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ORIGINAL ARTICLE

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Tourism climatology: evaluating environmental information for decision making and business planning in the recreation and tourism sector

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Abstract This work grew from initiatives of the International Society of Biometeorology's Commission on Climate, Tourism and Recreation (ISBCCTR). The ISBCCTR was formed during the 15th Congress of the ISB held in November 1999 in Sydney, Australia. The aim of ISBCCTR is to promote research in tourism climatology. The first formal meeting of the Commission took place at the Meliton Resort, Halkidiki, Greece, 5–10 October 2001. The aims were to (1) bring together a selection of scientists and tourism experts to review the current state of knowledge of tourism climatology and (2) explore areas and priorities for future work and the role of the Commission in this. The Workshop highlighted the fact that, although climate is widely recognised as vitally important to tourism, relatively little is known about its effects. Even less is known about the economic impact or significance of climate on commercial prospects for tourism. Important research themes that warrant attention were identified. Among these was the need for a tourism climate index (or indices) that integrates all facets of climate, uses standard data and is objectively tested and verified. Work is also required on developing a better understanding of what climate-related information is required by both tourists and the tourism industry, exploring the distinction between the impact of climate on tourists and the impact on the tourism industry, setting a standard approach to tourism climate assessment, assessing the role of weather forecasts and long-term expectations of climate on choices made by tourists, the risks to tourism caused by extreme atmospheric events, what climate-related criteria people use to make decisions about tourism and recreational choices, how products giving information about weather and climate are currently used by the recreation and tourism industry and what are the existing and future requirements for this climate information.

Keywords Tourism climate · Recreation climates · Bioclimate indices · Business planning · Human climate

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Introduction

Tourism is one of the world's biggest industries. It is also the fastest growing. World tourism grew by a record 260% between 1970 and 1990 (Hale and Altalo 2002). The recreation and tourism sector is a diverse group of businesses and their clients that includes the airline industry, travel agents, tour operators, car rental companies, convention organisers and resorts, to name just a few. For many regions tourism is the most important source of income. For example, tourism contributes to over half the gross domestic product (GDP) in many countries of the Caribbean. It represents 31% of the GDP for the region as whole and supports approximately 3 million jobs (Hale and Altalo 2002). Here climate is the main impetus for attracting visitors. There are other regions where the potential economic returns from the development of tourism are enormous but are as yet untapped. In these places it is generally accepted that climate is an important part of the region's tourism resource base, but the role of climate in determining the suitability of a region for tourism or outdoor recreation is often assumed to be self-evident and therefore to require no elaboration. Relatively little is known, other than in very general terms, about the effects of climate on tourism or the role it plays. And even less is known about the economic impact or significance of climate on commercial prospects for tourism.

The whole area of what climate-related criteria people use to make decisions about tourism and recreation choices is largely unresearched, but highly relevant to a variety of applications. Thus far, much of the research specifically on climate reported in the literature has been superficial, in that relationships between climate and

tourism are assumed rather than observed and seldom objectively tested. Moreover, the research is largely devoid of any clearly structured conceptual framework or frameworks that embrace important theory, paradigms, processes and interactions. These theoretical frameworks are important because they provide a basis for data generation, hypothesis testing and generating further theories. Without these, it is difficult to develop a coherent set of research methods, and, perhaps more importantly, develop models that constitute a bridge between the observational and theoretical levels that can assist in building a coherent knowledge base for understanding, explanation and prediction. This paper reviews the work so far on climate and tourism with a view to identifying useful concepts and theoretical frameworks, and looks to ways these may be drawn together in future research. It proposes that a fundamental "driver" of tourism climatology is the identification and evaluation of environmental information for business planning and decision-making in the recreation and tourism industry.

