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President Wolfensohn - Briefings Books for Presidents Meetings - Briefing Material
El Nino - Briefing Requested by James D Wolfensohn [JDW] - November 2, 1997

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WBG Archives

El Nino

Bank Briefing per your request

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A. CLASSIFICATION

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☐ Phone Logs
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☐ Press Clippings/Photos

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☐ Social Events
☒ Other

B. SUBJECT: El Nino - Briefing requested by JDW. // Submitted to JDW on 02/11/97. // Prepared by Robert Clement-Jones, (AFTE1) 10/10/97. Robert T. Watson, (ENV) 10/10/97, Eugene D. McCarthy (LCSFP) and Anthony J. Ody (LCRVP) (10/10/97, Malcolm Bale (EASRD) and N. Harshadeep (SASEN) // EXC: LP (11/02)

Brief includes:

- Impact on Southern Africa
- Scientific Aspects
- Impact on Latin America
- Impact on East & South Asia

DATE: 11/02/97

C. VPU

Corporate

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D. EXTERNAL PARTNER

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☐ MDB/Other IO
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☐ Part I
☒ Part II
☐ Other

E. COMMENTS:

File Location ☒ EXC ☐ ISC ☒ Archives	Cleared By Luigi Passamonti	Date: 11/19/97
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 View Update History

El Niño 1997/98 and Southern Africa

How will El Niño affect the weather in Southern Africa?

1. There is a strong correlation between El Niño events and below normal rainfall (usually resulting in drought) in Southern Africa, (i.e. countries south of Tanzania). The impacts are not uniform. The most recent overall forecast was prepared at a meeting of the Southern Africa Climate Outlook Forum (see map):

- for *October-November-December 1997* - higher than normal rainfall is expected in northern Tanzania, while in other areas normal conditions with perhaps favorable early rains (and early onset) are likely
- for *December-January-February-March 1997/8* - the northeastern regions are expected to experience normal- to above-normal rainfall. For the other areas there is a distinct downward trend towards below normal rainfall which may be significantly below normal over South Africa, southern Mozambique, Lesotho, Swaziland and Zimbabwe. The northern and western extent of the below normal conditions is uncertain at this stage. In particular, the likely impact in parts of southern Malawi and central Mozambique is unclear.

2. Based on experience from previous El Niño events - much of **Southern Africa is likely therefore to experience below normal rainfall**. The extent both in spatial and temporal terms is uncertain at this stage but could be extensive due to severity of the current El Niño event. This would mean severe drought in southern Africa, on a scale matching the 1982/83 event. Also uncertain is the follow on into the 1998/99 season, this will depend on the intensity and duration of the El Niño event.

What are foreseeable areas of vulnerability and the consequences?

3. Hard to predict with certainty. Experience from 1991/92 El Niño drought included:

- loss of GDP in Zimbabwe of +/-7%,
- loss of industrial production in Zimbabwe of +/- \$100 million because of loss of hydropower (from Lake Kariba),
- food deficit in region totaled 3 million tonnes (\$7 billion = 20 times - World Bank lending for African agriculture per year)

4. The current El Niño event could lead to:

- decrease in agricultural production (particularly rainfed smallholder sector)
- increase in poverty
- fall in GDP in region (one South African business group suggests that this event could knock one percentage point off South African GDP, the impact likely to be greater in other countries)
- increased pressure on balance of payments
- increased need for food imports
- decline in industrial production
- social dislocation

5. Mitigating factors this year include:

- better levels of water and food stocks than before the 1991/92 drought, particularly in South Africa and Zimbabwe
- much greater level of awareness and chance to prepare

Uncertainty remains but what can be done?

6. The rainy season starts in mid-October in Southern Africa so the region is very much in the planning and awareness raising mode. Awareness levels are far higher relative to any previous El Niño event and information is critically important. In Southern Africa this is due to a number of factors:

- Much better information being provided earlier than ever before
- NOAA and others have leading effort to (a) improve long lead forecast predictions and (b) develop applications so that users can benefit from them
- Southern Africa Climate Outlook Forum (sponsored by NOAA, EU, WMO and others) met in September 1997. Developed consensus forecast, used as basis for predictions in region (see above)
- Messages are getting out to farmers (see newspaper clippings) and others

What are key Governments doing?

7. All Governments in the Region are mobilized. All Governments except Angola participated in the Climate Forum Meeting. A few examples:

- **Mozambique** - The Government has convened a series of meetings for national drought preparedness, involving different ministries, NGOs and donors. Brochures have been prepared for farmers. World Food Programme (WFP) is lead donor for drought contingency planning exercise
- **Zimbabwe** - An Interministerial Committee headed by the Director of National Planning is meeting regularly. Frequent communications through the press, radio, and television have been made to warn people to prepare for a tough season ahead. The Grain Marketing Board is mobilized to ensure that grain stocks are sufficient. The Ministry of Finance is re-examining the Budget in light of the predicted drought.
- **Malawi** - Levels of awareness are very high. An Interministerial Group headed by the National Planning Commission is also meeting regularly. WFP is also leading the donors in the drought contingency planning exercise. The Government issues radio and press messages, and agricultural extension services are informing farmers on the prospect for a poor season, but encouraging them to plant early and grow drought resistant crops. Discussions have restarted between the Bank and the Government of Malawi on an emergency scheme for ensuring that hydropower is available from the Shire river.
- **South Africa** - Interministerial group mobilized and active. Meetings have been held at regional and national level to prepare. A very high level of awareness among the private and public sectors. Water managers are planning now for potential shortfalls.
- **Zambia** - Similar to other countries - with an interministerial group and a donor group headed by WFP. High level of awareness.

What is the Bank doing and what is the Bank's role?

8. The Bank has been very active with other partners to help ensure a high level of awareness. Since mid-August the Bank has had a standing group on drought for Southern Africa. The Bank was represented at the Climate Outlook Forum, and has helped disseminate the findings through the international and local media - Reuters, VOA, BBC, CNN, press conferences in South Africa.

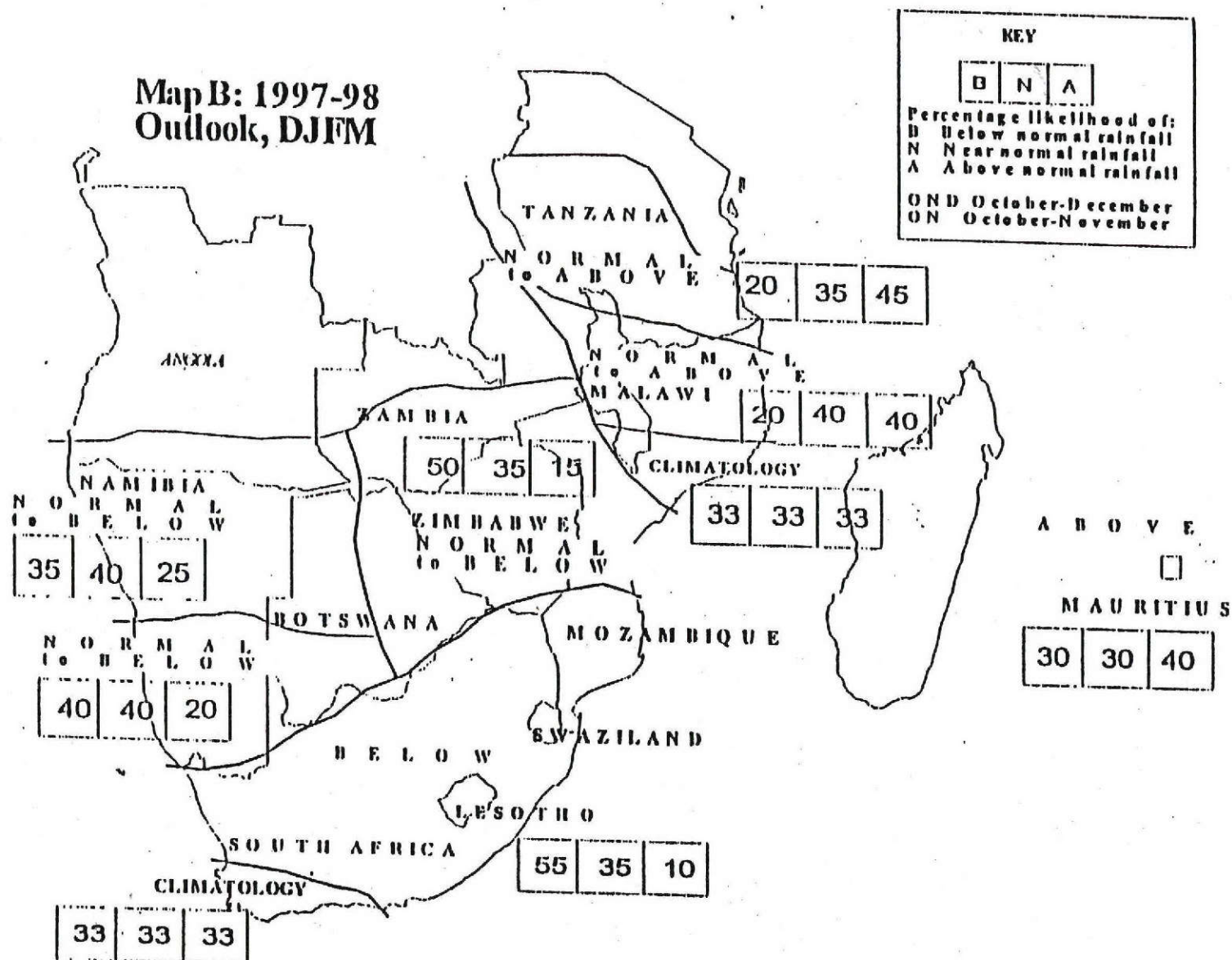
9. Country Directors have been visiting countries in the Region and have been discussing this with Ministers and others in-country. The Bank has hosted a number of meetings (e.g. in Zimbabwe and Malawi).

10. The Bank's role in Southern Africa:

- ***short term:*** helping disseminate information at all levels, participating in donor meetings, and contributing at the technical level (e.g. on promotion of short season crops, water harvesting)
- ***medium term:*** looking at existing and new operations to see how they can be mobilized and directed towards dealing with drought (e.g. agricultural extension programs, Zimbabwe Agricultural Services Management Project has drought component). Careful monitoring of economic conditions to determine whether additional support will be needed through BOP support/adjustment credits. Such support, if necessary, would not normally be needed until mid-1998.
- ***longer term:*** helping to develop capacity and institutions in the Region to use long-lead forecasting applications. Working with SADC and with member states on water resources management strategies for the region. Reorienting agricultural extension and research towards reducing drought vulnerability of farming systems. Building climate risk analysis into Bank projects and programs.

Robert Clement-Jones
Environment Group, Africa Region
Friday, October 10, 1997

Map B: 1997-98 Outlook, DJFM



Users are strongly advised to contact their National Meteorological Services for interpretation of this Outlook and for additional guidance.

All statistics are based on the period 1961 to 1990.
 SADC member states as of August 1997 are named.

Source: Southern Africa Regional Climate Outlook Forum, Kadoma, Zimbabwe, September 1997

Prepare for tough season, farmers warned

ZIMBABWE
HERALD
FRIDAY 12 SEPT
1997

SMALLHOLDER farmers should prepare for a difficult agricultural year because of the predicted poor season and financial institutions unwillingness to continue lending, owing to some farmers failure to service debts.

The warning was made by the Farmers' Development Trust executive director, Mr Lovegot Tendengu, in an interview.

He said after a meeting with a number of financial institutions, both established and emergent,

it had become apparent that borrowing this year would be tougher than last season.

This was mainly because some smallholder commercial farmers were unable to service debts and this made it difficult for financial houses to continue financing them.

Mr Tendengu could not say how much the farmers owed financial institutions.

He, however, noted farmers were not entirely

to blame for the failure to repay as the incessant rains which caused waterlogging and leaching had impacted on crop yields.

"As a result of the El Nino effects, we wish to warn all farmers to brace themselves for the possibility of a drought this season. All indications are that there will be a harsh dry weather this year," said the executive director.

Farmers should therefore retain enough food for domestic consump-

tion and also plant moderate hectarages that they could effectively manage.

Mr Tendengu said all forms of conservation tillage and water harvesting technologies should be implemented. Diversification into drought tolerant crops or short season varieties should be encouraged.

He said farmers should strive to reduce dependency on finance houses adding the farmers should also insure crops against hail and ban fires.

STEPHEN DEDZA WHO WOULD

Malawi

Make ready your farms urges DC

DEDZA:

THE district commissioner for Dedza Felix Mkandawire said on Wednesday that farmers needed to be aware of the catastrophic effects of the El Nino phenomenon in order for them to put measures in place to lessen the effects of the forecast drought.

Mkandawire was speaking at Chafumbwa EPA 1 in the area of chief Pemba in the district at an open day to launch an extension campaign on food security at household level during drought.

He explained that the drought, to effect the southern part of Africa including Malawi as forecast by the weather experts, was threat to the agricultural industry and as such farmers

needed to make some preparation to reduce its severity.

Mkandawire, who is also DDC chairman in Dedza asked farmers to prepare their fields in time in readiness for early planting and to plant early maturing maize varieties which can do well with little rainfall.

The district commissioner also called on farmers to follow soil and water conservation measures in order to boost agriculture.

He appealed to them to promote livestock production mostly small stocks which he said would be of great help in times of drought.

The MP for Dedza North East Francis Kangaude warned that unless farmers made preparations well ahead, the effects of the drought could be worse.

WORLD

World Bank joins team to save El Niño 'victims'

HOME

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NEWS & VIEWS

WASHINGTON - The World Bank has joined other lenders in looking at how to help countries threatened by drought and flooding caused by the El Niño phenomenon wreaking weather havoc around the globe.

Officials said on Tuesday that the international lending agency's involvement reflected growing concerns that a large number of countries faced withering staple crops due to drought and damaging storms and floods.

"We don't know yet how severe the crisis is going to be," said Robert Clement-Jones, an economist with the World Bank's Africa environmental group. "But we must be ready to provide assistance where needed."

Officials with the World Bank and the Inter-American Development Bank (IADB) have both started talks with countries in Central and South America threatened by El Niño, which is caused by the warming of Pacific waters off South America.

The government in Peru, the country closest to the phenomenon, and the World Bank are discussing an emergency loan of about \$150m, officials said. The bank has sent a team to Peru to assess the situation.

A World Bank official said an emergency loan for Ecuador was also being discussed.

In Africa, the World Bank has taken part in El Niño planning meetings with government authorities from Mozambique, Zambia and other countries to prepare for possible food shortages.

The bank plans for now to use existing loan funds in Africa to help governments prepare. "We don't know the extent of the crisis, of the food shortfalls," Clement-Jones said. "So obviously this requires constant monitoring."

The Peruvian government said IADB had already agreed to grant it a \$100m emergency loan.

IADB officials would not confirm the Peruvian loan, but said two bank teams would visit several countries in Latin America next week to discuss their emergency plans.

"We're now in the early phase of identifying the need," an IADB official said. "We're looking at a long process here because the El Niño has to play itself out."

The US Agency for International Development, which provides assistance to developing countries, may also step forward with aid.

The environmental group Sierra Club commended the World Bank's efforts.

"It's commendable the bank is trying to look ahead and help these countries prepare for this climatic event," said Larry Williams, director of the group's international programme.

The last major El Niño, in 1982-83, has been estimated to have caused more than \$13bn of damage worldwide. All the evidence suggests that the current El Niño pattern, the 13th since 1950, will rival the last. Across the globe, the phenomenon is already being blamed for economic turmoil. - Reuter.



OFFICE MEMORANDUM

DATE: October 10, 1997

TO: Mr. James D. Wolfensohn, EXC

FROM: Robert T. Watson, ENV



EXTENSION: 36965

SUBJECT: El-Niño: Scientific Aspects

Per your office request, here is a brief note regarding the scientific aspects of El Niño phenomena.

The El-Niño phenomena occurs naturally every two to seven years when a pool of warm water forms in the Pacific Ocean off South America near the equator. The warm ocean temperatures cause major changes in atmospheric circulation patterns, resulting in significant changes in rainfall patterns throughout the tropics and sub-tropics. Some areas experience droughts (e.g., north-east Brazil; the southern part of Africa; areas in south-east Asia, including Indonesia, Singapore, and Malaysia; and northern Australia) while others experience floods (e.g., north western Peru and the coastal areas of Ecuador)—Figure 1 shows the difference in rainfall between El-Niño years and non-El-Niño years, with the blue areas being areas of drought.

This year a major El-Niño event is underway. Ocean surface temperatures in the Pacific are already 5 degrees Centigrade above average, with the pool of warm water being larger in area than the whole of the United States of America—Figure 2 shows the large region of warm water in the Pacific.

Based on the observed rate of ocean warming, many scientists believe that this El-Niño will be the largest ever recorded (records go back 150 years), possibly even exceeding the 1982-83 event—Figure 3 shows the observed rates of warming for several recent events.

The latest “weather” predictions clearly suggest drought and flood patterns consistent with earlier El-Niño years—projected changes in rainfall are thought to be somewhat similar to what occurred in 1982-83.

While the El-Niño phenomena occurs naturally, it appears that the magnitude and frequency of these events has increased over the last twenty years, leading some scientists to speculate that this apparent trend may be linked to human-induced global warming, i.e., the greenhouse effect. However, this is still only suggestive, clearly not proven.

