Summary

The evaluation of the impact of Meteorological Institute services

Introduction

The evaluation of the impact of services provided by the Finnish Meteorological Institute is part of the 2006–07 EVASERVE project that develops information service evaluation tools and methods. The needs of transport and logistics information services are of primary importance, but the evaluation system is also meant to be applied to other sectors. One such area of application is meteorological information services.

Meteorological phenomena have a significant economic impact. Though weather forecasts and warnings can help prevent damages and plan operations and thus minimise economic losses, the socio-economic impact of meteorological services has not yet been explicitly calculated, or at least reported, with the exception of few published articles.

The main objective of this research was to evaluate the benefits of meteorological information services provided by the Finnish Meteorological Institute, covering the sectors of transport (all modes), logistics, construction and facilities management, energy production and agricultural production. The objective was to pinpoint the principal benefits of meteorological services in these sectors – especially in the case of frequently recurring common meteorological phenomena – and to valuate the magnitude of these benefits.

The impact analyses were limited to corporate and private services (including public information services) targeted to Finnish end users. In practice, this means the road weather information services that the Meteorological Institute provides through its Customer Service unit, the Internet and the media (newspapers, television, radio). The evaluation did not cover the Institute's internal operations.

Realisation and methods

The literature survey examined about 100 impact evaluations of meteorological services. Then the evaluations were supplemented with expert interviews and

statistical data. The evaluation of the other sectors than transport was carried out according to the same principles, but with more limited scope. The principle behind the evaluation process is shown in Figure S1.

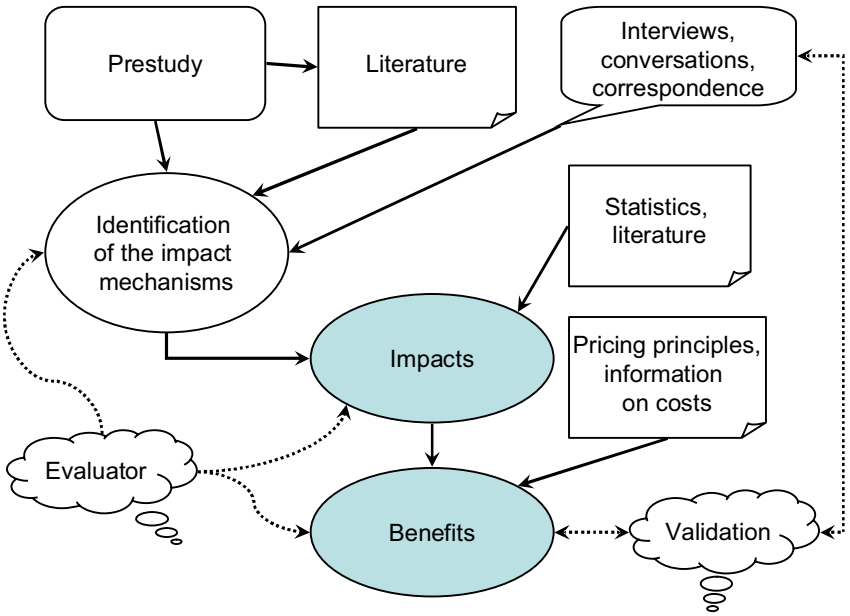

Figure S1. The principle of the evaluation process

Each sector was evaluated separately due to their unique natures, but still according to a common evaluation strategy. The Technical Research Centre of Finland (VTT) evaluated transport and logistics, construction and facilities management and energy production. The Meteorological Institute evaluated agricultural production. All of the evaluations utilised information service evaluation tools developed during the EVASERVE project.

Table S1 lists the evaluation data sources and the material used to valuate the impacts. The different evaluations emphasised different data sources (literature, interviews, statistics) due to the differing natures of the different sectors, the available source material and resources. For instance, the logistics evaluation method was based on a survey, whereas the road transport evaluation utilised also analytical models based on empirical and literary sources.

Table S1. Input data and valuation principles

Sector	Input data	Valuation, pricing
Transport		
- Road transport	Literature, statistics, expert interviews	Internalised unit cost values of driving costs in road transport, expert estimates
- Pedestrians and cyclists	Literature, statistics, expert interviews	Internalised unit cost values of driving costs in road transport, estimates based on the cost of medical treatment of slipping accidents, expert estimates
- Waterway transport	Literature, expert interviews, statistics	Internalised unit cost values of driving costs in road transport, estimates based on the actual cost of oil damage prevention, expert estimates
- Air traffic	Literature, statistics, expert interviews	Internalised unit cost values of driving costs in road transport, market prices, opportunity costs, expert estimates
- Rail traffic	Literature, statistics	Internalised unit cost values of driving costs in road transport, expert estimates
Logistics	Expert interviews	Expert estimates
Construction and facilities management	Literature, statistics, expert interviews	Statistics, individual expert estimates
Energy production	Literature, statistics, expert interviews	Expert estimates, literature
Agricultural production	Literature	Values found in the literature, expert estimates

The evaluation of the socio-economic impacts was kicked off by examining the impact mechanisms of meteorological services separately for each sector. These were then used to pinpoint the essential benefits of the services in each sector. Then the share of the benefits that was attributable to Meteorological Institute's services was allocated in accordance with the principles outlined in Figure S2. The annual costs used in the calculations are the Finnish Meteorological Institute's actual annual costs for 2005, i.e. 54 M€.