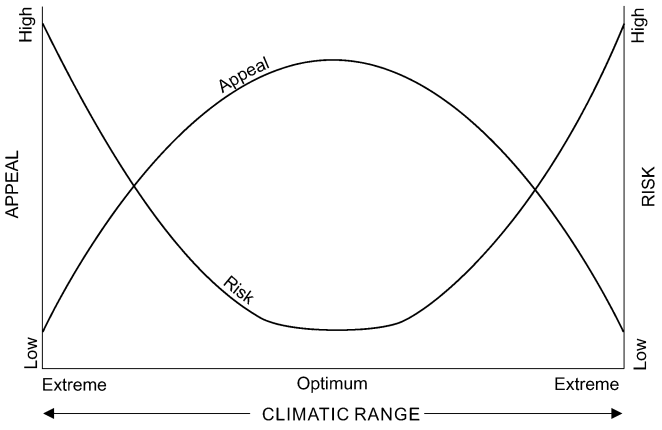

Fig. 1 A schematic representation of relationships between a climatic range and tourism potential. The climate potential of a particular location is a function of its climate and of the risks (e.g. to safety, profit-making) that weather may impose. (Modified from Perry 1997)

Definitions and key concepts

Tourism climatology

The study area labelled *tourism climatology* deals with the concepts of "climate" and "tourism" in the broadest sense. Climate invokes the concept of "weather" in that it is defined as the accumulation of daily and seasonal weather events over a long period of time, where weather is the condition of the atmosphere at any particular time and place. "Tourism" embraces the concept of "recreation" in that it is the practice of travelling for recreation, where recreation is defined as an activity in which individuals voluntarily engage for personal satisfaction or pleasure. Thus, in broad terms, there are elements of equivalence in the dual terms *weather* and *climate* on the one hand, and *tourism* and *recreation* on the other. They are often used interchangeably in tourism climate research, which may be broadly defined as the study of interrelationships of tourism and recreation with climate and weather.

Climate as a resource and economic asset

Together with geographical location, topography, landscape, flora and fauna, weather and climate constitute the natural resource-base of a place for recreation and tourism. The concept of tourism climate recognises a climatically controlled resource which, along with weather, according to Hibbs (1966), can be viewed as a recreational resource which, at various times and locations, may be classified along a favourable-to-unfavourable spectrum. Thus climate is a resource exploited by tourism, and the resource can be measured. In this way climate can be treated as an economic asset for tourism. The asset can be measured and the resource is capable of being assessed. But there are numerous problems.

One major problem is the selection of meteorological or climatological criteria. For example, what exactly are the criteria for *ideal, suitable, acceptable*, or *unacceptable* conditions? Only after appropriate climatological criteria have been clearly identified can key questions be answered. When is the best time to visit? What clothing or equipment is needed? What are the weather hazards or climate extremes likely to be?

Tourism potential and limiting factors

The characteristics of weather and climate are not necessarily determinants of tourism but constitute an important factor in both financial terms for tourism operators and the personal experiences of tourists. Every location has a "tourism potential" and "appeal" depending on its climate (Fig. 1) and weather and climate set limits. For example, tourism administrators do not promote places with little potential or appeal, as this would not be profitable. On the other hand, the tourist who chooses to visit such places might well suffer inconvenience (e.g. transport costs) or discomfort (e.g. heat or cold stress). Financial losses can also result from weather variations or unexpected climatic conditions. Rainy summers or less snowy winters can have significant impacts on tourism. For many tourist activities there are limits or limiting conditions beyond which there is increasing risk of one sort or another (Fig. 1).

Climate as a factor in tourism demand

Given that recreation is an activity in which individuals freely engage for personal satisfaction or pleasure, recreation is voluntary behaviour proceeding from one's

own free choice. As a result, participation will only occur if the potential participant perceives the climate to be suitable. The voluntary and discretionary nature of tourism means that participation will decrease as discomfort and dissatisfaction increase. Thus satisfaction affects participation, which can be taken as a measure of demand for the climatic resource, the so-called demand factor. Examples of indicators of demand in this context are visitation or attendance numbers (Paul 1971; de Freitas 1990) and hotel/motel occupancy or hotel "tourist nights" (Rense 1974).

The climate or weather circumstances to which the recreationist or tourist may react or respond (i.e. those that affect decisions) are (1) conditions anticipated by the tourist (say, gleaned from weather or climate forecasts, travel brochures etc.) and (2) on-site weather. These are collectively referred to as human responses to weather and climate. They can be identified and assessed using "demand indicators".

There are two categories of method that have been used for assembling data on the human response to climate and thus the demand for the climate resource:

1. Assess conditional behaviour by using, say, questionnaires and images (e.g. Adams 1973) to determine how people react or think, which includes assessing the influence or role of weather or climate forecasts.
2. Examine on-site experience. Since individuals are experiencing conditions first hand, this is a more reliable method than questionnaires and interviews. Ideally the approach must be activity-specific, and it is best not to lump all tourism together, but deal with specific categories of activities, either (a) *active* or (b) *passive*.