Attachments

Xie–Arkin DJF Precipitation Warm (83,87,92) – Cold (85,89)

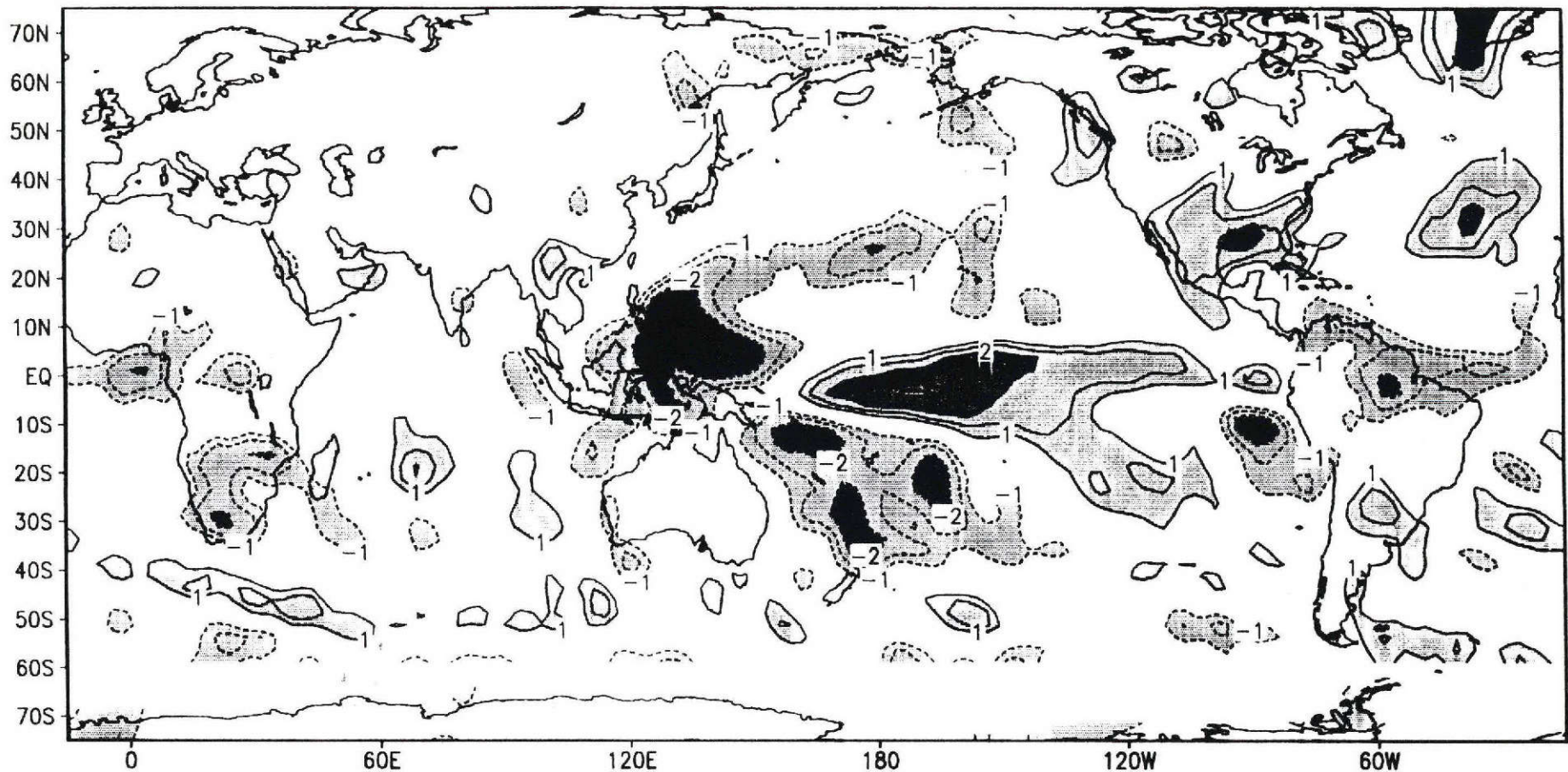
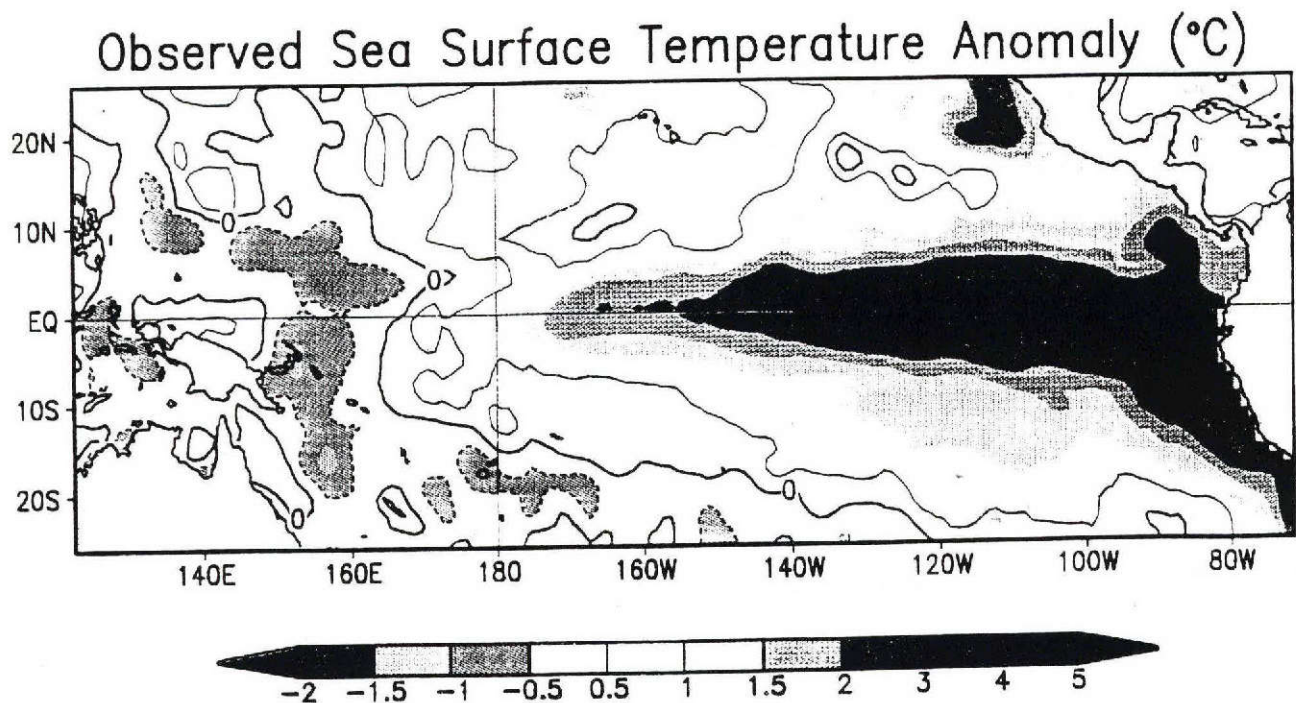
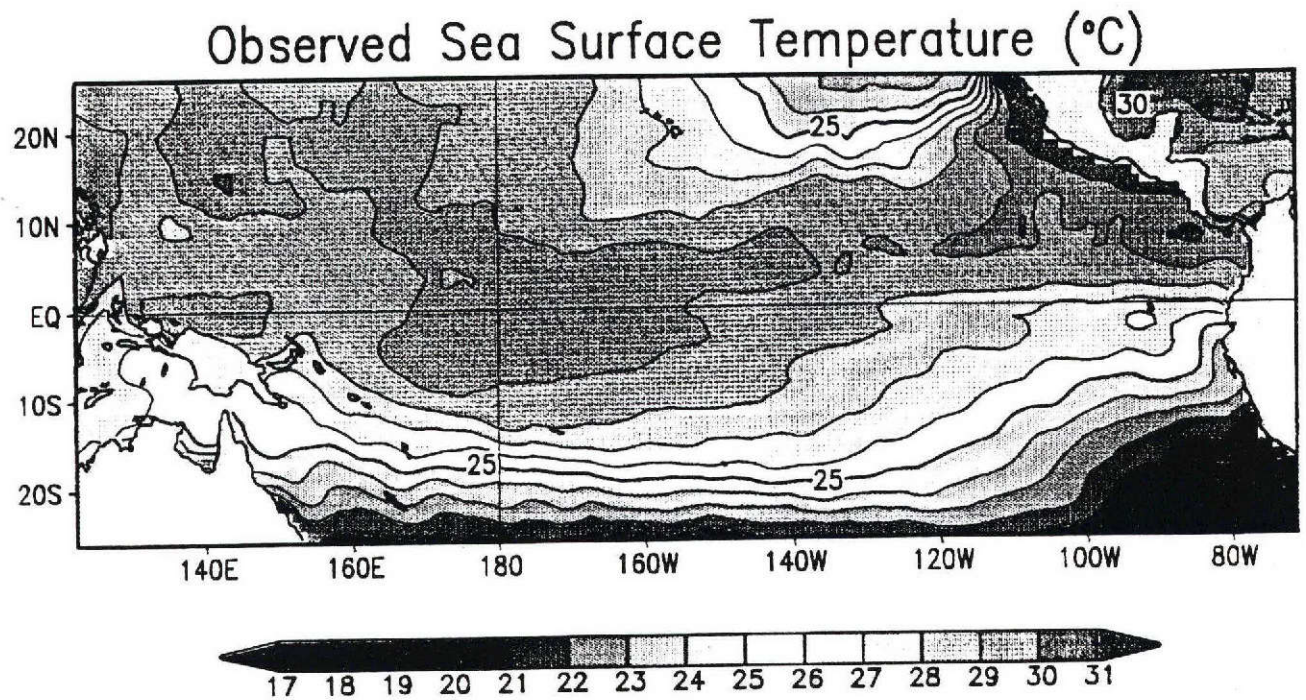


Figure 1

standard deviations
-2 -1 1 2
Center for Ocean–Land–Atmosphere Studies

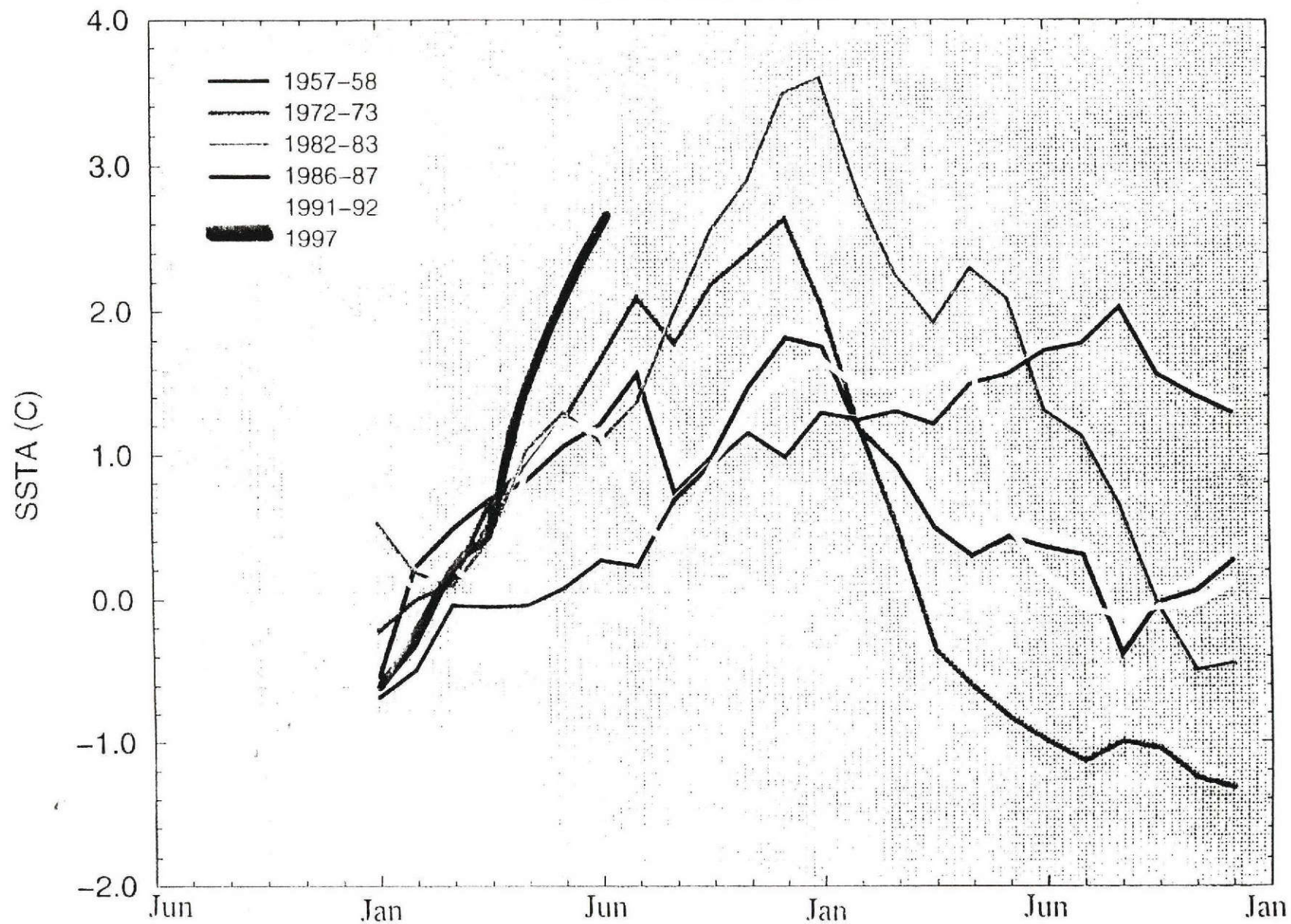
Figure 2



7-day Average Centered on 13 August 1997

NINO3 SST COMPARISON

REYNOLDS OI SST



Comparison of tropical Pacific sea surface temperature departures (SST, °C) averaged over NINO3 region (5°S - 5°N 150°W - 90°W) for six El Niño events.

El Niño and the LAC Region

Brief for Mr. J. D. Wolfensohn

The periodic disruption of Pacific weather patterns known as El Niño has in the past brought disaster in its wake to South and Central American countries: causing droughts where there is normally rain, severe flooding in arid regions, and major disruption to the economies of several of these countries. The 1982-83 El Niño, the most severe in recent history, led to up to 100 in. of rain falling over six months in the coastal desert region of Ecuador and Northern Peru, severe drought in the Andean highlands of Peru and Bolivia, and both severe drought and flooding in other regions of Latin America, extending from Central America through North-Eastern Brazil to the Paraná river basin area of Argentina. The combined impact of the 1982-83 event on the regional economy involved significant losses of agricultural production and fisheries' exports, major damage to physical infrastructure as a result of floods, as well as incidental losses of output due to e.g., shortages of electricity in drought-affected areas normally dependent upon hydro-power. Overall losses in GDP, in the most vulnerable countries of the region, are estimated to have amounted to perhaps 2 percent in Ecuador and -- on some estimates -- as much as 6 percent in Peru. Some climatologists are predicting that the 1997/98 El Niño, already evident in the anomalously high sea surface temperatures in the offshore coastal waters of western South America, could have a climatic impact that exceeds the earlier 1982/83 El Niño.

Scientific knowledge and understanding of El Niño has improved over the past two decades. This, together with improved remote sensing techniques, now allows the dramatic climate impacts to be predicted by ocean-atmosphere models with a higher degree of certainty than in the past (though even so, forecasts are still limited by an insufficient understanding of the intrinsic mechanisms responsible for the El Niño phenomenon). With better advance warning than ever before, the overall detrimental impact can be mitigated by taking the necessary preventive measures in advance - in particular, flood prevention infrastructure works and drought relief preparation activities.

Several South and Central American countries have been taking preliminary steps to prepare themselves for a 1997/98 El Niño emergency. In Peru, probably the most vulnerable of all South American countries, President Fujimori himself is taking a prominent personal role in the design and implementation of a major prevention program, including extensive upgrading of drainage systems (dredging river courses, etc.) estimated to cost \$150 million. Ecuador, possibly the second most vulnerable country, has for several years been implementing a Bank-supported flood control project to protect its coastal regions, and is now undertaking additional protective measures to the tune of about \$35 million. In Brazil, the major concern is expected drought in the Northeast of the country, with the state of Ceara expected to bear the brunt of the impact: state

authorities in the region are preparing for the water management challenge ahead of them. In Argentina, by contrast, the chief anxiety concerns flooding in the northern plains. Here, too, the Bank has for some years been supporting flood protection works, and preparatory programs are able to build on this foundation. In the countries of Central America, the likely impacts may vary significantly: broadly speaking, the Caribbean side of the isthmus faces the threat of excessive rains and flooding, while the Pacific coast is threatened by drought conditions. While all of the Central American countries are paying attention to the issue at the highest levels (and Costa Rica has already declared a national emergency), the nature of the threat will only become clear in a month or two's time, when we know whether the October/November rains will arrive as normal-- if they fail, small subsistence farmers in the sub-region could see their crops wiped-out, and be facing a very serious situation indeed.

The Bank is taking action at both the Region-wide and country levels to try to support our clients in preparing for the arrival of El Niño. At Regional level, we have organized a task force coordinated by our ESSD department to ensure access to the best available technical analysis and skills, share information across countries, and avoid duplication of effort. Regional management also took advantage of the recent Annual Meetings to offer help to our borrowers. By now, special El Niño missions have visited Peru and Ecuador, in each of which we are expecting to process new loans on an emergency basis, within the current calendar year, that will help governments both prepare for the arrival of El Niño and address its impact once it arrives. As IDB is also offering assistance, we are working out coordination and co-financing arrangements with them in each specific situation. The possibility of special new lending is also being pursued with Bolivia and at least three countries of Central America (Honduras, Guatemala and Nicaragua). Meanwhile, we are working with the authorities in both Brazil and Argentina to ensure that funds under existing projects for water management or flood protection can be utilized flexibly to meet the highest priority needs in the present context. More generally, reallocation of funds within existing projects is one of the instruments we are actively exploring.

A more detailed briefing paper on El Niño in LAC and the Bank's proposed response is currently under preparation and a first draft should be available within about 10 days.

October 10, 1997

Brief prepared by:

Eugene D. McCarthy (ext. 85190, or 31868) and Anthony J. Ody (ext. 82344).

