

CHAPTER 1 INTRODUCTION

1.1 Background and Objective of the Project

Dust and sandstorms (DSS) is the generic term for a serious environmental phenomenon in Northeast Asia. It causes considerable hardship, loss of income, disrupts communications, affects peoples' health and, in extreme cases, leads to death of people and destruction of livestock and crops over large areas in the affected countries.

At the request of the governments of the People's Republic of China (PRC) and Mongolia, the Asian Development Bank (ADB), United Nations Economic and Social Commission for Asia and Pacific (UNESCAP), United Nations Convention to Combat Desertification Secretariat (UNCCD), and United Nations Environment Programme (UNEP), initiated their own projects for the prevention and control of DSS in Northeast Asia. ADB prepared the concept paper for a regional technical assistance (TA) in early May 2002 and the three agencies of the United Nations made a project proposal to seek support from the Global Environment Facility (GEF) to address the same environmental problem in the region.

During a meeting among the environment ministries of PRC, Japan, Republic of Korea, and Mongolia in June 2002, it was proposed by the governments of the four countries that ADB, UNESCAP, UNCCD, and UNEP jointly develop an expanded TA to integrate the support from the international community, maximize the effects of the undertaking, and promote regional cooperation on DSS to be co-financed by ADB and GEF. A joint fact-finding and consultation mission comprising of representatives from the four international organizations led by ADB visited PRC and Mongolia from 26 August to 2 September 2002. The mission reached an understanding with the governments of PRC and Mongolia on all aspects of the Terms of Reference for the TA. The joint project on "Prevention and Control of Dust and Sandstorms in Northeast Asia (RETA 6068)" was then approved by ADB and GEF in December 2002 and its implementation commenced in March 2003.

The TA project was implemented together by ADB, UNESCAP, UNCCD, and UNEP in collaboration with the governments of PRC, Japan, the Republic of Korea, and Mongolia. A Steering Committee and three Technical Committees were organized for the implementation of the project with ADB as the executing agency responsible for the overall management and administration of the TA. UNEP, which is the implementing agency for the GEF co-financing resources, chairs the Technical Committee for the "Establishment of the Regional Monitoring and Early Warning Network."

The framework for the TA is shown in Appendix 3. The main objective of this collaborative project is to promote the establishment of a regional cooperation mechanism for the prevention and control of DSS in Northeast Asia. In this connection, specific outputs of the study come in two parts: (1) an initial institutional framework for regional cooperation on DSS, and (2) a regional master plan to guide regional cooperation to alleviate DSS in Northeast Asia. The components of the regional master plan will be (a) a phased program to establish a regional monitoring and early warning network for DSS in Northeast Asia, and (b) an investment strategy to strengthen mitigation measures to address root cause of DSS in source areas.

This report is the output of the study for the "Establishment of a Regional DSS Monitoring and Early Warning Network" conducted by the consultants under the guidance of a technical committee. It presents a phased program to establish a regional DSS monitoring and early warning network by strengthening the monitoring capacity in the two DSS source countries

(i.e., PRC and Mongolia), establishing an institutional framework among the four partner countries, and improving the information flow for effective early warning services.

1.2 Scope of the Project

1.2.1 Geographic Coverage

Although DSS in Northeast Asia affects a wide geographic area, the project involves four participating countries—PRC, Japan, the Republic of Korea, and Mongolia—all are members of ADB. Specifically, the geographic area covered includes part of continental Asia (PRC, the Korean peninsular, and Mongolia) and the neighboring islands of Japan. However, the wind and weather patterns of the DSS force may originate from the Russian Federation to the north and west and from Kazakstan to the west of PRC and Mongolia (see Figure 1.1). The DSS impact may be felt in Democratic People's Republic of Korea (DPRK) and in North America. Thus, DSS is an example of a trans-boundary environmental problem.

Figure 1.1 DSS Geographic Coverage in the PRC, Japan, the Republic of Korea, and Mongolia



1.2.2 Planning Timetable

The planning target of this project has a time horizon of 20 years commencing from 2004/2005. Due to advances in technology and the development of new and substantial information about DSS, recommendations specifically on monitoring and early warning are planned within the next two to five years.