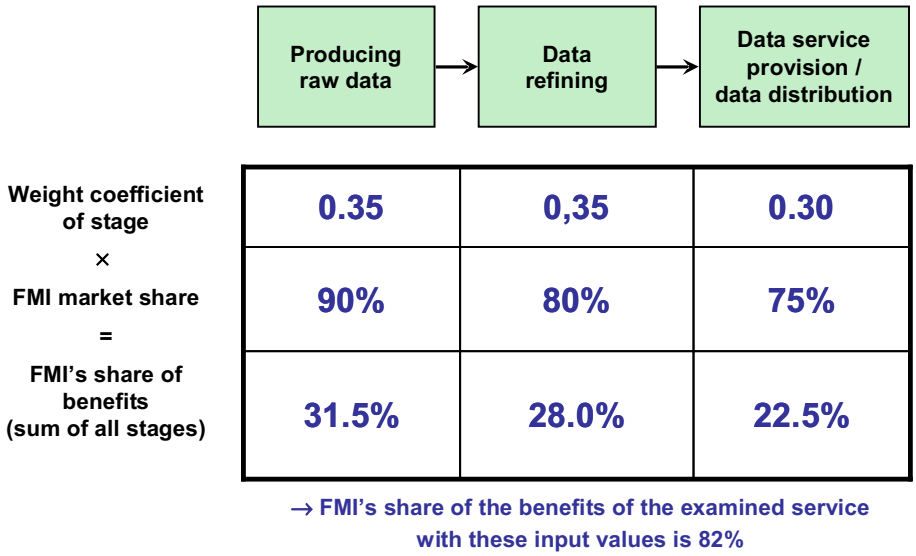

Figure S2. The principles used to allocate the benefits of weather information services (example case: air traffic).

During the allocation of the benefits of road weather information services, the service chain was divided into the production of raw data, data refinement and the provision of data to end users (including the packaging of information from a number of sources into one service), after which the market shares of the Finnish Meteorological Institute were estimated for each stage in every sector. Weight coefficients were determined for the different stages of the service chain. The sum of these weight coefficients is one. The weight coefficients are based on the use of resources (such as personnel, facilities and equipment) during the different stages of the service chain. The values of the weight coefficients of the different services were calculated for each sector based on the available material and the writers' own judgment. By multiplying the weight coefficients of the various stages with the estimated market share of the Meteorological Institute for each stage and by then adding up these sums we arrived at an estimate of how much of the benefits of road weather services in each sector are attributable to the Meteorological Institute.

Both current and potential benefits were examined. Current benefits are the benefits generated by existing services. Potential benefits are the benefits that could be attained by significantly improving the available meteorological services as well as their distribution and accessibility (Figure S3).

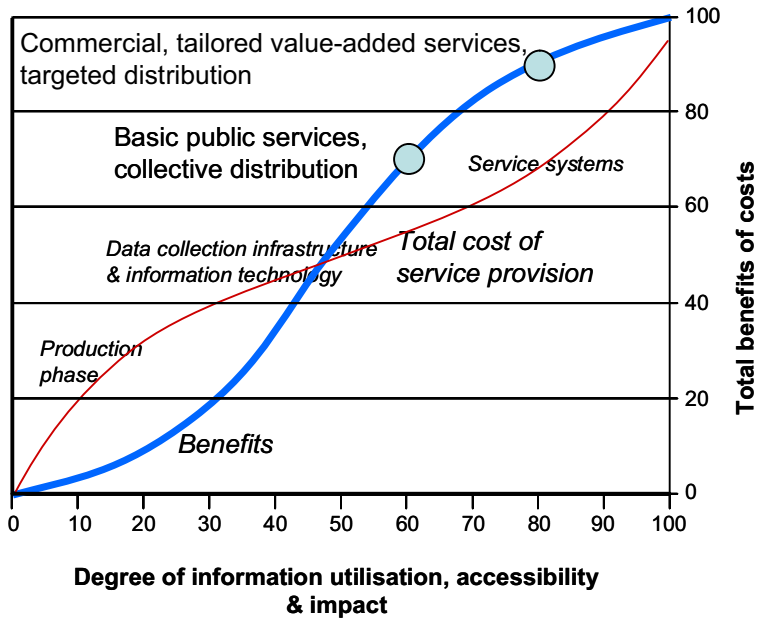

Figure S3. The accumulation of the benefits and costs of information services

The benefits are realised through services only when customers use the services and change their behaviour and decisions. The quality and number of users of each service determines the impact and consequent socio-economic benefits of the services. Costs are accrued from investments in meteorological observation systems and from the various activities included in the meteorological information production phase. The realisation of services and their consequent benefits also calls for the development of service systems and organisations based on observation and other data collection systems and the production phase.