Approaches to tourism climatology

Most research on tourism climate appears to be motivated by the potential usefulness of climatological information within planning processes for tourism and recreation. The research addresses the theme of tourism climate as an adjunct to a variety of decision-making processes ranging from those related to such things as the development and location of appropriate recreational facilities, or determining the length of the tourist season during which a facility will operate, to those as specific as planning future activities involving personal decisions of when and where to go for a holiday.

There has also been interest in the indirect effects of climate. For example, Perry (1972) suggested that people leave swimming pools and golf courses on wet days and converge on nearby towns in search of amusement indoors. Therefore, depending on the sensitivity to weather of the recreational activity, climatic information can help in the planning, scheduling and promoting of alternative indoor entertainment facilities. Perry (1972) also describes the use of climatic information in publicity campaigns to condition tourists' expectations of climate at certain locations.

It is clear, however, that if climatic information is to be useful in decision-making, it needs to be presented in a form appropriate to the problem. Tourists respond to the integrated effects of the atmospheric environment rather than to climatic averages. It is generally accepted, therefore, that standard weather data or even secondary climatic variables are not always reliable indicators of the significance of atmospheric conditions. At any given air temperature, for example, the thermal conditions experienced will vary, depending on the relative influence and often offsetting effects of wind, humidity, solar radiation and level of a person's activity. Moreover, the design of a particular thermal assessment scheme will depend on the intended use as well as on the nature of the thermal climatic conditions to which the scheme is to be applied. For example, schemes have been devised for groups of runners (de Freitas et al. 1985), survival in climates of extreme cold (de Freitas and Symon 1987) and for general purposes of human climate classification (Auliciems et al. 1973; Auliciems and Kalma 1979; de Freitas 1979, 1987). The importance of this has been recognised in climate/recreation research (Terjung 1968; Bauer 1976; Reifsnyder 1983), but so far there have been few convincing studies aimed at identifying optimal or preferred conditions for various outdoor recreational activities. There have been even fewer that examine the sensitivity of tourism to atmospheric conditions generally.

Climate information for business planning and decision-making

Type of information versus end-users

Climate and weather are pervasive factors in many economic activities, agriculture and tourism being foremost among these, and financial returns depend directly on them. Possibly because of this, Boniface and Cooper (1994) speculate that climate is one of the key factors influencing development in the tourism sector. Effective decision making, however, requires the right sort of information. Little is known about precisely what climate information is used by business, how it is used, or the decisions for which it is used (Hale and Altalo 2002). Environmental information in a variety of forms is now widely available, especially electronically via the internet, but the generation of information alone is not sufficient for business planning and decision-making. Information has to be delivered to end-users, processed and then put in a form relevant to them. Moreover, end-users must have the incentive, technical skill and intellectual capacity to use the information effectively.

Climate as experienced versus climate averages

Climate data must be presented in a form that relates to the response of a person or a business to weather or climate, that is *events* (or real conditions) rather than *averages*. Averages have no physiological or psychological meaning. Data should give an impression of the likelihood of the occurrence of the climate/weather conditions (events). Data should also reflect the fact that individuals respond to the integrated, combined effects of weather elements (thermal, physical, aesthetic etc.). Equal importance should be given to the nature and form of output data, which should be presented in a form that can be readily interpreted and understood by the user. Often we have to rely on standard meteorological or climate station data, which may not be representative of the recreational area – valleys, peaks, hills, coast, beach etc. Climate station data are intended to be representative of the bottom of the atmospheric column rather than a particular microclimate or location such as a beach, park or ski slope.

Types of data

There are three categories of "raw" climate data:

1. *Historical* archived data
2. *Real-time* (instrumental) data
3. *Forecast* data (predictions).

The type of climatic data and manner in which they are presented in tourism climate research depend on the purpose of the work. Information can be used by (1) the tourist planner, (2) the tourist operator and (3) the individual tourist. For example, a ski facility planner needs information on the length of snow season, whereas the skier wants a seasonal distribution of probabilities that a skiable depth of snow will exist at a particular location and time. A planner for a tropical island resort needs to know the length of period in which the climate is acceptable to tourists. Prospective tourists need to know when and where conditions will be optimal, acceptable, tolerable or unacceptable.

