to get some respiratory disease, heart disease; cerebral hemorrhage,... In the windy place, the number of illness people is very high. Studying result of experiment shows the following thresholds of wind for human health: 1-3 m/s - *appropriate*; > 3 m/s - *inappropriate*; < 1 m/s - *inappropriate*.

Rainfall: Rainfall affects directly on tourism activities such as swimming, surfing, water-skiing, sailboat, airdrop or parachute jump sports. Sometime heavy rain (daily rainfall > 50 mm) or very heavy rain (> 100mm/day) seriously harm seashore sanatoriums. In practice, rainfall of 5mm/daylight (from 7 am. to 7 pm.) has less effect on tourism activities [4]. Therefore, this value is the threshold for the assessment of daily rainfall, i.e.: ≤ 5mm - *appropriate*; > 5mm - *inappropriate*.

Fog: For the health resort and some weather therapies in mountainous regions, fog makes notable effect to heat regulation by sweat evaporation. The small water drops in fog when they get in touch with lung tissue, which has temperature higher, body heat can reduce quickly… It is very easy to catch pneumonia, angina, and cold in this weather. The existence of fog often affects on a lot of medical process treatments [5] and the threshold is: fog day: *inappropriate*; day without fog: *appropriate*.

In fact, these meteorological elements affect on human health completely. Furthermore, the weather in Vietnam is unstable, during a season some contrary weather types can be appear in several days: hot-dry, hot-humid, cold-dry, cold-humid with strong wind,... Therefore, in order to assess the weather condition in every day, the above-mentioned effects can be classified by the following terminologies:

Appropriate weather days for tourism, excursion, and health resort and weather therapy are the days when all four meteorological elements are in appropriate classification range. In these days, human health has not to make any significant regulation to adapt to the weather conditions. It isn't too hot or too cold day, air temperature is about 22-30°C, relative humidity is about 50-80%, wind speed is about 1 - 3 m/s, without fog (for the highland areas) or daylight rainfall ≤ 5mm (for the lowland areas).

Fairly appropriate weather days are the days, during which there is one of the four meteorological elements inappropriate or unsuitable. In these days, human health has to make some small regulation for fitting to the inappropriate element. In fact, these regulations are inside the thresholds that human health can be able to adapt to the environment. That is why

both appropriate and fairly appropriate weather days are called *the good weather days* for tourism, health resort, which are suitable for excursion activities and some medical weather therapies.

Inappropriate weather days are considered as the days when at least two meteorological elements are in inappropriate range, they are neither good for tourism, excursion nor good for medical weather therapy, as well as in health resort activities.

3. Results and discussions

The results of classification and assessment of bioclimatic conditions are shown in tables 2 and 3. Based on analysis of the results of weather combination classification, the average numbers of appropriate and good weather condition days for tourism, health resort activities and some weather therapies as the followings:

3.1. The number of appropriate weather days

The average numbers of appropriate weather days for tourism, excursion, health resort and some weather therapies are shown in Table 2.

For tourism, excursion, sea vacation in lowland areas

Con Dao Island and Vung Tau have most appropriate weather days for tourism in Vietnam. There are about 153.6 - 122.2 appropriate weather days in a year. It means in these days, human health has not to make any regulation to adapt to the weather conditions and these are the best places for human health in general and for tourism, excursion and sea vacation in particular.

Table 2. The numbers of appropriate weather days for tourism activities, health resort and some weather therapies in Vietnam (2001-2005)

N°	Stations	Regions	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
	Lowland														
1	Mong Cai	NE	3.4	3.8	7.2	13.0	7.2	1.4	0.6	1.6	3.0	13.6	11	3.6	69.4
2	Co To	I-NE	2.2	2.4	5.6	12.0	5.8	0.8	0.6	1.0	4.8	13	10.6	3.2	62.0
3	Ha Noi	BB	7.8	10.8	12	10.4	5.6	3.2	2	2.4	4.2	11.0	11.2	9.0	89.6
4	Sam Son	BB	4.8	2.6	4.6	8.4	3.4	2.0	0.8	00.	3.0	9.2	9.6	4.0	52.4
5	Dong Hoi	C	8.6	7.4	8.0	11.0	5.4	2.0	0.8	2.6	4.4	12.0	13.6	8.6	84.4
6	Hue	C	11.8	15	13.2	4.8	1.4	0.4	0.6	0.8	3.8	12.0	12.4	8.6	84.8
7	Nha Trang	C	16.8	15.4	12.8	2.6	1.0	0.6	0.6	1.4	2.4	9.2	9.8	12.2	84.8
8	Phan Thiet	C	15.8	10.6	6.8	0.4	2.4	4.6	4.4	4.4	3.0	3.2	9.0	9.2	73.8
9	Phu Quy	I-C	10.6	14.4	12.4	0.6	0.0	0.4	0.4	0.2	1.4	9.8	8.6	6.2	65.0
10	Vung Tau	NB	21	19.2	15.6	2.0	1.2	3.4	4.0	6.0	5.6	9.2	12.8	22.2	122.2
11	Tay Ninh	NB	5.0	1.0	0.0	0.0	0.4	2.2	2.2	3.4	1.8	1.2	2.6	6.4	26.2
12	HoChiMinh	NB	3.6	0.2	0.0	0.2	0.6	2.0	1.8	2.0	1.6	2.2	1.6	8.4	24.2
13	Con Dao	I-NB	24.4	24.0	21.8	5.0	2.8	3.8	4.2	7.4	7.6	11.2	19.4	22.0	153.6
14	Rach Gia	NB	23	12.2	2.2	0.0	3.0	2.0	2.4	3.2	4.2	6.0	9.4	16.4	84.0
15	Phu Quoc	I-NB	15.4	12.4	7.8	0.4	1.2	2.6	5.6	2.2	4.4	4.4	3.8	8.2	68.4
	Highland														
16	Moc Chau	M-NW	1.1	1.4	2.6	5.7	9.3	10.5	10.7	11.8	11.7	7.5	4.0	1.3	77.6
17	Sa Pa	M-NE	0.0	0.1	0.3	1.3	2.9	3.2	3.6	4.9	4.6	2.1	0.4	0.1	23.5
18	Tam Dao	M-NE	0.1	0.6	1.1	1.5	4.4	4.8	4.4	3.4	6.5	4.3	1.3	0.1	32.5
19	Da Lat	M-CP	2.9	2.1	3.3	5.5	10.1	7.7	6.1	6.1	5.3	5.1	4.3	2.6	61.0