ATTN: Phil Hay

1-11

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Addr/Prod: 3;NY YDB N2G LAS LMSG
Topic: PE EC CO LATAM NEWS ENV US

BC-WEATHER-ELNINO

Bank to assess El Nino plans in South America

WASHINGTON, Sept 22 (Reuter) - The Inter-American Development Bank (IADB) said on Monday it would send teams to Central and South America to help authorities plan for the El Nino phenomenon which can disrupt weather patterns worldwide.

The bank said two missions would visit Peru, Ecuador, Colombia and the countries of the Central American isthmus next week to discuss their emergency plans for El Nino, which is caused by the warming of Pacific waters off South America.

Officials in Washington said the bank was likely to offer loans, grants and other financial support to countries in need of assistance. The bank declined to be more specific.

But in a statement issued in Lima, the Peruvian government said the bank had agreed to grant it a \$100 million emergency loan to combat the harmful effects of El Nino.

The ministry statement said Economy Minister Jorge Camet agreed on the loan with IADB President Enrique Iglesias at a private lunch in Hong Kong.

"He (Iglesias) promised to send a mission in coming days to finalize an emergency credit support operation for \$100 million to cover the expenses the government is incurring to face the El Nino phenomenon," it said.

The statement did not give more details of the loan, but noted that the World Bank had also promised to loan Peru between \$150-200 million for the same purpose.

An IADB official declined to comment on the statement. But he said bank loans must first be approved by the board of executive directors, a process that could take several months.

"They (El Nino-related loans) have a high priority with the bank, but no loan is final until it is approved by the board," he said.

The bank said the weather phenomenon had already begun to create problems for several Pacific coast countries in Latin America.

The last major El Nino, in 1982-83, has been estimated to have caused more than \$13 billion of damage worldwide including more than \$2 billion of storm and flood damage in the United States.

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Topic: WASH IMP US PE CL EEC NEWS RSK ENV LATAM MZ ZH ZA ZW

BC-WEATHER-ELNINO-LOANS

Banks prepare loans to aid El Nino-hit nations

By Adam Entous

WASHINGTON, Sept 23 (Reuter) - The World Bank has joined other lenders in looking at how to help countries threatened by drought and flooding caused by the El Nino phenomenon wreaking weather havoc around the globe.

Officials said on Tuesday the international lending agency's involvement reflected growing concerns that a large number of countries face withering staple crops due to drought, and damaging storms and floods.

"We don't know yet how severe the crisis is going to be," said Robert Clement-Jones, an economist with the World Bank's Africa environmental group. "But we must be ready to provide assistance where needed."

Officials with the World Bank and the Inter-American Development Bank (IADB) have both started talks with countries in Central and South America threatened by El Nino, which is caused by the warming of Pacific waters off South America.

The government in Peru, the country closest to the phenomenon, and the World Bank are discussing an emergency loan of about \$150 million, officials said. To assess the situation, the Washington-based body has sent a team to Peru.

A World Bank official said an emergency loan for Ecuador was also being discussed.

In Africa, the World Bank has been participating in El Nino planning meetings with government authorities in Mozambique, Zambia and in other countries to prepare for possible food shortages caused by severe weather changes.

The bank plans for now to use existing loan funds in Africa to help governments ready themselves.

"We don't know the extent of the crisis, of the food shortfalls," Clement-Jones said. "So obviously this requires constant monitoring."

The World Bank's involvement backs efforts by the IADB, which has entered talks that may lead to emergency loans for Peru, Ecuador, Colombia and countries of the Central American isthmus.

The Peruvian government said IADB has already agreed to grant it a \$100 million emergency loan.

IADB officials would not confirm the Peruvian loan, but said two bank teams would visit several countries in Latin America next week to discuss their emergency plans.

"We're now in the early phase of identifying the need," an IADB official said on Tuesday. "We're looking at a long process here because the El Nino has to play itself out."

The last major El Nino, in 1982-83, has been estimated to have caused more than \$13 billion of damage worldwide.

All the evidence suggests that the current El Nino pattern, the 13th since 1950, will rival the last.

Across the globe, the weather phenomenon is already being blamed for economic turmoil.

3

Peru is bracing for the impact. The central bank has forecast a slowdown in economic growth to five percent in 1998 from six percent in 1997 because of likely flooding along the northern coast, droughts in the southern highlands and reduced fish catches.

A drought has been declared in Honduras, and the Nicaraguan government has promised to provide emergency food and agriculture aid to some 20,000 farming families because of the lack of rain.

In Asia, drought has also arrived, posing a fresh threat to a region already hit by reeling currencies and stock markets.

South African authorities fear the onset of the El Nino drought could halve the country's corn crop, costing more than one billion rand (\$213 million) in lost exports.

The Zimbabwean government has set aside \$1.5 billion for maize imports in case the southern African state suffers a severe drought due to the El Nino pattern.

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Topic: PE EC LATAM LDC EMRG NEWS ENV ENR WEA WASH US

EC-WEATHER-ELNINO

World Bank to assess El Nino damage in Ecuador, Peru

By Adam Entous

WASHINGTON, Sept 25 (Reuter) - The World Bank will send a mission to Ecuador next week to assess the economic threat posed by the powerful El Nino weather pattern to Latin America and other areas, officials said on Thursday.

Bank experts will meet with authorities in Quito to discuss emergency plans and the money needed to finance them.

"The goal on this kind of loan is to complete action within a couple of months," said a bank official in Washington. "We will make it as swift as we can."

A separate World Bank team has been meeting with the government in Peru. That country and the World Bank have been discussing an emergency loan of between \$150 million to \$200 million.

In a parallel effort, the Inter-American Development Bank (IADB) will send teams next week to several countries in Central and South America to assess the El Nino threat.

The Peruvian government said the IADB has already agreed to grant it a \$100 million emergency loan.

The U.S. Agency for International Development (USAID), which provides assistance to developing countries, has also held meetings with government officials across Latin America, including authorities in Brazil, to evaluate the situation.

The last major El Nino in 1982-1983 was estimated to have caused more than \$13 billion of damage worldwide. Evidence suggests the current El Nino pattern will be as severe.

Across Latin America, the weather phenomenon, caused by the warming of Pacific waters off South America, is being blamed for economic turmoil.

In Ecuador, El Nino has led to heavy rains and landslides, damaging crops. The International Monetary Fund estimated that the weather pattern could dampen Ecuador's economic growth by 0.3 percent to 1.5 percent.

El Nino also has caused serious damage in Peru. Its central bank has forecast a slowdown in economic growth.

Bolivia has decreed a state of national emergency, while the Nicaraguan government has promised to provide emergency food and agricultural aid to some 20,000 farming families suffering a severe drought.

World Bank officials said missions may be sent to other countries in Latin America as the El Nino pattern develops.

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Topic: NEWS LATAM EC PE BO EMRG LDC NI

NIÑO-ECUADOR

Banco Mundial envía equipo a Ecuador para evaluar daños El Niño
WASHINGTON, sep 25 (Reuter) - El Banco Mundial piensa enviar una misión a Ecuador la próxima semana para evaluar la amenaza para la economía que representa El Niño, el fenómeno meteorológico que causa estragos en América Latina, dijeron funcionarios.

Representantes del Banco Mundial tienen previsto reunirse con funcionarios ecuatorianos en Quito para discutir sus planes de emergencia y necesidades financieras.

Las conversaciones marcarán el inicio de un proceso de evaluación de crédito, dijeron funcionarios.

"El objetivo de este tipo de préstamos es completar la operación en dos meses", dijo un funcionario del banco en Washington. "Nosotros lo procesaremos a la mayor velocidad posible".

Funcionarios del Banco Mundial no quisieron precisar el tamaño del préstamo que es considerado para Ecuador.

Otro equipo del Banco Mundial se está reuniendo con funcionarios del gobierno peruano, cuyo país es el más cercano al fenómeno.

Perú y el Banco Mundial han estado discutiendo un préstamo de emergencia de entre 150 millones y 200 millones de dólares.

Por otro lado, el Banco Interamericano de Desarrollo (BID) tiene previsto enviar sus propios equipos la próxima semana a varios países del Centro y Sur América para evaluar los efectos de El Niño.

El gobierno peruano dijo que el BID ya aprobó un préstamo de emergencia de 100 millones de dólares.

En 1982 y 1983, El Niño provocó daños de más de 13.000 millones de dólares en todo el mundo y muchos creen que el actual fenómeno podría causar la misma cantidad de daños.

En Ecuador, el fenómeno climatológico es acusado de haber causado fuertes lluvias y deslizamientos de tierra que han dañado cultivos. El Fondo Monetario Internacional cree que El Niño podría reducir el crecimiento económico del país entre un 0,3 y un 1,5 por ciento del Producto Interior Bruto.

El Niño también ha causado problemas en Perú, y el banco central de ese país cree que el crecimiento económico del país será menor debido a ello.

Asimismo, Bolivia ha declarado un estado de emergencia nacional, mientras que el gobierno nicaraguense ha prometido proveer ayuda a más de 20.000 familias agrícolas que sufren por una severa sequía.

Funcionarios del Banco Mundial dijeron que podrían enviar equipos a otros países latinoamericanos.

REUTER/ AMD 20 GMT

This item appeared on page 30 of the October 8, 1997 issue of

EL MUNDO (Spain)DAVID JIMENEZ
FERNANDO MAS

Los caprichos de «El Niño» vuelven loco el clima de la Tierra

*Este año, sus efectos serán más devastadores que nunca
debido a que el cambio climático aumenta su violencia*

El mundo a merced de los caprichos de *El Niño*, los meteorólogos aturridos ante sus vaivenes y el clima más loco que nunca: lluvias torrenciales que provocan inundaciones en unos lugares y sequías interminables en otros. *El Niño*, ese calentamiento repentino del mar en el océano Pacífico que altera la meteorología en los cinco continentes, se ha convertido en una pesadilla. Sus efectos se han multiplicado por culpa del cambio climático, ese *niño* que, dicen los especialistas, ya está aquí.

Los científicos advierten que nos encontramos ante las variaciones meteorológicas más bruscas de los últimos 10.000 años. Lo saben los miles de pingüinos que agonizan en la Antártida, los ríos europeos que no dejan de perder caudal, los habitantes de un sureste asiático azotado por incendios o una Siberia cada vez menos Siberia.

Es para tomárselo en serio, como comienzan a hacer ya el Banco Mundial (BM) y 1.500 científicos que, ayer, pidieron a Bill Clinton, presidente de EEUU, medidas drásticas para salvar el planeta.

El BM ha pedido consejo y los especialistas le han dicho claramente lo que está pasando: las emisiones de gases que provocan el efecto invernadero (cambio climático) y los efectos de *El Niño* se están convirtiendo en una tragedia.

Pero, ¿qué es realmente lo que pasa a nuestro alrededor? Los cinco años más calurosos desde que existen registros meteorológicos han tenido lugar en la década de los 90. Este año será, sin ir más lejos, el más caluroso desde siempre.

Miles de personas mueren, cada año por enfermedades respiratorias directamente relacionadas con el calentamiento global, mientras

especies animales y vegetales de los cinco continentes le deben a esa manipulación ambiental el estar al borde de la desaparición.

Según el centro de recepción de datos climatológicos de las Naciones Unidas, las noches están sufriendo aumentos de temperatura al doble de velocidad que el día. En España, los meteorólogos dieron este año por oficialmente entrada la primavera 15 días antes de la fecha fijada en el calendario.

El deshielo en la Antártida ha provocado que el nivel de los océanos sea entre 10 y 25 centímetros más alto que hace un siglo, mientras que el 80% de las playas del mundo se están erosionando.

¿Algo más? «El aumento de la temperatura, causado principalmente por la contaminación, está provocando pérdidas y alteraciones de hábitats con la consiguiente destrucción de especies», asegura Carlos Vallecillo, portavoz de la organización ecologista Adena.

Si la Antártida se derrite, en España lo que han desaparecido por culpa del calentamiento del planeta son cuatro glaciares del Pirineo. En los Alpes, la masa de estas estructuras geológicas se ha reducido en un 50%. «Esto es un indicador irrefutable de que el cambio del clima ya está aquí», añade Vallecillo.

Y si hasta hace unos pocos años este cambio sólo se achacaba al efecto invernadero, éste tiene ahora que compartir su protagonismo con los estragos medioambientales que provoca *El Niño*. Cuenta la

leyenda que este fenómeno fue bautizado así por pescadores peruanos que en Navidad se quedaban sin pesca debido al cambio brusco de la temperatura del agua. No es nuevo, ya que las primeras referencias han sido rescatadas de los archivos coloniales suramericanos del siglo XVIII.

La ciencia lo define como un calentamiento superficial del agua (de hasta ocho grados) frente a las costas peruanas y cuyos efectos se dejan sentir sobre el clima entre tres meses y un año después de su aparición. (Ver gráfico).

Para que se haga una idea, las últimas grandes sequías sufridas en

España —tanto la del 82 como la que durante cinco años (del 91 al 96) llevó las restricciones de agua a casi todo el país— son achacadas a este fenómeno.

El descontrol sobre los niveles de contaminación han vuelto todavía más caprichoso y violento a *El Niño*, eliminando su periodicidad normal y haciéndolo especialmente virulento. Así, los científicos creen que *El Niño* detectado este año podría ser el más fuerte del siglo, al igual que sus consecuencias.

La buena noticia es que los científicos han logrado detectar su presencia con mucha

El Mundo (Spain.p.30) adds that the Bank and the 1,500 scientists attending the conference yesterday called on US President Bill Clinton to institute drastic measures to save the planet. The Bank has come to the conclusion that greenhouse gas emissions and the effects of *El Niño* are having tragic consequences, and that prevention is the only cure. "If plans for water supply and crops are made in advance, the disastrous consequences of *El Niño* could be avoided," Watson is quoted as saying.

Mr. Wolfensohn

Impact of El Nino Weather Phenomenon in East and South Asia

The attached papers provide a quick overview of the major issues related to the El Nino weather phenomenon in East and South Asia. El Nino normally tends to be strongly correlated with low rainfall during the monsoons, with resulting impacts on crucial sectors such as agriculture. At a broad level, the impact of this year's El Nino is likely to be quite serious in East Asia and the Pacific (see attached special note on Papua New Guinea), but appears to be relatively insignificant in South Asia. *Appendix A* contains a Special country-by-country report prepared by FAO on the impact on crop production in all Asian countries, and *Appendix B* reviews the possible health impacts linked to El Nino in South Asia.

East Asia and Pacific. Food shortages in the region are not likely to be a problem this season. The immediate cost of the drought will be in lost earnings from the export sector of agriculture. The Bank's Resident Missions are monitoring the situation and assessing the impact on the fiscal balance and balance of payments.

South Asia. This year, contrary to predictions, the monsoons remained generally normal over South Asia and may not necessitate any emergency or short-term tactical response. However, the Bank has initiated some strategic work to be able to respond to potential problems in the future.

The attached reports were prepared by Malcolm Bale (EASRD) and N. Harshadeep (SASEN).

cc: Ms. Nishimizu, Messrs. Severino, Drysdale, Passamonti.

WEATHERING EL NINO:

The East Asia and Pacific Region

October 10, 1997

Summary

It appears that food shortages in the region will not be a problem at least this season. The immediate cost of the drought will be in lost earnings from the export sector of agriculture. Estimates by country have yet to be made by the Bank, the countries themselves, or other institutions. The Resident Missions are monitoring the situation and assessing the impact on the fiscal balance and balance of payments. The region may need to provide additional balance of payments support for countries heavily dependent on export crops..

Introductory Comments

El Nino is the name given to a powerful weather phenomenon that occurs with global effects every four to eight years. It is manifest as drought and subsequent fires in some parts of the world (Southern Africa, Asia, and Australasia), and by additional precipitation and subsequent flooding in other parts of the world (the western coast of North and South America, the gulf states of the US). There have been 13 El Nino's since 1950, the most serious being in 1982-83 when it caused damage estimated in excess of \$13 billion (real 1997 \$). According to some observers, the effect is intensifying over time and the 1997-98 effect is predicted to be the largest ever.

The precise effects of El Nino on crop production and financial flows are hard to predict. El Nino interacts with other weather systems and human effects in ways that have yet to be modeled. In addition the impact on East Asia is much more variable, from episode to episode, than it is in Australia or Southern Africa. Forecasters are using the effects of the 1982-83 El Nino modified by most recent regional crop projections to hypothesize the effects in this round.

The Cost of El Nino?

In terms of the absolute cost, historically the largest burden has fallen on Australia and the United States (\$4 billion). This is because they are major grain producers. But the economies of East Asia suffer a larger effect in terms of the relative size and capability of their economies. Indonesia suffered a cost of \$500 million in 1982-83 from drought-reduced crops. This year (1997/98) the rice crop is larger than last year but slightly below record levels. The largest effect of El Nino in Indonesia will be the lost revenue from export crops -- coffee, rubber, and palm oil, and cocoa. Contrary to impressions in

the press, the fires burning in Kalimantan are not destroying the revenue-earning forest but are largely burning in recently harvested secondary growth areas. The loss from export crops is likely to be at least as large as in 1982-83.

The situation in the rest of East Asia is similar to Indonesia. Rice crops for 1997/98 are similar to the 1996/97 crop: Thailand, up 2%; Philippines, up marginally; China, yield up but area planted down giving a decrease of less than 1%; South Korea and Japan up marginally. As with Indonesia it is the perennial export crops such as rubber, palm oil, and copra that are recording downturns in production. Estimates of the cost of El Nino in Philippines are \$450 million and in Southern China are \$600 million. Thailand is less seriously affected and no estimates are available for Malaysia. Grain production in North China and North Korea is down and is being blamed on El Nino. Analysts in the US believe it is down because of causes other than El Nino. The Pacific Island and Papua New Guinea are more severely affected by the drought. The staple foods are root crops. The drought has caused severe crop losses and loss of planting material for the next crop. But the small population of that region make the absolute cost of the damage small and foreign aid, already being mobilized, will cover food shortfalls. The loss in PNG will be largely the result of lost mining revenues. Mines have closed as they cannot ship ore down the rivers.

