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**September 30, 1988.**

**My dear**

I thank you very much for your letter of September 26, enclosing an **Article on China's Experience in sowing from air.** I agree with you that we should consider this question very carefully. I hope at the workshop we are having in November **on Nitrogen Fixing Tree Species,** we can discuss this matter thoroughly. I shall meet you after I return from France in connection with **IUCN's 40th Anniversary.**

**With warm personal regards,**

Yours sincerely,

**(M.S. Swaminathan)**

Shri Duleep Matthai,
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D.O. No. NWDB/VC-V/V(i)/88

September 26, 1988.

My dear Dr. Swaminathan,

In case you have not seen this, I am enclosing a copy of a condensed version of a study prepared for FAO by officials of China's Department of Forests, Ministry of Forestry on "SOWING FROM THE AIR - CHINA'S EXPERIENCE".

2. I have recently returned from a fairly extensive tour of Pakistan which has also undertaken aerial seeding and claims to be in a position now to show evidence of how successful this has been.

3. The examples of these 2 countries strengthens my convictions of the potential of this technique despite the widespread scepticism that prevails among a number of India's foresters.

4. I consider it most important that an attempt should be made in India to follow China and Pakistan's examples and I would request you to use your influence to help overcome the current unjustified opposition. I am continuing to do whatever I can in this direction.

With my warm regards

Yours sincerely,

Duleep Matthai

(Duleep Matthai)

Dr. M.S. Swaminathan,
B-4/142, Safdarjang Enclave,
New Delhi.

PS: I am also enclosing a copy of an outline by Guest Editor, Norman Myres for a special issue of 'Climatic Change, Theme of Tropical Forests and Climate which I think will interest you in connection with the importance of sustaining our natural forest cover.

Encl : 2

Feature of:
TIGERPAPER Vol. XV: No. 1 Jan. - Mar. 1988

# FOREST NEWS

Vol. II: No. 1

GUEST ARTICLE

## SOWING FROM THE AIR : CHINA'S EXPERIENCE

*A condensed version of the study prepared for the FAO Regional Office, Bangkok, by Mrs. Chen Xinhua and Mr. Zhang Jingchun, Department of Afforestation, Ministry of Forestry, People's Republic of China.*

1. Sowing seeds by air, as a means to quickly reforesting inaccessible, denuded hills, was started on an experimental basis in China in 1956. Over the years, the programme was actively pursued and now covers 600 counties in 25 provinces. The area afforested through aerial sowing extends over 15 million ha.. Of this, it is estimated that 2 million ha. of the area sown in early years has already become a closed forest. Aerial sowing in China emerged over the years as a quick and effective way to enlarge the afforestation effort and to gradually improve the ecological environment of the country.

2. The earliest aerial sowing operations were directed by Mr. Zhu Zhisong, Chief Engineer of the Transportation Unit of the Airforce of the Guangzhou Military Region, in March 1956. Seeds of *Pinus massoniana* and *Acacia confusa* were sown by air over 600 ha. in Wuchuan Country, Guangdong Province in cooperation with the Forestry Department of Guangdong Province. Due to improper selection of the sowing season and the inadequate treatment of seeds, the experiment failed. But important lessons were learnt about the conditions necessary for successful aerial sowing, particularly the technical essentials such as: the selection of areas for aerial sowing; the timing of aerial sowing; the species of trees; and the correlation between the precipitation and the success or failure of aerial sowing. These early trials laid the foundation for continued aerial sowing operations in China.

### THE INITIAL SUCCESS

3. Under the auspices of the Department of Forestry of Sichuan Province, the experiment of aerial sowing of *Pinus yunnanensis* was carried out in the Tongxi River basin in the Liangshan Yi Autonomous Prefecture in Sichuan Province on September 11, 1958. The total area of aerial sowing was 1,120 ha.. According to the observations, after aerial sowing, germination was good. But because the aerial sowing was done too late (dry season started only one month after germination of seedlings), all the seedlings died due to the ensuing long period of drought. The experiment continued in the next year and the time for the aerial sowing was shifted to an earlier date of June 11, 1959. The total area of the aerial sowing was 700

ha.. The seedlings had grown 100 days before the dry season came and all the seedlings stayed alive through the dry season. This experiment turned out to be successful. According to the survey in the winter, the survival rate of the seedlings of *Pinus yunnanensis* was above 60%. The mixed species of *Alnus cremestogyne* and *Coriaria sinica* grew well on the damp soil. This experiment was the first successful example of aerial sowing operations in China.

4. After this initial success, forest technicians in the Department of Forestry of Sichuan Province and in the Liangshan Yi Autonomous Prefecture continued their efforts to expand the area of aerial sowing and paid more attention to correct techniques of sowing and the protection and maintenance of the aerially sown forests. A new forest with an area of 170,000 ha. has come into being through their arduous work over 20 years; the forest stand has now trees with an average diameter at breast height (DBH) of 14-16 cm. and an average height of about 13 meters. In the Tongxi River forest farm an area of 20,000 ha. was already thinned to obtain 150,000 cubic meters of logs. The forest farm has also supplied firewood for 150,000 inhabitants in 24 townships. More importantly, significant benefits in preventing soil erosion resulted. According to a survey, after the establishment of the forests by aerial sowing, the sand content of the Tongxi River was reduced by 77% and soil erosion in the area has been reduced by 80%. Since 1970, the precipitation has increased 21% in the dry season compared with before the aerial sowing. Ten rivers in the area have not been flooded again. Rice-growing in the area has expanded. Grain production reached 1.15 million kgs in 1982 from 0.4 million kgs in 1968; livestock increased to 13,000 from 3,000 in the Donghe township, Xide Country.

5. Professor Hubert Aulizky of Vienna University in Austria, made a survey of the aerial sowing area in Liangshan Yi Autonomous Prefecture in 1983. He regarded the effort as a large project of water and soil conservation and the best achievement he had ever seen.

## ACHIEVEMENTS OF 20 YEARS IN AERIAL SOWING

6. The aerial seeded area was increased annually in most of the provinces. Up to 1972, the accumulated area of aerial sowing was 3.95 million ha. with an average annual aerial seeded area of 520,000 ha.. Since the middle of the 1970's, the scale of aerial sowing has been further expanded and the operation of aerial sowing in afforestation has become one of the important methods to afforest the barren hills in the provinces and autonomous regions in southern China. The annual aerial seeded area was more than 70,000 ha. in the provinces and autonomous regions of Guangdong, Guangxi, Guizhou and Yunnan. In Guangxi Zhuang Autonomous Region, the annual aerial seeded area at its height reached 300,000 ha. and the preserved area of aerial sowing made up 43% of the total afforested area in the past 23 years. The existing extensive aerial seeded forests in southern China were mostly the result of aerial sowing during this period. New forest bases for the country have taken shape on the dense, thriving and extensive aerial sowing forests. There are 700,000 ha. of aerial sowing forests of *Pinus massoninna* in Guangdong Province with 3 extensive concentrated joint aerial sowing forests, each with an area of more than 130,000 ha., on the southern ridges of Nanling, Lianghua Shan and Yunwushan mountains in 10 counties. During the same period, the experiment of aerial sowing of *Pinus tabulaeformis* in the mountain areas of northern Hebei Province in north China had obtained success and was gradually popularized to all places in the province. Also, the experiment of aerial sowing of *Pinus tabulaeformis, Caraguna microphylla* and *Astraglus adsurgens* turned out to be a success in the Yanan region of the northern part of Shaanxi Province. Thus, aerial sowing in afforestation work has been developed successfully from moist rainy south China to the dry north China.

## TECHNIQUE OF AERIAL SOWING

### Selection of the Sowing Area

7. The principles for the selection of the sowing area are as follows:

(1) The barren land and hills urgently needed to be afforested in accordance with the local forest land classification and natural conditions for aerial sowing.

(2) The suitability of natural conditions for aerial sowing.

8. In order to be economical

and reduce the costs of aerial sowing in afforestation, the barren land and hills good for afforestation must be relatively concentrated and connected. The effective area should be no less than 70% of the sowing area.

**Proper Orographic Conditions for Aerial Sowing**

9. Aerial sowing in afforestation is carried out by means of aircraft. Due to the various configurations and the flying functions of different aircraft, there are different requirements on the orographic conditions among various types of aircraft, such as the height and height difference of operation, the conditions of the clear distance, the turning radius, the minimum sowing area, etc. The specific requirements of the different types of aircraft on the orographic conditions should be taken into consideration in the selection of the sowing area.

**Appropriate Social and Economic Conditions for Aerial Sowing**

10. There are three major points in this aspect: a strong desire of the local people to develop forestry; a clear ownership of hills and a definite boundary of land so as to solve the problems between forestry and agriculture, forestry and animal husbandry; and an ability to protect and manage the aerially seeded forests.

**Costs**

11. In order to keep the costs of aerial sowing low, the sowing area should not be too far from the airport.

**Selection of Species**

12. The species used in aerial sowing should first have the ability of regeneration by natural seeding. Many species used in afforestation may not be suitable for aerial sowing. It is impossible to select species according to the different orographic conditions such as the direction and the position of the slopes, vegetation and soil types everywhere in aerial sowing area. Furthermore, because of no site preparation before and after the aerial sowing, the germination of seeds and the growth of seedlings on the ground after sowing are more affected by the natural environmental conditions than that of man-made forests. Therefore, it is very critical to select the species correctly for the success of aerial sowing.

13. Among the major species presently used for aerial sowing in China, are such species as: *Pinus massoniana, Pinus yunnanensis, Pinus tabulaeformis, Pinus arandi, Pinus kesiya var langbianensis, Pinus thunbergii purl, Pinus tuiwauensis, Biota orientalis, Rhus verniciflus, Acacia confusa, Schima superba, Hedysarum scoparium, Hedysarum monglioun, Hippophae rhamnoides, Caragana microphylla, Artemisa desertorum, Astraglus adsurgens* and *Melilotus suaveduna,* etc. In many places of China, the aerial sowing of mixed coniferous and broad-leaf species has been conducted with *Pinus* species. The aerial sowing of mixed arbors, shrubs and grass has also been developed.