1.3 The Dust and Sandstorms (DSS) Phenomena in Northeast Asia

1.3.1 Description and Classification

DSS involves strong winds that blow a large quantity of dust and fine sand particles away from the ground and carry them over a long distance with severe environmental impacts along the way. It often has severe impacts across the countries in the region. The major DSS originating source areas in the region are the desert and semi-desert areas of the PRC and Mongolia. Long distance transport of dust aerosol particles links the biogeochemical cycles of land, atmosphere, and ocean, possibly even influencing the global carbon cycle and having a significant effect on regional radiative balances and human health. A geochemically significant quantity of dust from Asian source regions, estimated to be 400-500 Tg, is deposited in the North Pacific each year. Approximately 240 Tg of dust is re-deposited in deserts of PRC each year while 140 Tg falls out over other parts of PRC.

DSS as a natural phenomenon has occurred for thousands of years in the region. During the past 50 years, however, the frequency has increased, geographic coverage has expanded, and damage intensity has accelerated. Available PRC statistics indicate that average occurrence of DSS was 5 times a year in the 1950s, 8 times in 1960s, 14 times in 1970s, and 23 times in 1990s. The region experienced 32 DSS in 2001 and the most severe DSS for decades in early 2002.

Large-scale DSS has significant environment effects that cause enormous economic losses, present serious public health concerns over a wide geographic area, and sometimes take human lives. For instance, the DSS on 5 May 1993 directly affected 1.1 million square kilometers in PRC, which resulted in human casualties (i.e., 85 deaths and 246 injuries) and destruction of 4,412 houses, 120,000 livestock, and 373,000 hectares of crop land¹. The direct economic cost of this DSS within the PRC alone was more than CNY550 million (about US\$66 million at the 2002 exchange rate). The two most severe DSS events in decades took place in March and April 2002. They swept across Mongolia and hit 18 provinces in PRC, the Korean peninsular, and a large area of Japan. Total suspended particulate levels in these affected areas were recorded from tens to hundreds of times higher than the national standards in these countries. The DSS in early April was so severe that Mongolia had to close its international airport in Ulaanbaatar for three days. Also, the Republic of Korea had to close their primary schools and cancel more than 40 flights departing from Gimpo Airport in Seoul. According to quantitative analysis report of DSS damages, the total damage cost of DSS amount to 5,922 billion Korean won (0.8% of GDP or about US\$ 4.6 billion at the exchange rate that time) all over ROK in 2002.² Satellite images of DSS and analysis of the dust samples collected on the ground have revealed that impacts of strong DSS events are not limited to the region, but reach as far as North America across the Pacific Ocean.

Of the 32 DSS events in 2001, 18 originated from the deserts of Mongolia while the remaining 14 originated from the desert or semi-desert areas of Inner Mongolia Autonomous Region in PRC. Natural elements, large desert and semi-desert areas, the strong winds from Siberia (Russian Federation) sweeping through these DSS originating source areas, severe and persistent drought, late killing frosts, and other natural disasters, contribute to DSS. Moreover, their effects have been strengthened and intensified significantly by human interventions over the last few decades, particularly through overgrazing, overly-optimistic

¹ Yang Youlin and Lu Qi In "Global Alarm: Dust and Sandstorms from the World's Drylands". UN 2002 for an account of the severe DSS event in the Hexi corridor of Gansu Province, PRC












² K.K. Kang, J.M. Chu, H.S. Jeong, H.J. Han, 2004. A Study on the Analysis of Damage of Northeast Asian Dust and Sandstorm and of the Regional Cooperation Strategies, Korea Environment Institute, p. 106

conversion of grassland to cropland, deforestation, and over-exploitation of water resources in the DSS originating source areas, which led to rapid land degradation and desertification. Although all the countries in the region are affected by DSS, urgent actions are needed in the DSS originating source areas in PRC and Mongolia to arrest deterioration of the land, before the situation becomes irreversible.

In addition to various initiatives of the governments, non-government organizations and volunteers from the DSS-affected countries have been actively undertaking cross-border activities to mitigate DSS events (e.g., planting trees in the DSS originating source areas), but in a sporadic and uncoordinated manner.

The occurrence of DSS is built upon two prerequisites. They are: (i) dry and loose surface, and (ii) strong³ and persistent wind. In meteorology, DSS has long been treated as one of the observational elements, as it is classified a disastrous weather phenomenon. It has been further divided into 11 categories by the World Meteorological Organization (WMO) to represent different characteristics and developing stages of the phenomenon (see Table 1.1).