Note: Mountain - M; Island - I; Northeast Region - NE; Northwest Region - NW; Bac Bo Region - BB; Central Region - C; Central Plateau - CP; Nam Bo Region - NB.

Ho Chi Minh City and Tay Ninh have few appropriate weather days for tourism in general (24.2-26.2 days/ year). These places are in the South of Vietnam and according to the chosen criteria, the weather condition in these places may be too hot and/or too dry in some periods of a year.

For other places, the number of appropriate weather days varies in a range:

- From about 50 days in Sam Son to 70 days in Mong Cai or Phu Quoc Island.

- From about 85 days in Nha Trang, Hue to about 90 days in Hanoi.

For health resort and some weather therapies in highland areas

There are a lot of appropriate weather days in Moc Chau Plateau (77.6 days / year) and Da Lat City in Langbiang Plateau (61 days / year). These two places are the best places for some medical therapies and health resort.

There are very few appropriate weather days in mountainous areas, such as Sa Pa and Tam Dao (23.5 and 32.5 days respectively).

3.2. The number of good weather days

The average numbers of good weather days (total of appropriate and fair appropriate days) for tourism, excursion, health resort and some weather therapies are shown in Table 3.

In the territory of Vietnam, the number of good weather days for tourism and health resort varies in a wide range: from 308.4 days / year in Vung Tau to 109.6 days / year in Sa Pa.

For tourism, excursion, sea vacation in lowland areas

In the South and Northwest regions, there are a lot of good weather days for tourism, excursion and sea vacation.

In Vung Tau, Con Dao Island and Nha Trang, there are about 300 good weather days in a year.

Table 3. The number of good weather days for tourism activities, health resort 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

Phan Thiet, Hanoi, Dong Hoi, Hue, Rach Gia have about 250-280 good weather days in a year.

In other places, such as Co To Island, Tay Ninh, Ho Chi Minh City,... there are about 200 good weather days per year.

For health resorts and some weather therapies in highland areas

Just in mountainous regions, because of interaction between high elevation and activity of northeast cold winter monsoon, the temperature is low and the fogs often appear in the mornings or late evening. Therefore, the good weather days in the North are lower then in the South of Vietnam. Sa Pa has 109 good weather days per year; Tam Dao - 129 days / year; and Da Lat City - 183.7 days / year.

3.3. The good weather periods

In different regions of Vietnam, the good weather time for human health is not similar. Based on daily statistical data of 5 years (2001-2005), *good weather period* is the period when the number of good weather days excesses 18 days / month for tourism, sea vacation,... or 10 days / month for health resort and some medical weather therapies. Therefore, the good weather period in Vietnam has following characteristics:

For tourism, excursion, sea vacation in lowland areas

In the Northeast Region, the good weather period in is relatively short; it lasts from April to the end of November. Especially in such island as Co To, because of high wind speed, good weather period is shortened and interrupted.

In Hanoi or Sam Son of the Northern Region, the good weather period lasts longer; it is interrupted in February, when the weather is damp by mild drizzle.

In the Central Region, the good weather period is not only longer, but also distributed evenly during a year. Typically for that is Nha Trang, where tourism activities can take place all year round.

In the Southern Region, e.g. Vung Tau and Con Dao Island, the good weather period is around year, in other places the period can be interrupted by hot-dry weather.

Totally, in lowland of the Southern Region, period of good weather conditions (over 18 good days per month) is not only longer than that in the North, but also distributed evenly in the whole year. Therefore, the tourism business in the Southern Region, can get more benefits. In the North, especially in the Northeast Region, the tourism period lasts from summer to the end of autumn (from April to November). During the rest of year the cold and damp weather significantly limits tourism activities.

For health resorts and some weather therapeutic medical treatments in highland areas

In mountainous areas of the Northern Region, such as Sa Pa, Tam Dao and Moc Chau, the good weather period for health resort and some weather therapies is shorter then that is in the South and it is concentrated mainly in summer, from April to December in Moc Chau, and May to October in Sa Pa and Tam Dao.

In Central Plateau such as Da Lat City, the good weather period for health resort and some weather therapies is around year. In difference with highland climatic condition in the North, in Da Lat the number of good weather days distributes rather evenly in the whole year, here the month with the minimum good weather days is December, but even that, it has more than 11 good weather days.

Totally, Da Lat City is the best place for human health resort, medical weather therapeutic treatment in the highland area of Vietnam.

4. Conclusions

For the purpose of supporting tourism, excursion and sea vacation in lowland areas or health resort and some weather therapeutic treatment in highland areas, by using integrated analysis and quantitative method, this study have classified and assessed the daily weather combinations in 19 places through the period of 2001-2005.

As the results, the research provides useful information about: (i) the numbers and distribution of days per year with good weather conditions for the above purposes; (ii) classification of appropriate level of bioclimatic conditions in each region of Vietnam.

In other hand, regarding the distribution of good weather days in the month over the year, the study also proposes favorable periods for tourism development in different regions of Vietnam.

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