**The Selection of Sowing Time**

14. Just like agricultural operations, aerial sowing is also very sensitive to different seasons. The selection of the proper sowing time is an important factor to improve the efficiency of aerial sowing in afforestation. If aerial seeding is done too early, due to insufficient water and low temperature there will be a quantitative loss of seeds and a side effect on the growth of seedlings. If the aerial sowing is carried out too late, the growth period of seedling will be too short and it will be difficult for the seedlings to be drought-resistant and survive the winter.

15. According to the weather forecast, aerial sowing should be carried out in a period of continuous clear days on an extensive area to avoid unfavourable weather conditions such as successive cloudy or rainy days, strong winds, heavy clouds and hail, etc.

**Determination of Seed Quality**

16. The density requirements for different natural conditions and species in afforestation are quite different. Lower density is required for the fast-growing species and light-demanding trees, while a high density is required for the poor soil and drought areas, and in the places where there is a shortage of water and fertilizer. In the case of the latter, the seed quantity must be increased appropriately so as to boost the conservation rate of young seedlings and promote its canopy in advance, and especially to strengthen the resistant capability in adverse conditions.

17. The quantity of seed to be sown in unit area is derived by taking into consideration: the number of planned seedlings

per unit area; germination percentage of the seeds; purity of seeds; loss rate of the seeds by aerial sowing (due to the damage by birds and animals); germinating rate by aerial sowing; and the weight of seeds.

**Planning and Designing**

18. The planning and designing work in afforestation by aerial sowing usually proceeds through the following three procedures:

(1) Make an on-the-spot survey of land or hills suitable for afforestation by aerial sowing; observe the whole area planned to be sown and the topography within and around the sowing area, as well as the proportion of the acreage suitable for aerial sowing. The course of the flight generally keeps the same direction with the long side of the sowing area. The navigation mark line should be set up on the ridges of the high mountains so as to keep a good sight of each other. The alignment of the navigation mark line should be of verticality or near verticality to that of the flight direction. The scope of the sowing area should be framed on the map. The sowing area should as far as possible include the sectors suitable for aerial sowing and abandon the unsuitable areas. A rectangle or several rectangles should be formed because the rectangle facilitates the sowing operation for the fixed-wing aircraft.

(2) Carry out an investigation of the basic conditions of the area to be sown, such as: soil and vegetation; ownership of the land; distribution of the residents; the number of animals and the grazing habits; and local meteorological data.

(3) Navigation marks on ground are the guiding posts for aerial sowing operations. They must be set on the ground to indicate the design of the sowing area, the width of the sowing strips, and the topographic variations.

(4) The technical design and calculation includes the area of sowing, the area of sowing strips, the required amount of seeds (calculated by species), the sortie of the flight operation, flight time and the time of manoeuvre etc.

**Seed Treatment and Clearance of Vegetation**

19. Seeds are the physical basis for afforestation. The quality of the seeds and the selection of provenance are of key importance to the results of afforestation. In seed selection, great importance should be attached to the activities of collection, inspection, testing, treatment, storage, etc.

**Seed Collection**

20. According to the afforestation plan, the seeds must be collected in time from elite stands. If the local seed source is inadequate, it must be allocated and transported from outside. But, attention must be paid to the natural conditions of the seed producing areas.

**Seed Inspection and Testing**

21. The seeds collected from different districts should be inspected and tested by sampling using a checklist for quality control. The items of the checklist should include: the name of species, origin, time of collection, date of inspection, purity, germinating capacity, germinating percentage, moisture content and total weight per thousand seeds, etc. A sampling check or germinating test should be done once more after the seeds are transported to the airport. Stone and earth should be cleaned by screening.

**Seed Treatment**

22. The methods for seed treatment may be divided into general and special ones. The general one is coating. The coating materials, except for the adhesive and colouring agents, are mainly vemifugal (for reducing the harmful effects of birds and mice), water absorbent, nutrient and nodule bacteria, etc. The special treatment is by dewaxing. The seeds of lacquer trees and Taiwan acacia must

tanker. Due to the broad opening of the seed outlets, there is much less trouble with seed blocking. Five meters in total length, the spiral impeller is connected with the motor at one end and fixed up with the bearings on the wall at the other. Actuated by the motor, the spiral impeller runs 70-80 rpm, feeding the seeds uniformly into the seed outlets and spraying them out through the diffuser. The seeds sprayed per unit are uniform.

**Area Covered Daily by Aerial Sowing**

29. The calculation of the daily sowing area of the aircraft proceeds as follows:

30. Firstly, the sowing area and the flying time per sortie shall be calculated on the basis of the unit sowing amount of the loaded seeds of different types of aircraft and the flying speed. Then, the daily sowing area is obtained by calculating the flying sorties according to the daily flying time under normal conditions (including weather conditions, ground service, etc.).

31. Taking the YN-5 Aircraft as an example, the carrying capacity of the YN-5 Aircraft is 800-900 kg. If the seed rate per ha. is 2,250 grams, one sortie can afforest 356 to 400 ha. by aerial sowing.

32. The flying time per sortie is the combination of the following times:

(1) The take-off and landing time in the airport is reckoned as 3-6 minutes.

(2) The time (minutes) for the to and fro ranges between the airport and the sowing area equivalent to the distance from the airport to the sowing area as the crow flies (kilometers) divided by 2.6 (km./min.) by 2 (2.6 kilometers per minute is the flying speed of the YN-5 Aircraft).

(3) The operation time (minutes) in the sowing area is equivalent to the accumulated length of sowing belt (km.) divided by 2.6 (km/min.) (The common width of the sowing belt is 50 m.)

(4) The turning time of the aircraft in the sowing area is equivalent to the number of turning times 1' 40" (standard turning time of the YN-5 Aircraft).

33. Due to the differences in the three species used, seed rate per unit area and the distance between the airport and the sowing area, there is a striking contrast in sowing areas between the sorties. Even when there are the same number of sorties, the daily sowing areas are still different. Statistics in Jiangxi Province show that, in normal conditions, one sortie may sow an area of 400 ha. with *Pinus massoniana* with a seed rate of 2,250 grams per ha. One aircraft can fly 4-5 sorties per day, seeding an area of 1,600-2,000 ha. on the condition that the range between the airport and the sowing area is less than 100 km. Under the same sowing conditions for *Pinus tabulaeformis,* with a seed rate of 7,500 grams per ha., one sortie can sow 120 ha. and the daily sowing area will reach 400-600 ha.

**Weather Requirement for Aerial Sowing**

34. Weather conditions have a great influence upon the scheduled operation of the aircraft and the quality of the aerial sowing. Therefore, favourable weather conditions should be made full use of and unfavourable conditions be avoided, so that a safe operation is guaranteed and the task of aerial sowing can be fulfilled successfully.

**Meteorological Factors that Affect the Aerial Operation**

35. The practice of aerial sowing for many years and the characteristics of special flying demonstrate that the meteorological factors closely related with the aerial operation are mainly: visibility, cloud altitude, cloud cover, wind direction, wind speed, atmospheric temperature, thunderstorms, cumulonimbus clouds, etc. Good visibility is helpful for the pilot to find signals at an early time and to maintain the right direction for sowing. If the visibility is poor or the forecast of visibility is not accurate, the aircraft will have to return to the airport, which will mean a loss by not completing the task of aerial sowing. The amount of clouds and cloud altitude directly influences the weather conditions and, thus, the safety of the flight. Large amounts of low altitude clouds directly affect the take-off, landing and aerial operation of the aircraft. The direction and speed of the wind also has a great influence on the take-off and landing, on the sowing operation and on the quality of aerial sowing.

be dewaxed, otherwise, the wax on the seeds will affect water absorption and germination. To prevent the seeds from being blown into the low-lying side of leeward, thus causing an uneven growth of seedlings, they must be "balled" before sowing so as to increase the weight of seed by 3-5 times.

### Clearing the Vegetation

23. In order to create a favourable condition for the seeds to touch the soil easily, it is quite necessary to control the vegetation in the sowing area where the ground vegetation coverage exceeds 0.7. The way to control the vegetation is through general artificial weeding, brush cutting, use of weed killers, prescribed burning, etc.

## TYPE OF AIRCRAFT AND TECHNICAL REQUIREMENTS

### Type of Aircraft

24. The YN-5 Aircraft is a light and multipurpose biplane with a single shot piston used mainly for agro-forestry aerial operations. The length of the aircraft is 12.735 m. and it is 4.13 m. in height with a 18.176 m. upper wingspan and an engine of 1,000 HP. The maximum speed per hour of level flight (1,700 m. above sea level) is 245 km., while the minimum is 150 km. The maximum voyage distance is 870 km. The distance needed for taking off and landing is 150-180 m. The all-up weight is 5,000 kg. (including the dead weight of plane 3,600 kg. and loading weight 1,000 kg.). The operating height is usually 80-150 m. with the minimum of 30 m. The ascension rate is 1-2 m./sec. (maximum 4 m./sec.). The absolute height of operation is less than 2,600 m., and it can basically meet the requirements of afforestation by aerial sowing in China.

25. The characteristics of YN-5 Aircraft are as follows:

- i. It has two operational systems and a fixed landing gear with excellent performance reliability and is capable of low altitude flying;
- ii. It has a good adaptability to the areas of plateau, high temperature and frigid zone;
- iii. It has low demands on the conditions of airport, requiring only a short runway for taking-off and landing.
- iv. It is equipped with spraying devices for agricultural purposes. Since the YN-5 Aircraft has the above characteristics, it is widely used in agro-forestry work.