Table 1.1 Classification of DSS by WMO

Code	Symbol	Description
6		Widespread dust in suspension in the air not raised by wind at time of observation
7		Dust or sand raised by wind at time of observation
8		Well developed dust devil(s) within past hour
9		Dust storm or sand storm within sight of the station during past hour
30		Slight or moderate dust storm or sand storm has decreased during past hour
31		Slight or moderate dust storm or sand storm no appreciable change during past hour
32		Slight or moderate dust storm or sand storm has increased during past hour
33		Severe dust storm or sand storm has decreased during past hour
34		Slight or moderate dust storm or sand storm no appreciable change during past hour
35		Slight or moderate dust storm or sand storm has increased during past hour
98		Thunderstorm combined with duststorm or sandstorm at time of observation

Note: Meteorological codes associated with DSS storms.

³ Generally 6.5 meters/second (m/s) is regarded as the threshold wind velocity to initiate a dust outbreak provided that the soil surface is dry. Soil texture is also a determining factor.

WMO has not established the unified criteria for distinguishing these categories. Therefore, different criteria are used in different countries. In PRC, for example, the China Meteorological Administration (CMA) has classified DSS into four categories based on visibility and wind speed for its technical regulation for operational observation (see Table 1.2). In ROK, a dust and sand concentration observation network has been established to measure PM₁₀ value, which is used to determine the category of DSS.

Table 1.2 The Classification of DSS in PRC

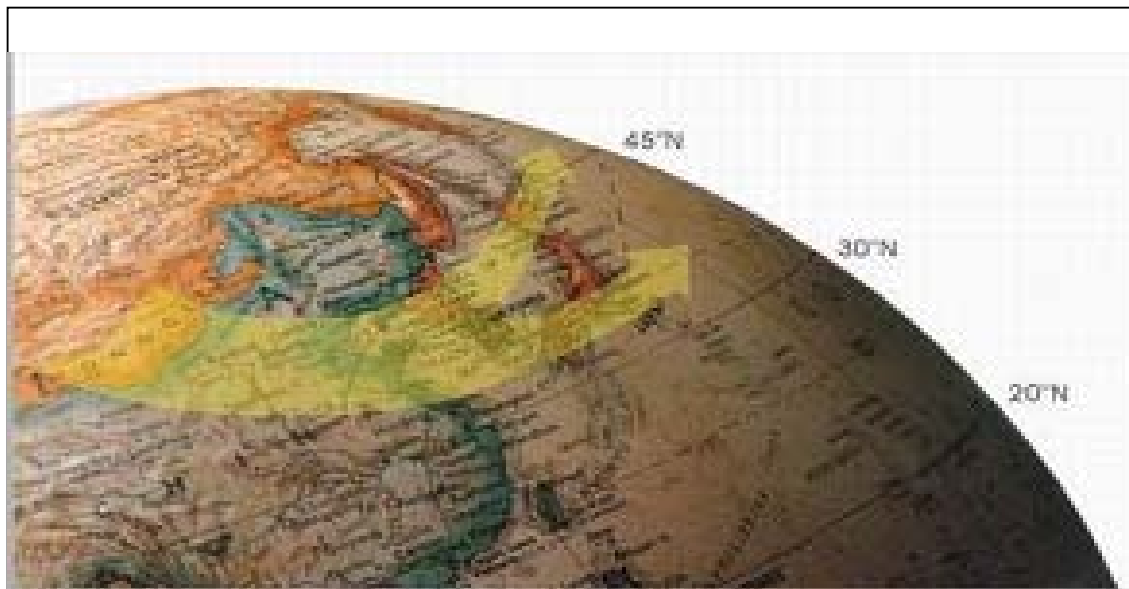
Categories	Characteristics	Horizontal Visibility	Weather Condition
Drifting dust	Dust suspending in the air	<10 km	Weak wind
Blowing dust	Dust or sand raising by wind	<10 km	Moderate wind
Dust and sand storm	Dust and sand raising by strong or turbulent wind	<1 km	Strong or turbulent wind
Severe dust and sand storm	Dust and sand raising by very strong or turbulent wind	<50 m	Very strong or turbulent wind

Source: China Meteorological Administration

1.3.2 Scientific and Technical Dimensions

Understanding a DSS event would entail the study of meteorological conditions and soil surface properties and how these interface with each other. This is briefly explained in this section. DSS in Northeast Asia mainly originates from the mid-latitude Desert Zone (N 40-45°E 90-120°). Driven by the East Asian winter monsoon, DSS generated from areas above moves southeast and then to the east parallel along N 40°, passing the Korean Peninsula and Japan to the northern areas of the Pacific Ocean (see Figure 1.2).