Other Effects

There are two other aspects of El Nino that warrant consideration. The first is the general level of food stocks in the world, and the second is the indirect/unmeasured costs of El Nino in East Asia.

On the issue of global food stocks, the world is entering this El Nino better prepared than before. The impact of the weather pattern is mitigated by the near record 1997 grain crop. Grain prices are well below their recent highs. And world grain stocks are up (280 million tons compared with 250 m.t. in 1995). More importantly nearly half of these stocks are held in exporting countries where they can be quickly shipped.

The likely impact on grain prices will occur over the next 18 months and could begin soon if production prospects deteriorate. If droughts or flooding become widespread then grain prices will reflect this information almost immediately. In the last three El Ninos, US corn yields have fallen in the year following the start of El Nino. The opposite appears to be the case for wheat and rice. During the last El Nino wheat and rice prices fell over a 4 year period and the effect on yields was small.

In terms of the indirect effects of the weather pattern, there are numerous aspects that are not adequately considered in assessing the cost but are of concern to the Bank. The drought not only has the potential of reducing perennial export crops in our region but it causes an increased incidence of water-borne diseases in the population, causes a severe but unmeasured loss of subsistence crops and vegetables for on-farm consumption, and is

causing life-threatening and life-shortening respiratory diseases from the carcinogens produced by the forest fires over much of East Asia.

The Regional Response

The East Asia and Pacific Region of the Bank is monitoring the situation and is prepared to assist countries that request assistance. Already, in Papua New Guinea, where the effects of El Nino are first felt, the Bank has had a mission in the field with an AusAID team assessing the drought/frost situation. Another leaves next week. The Bank is discussing the possible restructuring of a loan to provide assistance in strengthening the agency responsible for dealing with disasters and to provide assistance in the construction of wells and other infrastructure that would mitigate the effect of future events. The Resident Missions in other countries of EAP are monitoring and assessing the situation. For example, the Resident Mission in Indonesia reports that heavy rains have yet to begin thus delaying the planting of the rice crop. This could lead to lower yields. The Bank will be very responsive and timely in providing assistance, including balance of payments support, as appropriate.

WEATHERING EL NINO:

Effects on Papua New Guinea

Malcolm Bale, EASRD, October 14, 1997

Summary

This El Nino is developing into the most severe one that PNG has experienced in recent memory. Food shortages in PNG are occurring, local populations are at risk, and initial relief efforts have begun. The immediate public cost of the drought will be in lost earnings from the export sector of agriculture and from lost mining revenues rather than the additional cost of food and medicines. This is because of the generous offers of aid from foreign donors. Our estimates of costs must be considered highly variable and will be subject to change as more information on the extent and duration of the drought come to hand. The situation is being monitored by AusAID with whom we are in periodic contact. The Bank may wish to provide balance of payments support for lost export revenue and may wish to provide additional assistance to ameliorate the effects of future events. In assisting PNG through this episode, our greatest contribution would be to provide leadership and hard advice where little now exists.

Introductory Comments

El Nino is the name given to a powerful weather phenomenon that occurs with global effects every four to eight years. It is manifest as drought and subsequent fires in some parts of the world (Southern Africa, Asia, and Australasia), and by additional precipitation and subsequent flooding in other parts of the world (the western coast of North and South America, the gulf states of the US). There has been 13 El Nino's since 1950, the most serious being in 1982-83 when it caused damage estimated in excess of \$13 billion (real 1997 \$). According to some observers, the effect is intensifying over time and the 1997-98 effect is predicted to be the largest ever.

The precise effects of El Nino on crop production and financial flows are hard to predict. El Nino interacts with other weather systems and human effects in ways that have yet to be modeled. In addition the impact on East Asia is much more variable, from episode to episode, than it is in Australia or Southern Africa. Forecasters are using the effects of the 1982-83 El Nino modified by most recent regional crop projections to hypothesize the effects in this round.

Papua New Guinea is the first country to experience the effects of El Nino whenever one occurs. The effect is a delay in the onset of the wet season and low humidity in an area that is typically part of the humid tropics. The clear sky in turn allows frost to destroy tender crops in the higher elevations. Reduced water flows in lower elevations and on islands causes crop losses and precludes the processing of sago, a stand-by emergency palm. Since PNG feels the effects of the weather pattern first and as it is a small, isolated country, it does not get the type of international attention that such an event might get in a larger country.

The Consequences of El Nino in PNG

The AusAID team sent to assess the effects of the drought have covered the entire country asking a set of questions of those they contacted. In addition, they left questionnaires with provincial administrators in the event that the drought is prolonged. The comments below reflect their assessment:

- frosts have been widespread, repeated, and down to unusually low altitudes
- food shortages from frost of this nature become apparent about four weeks after the frost; frost first started in June thus food shortages are now very apparent in much of the highlands
- plant material for replanting has been destroyed thus putting the population in the highlands at food risk in three months time when a replanted crop would be harvested
- the staple food, sweet potatoes, is in very short supply and diets have been altered
- persons are showing the effects of nutritional distress but no evidence can be found to support the claim that people have died of starvation
- there is an increased incidence of pneumonia and typhoid related to the weakened state of persons
- immigration to relatives in provincial towns is occurring
- some food (rice, tinned fish) has been supplied to the worst areas
- coastal areas and many atolls are also suffering food and water shortages, giving reduced harvests and prolonging the time to crop maturity, while major islands are short of water but not nearing starvation
- public health concerns are rising as water becomes increasingly scarce and degraded. An outbreak of disease could spread very rapidly and have severe effects under the present conditions
- schools and health clinics are closed in many areas because of lack of water
- despite adequate aid, relief efforts are chaotic, disorganized, and inadequate as politicians are preoccupied with political survival or in fighting over the distribution of the aid.

The Public Cost of El Nino?

The largest effect of El Nino on PNG will be the lost revenue from export crops -- coffee, copra and coconut oil, palm oil, and cocoa. Additional losses will come from reduced mining activity. Contrary to impressions in the press, the fires burning in PNG are not destroying the revenue-earning forest but are largely burning in recently harvested secondary growth areas that are traditionally cleared by fire. Some have burned over existing gardens but those were already distressed or dead from frost or drought. The loss from export crops and mining will exceed that of the 1982-83 drought as this El Nino is more severe and more widespread than earlier episodes. Lost government revenue will be from taxes and royalties. Declining export revenues will require the financing of the trade deficit -- another public cost. And expenditures on relief efforts will exacerbate both government expenditure and the balance of payments.

The estimates provided here must be considered preliminary and subject to change as climatic conditions change. The estimates are for crop year 1997/98. There will be longer-term effects beyond 1997/98, the seriousness of which will be determined by the longevity of the drought. Most perennial crops are sufficiently deep-rooted so that they can survive drought with only a reduction in the current or current and succeeding harvest. Some crops can survive light frost with damage only to the current crop. But repeated heavy frosts can kill the bushes. Coffee grown in the highlands falls into this category.

Table 1: Value of Exports under Normal and Drought Conditions, 1997/98

Crop	Value of Exports (US\$ million)	Drought-reduced Value (US\$ million)
Coffee	90	56
Cocoa	36	18
Copra and oil	35	21
Palm Oil	65	39
Other Agriculture	44	20
Total	270	154

Source: PNG authorities and staff estimates

From this table, a reasonable estimate is that the lost foreign exchange earnings from agriculture will be on the order of US\$116 in 1997/98. Mining (excluding oil) makes a net contribution to the balance of payments of around \$240 million/year. Reports from Port Moresby indicate that this contribution will be down by 25 - 30 % as a result of the inability to ship ore down the Fly River. That is, the best estimate of lost foreign exchange earnings from mining in 1997/98 are \$64 million. Thus a reasonable working estimate of the effect on the balance of payments of lost revenues from agriculture and mining is \$ 180 million.

Regarding the effects of the drought on fiscal revenue and expenditure, it is not possible to provide credible estimates across all of the major sectors. The mining sector (excluding oil) typically contributes \$225 million/year to the fiscal balance in terms of taxes and royalties. This can be expected to decline by somewhat more than the drop in export earnings. A reasonable estimate is that the government will lose in the order of \$74 million from mining revenues. I do not have data on the contribution of agriculture to the fiscal balance and it is possible that the net contribution is negative in a normal year because of various producer assistance provided. If the government generates tax revenue from plantation agriculture, it is reasonable to assume that it will fall by more than the fall in export revenue; that is, it will fall by around 60-75%. In addition, despite offers of foreign aid coming to PNG, the government will spend additional resources on managing the aid and on managing the drought relief effort. This may amount to \$10 million.

Other Aspects of the Drought in PNG

The AusAID team has returned from the field and is putting together the results of its survey. I have discussed the preliminary findings with them, with officials of the National Disaster and Emergency Service, with the Deputy Secretary of the Ministry of Provincial and Local Affairs, and some bilaterals. The following comments are partly factual and partly based on impressions from my discussions.

In terms of the seriousness of the drought, there exist today over 200,000 persons without any food or money who are foraging for survival and migrating to urban areas. This population is likely to starve without assistance. There are a further 300,000 persons who have food or money at this point but will fall into the former category in 3-4 weeks when their resources are exhausted. All these individuals are in the highlands. The lowlands and islands are dry and short of food but not in danger of imminent starvation.

Intermittent rain has fallen over most areas, but not consistently. Some villagers with plant material are replanting and a load of seed potatoes from Australia is scheduled to arrive today along with medical supplies. This planting material is scarcely a beginning and will not survive beyond germination without further precipitation.

To date K4 million of aid has been distributed to the provinces and K34 million is committed. All district coordinators for the drought relief effort met in Medan yesterday (Monday 13th) to discuss coordination. The outcome of the meeting was unsatisfactory. District coordinators want money and food regardless of their particular need. The chairman of the Drought Relief Committee, Peter Barter, announced that no aid would be provided to any province without a correct accounting of what the first monies were used for and a plan on how the next tranche will be used. Response to the drought requires that action be prioritized so that the deepest affected get first attention. The political dynamic in PNG appears to make this an almost impossible approach.

There is a critical lack of organization and leadership in dealing with the drought. A Drought Committee has been formed and has never met! A Technical Committee to advise the Drought Committee has been formed and has never met! Provincial coordinators are performing poorly if at all. Since the Director-General of the Disaster and Emergency Service stepped aside, the D-G Designate, Colonel Eric Ani, has not taken up his position. He is acting chief of the armed forces until the commander returns from the Burnam peace talks. An interim D-G from Australia has been seconded to the office. He is good at emergency planning but inexperienced in PNG and somewhat overwhelmed by the organizational/political complexities. The Prime Minister is not exercising leadership as he is preoccupied with his political survival, and many cabinet ministers are distracted by electoral challenges from their opponents. In brief, in the face of a national catastrophe, PNG is in danger of losing foreign aid and subjecting its people to starvation simply because of inaction.

The World Bank Response

There are no leaders, domestic or foreign, emerging in this crisis. AusAID would appear to be the closest and they are being very cautious/diplomatic. The World Bank needs to decide what its approach should be. While a restructuring of a loan to strengthen the Disaster and Emergency Services and to provide small grants for construction of local wells would be worthwhile, we need to decide if we should do more. My inclination is that it is necessary for the Bank to challenge the political leadership in PNG on this matter. At a minimum, we must ask next week: who are on the committees; what is the function of the committees; why have they not met; why are the lines of authority confused and convoluted; why is financing not being disbursed; why is there no national leadership/concern on this issue? If the Bank does not do this there will be many deaths before the situation is given the attention and action it deserves. We could go further by requiring the appointment of an expatriate "El Nino Czar" with similar authority to the Control Board of Washington, D.C. whose job would be to cut through red tape in order to ensure the efficient and fair distribution of aid.

El Nino and South Asia

IMPACTS & RESPONSE STRATEGIES

October 23, 1997

SASEN

Summary

The El Nino event has historically been strongly correlated with a lower precipitation in South Asia due to its effects on subduing the monsoon. However, although this year's El Nino event has been the most severe on record, the average rainfall this monsoon over India has been relatively normal, contrary to climate experts' predictions.

There is little being done at the Bank in terms of any emergency or short-term tactical response to this year's El Nino event in South Asia, as there has been little impact on the Indian Subcontinent. There is some ongoing work on trying to determine strategic responses to El Nino - induced monsoon pattern changes in the water resources and agricultural sectors.

The El Nino Phenomenon

El Nino is a large-scale abnormal warming of the equatorial Pacific and is closely related to a global atmospheric anomaly called the Southern Oscillation (together called ENSO), disrupting patterns of tropical precipitation. This phenomenon occurs every 4-7 years interspersed with a reverse phenomenon known as *La Nina* (See Figure 1).

The causes for these phenomena are not very well understood but is an area of active research. Although no definitive association can be made between El Nino events and changes in climate, research into past El Ninos has shown highly consistent global anomaly patterns in precipitation and temperature (Figure 2) associated with their occurrence, either in the El Nino year or the year after. There are many direct and indirect impacts that have been associated with these changes.

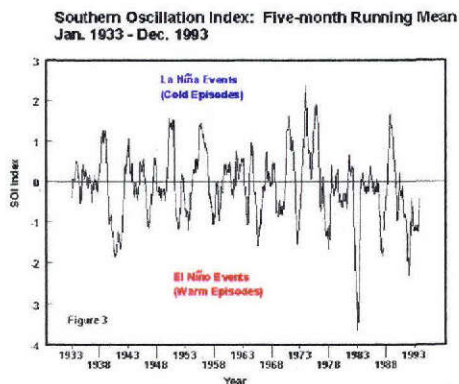
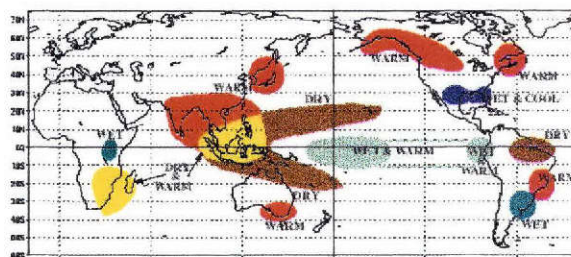


Figure 2 Frequency of Occurrence of El Nino and La Nina

WARM EPISODE RELATIONSHIPS DECEMBER - FEBRUARY



WARM EPISODE RELATIONSHIPS JUNE - AUGUST

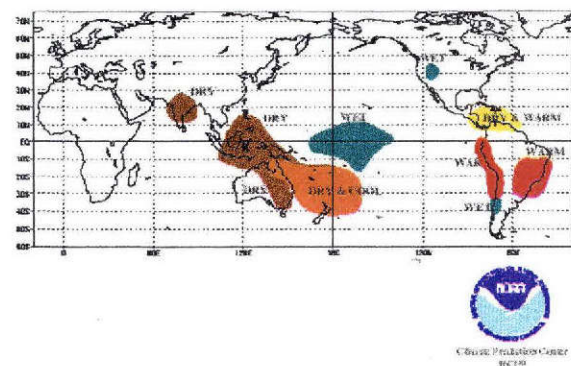


Figure 1 Global Effects of El Nino

Impact of El Nino in South Asia

In South Asia, the impacts of El Nino are primarily on their influence on the dynamics of the Indian Monsoon system, primarily affecting rainfall intensity (Figure 3). The Indian Monsoon is crucial for the success of agriculture in the Indian Subcontinent, and the economies of the countries of South Asia are still strongly agriculture-based (e.g., in India, the agricultural sector accounts for about a third of GDP and two-thirds of the labor force).

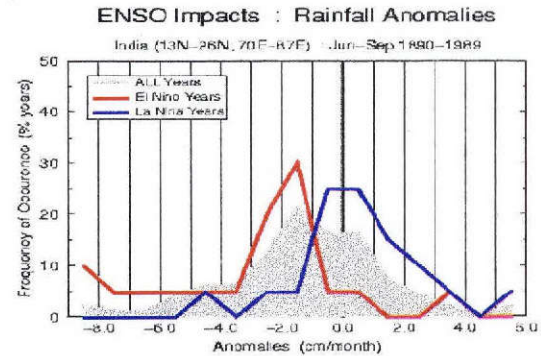


Figure 3 Impacts of El Nino and La Nina on Indian Rainfall

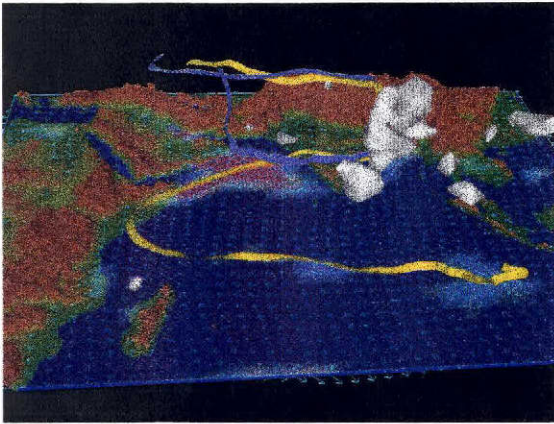


Figure 4 Schematic of Indian Monsoon

The Monsoon (Figure 4) is caused by the differential heating of land and sea every year, and are a result of complex interactions between the sea surface temperature and currents, atmospheric circulation and the topography. The rains in the Indian subcontinent are a result of tropical depressions in the Bay of Bengal, strong low-level winds (the Somali Jet) that intensify and progress northwards steadily, and variations in the areas of low pressure. About 80% of the rainfall in India occurs in the Monsoon months of June-September, and some areas north of the Bay of Bengal receive the highest rainfall in the world in these months. The Indian Monsoon system is very predictable in many years after its start (Figure 5) and any disruptions can severely affect the economy of the entire region.