### IL-14 Aircraft Made in USSR

26. The aircraft is a low monoplane. The fuselage and wings are fully metallized. It has a semi-hard shell structure with a length of 22.31 m., height of 7.8 m., and wingspan of 31.7 m. The chamber of the aircraft is well-equipped with radio devices and electric instruments and meters as well as being ice-proof, fire-proof and having a heating system. It can fly in day and night under complex weather conditions. The landing gear is hydaulic-controlled with less resistance during flight. The operational speed per hour is 250 km. at the general height of 300-500 m. The distance required for taking off and landing is 510-540 m. The all-up weight is 17,000 kg., including the dead weight of 13,500 kg. and loading weight 1,600-2,000 kg. There are two sets of engines with 1,900 HP. The plane has a big loading capacity and fast speed. It can operate above elevations of more than 3,000 m. and is suitable for afforestation purposes in the distant mountainous areas of southwestern China.

### Aerial Sowing Equipment

27. Aerial sowing equipment of the YN-5 Aircraft comprises a seed tanker, seed outlet (i.e. powder outlet, also called quantitative outlet), batcher, windmill, mixer, diffuser and operation control switch. Since 1972, the users have increased the loading capacity by 15-33% by repeated improvements of the seed tanker, seed outlet and diffuser, and by removing the windmill and mixer. However, the seeds are not as well-distributed as expected and the amount of seeds cannot be automatically controlled in the air due to the inconvenient adjustment of the batching device.

28. Developed in China, the design of the IL-14 Aircraft has been finalised after repreated improvements. The aircraft mainly consists of a seed tanker, seed outlet, spiral impeller, motor, diffuser and signal devices. The seed tanker is divided into six cabinets with a total volume of 4.6 cubic meters holding 1,600-2,000 kg. of seeds. Of the same length as the cabinets controlled by a mini-motor, the seed outlets are made on the bottom of each cabinet of the seed

36. Changes in temperature also affect the aerial sowing operation. Generally speaking, when the atmospheric temperature rises higher, the air density shall be thinner and the air infeed of the engine shall decrease, thus causing the flying speed to slow down and the distance required for taking-off and landing the aircraft is enlarged by the reduction of engine power and by the weakening of the impeller's tension. The cumulonimbus clouds bring gusts of rains, often with big winds and thunder, even with hail sometimes. All these factors pose great threats to the aerial operation.

**Weather Conditions for Aerial Operations**

(1) The minimum standard for the YN-5 Aircraft:

The cloud altitude for trail flying shall not be lower than 300 m. (not lower than 600 m. in the complex areas or highlands). The field visibility shall be more than 5 km.

The cloud altitude for operational flying shall not be lower than 300 m. (the highest point from the operation area). With the field visibility staying at more than 5 km. and without continuous toss or descending air currents. The wind speed shall be less than 5 m./sec.

(2) The minimum weather standard for the IL-14 Aircraft:

Cloud altitude shall not be lower than 500 m. (the highest point from the operation area). Other requirements are the same as those of the YN-5 Aircraft.

Aerial operations shall not be carried out under the following conditions:

i. The side wind speed in the sowing area is more than 5 m. sec., or the speed of the headwind or tailwind surpasses 8 m./sec.;

ii. Cumulonimbus clouds or thunderstorms are moving towards the airport or the sowing areas;

iii. Atmospheric temperature is more than 35 degrees Centigrade.

**QUALITY INSPECTION SYSTEM FOR AERIAL SOWING**

37. The evaluation of the sowing quality depends on whether the actual sowing width meets the requirements, whether the seeds are in proper places and whether the seeds are evenly distributed. It is generally expected that the actual sowing width be wider than that of the planned ones, but not wider than 30%. The seed distribution in the sowing area should be over 85%.

38. The method adopted in quality inspection is to establish a certain number of seed-receiving sample plots of equal distance and at right angles to the sowing width. These are used to determine the number of seeds sown, sown width and seed distribution. The distance between the sample plots is usually 1/4 or 1/2 of the planned sowing width; however, it is set each time in accordance with the planned sowing width and experiment requirements. 1 m. x 1 m. white cloth is often used as the sample plot with four corners nailed into the ground to keep it horizontal.

39. The following data should be calculated on the same day and entered in the recording forms:

i. The actual sowing width, i.e., the sample width receiving more than one seed;

ii. The effective sowing width, i.e., the sample width receiving over 4 seeds;

iii. Seed distribution: the sample plot receiving the maximum number of seeds is regarded as being accurate; any seeds that have fallen to the front or back of the sowing belts are regarded as "deviated" seeds that should be counted separately;

iv. The average number of the fallen seeds, i.e., the total number of seeds divided by the sample plots with fallen seeds;

v. The accuracy rate of seed distribution, i.e., the percentage made up by the sample plots receiving more than one seed in the total number of sample plots.

**Monitoring of Effective Area Sown**

40. One of the methods for monitoring is based on statistical sampling where representative sample units from the "population" are selected, and the seedlings enumerated. The advantage of this method is that the desired result can be achieved with minimum field work and the

statistical accuracy can be indicated.

41. Another method adopted is known as: "Subcompartment Investigation Method". This method is generally adopted in the sowing areas where the aerially sown young stands are taller than the bushes and grasses. The advantage in this method is that not only are the surviving seedlings enumerated, their growth characteristics are studied and a distribution map of the young stands prepared.

42. The major steps are needed for this investigation are:

(a) A base map is prepared using mountain ridges, rivers and other natural dividing lines to separate compartments.

(b) Subcompartments are distinguished in accordance with the land classification, site conditions, canopy density, elevation, location, slope, slope direction, any other natural factors and the density of young stands.

(c) Representative rectangular or square sample plots are chosen for enumeration of the number of trees, mean diameter at breast height, average height, etc.

(d) Data is recorded, analysed and used for further improving the management, administration and technical measures involved in aerial sowing.

43. In China these investigations are conducted 4-6 years after aerial sowing (4-5 years in the southern provinces and autonomous regions; 5-6 years in the northern provinces and autonomous regions). They provide the basis for the assessment of the work done by the provinces and autonomous regions in aerial sowing.

**Management of the Aerial Sowing Area**

44. When the aerial sowing is finished, the major task is to establish managerial organizations to take care of the aerial sowing areas. For example, a managerial bureau responsible for 8 satate-owned forest farms, 7 counties and 1 municipality has been established in Lianshan Yi Nationality Autonomous Prefecture in Sichuan Province. Some counties with a large area of aerial sowing plantation have set up managerial stations to check and supervise the maintenance work. In Fulin county of Yunnan Province, a managerial office, headed by the vice magistrate, has been established with one Deputy Director and 5 other members from the county forestry department to undertake the responsibility of the 29,000 ha. of aerially seeded forest. In some districts and townships, there are managerial committees headed by one of the leading members from the district or township. For instance, the authority of Liuzhou Prefecture, Guangxi Zhuang Autonomous Region, stipulates that a managerial committee should be set up in the district where the aerial sowing area is more than 2,000 ha. There are managerial groups at the township level in Badong County, Hebai Province. Generally speaking, most of the villages also have managerial teams or groups to manage the local aerial sowing plantations.

**Rules and Regulations to Protect the Aerially Seeded Areas**

45. Based on the relative awareness of the importance of protecting aerially seeded forests, various responsibility systems have been established. It is stipulated that after aerial sowing the areas should be closed off for at least 5 years. The government is responsible for issuing notices concerning the maintenance of the aerial sowing plantations. The local people themselves make the regulations and rules to protect the forests. Persons who do a good job in forest maintenance will get rewarded and those who destroy the forests will pay for the losses or be punished if the cases are serious. There are many good examples where the contradictions between grazing/fuelwood supply for the local inhabitants and protection of aerially seeded areas have been solved. Usually a certain proportion of afforested area and hills are closed in rotation.

**Replanting and Reseeding**

46. Due to many reasons, seeds do not germinate evenly after aerial sowing. In order to fully use the productivity of the land or hills, the principle of replanting and reseeding is that where there are no seedlings, it should be reseeded; where there are only a few seedlings, it should be replanted; where the seedlings are too dense, they should be thinned; where

there are naturally generated seedlings, they should be preserved, and where the seedlings are suppressed, they should be tended. The replanting and reseeding activities should be carried out 3 years after the aerial sowing has taken place. The species used for replanting and reseeding purposes should be the broad-leaved ones and should be suitable for the local site conditions so as to form mixed forests of coniferous and deciduous species. The broad-leaved trees in the aerial sowing area should be protected.

## THE SCOPE AND BENEFITS OF AERIAL SOWING IN CHINA

47. In China from 1958 to 1985, a total of 15 million ha. were aerially seeded at an average annual rate of 536,000 ha., of which the annual average from 1958 to 1980 was 456,000 ha. (maximum 1.03 million ha./year, minimum 10,000 ha./year). From 1981 to 1985, the annual average was 797,000 ha. (maximum 1.3 million ha./year, minimum 340,000 ha./year. The total aerially seeded forest (including mature and young sands) was 4.7 million ha., which accounts for about 31% of the total aerial sowing area and 16% of the total man-made forests.

48. Aerial sowing has produced impressive effects as shown in the following examples:

### Expedite the speed of afforestation of barren hills

49. The total area of man-made forests in Xichang Prefecture, Sichuan Province, from 1952 to 1957 amounted to 6,000 ha., increasing at an average annual rate of 1,100 ha. However, the total area of aerially seeded plantations soared to 65,000 ha. in the seven years from 1959 to 1965. Man-made forests would take 60 years to cover the same amount of acreage.

### Establish large-sized timber bases

50. Trees that were aerially sown in the early times have now become forests covering two million ha. In Guangxi Zhuang Autonomous Region there are 4 pieces of forested land which were seeded by aerial sowing that cover 70,000 ha. each, and 7 pieces of forested land with 30,000 ha. each. It is measured that the volume of the ten-year-old stand of *Pinus massoniana* is 120-150 cubic meters per ha., of which the best ones aerially seeded in 1967 can have 270 cubic meters per ha.