Figure 1.2 DSS Transport Process by Air Flows



Source: SEPA, Beijing

Normally, it takes one or two days to move from source areas to ROK and two or three days to Japan. In winter and spring, the area at N 40-45° is under the influence of the Mongolian high pressure system, which is cold and dry, while the land surface is very cold. Seasonal soil freezing may occur but temperature differentials between the land surface and the air mass develop as spring progresses.

A. Meteorological Conditions

The types of climatic conditions associated with DSS are as follows:

- *Cold wave* – Large scale DSS is always associated with strong cold wave, which comes from the areas of Siberia and Mongolia in winter and spring, generating strong air motion and, thus providing dynamic conditions for the occurrence and development of DSS.
- *Cyclone weather* – Mongolian cyclone is a typical weather system that may trigger and consequently facilitate the development of DSS. A strong Mongolian cyclone will form eddy circulation. Its size can be from the ground to a height of several thousand meters within which air flows violently both in the horizontal and vertical direction. Such a weather pattern is favorable for dust emission outbreak and transportation of DSS.
- *Atmospheric thermo-instability* – In desert areas, the near surface thermo-instability will cause vertical air motion and near surface turbulent motion, which will induce wind erosion and vertical transport of soil.
- *Sharp changes of weather elements* – Before and after the occurrence of DSS, some meteorological elements will change significantly such as low level pressure, temperature, humidity, wind, and visibility etc.

As DSS occurs under some typical weather conditions, the evolution of DSS outbreaks is predictable. Weather forecasts are the scientific basis for DSS forecasting.

B. Soil Surface Properties

The most critical surface parameters controlling the soil dust emission and associated DSS are the surface roughness length (highly related with land use/cover), soil texture, and moisture content. There is very limited information with respect to soil grain size distribution in the DSS source areas in Northeast Asia.

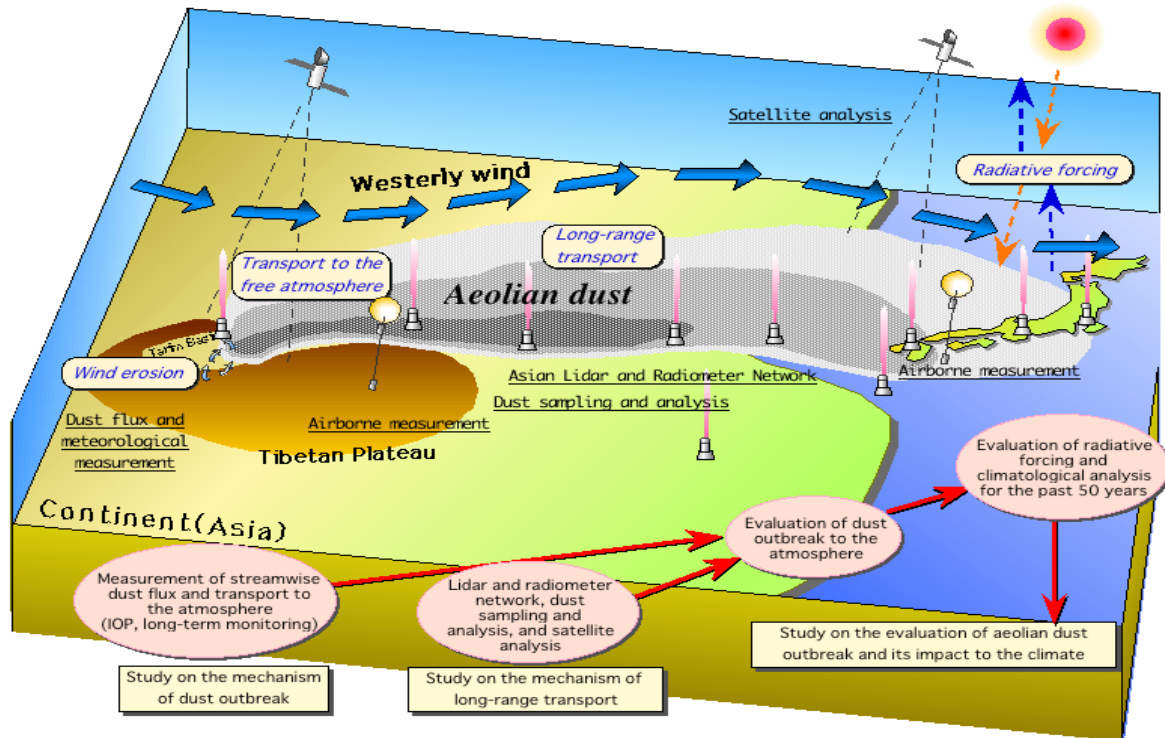
Dry and loose surface soil is a prerequisite for DSS. The types of soil and vegetation cover in the DSS source area are all factors influencing a DSS outbreak. A conceptual model shown in Figure 1.3 was developed by researchers of the Aeolian Dust Experiment Change Impact (ADEC)⁴ to help us better appreciate the factors and distances involved in DSS. It shows the components of DSS events in western PRC. It also shows the winds from the north that is implicated in the transboundary transport of dust aerosols to the Korean peninsula and Japan and areas beyond. It recognizes three important processes in each DSS event as follows:

- (1) The mechanism of the DSS “outbreak” (contributing factors and “drivers”);
- (2) The mechanism of long-range transport (contributing factors and “drivers”); and

⁴ Aeolian Dust Experiment on Climate Change Impact. (ADEC) is cooperative effort between Japan and PRC to assess the mechanism of dust supply to the atmosphere on a global scale and to evaluate the impact of Aeolian dust on climate through radiative forcing.

- (3) The evaluation of DSS and its impact (on people, on commerce, and on the regional climate via its effect on radiative forcing⁵).

Figure 1.3 ADEC Chart on Major Components of DSS Events



The model shows that the *first* step is the measurement of surface condition (even the dust flux and the associated meteorological conditions) in the source regions. This involves long term monitoring at ground based monitoring stations.

Secondly, airborne measurements are also used to assess dust transport, usually via aerosol sampler, weather balloons and instruments like transmissometer (visibility), sun photometer (optical depth), radar, radiometers and LIDAR (light detection and ranging equipment). Dust collection through sampling equipment installed along the expected storm path aids in the analysis and identification of dust sources. Satellite data are also used as both PRC and Japan have dedicated weather satellites. Data can also be obtained from geostationary and polar-orbit satellites maintained by USA, Russia, and other nations.

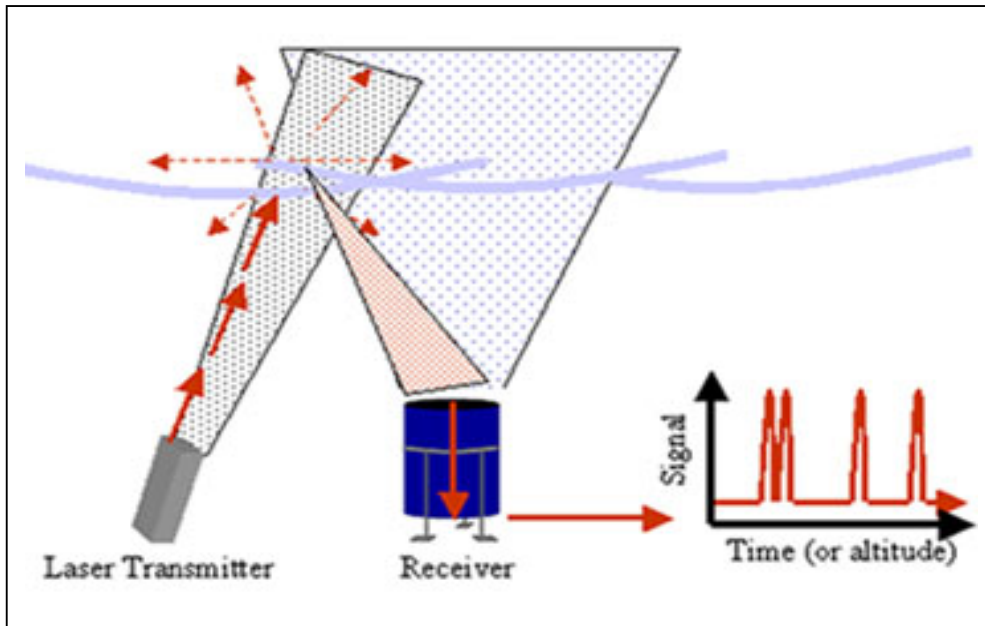
Thirdly, analysis of long-term weather records and associated data on DSS is helpful in the development of transport models as predictors of the DSS behavior and its impact on long-term climate change through the effect of radiative forcing.