Uses of climate data

The various types of raw or standard climate data can be used in various ways and for a variety of purposes:

- *Operational decision-making*, such as when to groom the golf course, undertake course and pitch maintenance, refurbish the resort; when to commence snowmaking; how to predict or cater for changed client demand; vacationers deciding where and when to go for a holiday etc.
- *Risk assessment*, involving timing and nature of severe weather events, for example, high winds, heavy rain, high levels of ultraviolet radiation; insurance needs; emergency preparedness etc. According to Perry (1997) the tourist industry is particularly vulnerable to natural disasters as 70% of holidays are coast-oriented. Moreover, tourists tend to be more vulnerable than locals as they are unfamiliar with the place they are visiting.
- *Marketing*, such as promoting attractive or appealing climate conditions; times of year or times of day to encourage business. Perry (1993) has shown that misleading or selective climate information on promotional holiday brochures gives a false picture of the climate at particular destinations. Portraying climate for potential customers of different ages, fitness, and cultural background who plan different activities is a difficult task.
- *Investment* decisions, such as which regional climate type is likely to be most appealing to vacationers and thus more profitable, what climate conditions will mean in terms of heat and air conditioning costs of building etc.
- *Siting* of accommodation, resorts and other tourism developments, such as decisions about where to locate a resort on a tropical island – leeward coast or windward coast, cloudy region or dry sunny region (rain shadow), cooler or warmer locations etc.
- *Design*, such as resort design, landscape and planning.
- *Finance and budgeting*, such as may be used to cater for seasonality or short-term changes in demand dictated by weather and climate, predict profit returns or cash flow etc.

Conceptual frameworks

Facets of tourism climate

Human response to climate is largely a matter of an individual's perception, with the exception of the thermal component. Some climate variables are entirely *physical* (e.g. rain), some are *physiological* (e.g. air temperature), some are *psychological* (e.g. clear blue skies) and some are *combinations of all three*. Many writers on the subject of tourism climate single out the thermal component of climate as the most important element. But within a broad range of moderate or "non-extreme" thermal conditions, other factors assume greater importance in determining the pleasantness rating of a given weather or climate condition.

The nature of the relationship between the atmospheric environment and the enjoyable pursuit of outdoor recreational activity may be seen to be a function of facets of on-site climatic conditions. A conceptual framework for this is shown schematically in Fig. 2. The facets of tourism climate given at the top of Fig. 2 are *thermal, physical*, and *aesthetic*.

Treatment of the *thermal* characteristics of on-site conditions involves four steps:

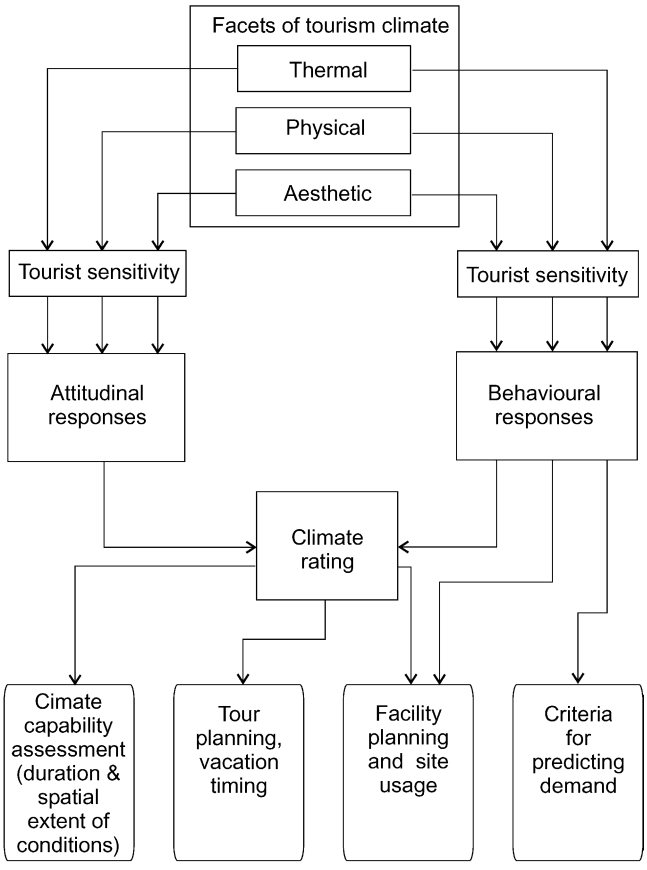

Fig. 2 Conceptual framework for the study of tourism climate showing the facets of climate and two independent methods for assessing human response. These can be used for rating tourism climate and weather in terms participant sensitivity and satisfaction with conditions