The El Nino events have been associated with Sea Surface Temperature (SST) anomalies that tend to result in a subduing of the Indian Monsoon phenomenon, leading to lower rainfalls in that year. On the other hand, the broad downdraft associated with the El Nino phenomenon also tends to reduce the number of tropical cyclones in the Bay of Bengal region. These

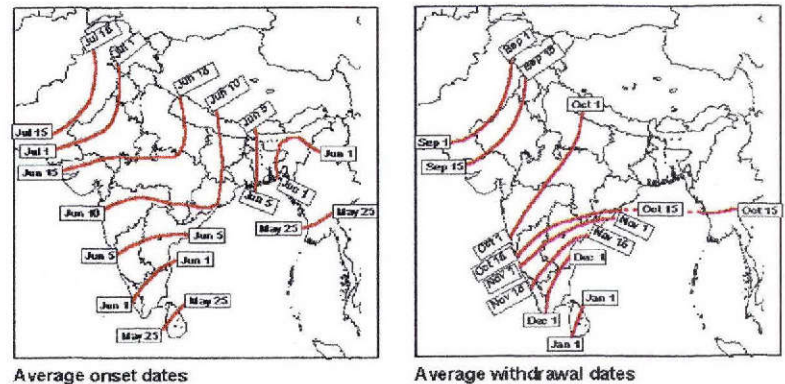


Figure 5. Average monsoon onset and withdrawal dates (From Das, 1987)

Figure 5 Average Monsoon Schedule

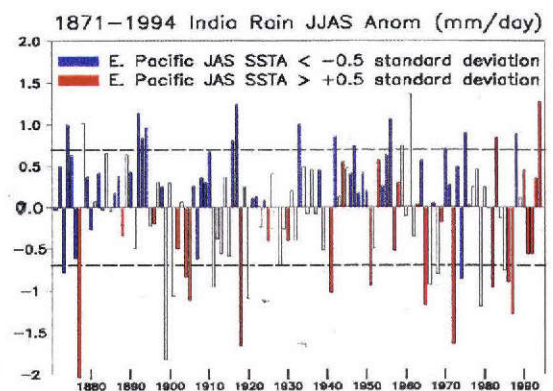


Figure 6 Correlation of Indian Rainfall with El Nino (red) and La Nina (blue)

effects are reversed in La Nina years. Figure 6 shows the correlation of Indian rainfall with the El Nino and La Nina phenomena.

The Current El Nino

The current El Nino event has started earlier than usual and is one of the worst on record (Fig. 7). This has resulted in widespread concern the world over regarding the occurrence of floods, droughts and other associated events such as fires, diseases, etc. The global impacts are dramatized in Figure 8. In South Asia, model predictions indicated that this severe El Nino may result in substantially decreases rainfall from the Monsoons; however, the latest data from the Indian Meteorological Service indicates that the 1997 Monsoon has been normal overall in India. Regional differences persist with parts of central India being in deficit but this effect is swamped in the national averages by the normal rainfall in the high-rainfall areas in the west (due to the presence of the Western Ghats on the west coast of India). This has led to normal Monsoon precipitation and temperature conditions unlike model predictions (Figures 9&10). This effect has puzzled Monsoon experts (especially as other predictions on Indonesian droughts have come true) and research is ongoing in order to explain the vigorous SST anomalies in a normal Indian Monsoon year by determining if the extreme nature of this year's El Nino event may have had unexpected impacts on the dynamics of the atmospheric circulation.

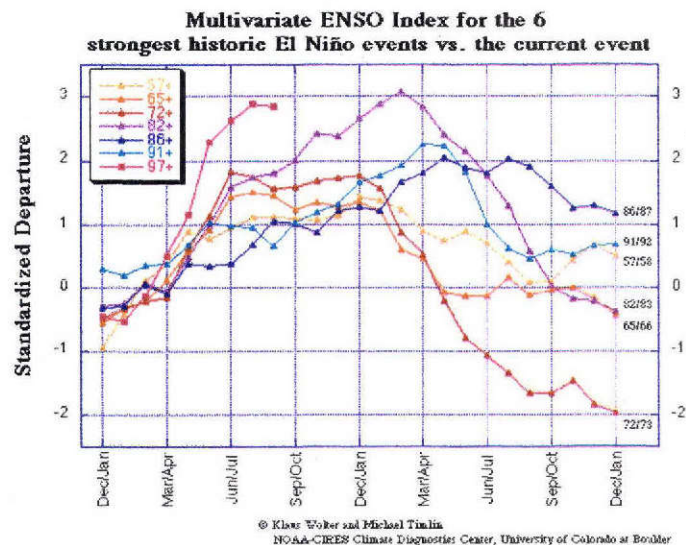


Figure 7 The Current El Nino in Perspective

EL NIÑO IMPACTS

June-September 1997

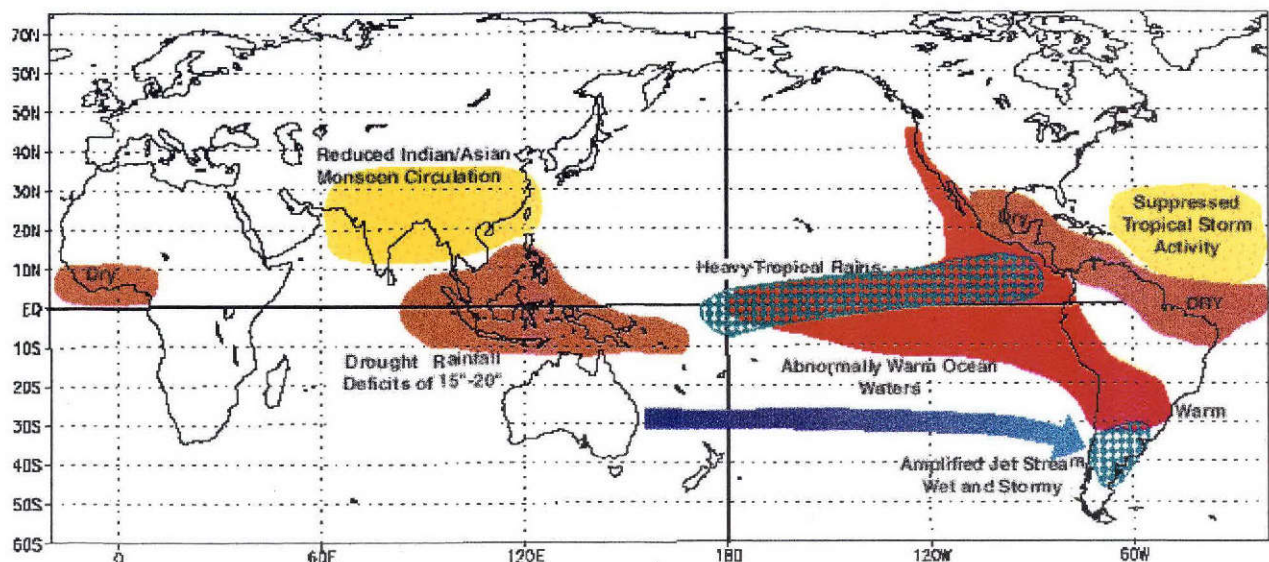


Figure 8 Global Impacts of Current El Nino

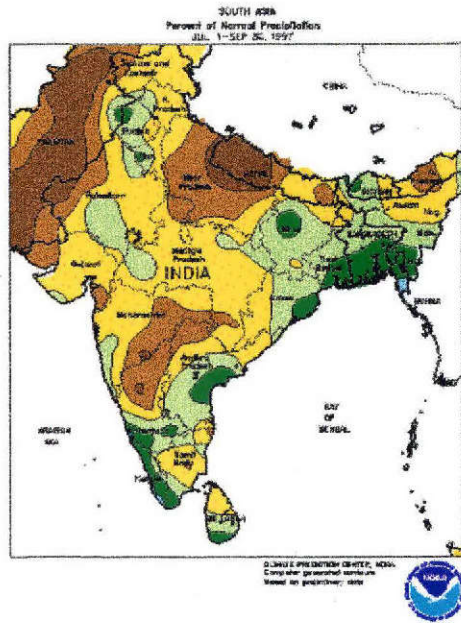


Figure 9 Impacts on Precipitation in South Asia

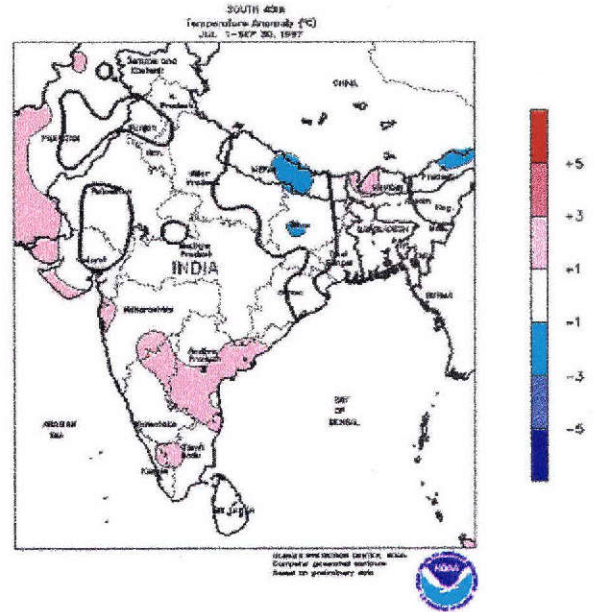


Figure 10 Impacts on Temperature in South Asia

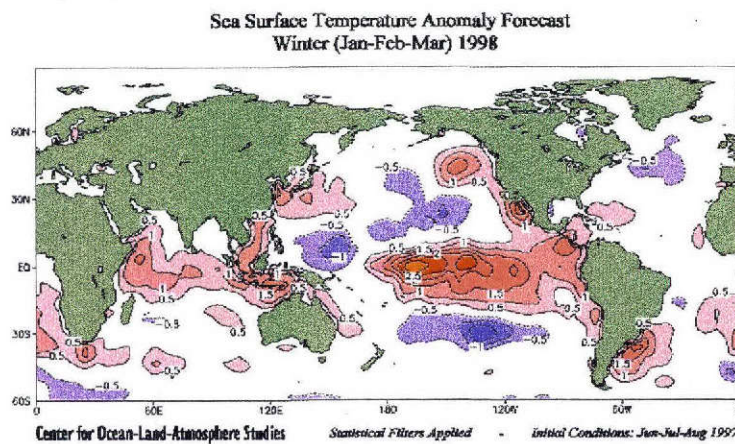


Figure 11 Forecast of Sea-Surface Temperatures in Next Few Months

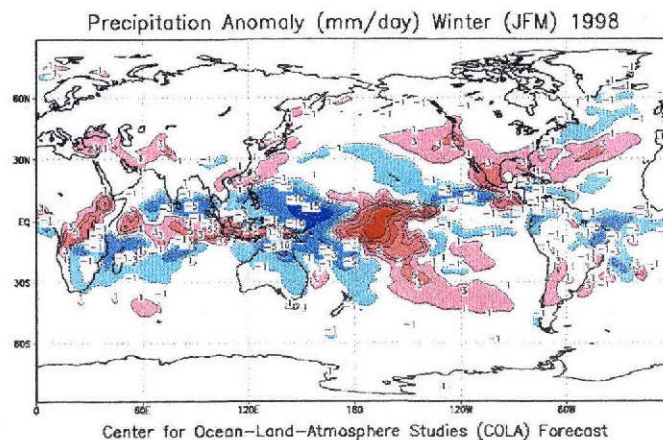


Figure 12 Forecast Impacts on Precipitation in the Next Few Months

Predictions for the next few months (the boreal or northern hemisphere winter) have been made globally and are shown in figures 11 and 12 in the form of expected changes in sea surface temperatures and precipitation patterns. This indicates that in the South Asian region, there may not be much cause for concern even for the winter crops. In a couple of months, researchers may also attempt to forecast implications for the Monsoons in 1998, if any (although El Nino normally impacts the Indian Monsoon in the same year, unlike in other regions such as Africa where the primary impacts are in the year following the El Nino event).

Chasing the Modeling of the Monsoon

Sustainable agriculture in the Indian Subcontinent is heavily dependent on a knowledge of the timing and intensity of the Monsoons. Attempts to understand the periodic Monsoon phenomenon have been ongoing for centuries, but have been enhanced by powerful new models and modeling techniques. However, the failure to predict this year's normal Monsoon in the Indian Subcontinent underlines the fact that there is much research needed in the area of studying and modeling the interannual variation in the Indian Monsoon in order to be able to predict the effects of phenomena such as El Nino and La Nina on the monsoon system. Such information would be invaluable and essential for mounting more informed emergency, tactical and strategic responses to these events in South Asia.

There is great interest in the Indian Subcontinent in trying to model the Monsoon phenomenon as it is the backbone of the Indian economy. It is not by coincidence that the first supercomputer built in India is located in Mausam Bhavan, the meteorological department, primarily to model the Monsoon phenomenon and predict the start and intensity of the monsoon. They use a statistical model to evaluate 16 precursor conditions (such as temperature, wind, pressure, anomalies, snowcover). Many attempts are also underway to model the effect of the ENSO phenomena on the Indian monsoon patterns by developing dynamical models of the atmospheric circulation. But problems of limited physical and dynamical information over vast regions around the high mountains in Asia, policies of data secrecy in some regions, computing limitations, and a still incomplete understanding of land-ocean-atmosphere interactions have hampered the development and use of these models for strategic decision making, although these limitations are pushed back every year. In addition, some climate models suggest that greenhouse gas induced global warming may contribute to increased incidence of anomalous weather patterns such as ENSO.

Impacts and Responses

The impacts of the El Nino events could generally result in decreased rainfall and increase in temperature, leading to many cascading impacts. For example, the 1987 El Nino (that was then the worst in this century) was held responsible for the Asian drought that year, and low rain and record heat resulted in stressed crops and livestock. In India, *kharif* grain and oilseed production was below expected and winter crops had to be delayed due to low residual soil moisture content. This resulted in an increase in commodity imports, reduction in exportable supplies and cascading impacts in other economic sectors. Problems in terms of increase in water pollution or impacts (especially in La Nina years) of an increase in waterlogging-induced diseases (such as malaria) are also possible, but not well-studied.

It is one problem to predict changes in the Monsoon and it is quite another to do something about it. The responses to expected changes in the Monsoon could be classified as emergency (short-term), tactical (medium-term) and strategic (long-term) responses. The El Nino events would generally be expected to have the effect of decreased rainfall in the Monsoons, leading to lower productivity in the agricultural sector. Emergency and tactical responses would be to prevent famine conditions, ensure better food storage and distribution, change cropping patterns and fertilizer use, change the variety of key crops planted, community aid, education and training programs, change reservoir operation, etc. In addition, the decreases in soil moisture due to low summer rainfall may necessitate changes in the time

frame of planting winter crops. Strategic responses could be to undertake long-term water resources and agricultural management strategies, such as shifts in the pattern of agriculture, construction of dams, intersectoral allocation plans, inter-basin transfers, etc. However, all such options should be evaluated with rigorous economic, environmental and social impact analysis.

The La Nina years may increase precipitation in the Monsoons, leading to problems at the other end of the hydrograph, causing more intense flooding. This is of serious concern in the Ganges-Brahmaputra basin for areas in Bangladesh and eastern and north-eastern India. In addition, the La Nina years are associated with a higher intensity of cyclones. Extreme events such as changes in cyclones are harder to predict (as compared to mean changes in precipitation) as these small-scale and short time-scale events in the Indian Ocean form, move and dissipate very rapidly. A La Nina event has been forecast in the winter of '98-'99 and this may be cause for concern, although the models used are still not very accurate.

In addition, there have been impacts estimated on other sectors such as public health in South Asia, but these have been more difficult to attribute to El Nino, except through statistical correlation. For example, Figures A-C in Appendix-B shows El Nino events and their correspondence with the incidence of malaria epidemics. This is due to changes in the disease cycle components such as breeding sites, longevity of the vector population, incubation period, etc. as a function of changes in the temperature and precipitation regimes. In addition, as is the case in other countries in Africa, epidemics such as the recent plague in Surat in Gujarat, India and the new cholera variant that affected India and Bangladesh in 1993 have been linked with ENSO events but there is little evidence to substantiate such claims.

Response of The World Bank

As this year's Monsoons have been relatively unaffected by the recent El Nino event, the Bank has not responded in this context in the South Asia region. However, the Bank is supporting work on a variety of associated themes for strategic decision-making in the water resources and agricultural sectors. One is a recent study on climate change impacts on Indian agriculture. In another instance, the South Asia Environment Unit is helping to develop a state-of-the-art decision support system called MEDUSA (Multi-objective Environmentally-sustainable Development Using Systems Analysis) for long-term integrated and strategic water resources, energy, trade/transport and environmental planning in the Ganges-Brahmaputra basin in India, Bangladesh, Nepal and Bhutan. In a unique partnership, the Bank is collaborating in a National Science Foundation project of Harvard University and the Center for Oceans, Land and Atmospheres (a research NGO that is renowned for its studies and models of the Indian Monsoon, especially as related to ENSO events), to develop interactive models that would generate monsoon events under various scenarios, convert them to runoffs, and interface them with water resources optimization and simulation models to aid decision-makers in long-term strategic planning of the river basin by analyzing infrastructure and policy options under various scenarios.

A major problem lies with the fact that there is little awareness or concern for the effects of El Nino phenomena and general climate change issues among decision makers. This has to do with the fact that there are always many other pressing issues that have to be dealt with, the lack of scientific understanding of the phenomena, the lack of integration of the inter-disciplinary sciences involved into the public policy process, lack of sensitization of decision-makers and the general public to these long-term strategic planning issues, and problems with coordinating plans among various ministries involved. In addition, there has been little in terms of a focal point in the Bank for worldwide coordination of monitoring and responding to ENSO related events, although certain regions have incorporated this into their work programs.