### Ecological effects

51. Aerial sowing plays a very important rolé in water and soil conservation, catchment protection, soil improvement, climate adjustment etc. For example, there are 5,300 ha. of aerially seeded forests in Daxian County, Sichuan Province. According to the measurements made by the local hydrometric sation, in the 1970's the Mingyue River annually carried away 1.14 million tons of sand. This was reduced to 320,000 tons in 1981, by which time the aerially seeded trees had become forests. In Longan Country, Guangxi Zhuang Autonomous Region, 60 square kilometers of catchment around Nalong Reservoir have been afforested by aerial sowing. The usual flow of the main watercourse was 0.032 cubic meters per second, before the aerial sowing. Now the normal flow of the main watercourse has increased to 0.2 cubic meters per second since the aerially seeded trees have grown up. The water storage of the reservoir in dry seasons increased by 17% when the aerialy seeded plantations were still young.

### Economic and social benefits

52. The aerially seeded plantations have not only provided society with timber, but have also supplied farmers with fodder, fertilizer and forest by-products. In particular, the supply of fuelwood from the plantations has effectively alleviated the rural energy crisis. For example, since 1961, Wuzhou Prefecture, Guangxi Zhuang Autonomous Region has afforested 165,800 ha. of *Pinus massoniana* by aerial sowing, of which 25,300 ha. was thinned from 1978-1984; 164,000 cubic meters of timber were yielded from thinning. The sum earned by selling the thinned timber was 5.9 times as much as that of the investment in aerial sowing in the whole area.

53. Another example comes from Wugi County, Shaanxi Province. The species chosen for aerial sowing was *Astragalus adsurgens,* which is a nice fodder and green manure plant. In the year that aerial sowing was carried out, the germinating rate was 20-30% with 45,000 – 195,000 seedlings per ha. Each ha. yielded 13.5 tons of fresh fodder in the second year and 72.5 tons in the third year. Therefore, the aerial sowing of *Astragalus adsurgens* has

promoted the development of local animal husbandry.

54. The first tending of the 86,700 ha. of aerially seeded plantations in Huidong County, Guangdong Province, was conducted in the sixth year after aerial sowing was done and the income from selling the fuelwood amounted to one million RMB yuan.

**Training a large number of specialized technicians in aerial sowing**

55. After many years of aerial sowing practice, a considerable number of technicians have been well-trained, who have not only mastered the theoretical knowledge, but also have gained rich experiences in practical operations. The Ministry of Forestry has transferred suitable technicians from provinces and regions to be trained. These trained technicians then go back to their own provinces or regions to hold short-term training courses to improve the skills of the people involved in aerial sowing. Working brigades at the three levels (provincial, prefectural and county) have been organized in the key provinces and regions to undertake the whole process of aerial sowing operations including planning, designing, organizing and inspection, etc.

56. The achievements made in aerial sowing in China are closely connected with the long-term assistance from the Civil Aviation Administration of China and the Chinese Air Force of P.L.A., and the close cooperation between the forestry departments concerned and research institutes and forestry colleges. Due to the combination of scientific research, teaching and production, great achievements have been made in the past twenty years and more. Many aerial sowing projects have won prizes variously awarded by the Ministry of Forestry, Ministry of Agriculture, Animal Husbandry and Fisheries, the State Commission of Agriculture, the State Commission of Sciences and the State Commission of Economy.

## PROSPECTS FOR AERIAL SOWING IN AFFORESTATION IN CHINA

57. China is vast in territory but poor in forest resources. Mountains and hills account for 67% of the total land area and the forest coverage is only 12%, with the per capita forest land of less than 0.3 ha. The problem of water and soil erosion is very serious because of the shortage of forest resources. Therefore, it is quite essential to mobilize all initiatives to plant trees and pastures for the purpose of increasing the coverage of vegetation in the whole country. The task facing the Chinese foresters is, on the one hand, to develop fast-growing and high-yielding forests, timber purpose forests and shelterbelts in the areas where the transportation is easy and the manpower can be employed, and on the other hand, to take the advantage of aerial sowing on the upper reaches of big rivers and remote areas in order to make the country green and to realize a healthy rotation of the ecological system as quickly as possible.

58. In the future, aerial sowing will be employed mainly in the sub-tropical and humid areas of the ten southern provinces. These provinces are very experienced in aerial sowing from earlier practice, such as the early aerially sown plantations which have become mature and now function as shelterbelts, which is tangible and convincing to the people. Furthermore, the local governments at different levels attach great importance to the acceleration of afforestation and the local people are eager to afforest the barren hills to improve the environment.

59. In the northern semi-humid and temperate areas where there is serious water and soil erosion, the main job is to establish shelterbelts and protective forests. Aerial sowing in these areas must be steadily developed drawing on past experiences gained and the according to the local weather conditions in order to make it successful.

60. In the semi-arid areas, the experiments on afforestation and grass planting by aerial sowing should be continued and the experiences on sand control by aerial sowing should be specially summarized.

61. The 5,000 km. sand dune running along the "Three North" (northeast, northwest and north of China) is seriously imperiling the production activities of about 100 million ha. of farmland and pastures, and any successful experience in sand control by aerial sowing is of strategical importance. However, this area suffers from bad natural conditions and the aerial sowing will have to be performed in a step-by-step manner, i.e. starting from the area with about 400 mm. of precipitation, and the careful selection of proper species and correct timing of sowing. Data

and rules of aerial sowing must be accumulated to enhance any future large scale aerial sowing.

62. Aerial sowing in China has a history of 30 years and proved that it is one of the major ways to make the country green. With the development of economic construction, the modernization of aerial sowing will be fostered. It is expected that by the end of this century aerial sowing in China will make a great leap forward and the achievements will exceed those of the past thirty years as long as continual and effective efforts are made by the people who are in charge of the aerial sowing activities. Technical cooperation on aerial sowing between China and rest of the world will be strengthened and experts from various countries are welcome to organise study tours in China. In the meantime, the Chinese experts are ready to go to the developing countries to assist afforestation efforts with advice on aerial sowing operations.

# *NGOS AND FORESTRY*

*Several Non-Governmental Organizations (NGOs) in Asia are taking an increasing interest in promoting environmental awareness and encouraging local level afforestation. They play a crucial role to represent local interests and often act as intermediaries between the governments and local communities. Although NGOs have proliferated in recent years, there is a lack of information about the precise nature of their activities. This section is devoted to their activities. The first installment published in the first issue of Forest News concerned Thailand. The second covered Indonesia, and the third India. In this issue Mr. Shanta Pandey reports on Jarajuri, a small voluntary NGO in Nepal which is encouraging community initiative in development work.*

## JARAJURI – A NEPAL NGO WITH A DIFFERENCE

1. Sometimes all local people need is merely recognition or someone to pat their backs for what they have been doing on their own initiative. This can be illustrated by an effort of "Jarajuri" in some villages of Nepal. Jarajuri is a small voluntary organization formed by a few environmentally–conscious people of Nepal in response to recognizing local community's initiative to protect forest. The founder of this organization, Dr. K.K. Panday, recognizing that there are pockets of local communities in Nepal who are planting and protecting trees in their communities reflecting their environmental consciousness, decided to contribute a royalty received from the sales of his book "Fodder Trees and Tree Fodder in Nepal", as an individual venture to boost their morale. Villagers of four villages in Ward No. 2, Nalang Panchayat, Dhading District of the Central Development Region of Nepal (where this author did a study on the traditional community forestry management system), received one of the six Jarajuri Awards for protecting a forest (Hattisunde Forest) in government-owned land. Villagers of 53 households (who are mostly illiterate, poor and politically powerless) of these four villages had been protecting this forest since 1979 without any external support (financial or otherwise). The forest has neither a fence nor a forest guard. All 53 households protect this forest by obediently following a self-imposed protection system. No one else, including the Forest Department of Nepal, had noted the environmental awareness of the people of these villages until one day when they were recognized by a Jarajuri Award of Rs 1,000.00. The award not only served as a morale boost to the people for what they had been doing for almost a decade, but also gave them prestige among the neighbouring villagers. Neighbouring villages in turn began to emulate the work of these villagers by beginning to protect denuded government land around their own villages as a spread over effect of the Jarajuri Award received by the Hattisunde forest protectors.

2. It was one of the best steps Jarajuri could have taken for the villagers of these four villages because their community-based efforts to protect Hattisunde forest had not yet been recognized by the Forestry Department. The current (1980 amended) Forestry Legislation of Nepal states four categories of forest which could be transferred to local communities for control and management: 1) Panchayat Protected (PF); 2) Panchayat Forest (PPF); 3) Religious Forests; and 4) Contract Forests.

3. Hattisunde Forest does not fall under any of the above categories of forest. This is probably because not much experience of this kind has been brought to the notice of the planners and policy-makers. Hattisunde forest is neither a Panchayat Forest nor a Panchayat Protected Forest. It is a forest protected by four villages of Ward No. 2 of Nalang Panchayat (a Panchayat is divided into nine political wards). It does not even involve all the people of that ward. Most importantly, the villagers of these four villages have neither applied for, nor have they received any legal document from the forestry department that shows that it is they who have on their own initiative protected this forest. The existing legal forest policy does not have a provision to accomodate this kind of forest.

4. Hattisunde Forest is a result of the total participation of both men and women. It is being protected by the local people, on government land, at the expense of the villagers' time, energy, food and livestock as a step towards achieving a sense of independence and self-reliance.

5. A community is composed of men and women, older people and children where a groups functions together to achieve a certain common goal. The composition of a community may vary from a few households of a village to several villages. A community could be composed of a homogenous or a heterogenous caste, ethnic or economic group. The four villages around Hattisunde Forest, for example, represent a true community unit in terms of managing this forest.