1. Integrate the physical factors influencing the body/atmosphere thermal state. The method used must include both the attributes of those exposed and the functional attributes of the environment as well as the complete range of atmospheric variables. For the atmospheric environment these include air temperature, humidity, wind, solar and long-wave radiation and the nature of the physical surroundings and, for the body, metabolic rate, posture and clothing.
2. Provide a rational index with sound physiological basis that adequately describes the net thermal effect on the human body.
3. Identify relationships between the thermal state of the body and the condition of mind that expresses the thermal sensation associated with this state.
4. Provide a rating of the perceived thermal sensation and corresponding calorific index according to the level of satisfaction experienced. This means identifying subjective reaction classified on a favourable-to-unfavourable spectrum as a measure of the desirability of climate conditions.

The *physical* category shown in Fig. 2 is identified in recognition of the existence of specific meteorological elements, such as rain and high wind, that directly or indirectly affect participant satisfaction other than in a thermal sense. The occurrence of high wind, for example, can have either a direct mechanical effect on the vacationer, causing inconvenience (personal belongings having to be secured or weighted own) or an indirect effect such as blowing sand along the beach causing annoyance. Others things that fall into the physical category are rain (duration), rain days (frequency), ice, snow, severe weather, air quality and ultraviolet radiation.

The *aesthetic* aspects relate to the climatically controlled resource attributes of the environment, which Crowe et al. (1973) have termed the atmospheric component of the "aesthetic natural milieu". Included within this category are weather factors such as visibility, sunshine or cloud associated with the prevailing synoptic condition (for example, "a nice, clear, sunny day"), day length and visibility.

The above factors are summarised in Table 1.

Table 1 Various facets of tourism climate, their significance and impact

Facet of climate	Significance	Impact
Aesthetic		
Sunshine/cloudiness	Quality of experience	Enjoyment, attractiveness of site
Visibility	Quality of experience	Enjoyment, attractiveness of site
Day length	Convenience	Hours of daylight available
Physical		
Wind	Annoyance	Blown belongings, sand, dust…
Rain	Annoyance, charm	Wetting, reduced visibility and enjoyment
Snow	Winter sports/activities	Participation in sports/activities
Ice	Danger	Personal injury, damage to property
Severe weather	Annoyance, danger	All of above
Air quality	Annoyance, danger	Health, physical wellbeing, allergies
Ultraviolet radiation	Danger, attraction	Health, suntan, sunburn
Thermal		
Integrated effects of air temperature, wind, solar radiation, humidity, longwave radiation, metabolic rate	Thermal comfort	Environmental stress Physiological strain Hypothermia Hyperthermia
	Therapeutic, restorative	Potential for recuperation

To identify and describe the experience of on-site atmospheric conditions, de Freitas (1990) used two separate forms of user response, shown in Fig. 2:

1. Sensory perception of the immediate atmospheric surrounds expressed verbally
2. Behavioural responses that modify or enhance effects of the atmosphere.

By employing, independently, separate indicators of the on-site experience, the reliability of each was examined and interpreted by comparison, and apparent threshold conditions verified.

On-site behaviour as a research tool

Little is known about the effects of climate on human behaviour, but it is clear that in some cases behaviour is a response that modifies or enhances the effects of the atmosphere. Behaviour can be used as a measure of human sensitivity and satisfaction. The significance of behaviour is that it is a manifestation of how individuals react, adapt or adjust. This, in turn, can be objectively interpreted There are five ways in which an individual can adapt, adjust or react behaviourally: he or she may

1. Avoid areas of unfavourable weather- or climate-determined conditions (for example, move from sun to shade, or vice versa; select vacation destination according to climate condition etc.)
2. Change activity to suit weather conditions so as to maximise enjoyment of the outdoor experience (for example: swim more/less, drive rather than walk, extend/reduce length of stay etc.)
3. Use structural or mechanical aids (for example, umbrellas, wind breaks, hats, shelters etc.)
4. Adjust thermal insulation of body (clothing)
5. Adopt passive acceptance.

