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Climate Information Services: Socio-economic Benefits

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ABSTRACT - This study highlights the economic gains (or reduced losses) available to decision makers as a result of the use of climatic information and services, Climate information and services are categoriesed into three groups in the study namely:- Historical and/or past data and derivation, short term climate based prediction and climate change forecasts and impact assessments. Beneficiaries include international aid agencies, government and regional administration, sectional interests and individual users including companies.

INTRODUCTION

Maunder (1970, 1986), quantifies the casual relationship between weather and/or climate variation and resources for and output from various activities. Relatively, few reports exist which quantify the actual or potential value of applying the climatic information, especially at market sector, regional or national levels.

In this study attempts are made to highlight the economic gains (or reduced losses) available to decision maker due to the use of climatological information and services. However, it should be noted that calculations which quantify economic value are complex and the results to an extent perishable; for example the net economic value, at sectoral level, of an increased national yield of a particular crop, due to intelligent application of climatological information, will also depend on institutional arrangements (e.g. subsidies), input costs, internal market conditions, overseas demand (itself dependent on local climate) and trade agreements some of which will vary with time. A few important social benefits are also considered especially in the area of food security and health.

Climatic information and services can be categories into many groups. In this study emphasis will be laid on three of them namely historical and/or past data and derivations. Short term climatic based prediction; climatic prediction and impact assessment.

The Historical Data and Derivation

These include raw and quality controlled observational data of various parameters of climate. Derivations from observations including averages, normals, frequency distributions, extremes, drought indices, soil moisture deficits, degree days, comfort and biometeorological indices. Time sequences of climatological data, comparison with earlier periods, anomalies, etc. Also included are the spatial analysis (including model analyses, gridded data sets and maps) of climatological variables and derivations.

The above types of information are very useful in decision making and planning for the future as they will provide the guideline for predictions. These types of information could be obtained on various time scales like daily, weekly, forthnightly, monthly or annually. Recently, some new indices (concerning extremes, greenhouse climate responses, environmental hazards, ecosystem health, and energy demand/renewable natural resources) have been proposed which capture those existing changes in climate which may have an impact on environment and society (Easterling and Kate 1995).

Short Term Predictions and Impact Assessments

These form of information and services are very useful for short term planning. They include the yield, demands, incidence, economic prediction of 5 to 10 days ahead, based on short period forecaste of those weather variables which have an established climatological correlation with the output or welfare of the user.

Climate Prediction and Impact Assessment

These could be in various time scales and of various parameters of climate. This includes 'next month' climate forecasts, 'next season' climate forecaste, long lead climate forecastes (e.g for a season starting 1-13 months ahead); decadal and climate change forecasts, statistics of predicted climate. Impact and response assessment associated with all of the above and the assessments of savings and costs associated with impacts and response strategies.

Many users require combinations of various types of information, including short period forecasts of weather as well as climatological data.

Beneficiaries

Beneficiaries of climate information and services can be categorised as the following decision makers:

(a) International aid and donor agencies. Information can help in determining the location and nature of greatest difficulties, and import, distribution and storage requirements.

(b) Government, their ministries and agencies. Climate information is applied in policy making, strategic and tactical planning aimed at the overall national well being of individuals, consumers, and commerce and industry.

Action at government level could be the optimisation of trading opportunities and control of imports and exports, regulation of internal water and power supplies, strengthening of distribution systems, charge of taxation and subsidies, and mitigation adaptation to large scale problem/disasters such as epidemics, seawater inundation, foods, drought desertification. Climate information can also assist policy making in intra-sectorial matters (e.g. water for power or agricultural use). Specific measures of benefit would increase national trade margins (or reduce gaps), reduce hazards related deaths, increase accurate benefits to cost ratios of different mitigative/adaptive strategies.

(c) Regional or other geographic administrations or groups which have authority over social, economic or ecological affairs and their application, is as stated for that governments, their ministries and agencies.

(d) Sectorial interest such as farming, forestry, fisheries, water resource management, environmental quality, energy, transport, health, leisure, retail, banking, insurance, legal, construction, urban design, etc. Groups involved with sectorial interest may be international, national, regional or local.