Findings

Many sectors and actors in our society utilise different types of meteorological information, from historical data and distributions to real-time information and warning services and from different types of forecasts all the way to climate scenarios. Table Y2 outlines the meteorological information requirements of the sectors examined during this research categorised by their time horizons.

Table S2. Summation of the benefits of meteorological information utilised by different sectors categorised by their time horizons (++ = highly beneficial, + = beneficial).

Sector	Historical data and climatological impacts	Real-time information and warning services	Daily forecast (12 h–2 days)	Few day forecast (3–5 days)	Medium-term forecast (5–10 days)	Seasonal forecast (1–6 m)	Climate scenarios
Road transport incl. pedestrians & cyclists		++	+				
Waterway transportation		++	++	+	+		
Air transportation	+	++	+				
Rail transportation		+	+	++	+		
Logistics	+	++	++	+			
Construction & facilities management	+	++	++			+	+
Energy production		++	++	+	+		
Agricultural production	++	++	+	+	+	+	+

The above table illustrates the current situation. In the future, the significance and exploitation of long-term forecasts will likely increase as their reliability increases and forecast models become more refined. The significance of climate scenarios will also increase as the preparing for and adaptation to climate change increasingly takes place. Furthermore, better forecast models and warning services will be needed in the future to help us to deal with diverse exceptional weather-based phenomena.

Road traffic accidents and the subsequent costs to society can be reduced by directing information services at road users. Significant benefits can also be reaped in winter road maintenance, as meteorological information may be used to time maintenance operations correctly and to prevent unnecessary work. Weather and road surface condition services can provide significant savings when it comes to pedestrians and cyclists by helping prevent damages caused by slipping acci-

dents (preparedness of travellers and maintenance contractors for slippery conditions and their prevention).

The benefits for waterway transport and air traffic involve the prevention of accidents and environmental damages, a reduction in fuel consumption and emissions and an increase in the efficiency of operations. Meteorological services help rail traffic services to be more prepared for weather and rail condition-related incidents and to reach savings not only in railway maintenance but also in passenger and freight transport. Logistics and supply chains will benefit from the increased predictability of deliveries and from reductions in storage costs and reduced number of accidents.

Construction and facilities management will benefit from the reduction of damages resulted by mold and mildew as well as from the increased efficiency of facilities maintenance operations. Construction site operations planning will also become more efficient, providing savings by improving the allocation of resources. In energy production, weather and road surface condition services will increase the efficiency of energy production capacity and availability predictions and improve damage and incident control. The benefits for agricultural production are founded on the increased efficiency of crop protection, pest control and harvesting operations.

Table S3 outlines the principal benefits of road weather information services provided by the Finnish Meteorological Institute in the examined sectors. More detailed analyses can be found in the sector-specific evaluations in chapter 4. The annual socio-economic benefits of these services were estimated to currently be around 264–287 M€, to the extent that the benefits could be given a monetary value. In other words, each Euro spent on these Meteorological Institute services produces a benefit of a minimum of five euros each year, considering that the annual total costs of the Meteorological Institute was around 54 M€ in 2005.

In addition to the current benefits, the potential additional benefits of Meteorological Institute services in the examined sectors were estimated to be around 173–294 M€ (i.e. 473–581 M€; theoretical maximum benefit). Significant additional benefits can only be attained if services, their distribution and exploitability are improved significantly and if additional investments are made.

Table S3. The socio-economic benefits of road weather information services provided by the Finnish Meteorological Institute for transport, logistics, construction, energy production and agricultural production.