The results of the research by de Freitas studying beach users in Queensland Australia showed that behaviour is a reliable indicator of the significance of weather conditions. Specifically (a) use of shade and clothing are the best indicators of heat and cold stress respectively, and (b) duration of visit (as opposed to total attendance) is the best behavioural indicator of the overall significance of the tourist climate. Certain behavioural adjustments, such as the use of shade umbrellas, windbreaks and possibly increased frequency of swims, serve to reduce the beach user's sensitivity to on-site atmospheric conditions, although stated preferences as regards beach weather remain the same. In the absence of ideal conditions, an individual can, up to a point, create a personal microclimate that is acceptable. Surprisingly, total attendance is a poor measure of demand, which means total attendance is a poor measure of the response of tourists to climate. Attendance only reflects the outer limits of acceptability. The work suggested that the time spent on site for each visit (duration of visit) is a more accurate measure of user response and preferences. Furthermore the findings of the research indicated that atmospheric conditions within the broad zone of acceptability are those that the beach user can readily cope with or effectively modify. Optimum thermal conditions are those requiring no specific adjustment or behavioural fine-tuning.

Integrated versus simple assessments of tourism climates

Generalised schemes

Several writers have portrayed climate for tourists in simple descriptive terms in preference to traditional taxonomic methods of portraying regional climates (Green 1967; Davis 1968; Murray 1972; Maunder 1972; Crowe et al. 1973, 1977a, b; Findlay 1973; Crowe 1976; Gates 1975a, b: Masterton et al. 1976; Masterton and McNichol 1981; Smith 1985). In some cases, as in the work of Paul (1972), standard thermal climatic indices such as the Thom discomfort index and the wind chill index have been included and, in the case of Green (1967), generalised quantitative summations of weather variables, arbitrarily weighted, have been employed.

Numerical indices

In addition to these generalised approaches, considerable effort has gone into devising numerical indices of climate that summarise the significance of climate for tourism. This is because of the multivariable nature of climate and the complex way these variables come together to give meaning to a particular weather or climate condition in terms of recreation or tourism. These indices aim to facilitate interpretation of the integrated effects of various atmospheric elements and permit places to be compared. Some of the work produced fairly rudimentary indices (Becker 1998; Davis 1968; Fergusson 1964; Hughes 1976; Murray 1972; Poulter 1962; Rackliff 1965). The problem is that most of the climate ratings are arbitrary as none has been empirically tested.

Bauer (1976), Danilova (1974), Harlfinger (1991), Terjung (1968) and Yapp and MacDonald (1978) have used more sophisticated measures of tourism climate based on the body's thermal exchanges with the environment. Mieczkowski (1985) has devised a broadly based climatic index for evaluating world climates for tourism. However, with the exception of the study by Harlfinger (1991), meaning attached to these measures has been secondarily derived and interpreted without field investigation. It was with the above in mind that the work by de Freitas (1990) set out to examine, by way of a case study in Australia, methods capable of giving information that can be used to appraise and rate recreational climates in terms of user sensitivity and satisfaction.

On-site empirical investigation – an example

Ideally, given the complexity of the problem of addressing the amenity role of climate, the research should concentrate initially on a well-defined human activity, preferably one that is clearly linked with amenity resource attributes of the atmospheric environment. These requirements are fulfilled by a variety of outdoor recreational activities of which beach recreation is one of the most appropriate. There are several reasons for this. (1) Beach recreation is an activity in which the human body is usually lightly clad and therefore directly exposed to atmospheric elements. (2) Beach users in Australia are normally clustered in a relatively small area (patrolled by surf-lifeguards). Therefore, sample populations can be readily observed, and the compact area facilitates on-site monitoring of atmospheric and associated environmental variables representative of ambient conditions. (3) For beach users, individual recreational aims or objectives of the occasion are similar. From a research standpoint these characteristics offer a relatively controlled situation. (4) Beach use is among the most popular of outdoor recreational activities in Australia and elsewhere, as measured by beach attendance figures. Thus, greater knowledge of the influence of climate on beach recreation is likely to be economically important to the coastal recreation and tourism industry.

Two broad categories of questions exist, around which the investigation was built (de Freitas 1990). Since the heat balance of the body is fundamental to assessments of human climates, the first category involves specification of the thermal environment.