There is also substantial ongoing activity in addressing El Nino related impacts in other parts of the Bank, such as in the EAP, AFR and LAC regions and at the ESD and EDI. ESD is beginning to take steps towards systematically improving our understanding of the linkages between global events such as El Nino and water resources disasters such as floods and droughts. During the ESSD conference earlier this month, ENV in conjunction with EDI held the seminar, "El Nino: An Impetus for Strategic Management of Drought" to sensitize decision makers about the science of forecasting and the need to address public policy questions related to strategic drought management. ENV is also preparing a background paper on the subject, and for Southern Africa, organizing an action oriented workshop targeting policy makers to convey messages regarding the need to factor drought as an integral part of the reforms for strengthening water resources management in the region. A central (ESSD) website is also being developed for sharing information (electronically across the regions) about forecast updates, likely impacts and proposed emergency, tactical and strategic responses which are being planned and implemented in different regions and countries. In the South Asia region, ENV is also working with EDI to organize a seminar on El Nino related impacts such vulnerability to forest fires (due to extreme dry conditions).

Strategy for The World Bank

The World Bank is in a unique position to take leadership on the issue of sensitizing decision-makers in developing countries to the impacts of phenomena such as El Nino. However, in regions such as South Asia, this sensitization cannot occur or even be useful without the Bank taking an active role in encouraging long-term planning strategies for sustainable development. The Bank can encourage client countries to adopt sustainable river basin planning strategies, coordinate water resources and agricultural development plans on a regional basis for shared international and inter-state river basins, take a serious look at inter-sectoral and inter-regional water allocation, restructure water resources and agricultural policies with regard to legal, institutional, economic and technical issues, use information technology to make the best use of the information that is currently known to aid strategic decision-making and develop plans for emergency, tactical and strategic responses to events such as El Nino, La Nina and changes in the Indian Monsoon start, intensity and duration.

Ad-Hoc emergency responses are necessary if the situation demands it, but the stress should be on developing strategic responses geared towards long-term planning. In addition, the Bank has relatively poor links to science in this area (both in client countries and in the international scientific community). The Bank seems to have a comparative advantage in accumulating, analyzing, and sharing knowledge regarding good response strategies in different parts of the world and advocating the use of lessons learned. However, the current El Nino has highlighted two issues - the fact that the Bank needs a focal point for systematically handling such issues in an integrated manner across regions and sectors; and the fact that the Bank needs to help client countries develop long-term planning approaches that can incorporate information on and predictions of climate changes and ENSO events into the decision-making process.

The droughts, floods and cyclones associated with ENSO events are a part of life in South Asia in most years due to the high degree of natural stochastic variability in the spatial and temporal distribution and sequence of rainfall and temperature. However, ENSO phenomena serve to exacerbate conditions and draw attention to these problems that are otherwise not perceived as crises due to their annual occurrence. The attention focused on the current El Nino should be used to promote more rational strategies in water resources, agriculture and other sectors. Unfortunately, it often requires crises such as these to bring about major changes in policy.

EL NINO AND SOUTH ASIA
SASEN, THE WORLD BANK

OCTOBER 23, 1997

APPENDIX-A

United Nations Food and Agriculture Organization
Current Report on El Nino Impacts on Asia



El Niño's impact threatens food supply in Asia

Extreme drought conditions threatening food security in several Asian nations have probably been triggered by the El Niño weather phenomenon, according to a Special Report issued by FAO's Global Information and Early Warning System on Food and Agriculture (GIEWS).



The report cautions that no definite association can be made between El Niño's events and changes in climate. Based on irregular weather patterns seen in the Asia and Pacific Rim region in the past, however, the report concludes, "It is most likely that the current drought situation in Indonesia, Papua New Guinea, the Philippines and Thailand can be traced back to the phenomenon".



Extreme drought conditions contributed to hundreds of devastating forest fires in Indonesia

El Niño is the name given to the local warming of surface waters in the central and eastern Pacific

Ocean off the coast of Peru, affecting atmospheric circulation worldwide (see Box). The report on weather anomalies in the Asia and Pacific region is the second in a series on El Niño's potential impact on the food supply situation in various parts of the world. The first report focused on the weather phenomenon's effects in Latin America.

Indonesia has been hit hard by the recent drought - the worst reported in 50 years. Southern Sumatra and Kalimantan, on the island of Borneo, Java and eastern parts of the country have suffered unseasonably dry conditions for several months. Although recent heavy rains have allowed some respite, the first monsoon rains may

not come till November - they normally begin in September. Crops most affected by the drought conditions are likely to be the staples, maize and rice. Official estimates currently indicate that drought could affect some 426 000 hectares of rice. Important income-generating non-food crops such as coffee, cocoa and rubber are also expected to suffer.

Prevailing dry conditions have also exacerbated forest fires that are threatening agriculture and forest plantations and reducing water supplies. A resulting choking haze is affecting the health of millions of people in Indonesia, as well as in neighbouring Malaysia, the Philippines, Singapore and Thailand.

An increase in food imports and a rise in prices of agricultural commodities may result next year in Indonesia if domestic production declines as predicted. Although national food stocks are reported to be sufficient at present, government agencies are making contingency plans to supply emergency food rations to vulnerable segments of the population should the food supply situation tighten.

In Papua New Guinea, the government has declared a state of emergency, as concern over the food situation increases. So far, official reports indicate that up to 1 million people have been affected by extreme weather conditions and face food shortages. Large numbers of highlanders, who rely on home gardens, are reported to be deserting villages in search for food as drought has resulted in widespread bushfires destroying homes, crops, grasslands and forests. Several atolls and small island communities in various provinces are also reported to be in need of assistance.

In the Philippines, weather problems may worsen with reduced rainfall later in the year. The Ministry of Agriculture has initiated programmes to limit the effects on crops, including campaigns to promote the use of rice varieties that mature earlier than traditional types and the distribution of organic and inorganic fertilizers to enhance yields. Although current food stocks are considered sufficient for the rest of this year, the food situation is being closely monitored. In mid-September the national authorities were authorized to import 300 000 tonnes of maize to mitigate the impact of a possible shortage.

In Thailand, prolonged drought from April to July and floods in August are expected to result in a reduction in crop output this year. The drought mainly affected food crops, sugar cane and coffee, while the floods reduced rubber, palm oil and shrimp production. The floods also resulted in a number of human casualties and left several thousand people homeless.

Other countries in the region that have had significant weather anomalies this year, including serious and prolonged drought in parts

of China and the Democratic People's Republic of Korea, are also covered in the report. The resultant deterioration in Korea DPR's food situation is of particular concern.

The third report in the series on El Niño's impact on crop production throughout the world will focus on southern Africa.

El Niño (Spanish for Christ Child) is the name given by Peruvian fisherfolk to the warming of the surface waters of the Pacific Ocean that tends to occur around Christmas. A natural event that recurs in more or less regular cycles (on average every four to five years), El Niño affects the Pacific from Peru to Indonesia. The local warming of the world's largest ocean also has repercussions for global atmospheric circulation of winds and waters.

Although some of its effects may be beneficial, the phenomenon is better known for the havoc it can wreak: harvests can be lost, fishery yields reduced and oceanic ecosystems endangered, threatening food security in many regions. The disturbance can produce droughts in southern Africa, parts of India, Indonesia, Australia and certain regions of the Americas, floods in Kenya, Argentina and the United States, erratic monsoons in South Asia and extremely high temperatures in Japan and some regions of Canada.

Although the warming of the waters may last from 12 months to five years, a time lag between the phenomenon itself and many of its most important climatic consequences means that repercussions are long term. The intense El Niño of 1982/83 brought devastation to more than 15 countries.

This year's El Niño - originally cited as the strongest this century, for the time of year - is now weakening and is said to be the strongest since the early fifties. A growing number of experts have criticized press coverage and interpretation of scientific predictions about the current El Niño as scaremongering. FAO agrometeorologist Rene Gommès said, "It is important not to minimize risks but also to remember that there have been El Niños without any catastrophes and catastrophes without any El Niños". [Back to article](#)

14 October 1997

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SPECIAL REPORT

THE IMPACT OF EL NIÑO AND OTHER WEATHER ANOMALIES ON CROP PRODUCTION IN ASIA

25 September 1997

OVERVIEW

Since March 1997 significant abnormal warming of sea-surface temperatures in the Pacific Ocean, off the coast of South America, has been observed and recognised as an El Niño phenomenon. Such an anomaly is known to occur every 2 to 7 years, with varying degrees of intensity and duration. The phenomenon usually peaks around late December. An El Niño is often associated with important changes in temperatures and precipitation, which may positively or negatively affect agriculture and water resources. The change in sea surface temperatures also affect natural conditions for marine ecosystems.

The last two El Niños occurred in 1982/83, which caused severe flooding and extensive weather-related damage in Latin America and drought in parts of Asia and 1991/92, which resulted in a severe drought in Southern Africa. This year's El Niño is being predicted by various experts as one of the most severe this century as record Pacific surface temperatures have been observed. Various climate agencies around the world also indicate that the phenomenon will continue throughout 1997 and possibly extend into 1998. The worst affects of El Niño are expected to be felt over the next few months.

Although no precise quantitative association between the occurrence of El Niño and changes in agricultural production can be deduced and while it is difficult to forecast precisely the impact of El Niño in specific areas, as a precaution it is necessary to follow developments and take preventive action to reduce possible adverse affects on agriculture. In keeping with this, in recent months FAO's Global Information and Early Warning System has been closely monitoring weather anomalies and assessing possible effects these may have on crop production and the food supply situation in various parts of the world.

This report, which follows an earlier one on Latin America, focuses on weather anomalies in Asia and the Pacific Rim, where a number of countries are recognised as being particularly susceptible to the possible effects of El Niño. Certainly over the last few months significant deviations in weather patterns in the region and the adverse effects these have had on crop production and food supply give cause for concern.

Although based on past occurrences of climate anomalies in this part of the world it is most likely that the current drought situation in Indonesia, Papua New Guinea, Philippines, and Thailand can be traced back to the El Niño phenomenon, other countries in the region which have had significant weather anomalies

of various origins this year are also covered in this report. The latest assessment by country is as follows.

Bangladesh

In August, the monsoon remained active across the country, with near- to above-normal rainfall. However, floods during the month caused by heavy rains, in south eastern parts of the country, left over 100 000 people homeless. Earlier floods in July killed around 100 people, made several thousand homeless and damaged crops and property. As a result of favourable cereal production last year, the overall food supply situation is considered to be satisfactory. As at the end of August 1997, Government held stocks were estimated at 919 000 tons of cereals, including 472 000 tons of wheat and 447 000 tons of rice.

Cambodia

No specific reports of serious weather anomalies affecting agriculture have been received. There have been reports, however, of heavy rainfall and floods, which have affected development of the early rice crop in parts of the country, specifically in Kratie province in the east, and of drought in other parts. The 1997/98 target for paddy production has been set at 3.6 million tons, slightly higher than estimated output of 3.39 million tons in 1996/97, from an area of 2.17 million hectares. Rice production in the last two years in the country has been favourable.

China

In July and August, the worst drought in 20 years is reported to have seriously affected crops, particularly in the provinces of Henan, Hebei, Shanxi, Hubei, Liaoning and Jilin in central and north eastern parts of the country. Officially it is estimated that up to two thirds of the country have been affected by prolonged dry spells, whilst six million hectares of crops have been particularly damaged. In the second dekad of September, rains eased conditions somewhat, but unseasonably low rainfall in central and southwestern regions, where drought conditions continue to affect some 3.1 million hectares of crops along the upper and middle reaches of the Yangtze river, may affect the autumn harvest. The recent rain also improved conditions for planting winter wheat, normally sown from the second half of September, in central parts of the country, though more rain is still needed.

Notwithstanding the adverse effects of the drought, the country's food supply situation remains satisfactory, as overall grain production this year is likely to remain favourable, due to a bumper summer crop and sufficient food stocks. Grain production is officially forecast at above 484 million tons, compared with a record 490 million tons last year.

India

No extreme weather anomalies have so far been experienced this year due to a possible El Niño effect. The southwest monsoon, which provides some 80 percent of annual precipitation, has begun withdrawing, most of the country having received average long term rainfall. Notwithstanding some dry pockets, rainfall in 74 percent of districts in the country was normal or above normal and 31 of 35 sub divisions have received good rains. In the second dekad of September, increased monsoon activity

favoured developing grain, oilseed and cotton across central parts of the country, particularly in Gujarat.

Although the overall rainfall situation has been normal, poor temporal and spatial distribution of rains adversely affected crops in southern states where reductions of output of winter foodgrains and oilseeds are expected. As a result, the output of winter grains is expected to be some 2 million tons below target and to fall from 105.1 million tons in 1996/97 to around 103.5 million tons in the current marketing year. Overall the output of rice is projected to increase, by some 1.6 million tons, compared to 1996/97, though production of coarse grains and pulses are both expected to fall. The 1997/98 target for rice production, from the kharif and rabi crop, has been set at 83 million tons.

Indonesia

The current drought is reported to be the worst in half a century. For the remainder of 1997 and into 1998, dry conditions are predicted to continue over southern Sumatra and Kalimantan, on the Island of Borneo, Java and eastern parts of the country. In these areas, although monsoon rainfall normally begins in September current projections indicate that the first rains are likely to come in November possibly December. The impact of this will be most noticeable on developing second season rice and maize in Java, the country's largest producing area. It will also affect soil moisture conditions for maize planting in November/December in eastern parts of Java and southern Sumatra. In addition to food crops, insufficient rainfall and dry conditions may also affect the output of coffee in key growing areas of Lampung and Bengkulu in south Sumatra, cocoa and rubber. Overall, official estimates indicate that the drought would affect some 300 000 hectares of rice.

Prevailing dry conditions have also exacerbated fires which have affected agriculture and forest plantations and reduced water supplies. In August/September, there have been various reports of falling water reserves in wells and rivers in parts of Sumatra and Java.

As a result of the potential decline in domestic production, imports may increase next year to meet demand, whilst prices of agricultural commodities may also rise. Although food stocks held by the National Food Logistics Agency (BULOG) are reported to be adequate at present, the food supply situation could tighten due to a decrease in domestic production and it is reported that Government agencies are making contingency plans for the supply of emergency food rations to vulnerable segments of the population.

Korea DPR

Between June and August the country was affected by a prolonged drought. This is expected to have serious and long reaching repercussions on the country's already grave food supply situation in coming months and the year ahead, especially as the health of its population has already been severely affected by a shortage of food over the last two years.

Although the 1997 season began favourably with appreciably above normal rainfall in May, subsequently precipitation fell sharply. Consequently, rainfall in the critical months of June, July and August fell to between 20 and 30 percent of the long term average. Crops were also adversely affected by significantly above normal temperatures at critical stages of growth.

The lack of rainfall this year is also likely to affect crop prospects in 1998 as the near depletion of water supplies in rainfed reservoirs will mean that little will be available next April/May for land preparation and

key planting operations.

The food outlook for Korea DPR in 1998 is considerably worse than that following the previous two years of disasters. Domestic production of cereals, even under the most optimistic scenario, will cover less than half the country's minimum food needs, whilst imports from commercial channels are likely to become increasingly strained due to growing economic difficulties and the lack of foreign exchange. Furthermore, as commercial imports last year were highly dependent on barter trade with neighbouring provinces of Jilin and Liaoning in China, the fact that the drought this year also seriously affected crop production in these provinces may reduce surpluses and the volume of trade next year. This, therefore, may exacerbate food problems.

Laos

No specific reports of serious weather anomalies affecting agriculture have been received. However, last month water levels in the Mekong River were reported to be above normal, increasing the probability of floods. Following last year's reduced harvest, the food supply situation in the country remains tight, especially for vulnerable sections of the population with low food reserves. In March 1997 an emergency operation was jointly approved by FAO and WFP, to raise 30 240 tons of rice for victims of floods in 1996.

Malaysia

Rainfall has been below and less frequent than normal. Although the main revenue crops of coffee, cocoa and sugarcane are reported to be in a satisfactory condition so far, in areas affected by severe dry conditions production is forecast to decline. Recently the Government declared a state of emergency in eastern Sarawak due to intense smoke haze from extensive forest fires in Indonesia. At one stage the air pollutant index measured 635 compared to 500 which is considered extremely dangerous.

Mongolia

No specific reports of serious weather anomalies affecting agriculture this year have been received. However, serious concerns regarding food security amongst vulnerable sectors of the population in the country persist due to transitional problems in the economy and falling domestic cereal production. An FAO Crop and Food Supply Assessment Mission is currently in Mongolia to assess domestic production this year and the need for food imports including emergency food assistance.

Myanmar

The worst flooding in 30 years across the country in July and August resulted in a number of deaths. More casualties are expected due to disease, particularly cholera. The floods were as a result of unusually heavy monsoon rains since May. Unconfirmed reports estimate the number of people affected by the floods at between one and two million people, with some 500 000 left homeless. The worst affected areas were central Pegu and Irrawaddy divisions and Mon state in the southeast. Some of the current rice crop may be affected by the floods and there are possibilities of localised food supply difficulties emerging.

Pakistan

Overall, the performance of the 1997 southwest monsoon has been somewhat disappointing with a lack of significant moisture till August. In late August, floods and landslides caused by heavy monsoon rainfall in Punjab and North West Frontier Province killed over 140 people, displaced over 21 000 and resulted in extensive damage to property and crops, principally rice and sugar cane. An estimated 52 000 hectares of crop land were destroyed in Punjab, the main agricultural province in the country. Three of the country's five major rivers, the Ravi, Chenab and Jhelum, are still reported to have exceptionally high water levels, which may result in further flooding as the extra volume of water may damage dykes and embankments. Planting of wheat, the country's main food crop, will commence in October for harvest next April/May. The 1997/98 target for wheat production is 18 million tons, from around 8.2 million hectares, compared to production of 16.4 million tons in 1996/97 and 16.9 million the previous year. The Government plans to import 4 million tons of wheat in the 1997/98 marketing year to meet demand and replenish buffer stocks.