(e) Specific individual decision makers (Users or companies) including a producer/supplier of goods or services, a consumer, a distributor, a profit taker, an insurer and a subsistence farmer.

A company can range from a small localised unit to a major international conglomerate. In the last case climate information and services will have significant value to operations (e.g inputs, supply, pricing, trade) and to strategic planning (e.g. location of works, diversification partnerships).

It is note worthy that there are several cases where use of climate information by a beneficiary causes disbenefit to others (e.g. it can offer one producer a competitive advantage over others, or reduce process to the consumer at the expense of the suppliers revenue). Hence market or national benefits cannot in general be obtained by multiplying up an individual producers benefit (or loss). Further, a limit on the distribution of some products (e.g seasonal forecasts) may yield a very large benefit to those who do receive them (e.g a future marketeer) but not be society at large in the geographic region covered by the climate information (especially if it is not in receipt of the product).

Measures of Benefits

These are the benefits derived from the availability and input of climate information and services to a user and their use in decision making processes of the recipient. A benefit can be defined as a marginal charge in the outcome of a user (or set of users) which is welcomed by the user(s) and ascribed to the application of the climatological input. Measures of benefits include: specified improvement in the quality of a decision, environment, output, etc. with the improvements expressed in descriptive, non-numerical terms, a quantification of a change of outcome (e.g. of commodity yield or demand) for a user of the information, though not converted into economic value; a change in out-come quantified economically.

General and Qualitative Benefits

The are varied but they normally fall into one of the following categories:

(a) Planning a specified action (A) (e.g choice of appropriate land usage, crop type, livestock types) irrigation systems, pesticide, antibiotic) taken in the light of climate information, is in some (unquantified) way better than the alternative.

(b) The use of climate information which has improved or will improve general design e.g of facilities for urban, working and domestic health and comfort, for food and live-stock protection, for protection against hazard/damage disaster.

(c) Use of recent observational data reduces wasted operational effort (e.g on spraying, transportation, application of fertilizer or pesticides) or enables irrigation, production distribution, storage to be optimized, especially if data are packaged with short period forecasts.

(d) Use of Climate information facilitates good justice (e.g in litigation/ liability cases, in determination of insurance conditions and premia).

(e) Use of climate information improves regional, national and international health, welfare and economy

(f) Use of climate information widens the horizons of thought and hence the option available to decision makers. A detailed qualitative assessment benefits have been documented (Schneirder 1974;

Berggren 1975, Eddy 1983). More up-to-date account of the qualitative benefits of the use of climatological information and services exist. (Maunder 1986; Philips 1986a, 1986b, 1989).

These cover areas like land area planning, water resources and supply, town planning, agriculture, forestry, fisheries, transport, building design, construction/engineering, energy, supply, communication, manufacturing, commerce, business indices, insurance, financial services, recreation sports and tourism, and medical/health services. It is important to note that qualitative climate information/services are very clear and persuasive (Hulme 1992). It is also very important to judge carefully the level of understanding or acceptance of a decision especially of quantitative information, and not to make such information over-complex in nature.

Quantitative Benefits of Information

These are those benefits that have not been converted to economic values. These include improvement (or loss reduction) in yield (e.g tonnage or corps, volume or tonnage of livestock products, volume of surplus reservoir water); improvements in production efficiency through control resources (e.g. dates and numbers of crop sprayings, fertilizer and pesticide applications; frequency of irrigation); improved prediction of demands (e.g. volume or number of retail goods, medical supplies, power, water supply, tourist accommodation); through optimized design of buildings structures, transport systems and urban areas, reduced power consumption (e.g. in KW hours), reduced maintenance effort (in man hour), lower incidence rate of structural failure or damage, reduced hazard risk, reduced incidence of disruption, increased utilization of natural energy, reduction in pollutant concentration, improved comfort indices and reduction of death and diseases.

The benefits are often determined prior to an economic values of the information. however, Cane (1994) has established a very high correlation between ENSO (EL-NINO and Southern Oscillation), event and the yield of maize in Zimbabwe, and the ability to use forecasts with a twelve month or so lead time to predict yield is clearly demonstrated. Hammer (1994) had done some quantification of value of ENSO and Southern Oscillation. Index (SOI) in prediction.