1. Given methods of body-environment energy budgeting, how are outdoor thermal conditions best quantified?
2. How should thermal index values be interpreted?

The second category of questions centres on assessing the atmospheric resource generally in terms of recreation:

1. What thermal atmospheric conditions are those most preferred for recreation?
2. To what extent is the level of user satisfaction influenced by non-thermal atmospheric conditions?
3. What are the relationships between atmospheric conditions and participant satisfaction?

The results of the research (de Freitas 1990) showed that a body/atmosphere energy balance model can be used to integrate the effect on the body of thermal components of climate as well as thermophysiological variables and produce a unitary index that can be used to derive the levels of thermal comfort or discomfort experienced by tourists. Also, it provides a method for isolating the thermal component of beach climate, enabling the identification of important non-thermal recreational resource attributes of the atmospheric environment.

The results showed that optimum thermal conditions appear to be located in the zone of vasomotor regulation against heat, subjectively interpreted as warm, rather than precisely at the point of minimum stress or thermal neutrality. Sensitivity to thermal conditions appeared to be greatest in the zone of moderate environmental heat stress.

The immediate thermal environment of the tourist is the main contributing factor to assessments of the overall desirability of on-site climate conditions, followed by cloud cover and wind. Rainfall events of half an hour duration or longer have an overriding effect on the perceived level of attractiveness of atmospheric conditions, resulting in ratings dropping to their lowest levels. Cloud cover/sunshine is the main aesthetic variable. High wind at speeds in excess of 6 m s^{-1} has an important direct physical or mechanical effect on the beach user (personal belongings blown around) as well as an indirect effect stemming from the annoyance caused by blowing sand. Generally, ideal atmospheric conditions are those producing "slightly warm" conditions in the presence of scattered cloud (0.3 cover) and with wind speeds of less than 6 m s^{-1}. In the absence of rainfall, the relative weighting of the various facets of tourism climate are 0.6 thermal (i.e. heat balance of the body including activity level, air temperature solar and long-wave radiation, wind), 0.3 aesthetic (e.g. cloud/sunshine) and 0.1 physical (e.g. wind).

The ideal tourism climate index

The popularity of Mieczkowski's tourism climate index (TCI) shows that there is a demand for this type of unitary indicator of climate. What is now required is research that tests the accuracy of such an index or devises a similar index, using systematic surveys to interpret it rather than relying on arbitrary and subjective value judgements of the researcher, as in the case of TCI. Going some way towards this, de Freitas's (1990) work uses empirical field data to identify both the main components of tourism climate and their relative weightings, as discussed above.

An ideal index would:

- Rely only on standard climate data
- Minimise reliance on averaged climate data and maximise reliance on actual (real) observations
- Use as input all attributes of the atmospheric environment
- Use an integrated body/ atmosphere energy balance assessment of the thermal component of climate
- Include all three attributes of tourism climate: thermal, aesthetic and physical/mechanical
- Recognise the notion of climate as a limiting factor, or climate limits to tourism, with a focus on thresholds.

In all of this, the aim should be to adopt standard methods and indices as far as possible. There is also a need to provide potential tourists with probabilistic

information on the climate to be expected at various destinations. This will lead to better information and improved choice.

Future directions

Possible directions in tourism climate research are diverse and sundry. They depend on what is required by planners, members of the tourism industry and tourists themselves. Climatologists need to translate their technical work into simple language and explain this in uncomplicated terms for planners, tourist operators, the tourist sector generally and the public. Methods used should be transparent as well as simply expressed and clearly explained. Above all, planners require climate data that is quality-checked, and easy to use (i.e. well sorted). Applications aimed directly at the tourist involve, among other things, the role of climate in considerations of destination choice – especially in relation to the increasing use of the internet.

Specific applied research themes include:

- Assessment of the suitability or appeal of climatic conditions for a variety of resorts in climatically diverse locations with a view to identifying the "true" length of period a tourist or recreational facility can operate.
- Developing ways in which standardised tourism-climate information may be assembled to inform choices on where and when to go for a holiday, or form the basis for selecting an alternative activity
- Looking into the provision of information for publicity or marketing campaigns to condition tourist expectations of the true recreational climate at given locations
- Assessment of changed opportunities because of climate change or changes in climate variability
- Developing an understanding of how weather/climate affects on-site behaviour so that businesses can plan to meet demand for certain activities
- Developing hybrid systems for tourism-climate forecasting of on-site conditions, as well as advisory services to inform travellers of what to expect (thermal conditions, cloud, rain, extremes etc.)
- Investigating ways to help tourists bring together expectations of climate at a place and actual climate at that place
- Investigating how the tourism climate of particular destinations may be packaged and marketed to potential visitors.