6. These villagers have made significant sacrifices in bringing up this forest. They will continue this trend as long as they are sure that the decision to manage and use this forest will rest with them. The moment there is any doubt in trust that they are no longer the only users or managers of this forest, the villagers might begin harvesting it indiscriminately. The responsibility of the forestry-related experts here is to make sure that these people continue to feel the same, if not a better, sense of trust and ownership for this forest.

7. Any action of the forestry department or forest-related projects that discourages these villagers from what they are doing would not only mean the destruction of this forest, but would also be a step towards moving the villagers towards dependence on external help. Further, it might erode their confidence that they can take community initiative to solve other similar problems. In addition, such activities would also destroy the inspiration this forest has generated among neighbouring villages. Today, the people of Hattisunde Forest do not stand alone in this venture, although they seem to be the first people to have initiated a forest management project in Dhading District. Several patches of land are being protected by people in Nil Kantha Panchayat of Dhading District. Similarly, villagers around Hattisunde Mahadevsthan have also begun protecting the forest on their own initiative. This kind of venture costs less to the forest department of Nepal. In addition, how better could participation in development be than for the villagers themselves to begin initiating development? What better way could there be to enhance their sense of self-reliance than by approving their self-motivated development work? If the purpose of rural development is to promote self-reliance, why not make an effort to understand and approve programmes that are already self-reliant? It is, therefore, time for the policy-makers and planners to recognize the existence of such types of local level forests that are truly community – based.

8. Further, villagers have a lot to offer to the community forestry programme of Nepal, especially in terms of enabling people's participation in forestry activities.

**What Can Be Learned from People of Hattisunde-Mahadvesthan in Development?**

9. People involved in Hattisunde forest protection have demonstrated that:

- Development can be purely village-based.
- Participation in development can

happen in an informal setting and that formal organization is not a crucial factor necessary for the success of participation.

- Even though local people may not be aware of various government policies and know how to go about using them, they do not always need support from the government or a project in development.
- Monetary expenditure is not always necessary to produce a good result and that development can take place even without any financial support.
- Educated people are not always required to provide a knowledge source in rural development. Even illiterate villagers can come up with excellent ways of handling the problem of decreasing resources.
- Even uneducated, poor and politically powerless people are aware of the decreasing forest resources of Nepal.
- Local people are not always the users and exploiters of natural resources. Many also share a sense of responsibility towards reversing the current trend of decreasing forestry resources.

10. To sum up, they have shown that development can take place even without the intervention of development projects, external stimulation or monetary help. They have shown that local people can get stimulated or energized from within the villages and demonstrate their sensitivity to the disaster of decreasing natural resources in their neighbourhood, if not in the whole of Nepal. The people of these four villages should be allowed to harvest the products of Hattisunde forest without having to pay a royalty or should be charged a minimum amount of royalty, especially when the time to harvest the timber comes. This view would be shared by many other community forestry experts as well. The protection system of Hattisunde Forest does not involve any financial expenditure. In other words, it is based on faith and trust. It is community-based and not panchayat-based. It would be interesting to watch them from the outside and learn the type of system they will come up with when the time to use the forest arises. The community forestry division of Nepal may be able to learn a lesson on how to go about developing a more user-suitable management system from these people.

11. The Nepal Forum of Environmental Journalists (NFET), an NGO whose members include some environmentally conscious people of Nepal, has, among other things, made visits to various environmentally deteriorated places of Nepal and have disseminated their concern about the threat to the environment through media coverage. NFET mainly aims at promoting greater public awareness and sensitizing the planners and policymakers regarding environment-related problems of Nepal.

## *SAARC SCIENTISTS ON FORESTRY MEET AT KATHMANDU, APRIL 10–12, 1988*

**By V.R. Nanayakkara, Chief Conservator of Forests, Sri Lanka**

1. The Second Meeting of SAARC Counterpart Scientists on Forestry was inaugurated by Mr. B.N. Khunjeli, Secretary to the Ministry of Forests and Soil Conservation on 10th April 1988. The meeting was attended by the delegates from: Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. Country reports were presented by respective delegates. Delegates from all the participating countries unanimously felt that forestry deserves higher priority than assigned to it in the Technical Committee on Agriculture.

2. Discussions were held on items identified at the first meeting of SAARC held at Thimphu,

Bhutan in September 1987. (Reported in Tigerpaper Vol. XIV: No. 4). The second meeting made the following recommendations:

**Separate Technical Committee for Forestry**

3. Forests constitute the most important natural resource in a majority of SAARC countries. They contribute substantially to the economy of the people in these countries. Their conservation and proper management is essential for environmental stability and for sustained agricultural production. The committee therefore unanimously and very strongly recommended that a separate Technical Committee should be constituted for Forestry.

**Creation of Data Base and a System for Exchange of Scientific Information**

4. In order to create a data base and a system for exchanging scientific information among SAARC countries, it was recommended that:

i) Each member country identify an institution as a focal point in the country to be charged with the responsibility of collection, compilation and publication of scientific information.

ii) Scientific information should be exchanged through the SAARC Secretariat.

iii) Information may be compiled on a priority basis in respect of the following:

– Forest resources: their management, production of various forest products and their marketing and processing;

– Forest research and training facilities in each country and a directory of research workers and specialists in different disciplines of forestry.

– Annotated bibliography on the following should be prepared:

a) Silviculture and management of the following natural forests: spruce and silver fir forest; chir pine forests; blue pine forests; oak forests; sal forests; and humid evergreen forests.

b) Nursery and planting techniques of the following species: chir pine; tropical pines; important fodder and fuelwood species including shrubs; Causarina; Eucalyptus; *Dalbergia sissoo;* Teak; *Acacia catechu; Azadirachta indica;* Poplars; and Dipterocarps.

c) Biomass production and utilization for energy.

d) Wood properties and recommended uses of species including lesser known species.

– List of important medicinal plants and endangered species of plants and wildlife.

**Study Tours and Symposia**

5. The delegates unanimously felt that a large volume of useful work in forestry has been done by SAARC countries but very little is known about the same in other member countries. It was realised that arranging workshops and study tours will be extremely useful for dissemination of useful information to the member countries. Keeping this in view, the delegates felt that definite areas may be identified and a plan be drawn up for the study tours and symposia to be arranged within one year.

6. It was agreed to hold symposia, workshop and study tours in the following probable areas, which were assigned first priority for the purpose:

| Topic of Symposia | Host Country |
|---|---|
| i) Community Forestry | Nepal |
| ii) Integrated Forest Management in Catchment Areas and Agroforestry | Sri Lanka |
| iii) Wildlife Habitat Mangement | India |
| iv) Forest Research Mangement and Priorities | India |

7. The Bangladesh and Pakistan delegations agreed in principle to host workshop and study tours, but added that they will be consulting their experts and will report later on to the SAARC Secretariat.

8. Dates convenient to the host countries should be communicated in the next TCA meeting.

**Exchange of Seeds/Germplasm and Other Planting Materials**

9. The delegates realised the importance and agreed to exchange these materials. To facilitate the exchange of materials, it was decided to identify institutions to be made responsible for collection and exchange of the materials, and also to arrange for the necessary Phytosanitary Certification. The following institutions were identified for the purpose:

| Country | Institutions |
|---|---|
| Bhutan | Research Division, Forest Dept. Thimphu |
| India | Forest Research Institute, P.O. New Forest, Dehradun |
| Nepal | National Tree Seed Unit, Hattisar, Naxal, Kathmandu |
| Pakistan | Pakistan Forest Research Institute, Peshawar |
| Sri Lanka | Forest Research Branch, Forest Dept. P.O. Box 509, Colombo |

## *EXPERTS DISCUSS FORESTRY AND FOOD PRODUCTION/SECURITY*

The FAO-organized Expert Consultation on Forestry and Food Production/Security held at Bangalore, India from February 14 to 20 was attended by 48 participants/observers from Latin America, the Middle East, Africa and Asia.

Conclusions and recommendations of the Consultation focussed on the following aspects:

**Production**

Agroforestry: In certain situations agroforestry is clearly an improved and preferred land use for increasing food production without endangering the environment. It can serve to rehabilitate degraded lands as well as produce the food and fodder requirements of local communities.

Fodder production: Where possible, fodder production in forest areas should be enhanced through projects meant for raising either fodder grasses or fodder trees in blocks to be financed by the Government in the same way as for other forestry operations.

Fuelwood production: Sources of domestic fuel extend beyond fuelwood and include agricultural residues and animal dung. Methods for estimating the availability of biomass useful as fuel have not yet been perfected and more work is needed in this area.

Food production from mangroves ecosystems: Joint production of fishery and forest products is possible in mangrove ecosystems.

Production and supply of food from forests: Inventories are needed of the kinds of food available in forest areas from wild and some domesticated species and steps should be taken to ensure their collection and distribution to the needy communities.

Wildlife for food: Captive breeding of wildlife for food and economic products has potential in some areas, to be incorporated in an overall food production strategy.

**Environment**

Effects of forests: There is considerable controversy about the global effects of forests on precipitation, floods and droughts. The Consultation expressed reservations about conclusions based on hypotheses, computerised models and data from specific and dispersed locations, without relating them to the actual field situations. Whereas an understanding of the state of knowledge is important, environmental dimensions should not be looked at in isolation. Evaluation of environmental impacts of other kinds of land use, particularly those that follow deforestation, was emphasized.

Effects of shelterbelts: Shelterbelts have both negative and positive impacts on crop production. Shelterbelts are undoubtedly beneficial in those places where strong, harmful winds prevail. Some negative effects on crops in the immediate vicinity of shelterbelts have also been reported. However, where appropriate, culturally compatible and technically sound, shelterbelt systems including the right species and design should be put in place to increase the overall productivity.

Shifting cultivation: In countries where shifting cultivation is practiced as an unsustainable form of agriculture, a package of measures which include population planning, health, housing, education, crop diversification and market support should be developed. Inmediate results are difficult to obtain, but durable long-tern changes will be achieved. Development plans concerning shifting cultivation should span over a long period, say a quarter century or more.