Economic Assessment

The economic assessment which quantifies the potentials or actual value of the application of the climate information and/or service to the economic welfare of individual decision maker are quite numerous, especially with regards to historical data services: but those for a market sector region or country are limited in number with regard to information on both historical and forecast climate. In general, different techniques are appropriate to benefit assessments for a market sector or a nation from those for an individual operator (or supplier) within a market. This is because information gives an individual decision maker a competitive edge; with the spread of the information within a market, that edge is lost and, probably of more importance, surpluses may be created resulting in a relative reduction of revenue to suppliers (Lave 1963). Thus, value cannot be simply multiplied up, to convert it from an individual to a market or national assessment. An exception to this would be where surpluses are not created e.g. where the information enables subsistence levels or yields to be reached and thus reduces import and distribution cost. The measures of benefits comprises improved earnings or reduced losses; net financial savings (i.e with an analysis of revenues and costs) or benefits to cost ratios; net present values. Quantitative assessments of economic values therefore range between the anecdotal to high complex, in depth economic investigations.

Types of Economic Benefit Assessment

It is possible to categories various types of assessment of economic benefits in order to indicate the depth of analysis in the assessment. However, it has to be admitted that such categorisation is subjective, contain overlaps and is based on the details in the literature. It should be noted that many assessments contain predictions rather than proof of savings. The type can be broadly described as:

(a) Assessment lacking utility information: Many statements and evaluations of economic savings and gains exist which do not openly take account of the ability of the user to act upon the advice given. The decision maker may be constrained in his options by institutional, resource, or technological problems. Whilst the apparent lack of consideration of the decision makers position the key factor in this group; other limitation sometimes exist in common with other types of assessment. These are: no account being taken of the cost of the information; no evidence of the marginal cost of responsive action; at sectorial level, economic value based on multiplying up improvements in individual income without consideration of impact of surpluses on market price; at national level, no account being taken of inter-sectorial gains and losses. A significant proportion (not all) of the assessments at this level are anecdotal.

(b) Assessments including Subjective Utility Information: These include evaluations which account at least implicitly for the actual or likely utility of the information when in the hands of the decision maker. The key factor here is that the calculation present some figures or evidence on the uptake and application of the climatological information in determining value, although it is not always clear if the figures have been agreed by the user. Such figures may be intuitive and the accuracy depends on the experience of the activity or market sector. Informed assessments of the fraction of decision makers expenditure or revenue which is weaker sensitive, and of the percentage of that fraction which may be saved by the application of climate information, have been used effectively to determine sectorial and national benefits, although few take accounts of inter-sectorial effects or international trading on revenue improvement (Basher 1996).

(c) Assessment Base on user Surveys: In these, utility is determined from the results of interviews with or survey of users and sometimes also based on detailed monitoring of their information processing and decision making in climate sensitive situation. Some surveys secure information on "willingness to pay" but this does not necessarily quantify value to the user, except that it is likely to be positive. The key feature of this category is that the user is definitely and directly involved in the generation of the actual economic values.

(d) Objective Models of Future Use and value: With respect to climate predictions, predicted economic benefits to individual users have been derived from objective modelling of decision making, this includes identification of the users feasible action and the economic consequences of various combinations of a prior action and the actual climatic conditions, and modelling of how action will be chosen in the light of the user's baseline expectation of the future climate and revised expectations given climate probability forecasts (Johnson and Holt 1986). The assumptions are made that the decision maker will wish to maximize the financial benefits of his operations. The actual benefits are predicted knowing the error distribution of the forecasts. The application of this technique has shortcomings. Predictions often assume that the historic price of the commodity will be the same for the future i.e be independent of yields, subsidy policy etc. Treatment of cost is variable, and there sometimes, appear little consideration for weather. A different action chosen on the basis of climate prediction would incur extra resource costs. Murphy (1995) notes various problem with the methodology used, e.g the assumption that decision makers are not risk averse (whereas many are), lack of account of institutional and cultural factors, uncertainty of what the baseline is based on, no account being taken of forecast format and specificity. Additionally, most studies relate to the developed world, and to agriculture, and to producers only.