Sector	**Principal impacts and benefits of weather and road surface condition information services**	**Value of current benefits [M€ / y]** - existing services	**Value of potential additional benefits [M€ / y]** - developed services - Meteorological Institute's current market shares
Road transport (public roads)	Reduction in number of accidents, more efficient maintenance	11–20 M€ in total - accidents 9–18 M€ - maintenance 2 M€	- accidents 9–18 M€ - maintenance, not calculated
Pedestrians & cyclists	Reduction in number of slipping accidents, more efficient maintenance	- slipping accidents 115 M€ - maintenance, not calculated	- slipping accidents 129–214 M€ - maintenance, not calculated
Waterway transport	Reduction in number of accidents and environmental damages, more efficient operations, reduction in fuel consumption	25–39 M€ in total - accidents 14–28 M€ - oli combatting 10 M€ - rescue operations, fuel savings etc. 1 M€	Not calculated
Air traffic	Reduction in number of accidents and emissions, more efficient operations, time savings for travellers	54 M€ in total - accidents 46 M€ - fuel savings 4 M€ - airport maintenance 3 M€ - environmental damages 1 M€	Around 4 M€
Rail traffic	Higher accuracy of train timetables	0.3 M€	0.2 M€
Logistics, supply chain	Higher predictability of deliveries, reduction in storage costs and risks (accidents, damages)	Not calculated	5 M€
Construction & facilities management	Prevention of mold and mildew damage, more efficient maintenance (worksites and courtyards)	15 M€ in total - construction 10 M€ - facilities management 5 M€	15 M€ in total - construction 10 M€ - facilities management 5 M€
Energy production & distribution	Energy production capacity and availability predictions, prevention of damages and production and distribution interruptions	10 M€ in total - prevention of interruptions 2 M€ - production predictions 3 M€ - peat production 5 M€	8–23 M€ in total - prevention of interruptions 3–8 M€ - production predictions 5–15 M€
Agriculture	Crop protection, pest control, harvesting	34 M€ in total - increased crops 12 M€ - crop damages 12 M€ - more efficient cultivation 8 M€ - other benefits 2 M€	3–15 M€ in total - more accurate forecasts 1–5 M€ - seasonal forecasts 2–10 M€
Total	Higher predictability, better planning, more efficient operations, reduction in damages and number of accidents	264–287 M€ in total Note! The monetary value of all benefits has not been calculated	Potential additional benefits 173–294M€ (473-581 M€ in total for the analysed sectors)

Conclusions

The money annually invested in the Finnish Meteorological Institute is currently returned to society at least fivefold in benefits in the examined sectors. These benefits are to a great extent due to higher predictability rates and better planning of operations as well as better preparedness for accidents and the reduction of human and material losses caused by these accidents. Transportation sector is definitely one of the major beneficiaries.

The services provided by the Finnish Meteorological Institute have a significant impact not only on the examined sectors but also on other functions of society, such as the comprehensive management of natural disasters and major accidents (prevention, preparedness, advance planning, operational measures, information services). It is difficult to valuate these benefits, but they will come to a minimum of tens of millions of Euros.

It is further expected that exceptional weather phenomena will become more common. Therefore, the financial significance of climate scenarios needed to help us prepare for the effects of climate change is likely to increase.

The benefit-cost ratio of the services provided by the Finnish Meteorological Institute – calculated during this research – appears roughly to match the findings of several international studies.

The differences between the sectors that utilised meteorological services proved challenging for the research. Despite the partial heterogeneity of the sectors, the chosen research methods could be used to identify and valuate the magnitude of the main impacts of the services in all the examined sectors.

It was found that the methods used still need to be developed further, especially with regard to the consistent allocation of the current and potential benefits of meteorological services in the different sectors and the valuation of the monetary value of the benefits.

General proposals for further development

Since the Finnish meteorological observation network is by and large completed, considerable additional benefits can be achieved at reasonable marginal costs by investing in and developing various service systems. Not only should the services be developed, but their availability and useability should be improved,

communications technology should be developed and public awareness of the benefits of various services should be increased.

The Finnish Meteorological Institute's weather and road surface condition services are some of the best in the world. Their further development will create new equipment, advanced systems and deeper expertise, providing opportunities for the whole cluster of service providers, equipment manufacturers and research institutions.

The needs of customers should be examined thoroughly before developing meteorological information services. All potential users of meteorological services are not necessarily sufficiently aware of the opportunities and benefits better services might offer them.

Empirical study of the impact mechanisms of information services is one of the issues most in need of additional scientific research. For instance, how much can higher-quality weather and road surface condition information reduce the costs of road maintenance? The conceptual modelling of impact mechanisms – a prerequisite of empirical testing – began during this research. These initial steps have laid the foundations for further modelling.

The value of meteorological information for different actors can be assessed in greater detail by applying more sophisticated information valuation methods. Valuation methodologies were studied in another section of EVASERVE project. The first results were reported in VTT Research Notes 2394 (http://www.vtt.fi/inf/pdf/tiedotteet/2007/T2394.pdf). The methods used to allocate and determine the current and potential benefits of information services for use in evaluations need to be developed further.

The proposals for further development are outlined in greater detail in the sector-specific evaluations in chapter 4.