Effects of genetic resources: While *ex-situ* conservation of genetic resources is necessary, the Consultation stressed that *in-situ* conservation is an even more important method since it offers scope for conserving a wider range of species.

**Socio-economic Aspects**

Contribution of forest foods: Forest foods are often important in bridging seasonal "hunger gaps" and periods of work stress. Medicines generated from forest areas enable the upkeep of the health of the local communities.

Forestry's contribution to income: Gathering, processing, and sale of various forestry products such as fodder, fuelwood, and minor forest products contribute to food security by enhancing the purchasing power of rural households and enabling them to buy food.

People's participation: People's participation in all aspects of planning, developing and utilising the forest resource should be ensured. These should take the form of consultation with communities on the basic needs and their perspectives of approaches to meet these needs.

Promoting forest-based small-scale enterprises (FBSSEs): Promotion of FBSSEs needs the establishment of a total supportive environment in which these enterprises can flourish.

Women as beneficiaries of forestry activities: To enhance forestry benefits to women, surveys of the forest and tree species utilized by women in different socio-economic groups should be undertaken. A sufficient number of women should be incorporated into agricultural and forestry extension services and informal women's groups and other local organizations should be utilized in the planning and implementation of forestry strategies and actions.

**Institutional Aspects**

Policy issues: There is a clear linkage between forest policies and land use policies at the interface between forestry and food security. The vulnerable rural groups in relation to food security are particularly dependent on common property resources (CPR) and on public lands. In situations where common resources are unavoidably diverted to other more productive uses, managers of CPR should find alternative ways of ensuring the livelihood of those groups who originally had open access to CPR.

NGOs: NGOs can often play a useful role as brokers, facilitators, clearing groups and advocates of the interests of rural communities. Whereas the strength of NGOs lies in their capacity to organise people and their easy access to local communities, their ability to give specific advise on technical aspects is often limited. Training of staff of NGOs in tree growing and management and in forest products utilization at the local level is frequently needed. Financial resources of NGOs also need to be augmented to make them more effective.

Research and extension: Inter-disciplinary research in support of forestry for food security should be encouraged and the teams carrying out such research might include universities' staff, NGOs and government personnel such as extension workers.

*FOREST NEWS is issued by the FAO Regional Office for Asia and the Pacific as part of TIGERPAPER. This issue of FOREST NEWS was compiled by Dr. Y.S. Rao, Regional Forestry Officer.*

Feature of:
TIGERPAPER Vol. XV: No. 1 Jan. - Mar. 1988

# FOREST NEWS

Vol. II: No. 1

GUEST ARTICLE

## SOWING FROM THE AIR : CHINA'S EXPERIENCE

*A condensed version of the study prepared for the FAO Regional Office, Bangkok, by Mrs. Chen Xinhua and Mr. Zhang Jingchun, Department of Afforestation, Ministry of Forestry, People's Republic of China.*

1. Sowing seeds by air, as a means to quickly reforesting inaccessible, denuded hills, was started on an experimental basis in China in 1956. Over the years, the programme was actively pursued and now covers 600 counties in 25 provinces. The area afforested through aerial sowing extends over 15 million ha.. Of this, it is estimated that 2 million ha. of the area sown in early years has already become a closed forest. Aerial sowing in China emerged over the years as a quick and effective way to enlarge the afforestation effort and to gradually improve the ecological environment of the country.

2. The earliest aerial sowing operations were directed by Mr. Zhu Zhisong, Chief Engineer of the Transportation Unit of the Airforce of the Guangzhou Military Region, in March 1956. Seeds of *Pinus massoniana* and *Acacia confusa* were sown by air over 600 ha. in Wuchuan Country, Guangdong Province in cooperation with the Forestry Department of Guangdong Province. Due to improper selection of the sowing season and the inadequate treatment of seeds, the experiment failed. But important lessons were learnt about the conditions necessary for successful aerial sowing, particularly the technical essentials such as: the selection of areas for aerial sowing; the timing of aerial sowing; the species of trees; and the correlation between the precipitation and the success or failure of aerial sowing. These early trials laid the foundation for continued aerial sowing operations in China.

### THE INITIAL SUCCESS

3. Under the auspices of the Department of Forestry of Sichuan Province, the experiment of aerial sowing of *Pinus yunnanensis* was carried out in the Tongxi River basin in the Liangshan Yi Autonomous Prefecture in Sichuan Province on September 11, 1958. The total area of aerial sowing was 1,120 ha.. According to the observations, after aerial sowing, germination was good. But because the aerial sowing was done too late (dry season started only one month after germination of seedlings), all the seedlings died due to the ensuing long period of drought. The experiment continued in the next year and the time for the aerial sowing was shifted to an earlier date of June 11, 1959. The total area of the aerial sowing was 700

ha.. The seedlings had grown 100 days before the dry season came and all the seedlings stayed alive through the dry season. This experiment turned out to be successful. According to the survey in the winter, the survival rate of the seedlings of *Pinus yunnanensis* was above 60%. The mixed species of *Alnus cremestogyne* and *Coriaria sinica* grew well on the damp soil. This experiment was the first successful example of aerial sowing operations in China.

4. After this initial success, forest technicians in the Department of Forestry of Sichuan Province and in the Liangshan Yi Autonomous Prefecture continued their efforts to expand the area of aerial sowing and paid more attention to correct techniques of sowing and the protection and maintenance of the aerially sown forests. A new forest with an area of 170,000 ha. has come into being through their arduous work over 20 years; the forest stand has now trees with an average diameter at breast height (DBH) of 14-16 cm. and an average height of about 13 meters. In the Tongxi River forest farm an area of 20,000 ha. was already thinned to obtain 150,000 cubic meters of logs. The forest farm has also supplied firewood for 150,000 inhabitants in 24 townships. More importantly, significant benefits in preventing soil erosion resulted. According to a survey, after the establishment of the forests by aerial sowing, the sand content of the Tongxi River was reduced by 77% and soil erosion in the area has been reduced by 80%. Since 1970, the precipitation has increased 21% in the dry season compared with before the aerial sowing. Ten rivers in the area have not been flooded again. Rice-growing in the area has expanded. Grain production reached 1.15 million kgs in 1982 from 0.4 million kgs in 1968; livestock increased to 13,000 from 3,000 in the Donghe township, Xide Country.

5. Professor Hubert Aulizky of Vienna University in Austria, made a survey of the aerial sowing area in Liangshan Yi Autonomous Prefecture in 1983. He regarded the effort as a large project of water and soil conservation and the best achievement he had ever seen.

## ACHIEVEMENTS OF 20 YEARS IN AERIAL SOWING

6. The aerial seeded area was increased annually in most of the provinces. Up to 1972, the accumulated area of aerial sowing was 3.95 million ha. with an average annual aerial seeded area of 520,000 ha.. Since the middle of the 1970's, the scale of aerial sowing has been further expanded and the operation of aerial sowing in afforestation has become one of the important methods to afforest the barren hills in the provinces and autonomous regions in southern China. The annual aerial seeded area was more than 70,000 ha. in the provinces and autonomous regions of Guangdong, Guangxi, Guizhou and Yunnan. In Guangxi Zhuang Autonomous Region, the annual aerial seeded area at its height reached 300,000 ha. and the preserved area of aerial sowing made up 43% of the total afforested area in the past 23 years. The existing extensive aerial seeded forests in southern China were mostly the result of aerial sowing during this period. New forest bases for the country have taken shape on the dense, thriving and extensive aerial sowing forests. There are 700,000 ha. of aerial sowing forests of *Pinus massoninna* in Guangdong Province with 3 extensive concentrated joint aerial sowing forests, each with an area of more than 130,000 ha., on the southern ridges of Nanling, Lianghua Shan and Yunwushan mountains in 10 counties. During the same period, the experiment of aerial sowing of *Pinus tabulaeformis* in the mountain areas of northern Hebei Province in north China had obtained success and was gradually popularized to all places in the province. Also, the experiment of aerial sowing of *Pinus tabulaeformis, Caraguna microphylla* and *Astraglus adsurgens* turned out to be a success in the Yanan region of the northern part of Shaanxi Province. Thus, aerial sowing in afforestation work has been developed successfully from moist rainy south China to the dry north China.

## TECHNIQUE OF AERIAL SOWING

### Selection of the Sowing Area

7. The principles for the selection of the sowing area are as follows:

(1) The barren land and hills urgently needed to be afforested in accordance with the local forest land classification and natural conditions for aerial sowing.

(2) The suitability of natural conditions for aerial sowing.

8. In order to be economical

and reduce the costs of aerial sowing in afforestation, the barren land and hills good for afforestation must be relatively concentrated and connected. The effective area should be no less than 70% of the sowing area.

**Proper Orographic Conditions for Aerial Sowing**

9. Aerial sowing in afforestation is carried out by means of aircraft. Due to the various configurations and the flying functions of different aircraft, there are different requirements on the orographic conditions among various types of aircraft, such as the height and height difference of operation, the conditions of the clear distance, the turning radius, the minimum sowing area, etc. The specific requirements of the different types of aircraft on the orographic conditions should be taken into consideration in the selection of the sowing area.

**Appropriate Social and Economic Conditions for Aerial Sowing**

10. There are three major points in this aspect: a strong desire of the local people to develop forestry; a clear ownership of hills and a definite boundary of land so as to solve the problems between forestry and agriculture, forestry and animal husbandry; and an ability to protect and manage the aerially seeded forests.

**Costs**

11. In order to keep the costs of aerial sowing low, the sowing area should not be too far from the airport.

**Selection of Species**

12. The species used in aerial sowing should first have the ability of regeneration by natural seeding. Many species used in afforestation may not be suitable for aerial sowing. It is impossible to select species according to the different orographic conditions such as the direction and the position of the slopes, vegetation and soil types everywhere in aerial sowing area. Furthermore, because of no site preparation before and after the aerial sowing, the germination of seeds and the growth of seedlings on the ground after sowing are more affected by the natural environmental conditions than that of man-made forests. Therefore, it is very critical to select the species correctly for the success of aerial sowing.