Some do not have assessments of value as their main focus, but concentrate on decision theory, or risk analysis, or forecast quality assessment and use value assessment as an application of these.

The models for determining the economic value of information at market level are very complex and still not well developed (Johnson and Holt 1986, Anaman 1995). Evaluations which simply multiply up the results for an individual operator neglect the impact of surpluses (and thus price) of the information being available at market level, and yet few other evaluation exist. Models have to reflect how market equilibrium is modified by the introduction of extra information, and use hypotheses that individuals understand the basic structure of the market in which they operate, and act accordingly.

In summary whilst there have been major improvements in objectives methods for assessing the economic value of climate predictions, involving modelling of both single and subsequences of decisions, many results require sensitivity assessment to be applied to assumptions about the decision maker's resource costs, output process, inflation baseline, climatology and risk aversion, as well as subsidies and other factors affecting market or trade equilibrium. (Mjelde 1988, 1997). Whilst types (a), (b) and (c) apply to either past data or climate predictions, type (d) mostly refers to the later.

Examples: Specific examples of economic value of climate information and services are provided for historical data and derivatives (Table 1) short term climate based prediction, monthly/seasonal predictions climate impact assessment and other climate information (Table 1). The examples are combined under activity e.g. (agriculture, construction). Whilst examples which describe financial benefits to decision makers exist for many years of application, they are dominated by cases relating to agriculture (for all types of information), construction (for historical data), manufacturing and energy supply (for monthly and seasonal forecasts).

For historical data the examples cover all continents and most climatic regimes. For seasonal forecast they relate mostly to the tropics, subtopics and continental North America, which is not surprising, considering both the location of centres of forecasting excellence, and the strong connection between EL NINO/Southern Oscillation and Predictability in the tropics.

For historical data there are many examples of economic benefits to national or regional treasures, and at the level of individual end users such as farmers or companies. Many describe actual (rather than predicted) benefits, but a significant proportion (over 50%) appear to have been derived without input from the decision maker. Cases exist where damage avoided, or avoidable by the gathering and or application of climatic data is very highly valued. There can be no doubt, noting the analyses already available for tropical and sub-tropical areas and especially those pertaining to developing countries in South America and Africa, that ENSO based climate predictions can be a major tool in maintaining economic stability and sustaining development. The value of climate change and impact studies cannot be quantified as yet, but massive potential benefits exist.

SUMMARY AND CONCLUSION

The economic benefits clearly demonstrate the financial value to users/ decision makers of climate information and prediction services, not withstanding the several imperfections which exist in the assumption and methods used to determined value.

Information and services include provision of historical data or derivations from these, short period climate-base prediction, monthly and seasonal forecasts, climate change forecasts and impact assessments. Beneficiaries include international aid agencies, government and regional administrations, sectorial interest end individual and users including companies. Benefits are derived from the availability and input of information and services to a user and their use in decision making processes. A benefit is defined as a marginal change in the outcome for a user, welcome by the user(s) and ascribed to the application of the climatological input. Use of information by a beneficiary can cause disbenefits to others, which may not be acceptable in all cases to society at large; the distribution of seasonal forecasts needs careful consideration in this context.

Benefits are often expressed as improvement in quality (e.g of plans. designs, operation) or in quantitative but not-financial terms (improvements in yields. efficiency, safety, demands), or in economic terms. Whilst examples which describe financial benefit to decision makers exist for many areas of application. they are dominated by cases relating to agriculture (all types of information, construction (historical data), manufacturing and energy supply monthly and seasonal forecasts. For historical data. the examples cover all continents and most climatic regimes. For seasonal forecast they relate mostly to the tropics. sub-tropics which is not surprising considering both the location of centres of forecasting excellences and the strong connection between EL NINO/Southern Oscillation and Predictability in the tropics.