Another possible research theme would be to investigate how information might be constructively used to affect the "climate image" of a tourist destination ("destination image"). Some time ago Anderssen and Colberg (1973) showed that, among the factors that affect tourism demand, the dominant attributes of a tourist destination are cost, climate and scenery. Research is needed to assess the relative importance and role of the climate attribute as a component of the tourist destination image.

Ross (1992) showed that climate, as a component of destination image, does strongly influence tourist behaviour. Hunt (1975) pointed out that images and expectations of a destination may have as much, or more, to do with the projection of an area's tourist image than the more tangible recreation resources. Publicity about the climate to be expected in an area can also modify a tourist's expectations and thus their degree of satisfaction with the outcome of the experience. There is the often-quoted example of the Irish Tourist Board, which shrewdly promoted the delights of a cool and rainy Irish summer. It was thought to have influenced the expectations of tourists, thus reducing their disappointment.

Ross (1992) has explored the influence of a variety of climatic conditions on both ideal holiday destinations and on perceptions of the wet tropical area of Far North Queensland in Australia. Given that distinct patterns were found, the results of research like this have implications for those involved in the tourism/hospitality industry, as they should influence the way the area is marketed to potential visitors to Far North Queensland as a holiday destination.

There is also the question of forecasting tourist travel overseas on the basis of climate. Palutikof (1999), Palutikof et al. (2000) and Agnew and Palutikof (2000) have explored this area. They found that (a) outward and inward visitor movement is a response to both weather during the year of travel and weather the previous year; (b) rainfall is a better indicator of outward travel than inward, with wetter conditions encouraging more visits abroad; and (c) autumn temperatures and sunshine have the greatest influence on inward travel. Predictions of tourist travel based on these findings could be important to the travel industry and justify further research.

There are costs to both tourists and tourism operators resulting from the occurrence of unexpected less-than-satisfactory climate. These need to be fully documented and methods and approaches to studying these require more careful attention. Even now tourists and tour operators can take out insurance against the likelihood of "bad" weather conditions occurring while on vacation. The question arises of how insurance companies define "bad weather" and the extent to which this is accurate or appropriate; how this compares to perceptions of the "quality" of conditions experienced by tourists themselves, on the one hand, and how it varies with different recreational activities on the other.

Thus far, most work in tourism climatology, on tourism climate indices or climate suitability assessments, has been based on subjective criteria of the researchers themselves rather than the verified perceptions of tourists. More field studies are required along with work that assembles observational data to determine the actual responses, perceptions, needs, reactions and expectations of vacationers.

Conclusions

Climate is an important part of a region's tourism resource base, but its role in determining the suitability of a region for tourism is often assumed to be self-evident and therefore to require no elaboration. Relatively little is known, other than in very general terms, about the effects of climate on tourism or the role it plays. And even less is known about the economic impact or significance of climate on the commercial prospects for tourism. The whole area involving which climate-related criteria people use to make decisions about tourism and recreation choices is largely unresearched, but highly relevant to a variety of applications.

Thus far, much of the research specifically on climate reported in the literature has been superficial in that relationships between climate and tourism are assumed rather than observed and seldom objectively tested. Moreover, the research is largely devoid of any clearly structured conceptual framework or frameworks that embrace important theory, paradigms, processes and interactions. Theoretical frameworks are important because they provide a basis for data generation, hypothesis testing and the generation of further theory. Some have been suggested here.

Research on climate and tourism has been reviewed here with a view to identifying important concepts and theoretical frameworks and ways these may be drawn together in future research. This paper has attempted to take the first step towards developing a coherent set of research methods and proposing models that might constitute a bridge between the observational and theoretical levels that can assist in building a coherent knowledge base for understanding, explanation and prediction. It is proposed that a fundamental driver of tourism climatology is the identification and evaluation of environmental information for business planning and decision-making in the recreation and tourism industry. Ways of achieving this have been suggested, with the hope that interest in the field of tourism climatology will grow and stimulate research on a variety of worthwhile themes.

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