13. Among the major species presently used for aerial sowing in China, are such species as: *Pinus massoniana, Pinus yunnanensis, Pinus tabulaeformis, Pinus arandi, Pinus kesiya var langbianensis, Pinus thunbergii purl, Pinus tuiwauensis, Biota orientalis, Rhus verniciflus, Acacia confusa, Schima superba, Hedysarum scoparium, Hedysarum mongliuon, Hippophae rhamnoides, Caragana microphylla, Artemisa desertorum, Astraglus adsurgens* and *Melilotus suaveduna,* etc. In many places of China, the aerial sowing of mixed coniferous and broad-leaf species has been conducted with *Pinus* species. The aerial sowing of mixed arbors, shrubs and grass has also been developed.

**The Selection of Sowing Time**

14. Just like agricultural operations, aerial sowing is also very sensitive to different seasons. The selection of the proper sowing time is an important factor to improve the efficiency of aerial sowing in afforestation. If aerial seeding is done too early, due to insufficient water and low temperature there will be a quantitative loss of seeds and a side effect on the growth of seedlings. If the aerial sowing is carried out too late, the growth period of seedling will be too short and it will be difficult for the seedlings to be drought-resistant and survive the winter.

15. According to the weather forecast, aerial sowing should be carried out in a period of continuous clear days on an extensive area to avoid unfavourable weather conditions such as successive cloudy or rainy days, strong winds, heavy clouds and hail, etc.

**Determination of Seed Quality**

16. The density requirements for different natural conditions and species in afforestation are quite different. Lower density is required for the fast-growing species and light-demanding trees, while a high density is required for the poor soil and drought areas, and in the places where there is a shortage of water and fertilizer. In the case of the latter, the seed quantity must be increased appropriately so as to boost the conservation rate of young seedlings and promote its canopy in advance, and especially to strengthen the resistant capability in adverse conditions.

17. The quantity of seed to be sown in unit area is derived by taking into consideration: the number of planned seedlings

per unit area; germination percentage of the seeds; purity of seeds; loss rate of the seeds by aerial sowing (due to the damage by birds and animals); germinating rate by aerial sowing; and the weight of seeds.

**Planning and Designing**

18. The planning and designing work in afforestation by aerial sowing usually proceeds through the following three procedures:

(1) Make an on-the-spot survey of land or hills suitable for afforestation by aerial sowing; observe the whole area planned to be sown and the topography within and around the sowing area, as well as the proportion of the acreage suitable for aerial sowing. The course of the flight generally keeps the same direction with the long side of the sowing area. The navigation mark line should be set up on the ridges of the high mountains so as to keep a good sight of each other. The alignment of the navigation mark line should be of verticality or near verticality to that of the flight direction. The scope of the sowing area should be framed on the map. The sowing area should as far as possible include the sectors suitable for aerial sowing and abandon the unsuitable areas. A rectangle or several rectangles should be formed because the rectangle facilitates the sowing operation for the fixed-wing aircraft.

(2) Carry out an investigation of the basic conditions of the area to be sown, such as: soil and vegetation; ownership of the land; distribution of the residents; the number of animals and the grazing habits; and local meteorological data.

(3) Navigation marks on ground are the guiding posts for aerial sowing operations. They must be set on the ground to indicate the design of the sowing area, the width of the sowing strips, and the topographic variations.

(4) The technical design and calculation includes the area of sowing, the area of sowing strips, the required amount of seeds (calculated by species), the sortie of the flight operation, flight time and the time of manoeuvre etc.

**Seed Treatment and Clearance of Vegetation**

19. Seeds are the physical basis for afforestation. The quality of the seeds and the selection of provenance are of key importance to the results of afforestation. In seed selection, great importance should be attached to the activities of collection, inspection, testing, treatment, storage, etc.

**Seed Collection**

20. According to the afforestation plan, the seeds must be collected in time from elite stands. If the local seed source is inadequate, it must be allocated and transported from outside. But, attention must be paid to the natural conditions of the seed producing areas.

**Seed Inspection and Testing**

21. The seeds collected from different districts should be inspected and tested by sampling using a checklist for quality control. The items of the checklist should include: the name of species, origin, time of collection, date of inspection, purity, germinating capacity, germinating percentage, moisture content and total weight per thousand seeds, etc. A sampling check or germinating test should be done once more after the seeds are transported to the airport. Stone and earth should be cleaned by screening.

**Seed Treatment**

22. The methods for seed treatment may be divided into general and special ones. The general one is coating. The coating materials, except for the adhesive and colouring agents, are mainly vemifugal (for reducing the harmful effects of birds and mice), water absorbent, nutrient and nodule bacteria, etc. The special treatment is by dewaxing. The seeds of lacquer trees and Taiwan acacia must

be dewaxed, otherwise, the wax on the seeds will affect water absorption and germination. To prevent the seeds from being blown into the low-lying side of leeward, thus causing an uneven growth of seedlings, they must be "balled" before sowing so as to increase the weight of seed by 3-5 times.

### Clearing the Vegetation

23. In order to create a favourable condition for the seeds to touch the soil easily, it is quite necessary to control the vegetation in the sowing area where the ground vegetation coverage exceeds 0.7. The way to control the vegetation is through general artificial weeding, brush cutting, use of weed killers, prescribed burning, etc.

## TYPE OF AIRCRAFT AND TECHNICAL REQUIREMENTS

### Type of Aircraft

24. The YN-5 Aircraft is a light and multipurpose biplane with a single shot piston used mainly for agro-forestry aerial operations. The length of the aircraft is 12.735 m. and it is 4.13 m. in height with a 18.176 m. upper wingspan and an engine of 1,000 HP. The maximum speed per hour of level flight (1,700 m. above sea level) is 245 km., while the minimum is 150 km. The maximum voyage distance is 870 km. The distance needed for taking off and landing is 150-180 m. The all-up weight is 5,000 kg. (including the dead weight of plane 3,600 kg. and loading weight 1,000 kg.). The operating height is usually 80-150 m. with the minimum of 30 m. The ascension rate is 1-2 m./sec. (maximum 4 m./sec.). The absolute height of operation is less than 2,600 m., and it can basically meet the requirements of afforestation by aerial sowing in China.

25. The characteristics of YN-5 Aircraft are as follows:

i. It has two operational systems and a fixed landing gear with excellent performance reliability and is capable of low altitude flying;

ii. It has a good adaptability to the areas of plateau, high temperature and frigid zone;

iii. It has low demands on the conditions of airport, requiring only a short runway for taking-off and landing.

iv. It is equipped with spraying devices for agricultural purposes. Since the YN-5 Aircraft has the above characteristics, it is widely used in agro-forestry work.

### IL-14 Aircraft Made in USSR

26. The aircraft is a low monoplane. The fuselage and wings are fully metallized. It has a semi-hard shell structure with a length of 22.31 m., height of 7.8 m., and wingspan of 31.7 m. The chamber of the aircraft is well-equipped with radio devices and electric instruments and meters as well as being ice-proof, fire-proof and having a heating system. It can fly in day and night under complex weather conditions. The landing gear is hydaulic-controlled with less resistance during flight. The operational speed per hour is 250 km. at the general height of 300-500 m. The distance required for taking off and landing is 510-540 m. The all-up weight is 17,000 kg., including the dead weight of 13,500 kg. and loading weight 1,600-2,000 kg. There are two sets of engines with 1,900 HP. The plane has a big loading capacity and fast speed. It can operate above elevations of more than 3,000 m. and is suitable for afforestation purposes in the distant mountainous areas of southwestern China.

### Aerial Sowing Equipment

27. Aerial sowing equipment of the YN-5 Aircraft comprises a seed tanker, seed outlet (i.e. powder outlet, also called quantitative outlet), batcher, windmill, mixer, diffuser and operation control switch. Since 1972, the users have increased the loading capacity by 15-33% by repeated improvements of the seed tanker, seed outlet and diffuser, and by removing the windmill and mixer. However, the seeds are not as well-distributed as expected and the amount of seeds cannot be automatically controlled in the air due to the inconvenient adjustment of the batching device.

28. Developed in China, the design of the IL-14 Aircraft has been finalised after repreated improvements. The aircraft mainly consists of a seed tanker, seed outlet, spiral impeller, motor, diffuser and signal devices. The seed tanker is divided into six cabinets with a total volume of 4.6 cubic meters holding 1,600-2,000 kg. of seeds. Of the same length as the cabinets controlled by a mini-motor, the seed outlets are made on the bottom of each cabinet of the seed

tanker. Due to the broad opening of the seed outlets, there is much less trouble with seed blocking. Five meters in total length, the spiral impeller is connected with the motor at one end and fixed up with the bearings on the wall at the other. Actuated by the motor, the spiral impeller runs 70-80 rpm, feeding the seeds uniformly into the seed outlets and spraying them out through the diffuser. The seeds sprayed per unit are uniform.

**Area Covered Daily by Aerial Sowing**

29. The calculation of the daily sowing area of the aircraft proceeds as follows:

30. Firstly, the sowing area and the flying time per sortie shall be calculated on the basis of the unit sowing amount of the loaded seeds of different types of aircraft and the flying speed. Then, the daily sowing area is obtained by calculating the flying sorties according to the daily flying time under normal conditions (including weather conditions, ground service, etc.).

31. Taking the YN-5 Aircraft as an example, the carrying capacity of the YN-5 Aircraft is 800-900 kg. If the seed rate per ha. is 2,250 grams, one sortie can afforest 356 to 400 ha. by aerial sowing.

32. The flying time per sortie is the combination of the following times:

(1) The take-off and landing time in the airport is reckoned as 3-6 minutes.