Table 1: Benefits of Climatic Data and Information

Option	Place	Savinig/Gain (per annum unless stated otherwise)	Detail
(a) AGRICULTURE NATIONAL/REGIONAL			
Crop Choice	East Africa	$US 100M capital (early 1950s)	Loss on groundnut scheme
	Senegal	$US 1.3 - 2.3M (1984)	Gain from earlier maturing variety of millet.
	USSR	250 - 700%	Based on agro-climatic zoning
Relocation of crop	Chile	$US 075 - 2.5M (1986)	Avoidance of fruit frost damage.
	Wales	£45 per acre (1970)	Earlier harvesting of potatoes
Crop production efficiently change of planting, spraying, etc. irrigation etc. dates.	Canafa (Nebraska)	$US 50-100M (1982)	Reduction in irrigation costs given climate information.
	Germany	DM11M (1988)	Use of recent climate based spraying for potato blight.
	Ireland	£1M (1987)	Use of model based spraying for potato blight.
	Senegal	$US 30k (1987)	Reduced pumping costs from dam related to SMD.
	UK	£1M (1966)	Use of climate based spraying for potato blight.
	UK	£1M (1966)	Use of climate based spraying for sugar beet virus.
	USA (Michigan)	$US 1.5M (1982)	Fruit spraying frequency reduced, based on climate data.
	USA (Missouri)	$US 475K (1965)	Use of climate data to avoid cotton replanting.

Change of livestock type.	St. Lucia	$US 250K (1987)	To improve milk production in prevailing climate.
General	Mali	$US 40 per hectare (1986)	Wide ranging improvements through use of agromet data.
(b) AGRICULTURE FARM LEVEL			
Crop production efficiency change of seeding rate, irrigation, fertilisation, etc.	Australia - farm	$A 10 per hectare (1994)	Use of SO1 to determine fertiliser application.
	Guadalaupe - plantation	$US 2.8M (1989) Cover 3500 hectares.	Fungicide application based on recent data.
	Kenya - farm	$US 217 per hectare (1982)	Basing all operations on onset of rainy season.
	UK - farm	£62 per acre (1963)	Use of SMD to decide date t potato irrigation.
	USSR - farm	Roubles 5 per hectare (1976)	Use of climate data to give barley seed density.
	USSR - farm	Roubles 2.6 per hectare (1979)	Use of climate data to decide fertilizer application date for wheat.
Relocation of crop	UK - farm	£66 per acre (1970)	Avoidance of soft fruit damage by frost.
(c) CONSTRUCTION			
Design of drainage systems	Australia	33M capital (1988)	Road drainage nationally - use of appropriate hydromet data.
	Canada	C1.5M capital (1994)	Use of site specific data for Nipawin dam spillway.
	UK	£300k (1966)	Use of dense guage network for deisgn of storm drains.
Design of power lines	Canada	$US 30M capital (1969)	Loss due to inadequate ice/wind stress loading.
	German	$US 125k capital (1968)	Saving on pylon costs based on climate data.

Design of leisure facilities	Canada	$US 1.5M capital (1986)	Saving on unprofitable outside viewing facility.
	Canada	$US 55k/25k capital	Saving on repair of commos/leisure facilities.
Design of oil platform	North Sea	£3.5M capital (1989)	Climate data prevented over-design, and improved operations.
Design of industrial complex	China	$US 20M capital (1985)	Saving on cost of iron-steel complex usin climate data.
Design of office block	USA	$US 17M capital (1973)	Loss due to inadequate window design.
Selection of all drillship	USA	$US 200M capital	Loss avoided by use of iceberg climatology.
Road/bridger design	Germany	$US 750k capital	Savings due to environmental impact study.
	USA	$US 200M capital	Avoidable replacement costs, if appropriate climate data had been used.
(d) OTHERS			
forest fires prevention	Canada	$US 20M (1986)	Forest wood saved by use of fire-indices
	Chile	$US 400k (1987)	Forest wood saved by use of fire indices.
Flood prevention measures	Canada	$US 185M capital (1979)	Savings on flood damage, with new dams' design based on climate data.
Gas/electricity supply	New Zealand	$US 2M (1988)	Savings by use of climate/ demand relationships, and use of short period forecasts.
	UK	£100M (1993)	As above.
Import dosts	Unknown	$US 5M (1984)	Extra cost of corn imports through delay in assessing drought data.
Manufacturing	UK	£10M (1993)	Production geared to relatier demand, based on demand/climate correlations.

Source: WMO Technical Notes 780 (1996).

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