Papua New Guinea

In response to a devastating drought, the most serious for fifty years, the Government recently declared a state of emergency allocating an additional US \$14 million in aid to 19 of the country's 20 provinces as concern over food shortages increases. Conditions are expected to deteriorate in the coming months as water supplies for agriculture and human consumption are expected to decline significantly. Large numbers of highlanders, who rely on home gardens, are reported to be deserting villages in search for food as drought has resulted in widespread bushfires destroying homes, crops, grasslands and forests. Rivers and dams have also been severely depleted in highland areas, which have been the worst affected by a combination of four months of drought and serious frosts. The areas most affected include Enga and southern and western Highland provinces, where extensive damage to the sweet potato crop has left communities with severely reduced food supplies and planting material. These regions are also the most vulnerable to food shortages as there are limited alternative foods available and no cash crops to generate income to allow food purchases. In addition to these areas, communities in the upper Fly River, especially those around Kijunga, are experiencing difficulties in meeting food needs as the main river supply line is no longer functioning due to the drought and seriously reduced water levels. Several atolls and small island communities in various provinces are also reported to be in need of assistance.

Although there is possibility of some rainfall later in the year, overall serious drought conditions are likely to continue into December or January 1998 and possibly to March. The food supply and water situation, therefore, is likely to deteriorate significantly. So far official reports indicate that between 700 000 to one million people have been affected by extreme weather conditions and face food shortages. Unconfirmed reports indicate that the country's 1997 coffee crop, a key export, will be reduced by up to 50 percent by the drought, while damage to cocoa and palm oil is being assessed.

Philippines

Various parts of the country have been devastated by the worst drought in years and there are expectations that the southwest monsoon may end prematurely this year. In northern parts of the country, rainfall has been below-normal since May affecting major rice and maize growing areas. Elsewhere, large portions of the country, including eastern Luzon, Visayas and Mindanao, experienced little rainfall throughout August and the number of tropical storms across the country, which bring significant amounts

of rainfall, has been fewer than normal.

Current official projections estimate that the output of maize in 1997/98 will drop to 3.92 million tons compared to 4.22 million tons in the previous marketing year. With current demand, the shortfall is estimated to be in the region of 1.4 million tons.

As possible weather anomalies are expected to worsen later this year around November/December, and the beginning of the northeast monsoon, the Ministry of Agriculture has initiated programmes to limit the effects on crops, including campaigns to promote the use of early maturing rice varieties, which can be harvested in three months, and the distribution of organic and inorganic fertilizers to enhance yields. In addition to possible cloud seeding to prompt rain the Government has also increased irrigation capacity through wells and water reservoirs throughout the country.

The current food situation is reported to be satisfactory as the country has sufficient food stocks, particularly rice, for the rest of 1997. However, the situation is being closely monitored and, depending on production in the last quarter, for which planting begins October/November and harvesting next year, there are indications that imports may increase. In mid September the National Food Authority (NFA) was authorised to import 300 000 tons of maize to mitigate the impact of a possible shortage.

Sri Lanka

In the second dekad of September, floods and landslides resulted in a number of deaths and left several thousand people homeless in various parts of the Island. Approximately 5 000 homeless people are being housed in temporary relief camps. The water in the Kelani river is reported to be at dangerously high levels and there is further risk of flooding, especially in low-lying areas. Rice production from this year's main 'maha' and second 'yala' crop is expected to be around 1.68 million tons (milled equivalent), some 20 percent higher than last year's drought reduced crop. The country requires some 2.17 million tons for rice utilisation and has an import requirement of around 500 000 tons. Significant quantities of wheat are also imported. In 1996 an estimated 913 000 tons came into the country compared to over a million tons in 1995. Although the overall food supply situation remains satisfactory, there are concerns regarding supplies to the displaced population in parts of the north, especially around Kilinochchi district, where shortages have been reported.

Thailand

A prolonged drought from April to July, and floods last month are expected to result in a reduction in crop output this year. Maize is likely to be affected most, whilst prospects for rice improved with rainfall in August. In recent weeks, widespread rainfall over most of the country increased moisture supplies for main-season crops.

In June official estimates projected rice and maize output for 1997/98 at 18.18 million tons and 4.52 million tons, whilst current projections put output at 17.84 million tons and 4.15 million tons respectively. The drought mainly affected foodcrops, sugar cane and coffee whilst the floods affected rubber, palm oil and shrimp production. The floods also resulted in a number of human casualties and left several thousand people homeless.

Viet Nam

No specific reports of serious weather anomalies affecting agriculture have been received. In early September, the development of the main 10th month rice may have been affected somewhat by excessive wet conditions and flooding. However, more recently the wet conditions eased in northern parts, whilst drier, warmer weather benefited maturing rice across southern parts. Overall the food supply situation is satisfactory and the Government target for rice exports this year remains 3.5 million tons, of which some 2.7 million tons has already been exported.

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EL NINO AND SOUTH ASIA
SASEN, THE WORLD BANK

OCTOBER 23, 1997

APPENDIX-B

Health Impacts Linked to El Nino in South Asia



HEALTH IMPLICATIONS
OF
CLIMATE VARIABILITY AND CHANGE

for
NATIONAL ACADEMY of SCIENCES

Climate Research Committee
National Academy of Sciences
National Research Council

May 8 - 9, 1995
Washington, DC

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El Nino events and malaria epidemics the Punjab and Sri Lanka (1874-1945)

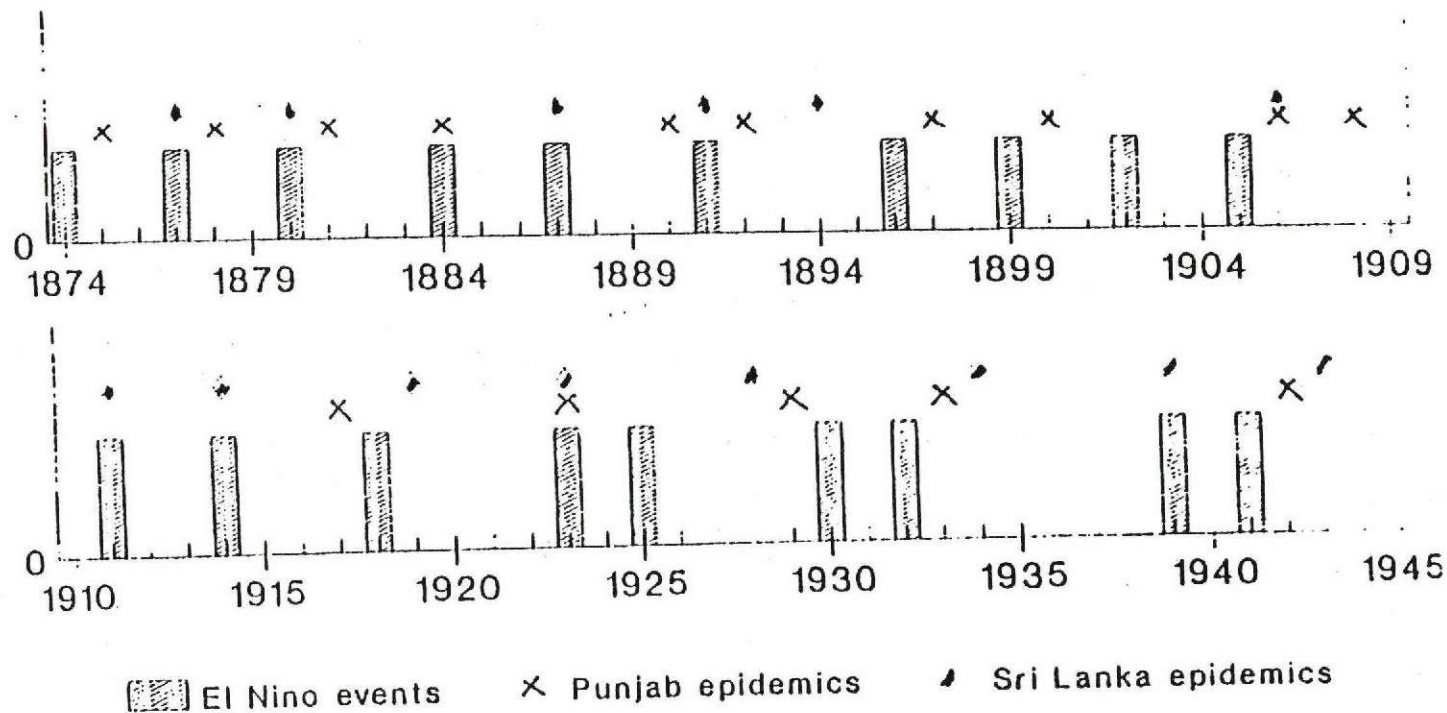


FIGURE A.

M. J. Bouma 1994

Punjab

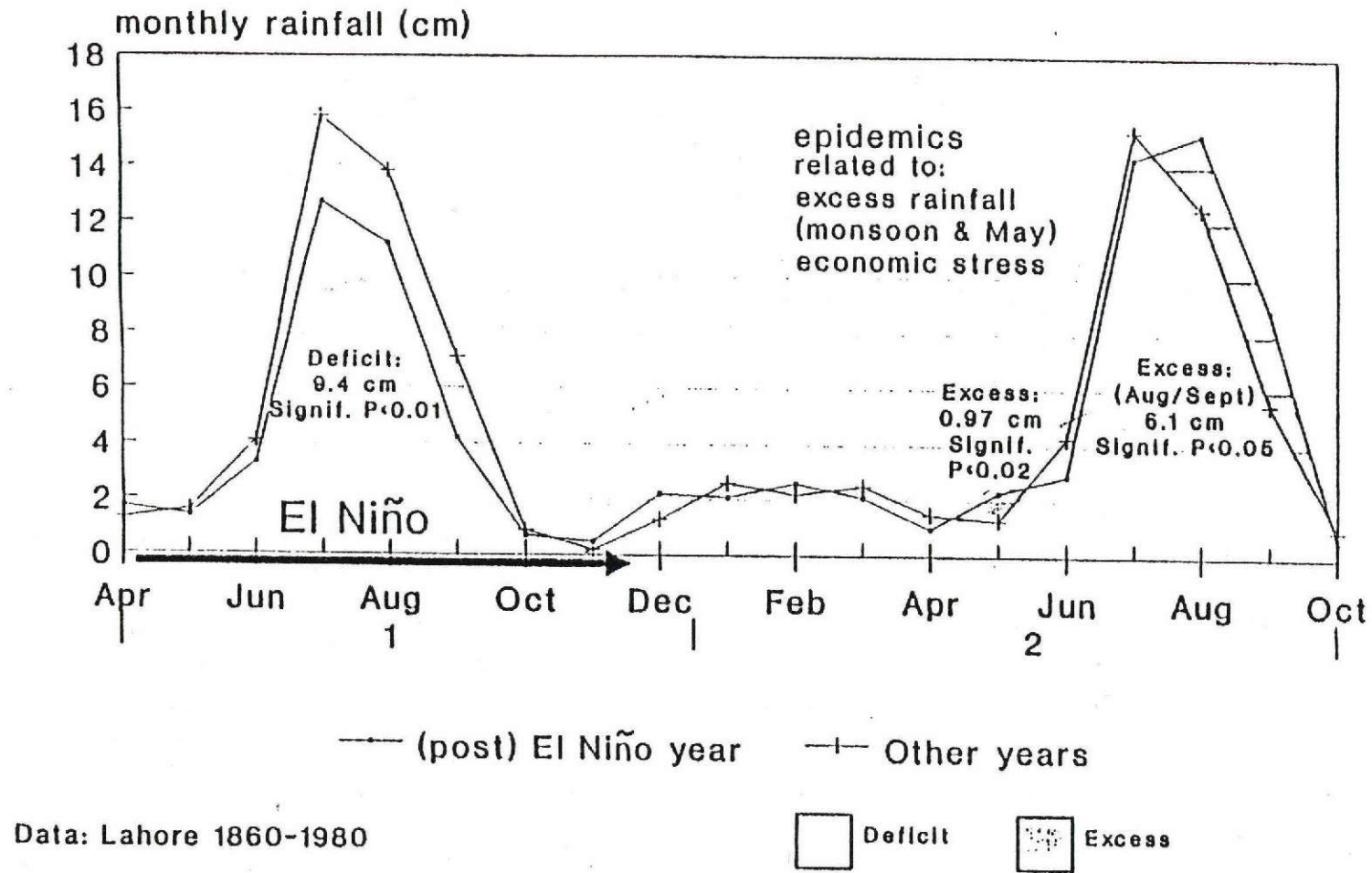


FIGURE B

Sri Lanka

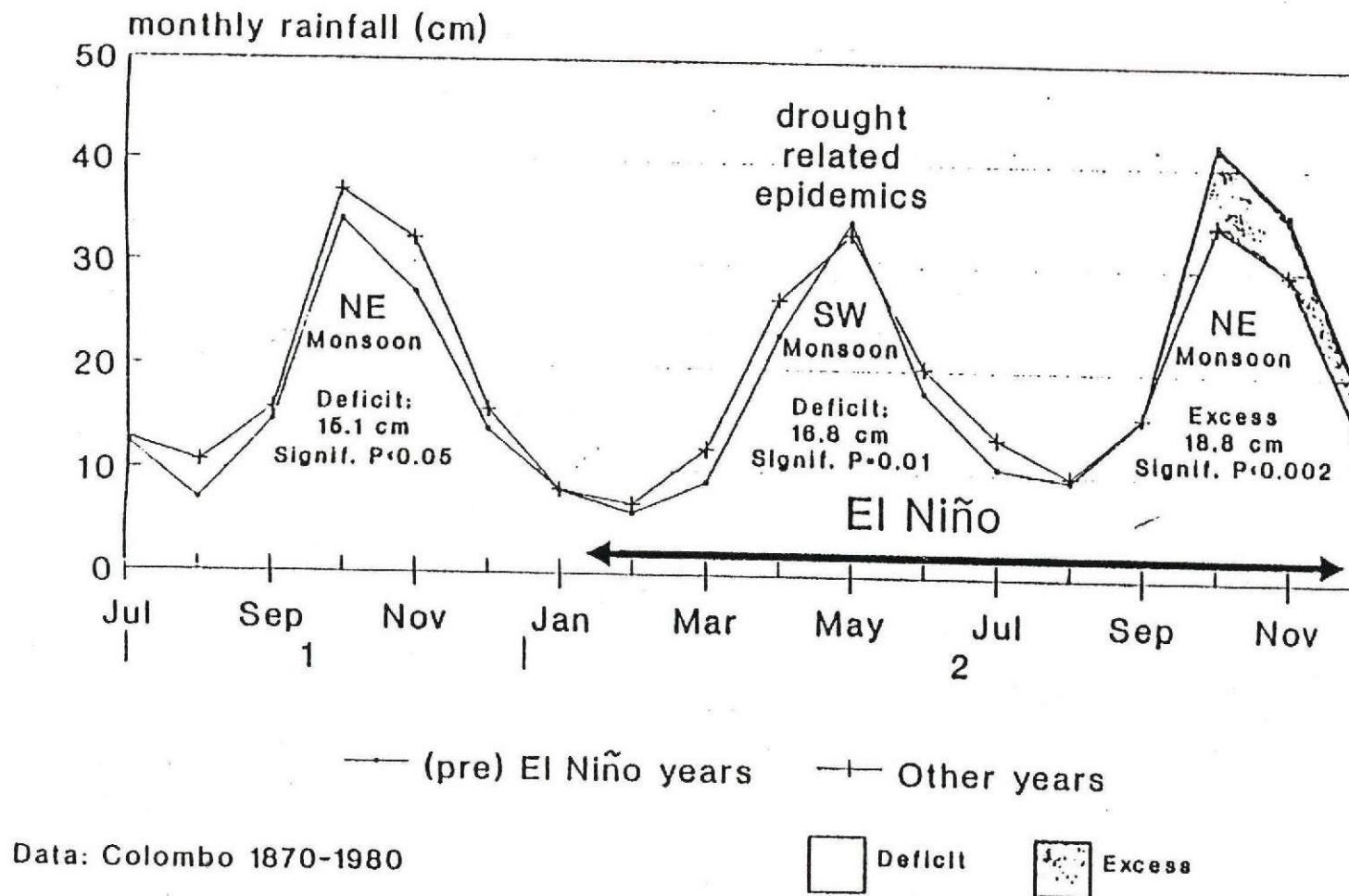


FIGURE C

Climate change and periodic epidemic malaria

SIR—In *The Lancet's* 1993 series on health and climate change, outbreaks of malaria in Ecuador, Peru, and Bolivia were related to the heavy rains that accompanied an El Niño-Southern oscillation (ENSO) event in 1983.¹ In other areas malaria seems clearly affected by this climatic phenomenon. Of particular interest are areas which have experienced periodic epidemics (with 5–8 year cycles). Climatic fluctuations have long been suspected as a contributing factor. We propose that ENSO is the driving force behind these fluctuations.

Epidemic malaria is recorded in areas where conditions for malaria transmission are unstable and the population lacks protective immunity; usually this is at the fringes of whichever climate factor limits malaria's distribution. For example, in temperate climates and in tropical highlands, temperature restricts vector multiplication and the development of the parasite in the mosquito, while in arid climates precipitation restricts mosquito breeding. The figure shows a striking correspondence between periodic epidemic malaria and geographical areas where the "teleconnections" ENSO affect precipitation and temperature. The figure shows the precipitation anomalies for dry and wet areas. Dry and wet areas can be reversed for the cold event (La Niña) of the Southern Oscillation. Excessive rainfall has been incriminated in the epidemics of the Punjab,² sub-Saharan Africa, and South America.⁴ The historic epidemics in Argentina and the Punjab were mostly seen during ENSO events.