⁴Radiative forcing refers to the adsorption and scattering of both incoming and terrestrial radiation. It has the potential to impact on global climate.

Box 1.2 LIDAR – A Useful Tool for DSS Monitoring

LIDAR (Light Detection and Ranging) is a kind of radar using light instead of radio waves. It transmits pulsed laser light to the atmosphere: and collects the light reflected from the atmospheric molecules, clouds, and aerosols with the help of a receiving microscope. Distribution of the atmospheric minor constituents of vapor, temperature, aerosols, and clouds are derived from the intensity of the received light; and distribution of wind is derived from the Doppler shift.

Figure 1.4 Illustration on the Operation of LIDAR



1.4 Technology and Methodology of DSS Monitoring, Forecasting, and Early Warning

This section presents some definition of terms and general view on technologies and methodologies relating to DSS monitoring, forecasting, and early warning in support of the flow of discussion in this report. An expanded explanation of the technologies and methodologies involved in DSS monitoring and forecasting is given in Appendix 4.

A. Monitoring

Monitoring is the systematic and repeated observation of a specific phenomenon, usually organized through appropriate planning for some particular purpose(s). It is focused on the occurrence frequency, significance or severity, dimension, and duration of the target events. For DSS events, the contributing factors that need to be monitored are the climatic conditions and land surface conditions. Impacts of the events that also need to be monitored are the damages to infrastructure and adverse effects on social and economic activities, air quality, and public health.

Monitoring can help build up a profile of events for better understanding, which in turn help in preparing appropriate actions for response to subsequent events. Moreover, analysis can

be conducted based on a large quantity of monitored data and through the application of very sophisticated analytical instruments.

B. Forecasting

Forecasting is an assessment made (based on the analysis of data derived from monitoring activities) of the possibility of the occurrence of certain events in a certain future timeframe, which may include the scope, dimension, severity, duration, and impacts of the events under consideration. Forecasting can be classified by different criteria. One commonly used classification is based on the following timeframe of the forecasting assessment:

- Short Term Forecasting – the possibility of occurrence of the event within a short timeframe of say one or two days;
- Medium Term Forecasting for one or two weeks; and
- Long Term Forecasting for one or two years.

Actual duration varies from place to place and may depend on the purpose of the forecast.

C. Early Warning

Early warning (EW) is the advice that is provided, normally based on monitoring and forecasting analysis, to concerned parties of a forthcoming event before it occurs. The purpose of the early warning is to raise awareness and preparedness of the concerned/affected parties for minimizing, if not avoiding, possible adverse consequence.

The relationship among monitoring, forecasting, impact assessment, and early warning are shown in Figure 1.5. DSS monitoring systems rely on data that are either derived from surface-based observations or satellite-based observations. With the use of available forecasting systems, DSS outbreaks can be predicted and a system of EW can be employed. Moreover, monitoring systems can be expanded to assess DSS impacts and source identification for other analytical studies.

Modern technologies for monitoring include satellites that provide imagery and other digital data. The first earth resources satellite went into orbit in 1972. Since then many different satellites have been launched. The main characteristics of the data provided by these satellites that are relevant to EW relate to cost-effectiveness, image quality, and frequency. Aspects include Orbit Return time (repetitive), scene area coverage, ground resolution (pixel size) and spectral resolution. There are both polar-orbiting and geostationary weather satellites maintained by USA, Russia, and others. Both China and Japan maintain their own dedicated satellite systems that aid in tracking and mapping DSS events. The Japanese satellites are ADEOS I and II.

The use of advanced aerospace technology, remote sensing, and Geographical Information Systems (GIS) as well as ground-based radar and LIDAR have enhanced rapid development of early warning in a more visually useful and cost-effective manner.

Figure 1.5 Relationship of DSS Monitoring, Forecasting, Early Warning, and Impact Assessment