In Sri Lanka, drought causes rivers to pool, increasing breeding sites for local vector species. Usually during ENSO years in the north-east, monsoon in Sri Lanka brings abundant rain (figure). However, the south-west monsoon tends to fail during these events, and this failure is held responsible for past epidemics in the wet and intermediate zone of the island, especially when the north-east monsoon (pre-ENSO years) also failed.

Recent resurgences are also likely to be related to droughts during ENSO events. In Pakistan, periods of increased *falciparum* transmission in recent decades were related to higher late season temperatures associated with ENSO years, as we showed in our Jan 29 letter (p 302). Epidemics in areas with tropical highland malaria have been reported from Ethiopia and Madagascar, in which above normal temperatures were suspected (WHO Expert Committee on Malaria WHO/CTD/92.1). Higher temperatures in these areas are observed during ENSO events. The historic unexplained epidemics in south-eastern USA³ were reported

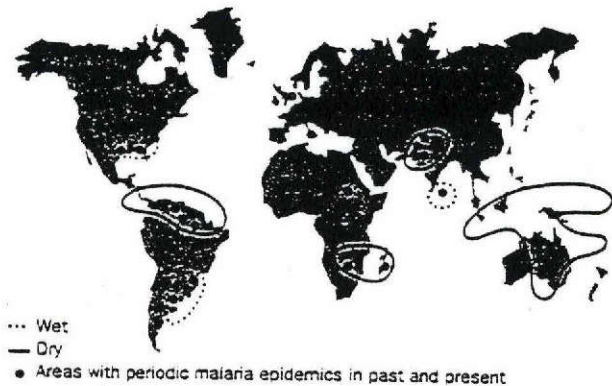


Figure: ENSO-related precipitation anomalies and periodic malaria epidemics

Source: Ropelewski and Halpert.²

between ENSO years, and may have been determined by lower temperatures during the ENSO events which temporarily restricted transmission in a period during which malaria was in decline due to other causes.

It seems that recurrent malaria epidemics, past and present, can be explained by climate fluctuations associated with the Southern Oscillation. In Europe, affected by the North Atlantic Oscillation, the now historic epidemics with a 20-year cycle⁴ may need another explanation. The advances made in the past decade in meteorological forecasting of the phases of the Southern Oscillation may help to predict areas at risk of malaria epidemics. This offers possibilities for developing early warning systems that can facilitate epidemic preparedness.

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Commentary

Emerging Diseases and Ecosystem Instability: New Threats to Public Health

ABSTRACT

Ecologists have begun to describe an environmental distress syndrome, whereby widespread loss of top predators and harsh environmental conditions are encouraging the selection of opportunistic pests and pathogens across a wide taxonomic range of plants and animals. Environmental change and pollutants stress individuals and populations, and this may be reflected in the global resurgence of infectious disease as these stresses cascade through the community assemblages of species. In 1993, the sudden appearance of a virulent, rodent-borne hantavirus in the arid US Southwest accompanied anomalous weather patterns, and a novel *Vibrio cholerae* variant (O139 Bengal) emerged in Asia where marine ecosystems are experiencing a pandemic of coastal algal blooms, apparently harboring and amplifying the agent. This paper suggests a framework for integrating the surveillance of health outcomes and key reservoir and vector species, with ecological and climatic monitoring. (*Am J Public Health*. 1995;85:168-172)

Paul R. Epstein, MD, MPH

Introduction

The 1980s marked the return of infectious diseases to front stage. Of course, infectious diseases never disappeared outside the West. Today, many direct contagions, such as tuberculosis, multidrug resistant tuberculosis, pertussis, and diphtheria,¹ and those involving vectors and animal reservoirs, such as yellow fever,² malaria,³ and dengue,⁴ are undergoing redistribution. Indeed, the present period of unprecedented ecological change and the growing economic and social crises that are driving vast movements of hosts are together contributing to the resurgence of old pests and the appearance of new ones. Important components in this rapid evolution are the vulnerabilities of ecosystems and instabilities in climate.

The Centers for Disease Control and Prevention (CDC) has launched a program to monitor and mitigate emerging diseases by focusing on the evolution of new pathogens and the reemergence or redistribution of old ones.⁵ The range of issues involved were recently reviewed⁶ and were the subject of an interdisciplinary workshop in Woods Hole, Mass, sponsored by Harvard School of Public Health New Disease Group in November 1993.⁷

Two new diseases of 1993—a virulent viral strain appearing in the United States and a novel cholera variant bursting upon the scene in Asia—are cause for alarm and demand pause for reflection. But once the precise agents have been identified, a deeper comprehension of the web of environmental, social, and host factors from which they have emerged, and of the breakdowns in “natural” controls on species abundance that they represent, can reveal a great deal about the “health”—the stability, resilience, di-

versity, and vigor—of Earth's life-support systems.

The Hantavirus

In the southwestern United States, hantavirus infection has been confirmed in 94 persons in 20 states with 48% mortality (Dr J. Woodall, New York State Department of Health, personal communication, October 10, 1994).⁸⁻¹³ In Louisiana, a variant close to but distinct from the “four-corners” strain killed a bridge worker⁸; a “cousin” hantavirus was found in a Floridian (who survived) and remains present in local cotton rats (*Sigmodon hispidus*)¹⁴; another variant was found in Indiana¹²; and in February 1994, a 22-year-old student in Rhode Island died of possibly another variant.¹⁵

The sudden appearance of an unexpected and lethal clinical presentation (hantavirus pulmonary syndrome), caused by viruses that have perhaps long existed at low levels in rodent populations and were previously associated with distinctly different clinical entities, raises important questions. Was the related virus that was identified in 1983 by serology and polymerase chain reaction¹⁶ in similar mouse populations in the Southwest as virulent then for humans as it is today, or is the current high mortality indicative of a new strain? Are the extreme virulence and new cell tropism (pulmonary versus renal and hemopoietic) also signs of a novel variant? Or has an extant viral agent been amplified through changes in rodent ecology, and have conditions helped select and disseminate a highly virulent variant?

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An Evolving Agent?

In the past, hantaviruses have been associated with hemorrhagic fever with renal syndrome and perhaps with chronic nephropathy.¹⁷ Four distinct hantaviruses of the family *Bunyaviridae*—Hantaan, Puumala, Seoul, and Prospect Hill¹¹—have been identified, and several others have been described in Southeast Asia and in Europe.^{18–20} In the 1950s, Hantaan virus caused Korean hemorrhagic fever with renal syndrome in thousands of United States and United Nations troops,^{21–23} although the etiology remained obscure until 1976. Puumala virus, carried in the European bank vole (*Clethrionomys glareolus*), produces a milder nephropathy epidemics in Scandinavia and the Balkans,²⁴ as does Seoul virus in Asia.²¹ During the 1980s, hantaviruses were isolated from domestic rats in Texas²⁵; from deer mice (*Peromyscus maniculatus*) and humans in California, Colorado, and New Mexico^{26,27}; and from a meadow vole captured on Prospect Hill, Md.²⁸ To date, this last has been unassociated with human disease. The current variant was named Muerto Canyon virus after the locale of recognition, which prompted some Native Americans to contest the name; it has been since designated “Sin Nombre.”¹²

Hantaviruses, apparently asymptomatic in rodents and transmitted in their saliva and excreta, may be associated with hypertension and chronic renal disease in the United States.^{29,30} However, the 1993 appearance was the first outbreak of acute illness associated with the hantavirus in the United States, and its flulike presentation, followed swiftly by acute respiratory distress syndrome, is unique. In the four-corners area, *P. maniculatus*, which is widespread in North America, appears to be the primary reservoir host (as it is for Lyme disease [*Borrelia burgdorferi*]), while another close relative may harbor the Louisiana strain. The CDC has issued guidelines for minimizing indoor and outdoor exposure to all rodents.¹¹

Reports of new *Hantavirus* isolates from new areas of Europe suggest that other hantaviruses are present in other geographically isolated rodent populations (Dr S. S. Morse, Rockefeller University, personal communication, March 1994). The identification of Puumala virus (normally found in voles) in the house mouse (*Mus musculus*) in Yugoslavia³¹ suggests that interspecies transfer of hantaviruses can occur under suitable conditions. Because emerging infections often

arise in areas undergoing ecological or demographic change,^{32–35} the former Yugoslavia, beset by war and economic breakdown, is a critical region and deserves close monitoring.

A Changing Environment

A likely scenario in the southwestern United States is that heavy rains following 6 years of drought caused pine nuts and grasshoppers to flourish, thereby nourishing deer mice. Then, driven from underground burrows by flooding, a swollen population of natural hosts (a 10-fold increase from May 1992 to May 1993³⁵) enhanced the chance for the virus to thrive and be passed on. Thus, whatever the hantavirus' route of entry into the human population, alterations in nutrient supplies and in the ratio of prey with *Peromyscus* predators (owls, snakes, coyotes, and cats) created selection pressures for the emergence or amplification of an apparently new variant of *Hantavirus*.

A Navajo chief reflected, “We suffer for we have not taken better care of the earth” and “our people have lost harmony with nature.”³⁶ The landscape and diversity of animals in the region, where rainwater channeled from rocky outcrops once irrigated the fields, have declined from overgrazing and deforestation.³⁷ But large climatological swings and a year of great storms (witness the blizzards and the floods of 1993 and 1994) may reflect even greater instability in Earth's natural systems.

Weather patterns and jet streams across North and South America, western Europe, Asia, and Africa are strongly influenced by the Pacific Ocean warming center. El Niño events, which begin at Christmastime, determine patterns for a year and have, until recently, occurred about twice a decade.^{38,39} Warmer seas evaporate quickly, yielding greater precipitation over some areas and drought in others. The strength of the 1992/93 El Niño was unexpected, and the endurance of +2 to 3°C anomalies in ocean temperatures into summer was unprecedented. Because the persistence of negative South Pacific sea-level pressures that drive El Niño now span over 4 years (an occurrence without analogue in the historical record), and warming is predicted to continue at least through the 1994/95 winter, weather patterns have become particularly erratic and volatile (i.e., unstable).⁴¹

Leading climatologists have projected more frequent El Niño events, with greater variation in storm frequency,

onset, intensity, and duration, accompanying a continued increase in greenhouse gases.^{42,43} The ocean is a “global thermostat,” explains Rachel Carson in *The Sea Around Us*,⁴⁴ and the warming atmosphere transfers heat to the oceans for worldwide distribution.^{39,40,45,46} It is the global “conveyor belt” of warm Gulf Streams moving north, and of deep, cold southward currents, that may have stalled (or reversed directions)⁴⁷ to produce the rapid climate swings of the past, as disclosed in Greenland ice-core records.^{48,49}

Monitoring El Niños, temperature, wind, and precipitation patterns, and biodiversity has enormous implications for surveillance of disease vectors⁵⁰ and reservoirs; indeed, the widespread resurgence of infections may have profound implications for future fossil fuel and forestry policies.

A Novel Variant of Cholera

In India and Bangladesh, a new variant of cholera erupted in January 1993.^{51–55} By mid-April, the novel form of *Vibrio cholerae*—armed with cholera enterotoxin plus a colonizing gene and bearing a previously undetected antigen (O139)—had invaded Calcutta (15 000 cases, 230 dead) and saturated Dhaka (600 cases per day at peak). The novel strain, dubbed “O139 Bengal,” which is considered more hardy than biotype El Tor in terms of its environmental adaptation⁵⁴ (Dr R. B. Sack, Johns Hopkins University School of Hygiene and Public Health, personal communication, April 1994), is spreading in Thailand⁵⁶ and Pakistan and is present in 10 Southeast Asian nations (R. Cash, MD, Harvard School of Public Health, personal communication, May 1994). Its epidemiological spectrum, infecting adults and children, indicates the absence of cross-immunity between it and El Tor, the agent of the ongoing seventh pandemic that left Asia in 1961. One case has been imported into the United States,⁵⁷ but the “anastomoses” between water supplies and sanitation requisite for endemicity are largely absent, save for the Mexico-US border region.

The Algal Reservoir

Aquatic plants, seaweeds, and free-floating phyto- and zooplankton can harbor vibrios in viable but nonculturable, sporelike forms, as demonstrated by fluorescent antibody and polymerase chain reaction techniques.^{58–66} (Note that O139 Bengal has not been tested in this regard,

but there is no reason to suspect that its affinity for algae and weeds is different from that of other O1 and non-O1 vibrios.) The growth of marine and freshwater photosynthesizers is prompted by nitrogen-rich wastewater, fertilizers, acid rain, and runoff soil (eutrophication). Wetlands and mangroves ("nature's kidneys") filter out nitrates and phosphates. While inputs are increasing, the filtration systems are being lost to development and aquaculture, diking and drilling. Concurrently, fish stocks (predators of plankton) are in decline in 14 of the world's 17 major fishing grounds.⁶⁵ In addition, climate-related warmer sea surface temperatures also increase algae growth by (1) augmenting photosynthesis and algal metabolism,⁶⁷ (2) increasing nutrient-rich coastal upwelling,⁶⁸ and (3) shifting the community of organisms toward more toxic species⁶⁷ ("red tides," fish and shellfish poisoning^{69,70}), which are in turn less palatable to grazers. Indeed, planktonologists postulate a "global epidemic" of coastal algal blooms^{71,72} that may well represent one of the first biological signals of global change (Dr T. J. Smayda, University of Rhode Island School of Oceanography, personal communication, June 1994).

Other Vibrios

El Tor *V. cholerae* may have arrived in the Americas in the ballast and bilgewater of ships coming from Asia,⁷³ there finding abundant algal blooms for amplification; from there it hitchhiked in Latin American ship hulls to the US Gulf Coast.^{74,75} And in the Gulf, another vibrio (*Vibrio vulnificus*), found in oysters, has caused deaths in Florida residents with preexisting liver disease.⁷⁶

Sanitation and water supplies—environmental conditions inside national boundaries—have been the primary focus of public health interventions (and are certainly not meant to be minimized by this analysis). However, it may be that widespread changes in coastal ecology are generating "hot systems" in which mutations (random, perhaps adaptive—bacteriophage, ultraviolet-B light, or chemically initiated) are being selected and amplified under new environmental pressures and then transferred to human populations through the food chain (fish and shellfish).⁶⁵ In addition to O139 Bengal, more antibiotic-resistant forms of *V. cholerae* O1, biotype El Tor, have emerged; and in Peru, a chlorine-defiant "rugose" variant⁷⁷ has surfaced (perhaps related to intermittent disinfection), adding a new mixture of cholera organisms to penetrate

poor populations that have little access to potable water.⁷⁸

As threats to marine resources, food safety, and sustainable yields result in direct costs to fishing communities, marine biologists are becoming increasingly concerned for the overall health of marine ecosystems.^{79,80} The new variant of *V. cholerae* intrudes upon planned trials of an oral recombinant vaccine, and although it took the seventh pandemic 30 years to become global, we may expect a more rapid dissemination of O139 Bengal, the agent of an eighth world pandemic. An early warning system—monitoring algal blooms (guided by remote sensing), fish, and shellfish samples for vibrios—is feasible.

Conclusions

The links between the environment and health may be direct (from toxins to heat waves or cold spells) or indirect (involving intermediate species as vectors and/or reservoirs). At the 1993 Woods Hole conference,⁷ participants from the CDC and the World Health Organization, and from universities and institutes in the United States and abroad, concluded that a major impediment to disease monitoring and detection was the fragmentation of epidemiology and scientific disciplines. In response, a new framework is emerging, one that incorporates meteorological mean values (i.e., the climate regime) and anomalies, ecosystem-based findings, molecular epidemiological techniques, and surveillance of indicator species (e.g., rodents, insects, and algae) and health outcomes.⁸¹ Integrating surveillance of biological indicators that carry disease—that is, of rapid responders that are therefore sensitive indicators of perturbed environments—is key. It was fortuitous that an ecological station in Sevilla, NM, was monitoring deer mice, and our knowledge of the marine food web comes from microbiologists, oceanographers, and ichthyologists—groups that do not readily coordinate their findings and data. Geographic information and mapping systems⁸² offer a new methodology to integrate systems by overlaying and fusing data sets.

Focusing on critical regions⁸³ where life-support systems such as water and soil fertility are fragile can also improve monitoring. Land-use changes (deforestation for farming) leading to shifts in rodent species, combined with an influx of nonimmune workers, are apparently related to five emerging arenaviruses in Latin America (Lassa in several nations, Junin in Argentina, Machupo in Bolivia,

Guaranito in Venezuela, and Sabia in Brazil), all of which are associated with hemorrhagic fevers and high case fatality.^{84,85} Many new and resurgent diseases reflect bioclimatic conditions permissive for parasite and pest persistence,⁸⁶ and the emergence of hantavirus in a US terrestrial setting, as well as the evolution and spread of cholera in the marine environment, provide illuminating case studies for future health monitoring and environmental management.

Finally, while social, political, and economic factors are not the immediate focus of this paper, they are clearly integral to the condition and management of the environment, for therein lie the driving forces of global change (the cumulative effects of local inputs and transformations) and the inequitable distribution of exposures, vulnerabilities, and access to treatment. Just as the 19th-century confluence of urban epidemics (tuberculosis, cholera, and smallpox) gave rise to modern epidemiology and sanitary reform, so too must the emergence and resurgence of infectious diseases today stimulate interdisciplinary, comparative, and collaborative epidemiology, as well as a renewed focus on primary prevention—that is, on the forms of development and the fossil fuel-based economies that drive global change.

The health professions and teaching institutions must reach across scientific disciplines to study the implications of accelerated environmental change.⁸⁷ As interpreters to the public of the impacts of global change, the medical and public health professions can assume an influential role in policies that address our common safety.⁸⁸ Finally, risk assessment of anthropogenic activities—from chemical contaminants to development practices—must include indirect ecological effects, to best ensure that the untoward impacts of our interventions do not overwhelm the direct effects intended. □

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