(2) The time (minutes) for the to and fro ranges between the airport and the sowing area equivalent to the distance from the airport to the sowing area as the crow flies (kilometers) divided by 2.6 (km./min.) by 2 (2.6 kilometers per minute is the flying speed of the YN-5 Aircraft).

(3) The operation time (minutes) in the sowing area is equivalent to the accumulated length of sowing belt (km.) divided by 2.6 (km/min.) (The common width of the sowing belt is 50 m.)

(4) The turning time of the aircraft in the sowing area is equivalent to the number of turning times 1' 40" (standard turning time of the YN-5 Aircraft).

33. Due to the differences in the three species used, seed rate per unit area and the distance between the airport and the sowing area, there is a striking contrast in sowing areas between the sorties. Even when there are the same number of sorties, the daily sowing areas are still different. Statistics in Jiangxi Province show that, in normal conditions, one sortie may sow an area of 400 ha. with *Pinus massoniana* with a seed rate of 2,250 grams per ha. One aircraft can fly 4-5 sorties per day, seeding an area of 1,600-2,000 ha. on the condition that the range between the airport and the sowing area is less than 100 km. Under the same sowing conditions for *Pinus tabulaeformis*, with a seed rate of 7,500 grams per ha., one sortie can sow 120 ha. and the daily sowing area will reach 400-600 ha.

**Weather Requirement for Aerial Sowing**

34. Weather conditions have a great influence upon the scheduled operation of the aircraft and the quality of the aerial sowing. Therefore, favourable weather conditions should be made full use of and unfavourable conditions be avoided, so that a safe operation is guaranteed and the task of aerial sowing can be fulfilled successfully.

**Meteorological Factors that Affect the Aerial Operation**

35. The practice of aerial sowing for many years and the characteristics of special flying demonstrate that the meteorological factors closely related with the aerial operation are mainly: visibility, cloud altitude, cloud cover, wind direction, wind speed, atmospheric temperature, thunderstorms, cumulonimbus clouds, etc. Good visibility is helpful for the pilot to find signals at an early time and to maintain the right direction for sowing. If the visibility is poor or the forecast of visibility is not accurate, the aircraft will have to return to the airport, which will mean a loss by not completing the task of aerial sowing. The amount of clouds and cloud altitude directly influences the weather conditions and, thus, the safety of the flight. Large amounts of low altitude clouds directly affect the take-off, landing and aerial operation of the aircraft. The direction and speed of the wind also has a great influence on the take-off and landing, on the sowing operation and on the quality of aerial sowing.

36. Changes in temperature also affect the aerial sowing operation. Generally speaking, when the atmospheric temperature rises higher, the air density shall be thinner and the air infeed of the engine shall decrease, thus causing the flying speed to slow down and the distance required for taking-off and landing the aircraft is enlarged by the reduction of engine power and by the weakening of the impeller's tension. The cumulonimbus clouds bring gusts of rains, often with big winds and thunder, even with hail sometimes. All these factors pose great threats to the aerial operation.

### Weather Conditions for Aerial Operations

(1) The minimum standard for the YN-5 Aircraft:

The cloud altitude for trail flying shall not be lower than 300 m. (not lower than 600 m. in the complex areas or highlands). The field visibility shall be more than 5 km.

The cloud altitude for operational flying shall not be lower than 300 m. (the highest point from the operation area). With the field visibility staying at more than 5 km. and without continuous toss or descending air currents. The wind speed shall be less than 5 m./sec.

(2) The minimum weather standard for the IL-14 Aircraft:

Cloud altitude shall not be lower than 500 m. (the highest point from the operation area). Other requirements are the same as those of the YN-5 Aircraft.

Aerial operations shall not be carried out under the following conditions:

i. The side wind speed in the sowing area is more than 5 m. sec., or the speed of the headwind or tailwind surpasses 8 m./sec.;

ii. Cumulonimbus clouds or thunderstorms are moving towards the airport or the sowing areas;

iii. Atmospheric temperature is more than 35 degrees Centigrade.

### QUALITY INSPECTION SYSTEM FOR AERIAL SOWING

37. The evaluation of the sowing quality depends on whether the actual sowing width meets the requirements, whether the seeds are in proper places and whether the seeds are evenly distributed. It is generally expected that the actual sowing width be wider than that of the planned ones, but not wider than 30%. The seed distribution in the sowing area should be over 85%.

38. The method adopted in quality inspection is to establish a certain number of seed-receiving sample plots of equal distance and at right angles to the sowing width. These are used to determine the number of seeds sown, sown width and seed distribution. The distance between the sample plots is usually 1/4 or 1/2 of the planned sowing width; however, it is set each time in accordance with the planned sowing width and experiment requirements. 1 m. x 1 m. white cloth is often used as the sample plot with four corners nailed into the ground to keep it horizontal.

39. The following data should be calculated on the same day and entered in the recording forms:

i. The actual sowing width, i.e., the sample width receiving more than one seed;

ii. The effective sowing width, i.e., the sample width receiving over 4 seeds;

iii. Seed distribution: the sample plot receiving the maximum number of seeds is regarded as being accurate; any seeds that have fallen to the front or back of the sowing belts are regarded as "deviated" seeds that should be counted separately;

iv. The average number of the fallen seeds, i.e., the total number of seeds divided by the sample plots with fallen seeds;

v. The accuracy rate of seed distribution, i.e., the percentage made up by the sample plots receiving more than one seed in the total number of sample plots.

### Monitoring of Effective Area Sown

40. One of the methods for monitoring is based on statistical sampling where representative sample units from the "population" are selected, and the seedlings enumerated. The advantage of this method is that the desired result can be achieved with minimum field work and the

statistical accuracy can be indicated.

41. Another method adopted is known as: "Subcompartment Investigation Method". This method is generally adopted in the sowing areas where the aerially sown young stands are taller than the bushes and grasses. The advantage in this method is that not only are the surviving seedlings enumerated, their growth characteristics are studied and a distribution map of the young stands prepared.

42. The major steps are needed for this investigation are:

(a) A base map is prepared using mountain ridges, rivers and other natural dividing lines to separate compartments.

(b) Subcompartments are distinguished in accordance with the land classification, site conditions, canopy density, elevation, location, slope, slope direction, any other natural factors and the density of young stands.

(c) Representative rectangular or square sample plots are chosen for enumeration of the number of trees, mean diameter at breast height, average height, etc.

(d) Data is recorded, analysed and used for further improving the management, administration and technical measures involved in aerial sowing.

43. In China these investigations are conducted 4-6 years after aerial sowing (4-5 years in the southern provinces and autonomous regions; 5-6 years in the northern provinces and autonomous regions). They provide the basis for the assessment of the work done by the provinces and autonomous regions in aerial sowing.

**Management of the Aerial Sowing Area**

44. When the aerial sowing is finished, the major task is to establish managerial organizations to take care of the aerial sowing areas. For example, a managerial bureau responsible for 8 satate-owned forest farms, 7 counties and 1 municipality has been established in Lianshan Yi Nationality Autonomous Prefecture in Sichuan Province. Some counties with a large area of aerial sowing plantation have set up managerial stations to check and supervise the maintenance work. In Fulin county of Yunnan Province, a managerial office, headed by the vice magistrate, has been established with one Deputy Director and 5 other members from the county forestry department to undertake the responsibility of the 29,000 ha. of aerially seeded forest. In some districts and townships, there are managerial committees headed by one of the leading members from the district or township. For instance, the authority of Liuzhou Prefecture, Guangxi Zhuang Autonomous Region, stipulates that a managerial committee should be set up in the district where the aerial sowing area is more than 2,000 ha. There are managerial groups at the township level in Badong County, Hebai Province. Generally speaking, most of the villages also have managerial teams or groups to manage the local aerial sowing plantations.

**Rules and Regulations to Protect the Aerially Seeded Areas**

45. Based on the relative awareness of the importance of protecting aerially seeded forests, various responsibility systems have been established. It is stipulated that after aerial sowing the areas should be closed off for at least 5 years. The government is responsible for issuing notices concerning the maintenance of the aerial sowing plantations. The local people themselves make the regulations and rules to protect the forests. Persons who do a good job in forest maintenance will get rewarded and those who destroy the forests will pay for the losses or be punished if the cases are serious. There are many good examples where the contradictions between grazing/fuelwood supply for the local inhabitants and protection of aerially seeded areas have been solved. Usually a certain proportion of afforested area and hills are closed in rotation.

**Replanting and Reseeding**

46. Due to many reasons, seeds do not germinate evenly after aerial sowing. In order to fully use the productivity of the land or hills, the principle of replanting and reseeding is that where there are no seedlings, it should be reseeded; where there are only a few seedlings, it should be replanted; where the seedlings are too dense, they should be thinned; where

there are naturally generated seedlings, they should be preserved, and where the seedlings are suppressed, they should be tended. The replanting and reseeding activities should be carried out 3 years after the aerial sowing has taken place. The species used for replanting and reseeding purposes should be the broad-leaved ones and should be suitable for the local site conditions so as to form mixed forests of coniferous and deciduous species. The broad-leaved trees in the aerial sowing area should be protected.

## THE SCOPE AND BENEFITS OF AERIAL SOWING IN CHINA

47. In China from 1958 to 1985, a total of 15 million ha. were aerially seeded at an average annual rate of 536,000 ha., of which the annual average from 1958 to 1980 was 456,000 ha. (maximum 1.03 million ha./year, minimum 10,000 ha./year). From 1981 to 1985, the annual average was 797,000 ha. (maximum 1.3 million ha./year, minimum 340,000 ha./year. The total aerially seeded forest (including mature and young sands) was 4.7 million ha., which accounts for about 31% of the total aerial sowing area and 16% of the total man-made forests.

48. Aerial sowing has produced impressive effects as shown in the following examples:

### Expedite the speed of afforestation of barren hills

49. The total area of man-made forests in Xichang Prefecture, Sichuan Province, from 1952 to 1957 amounted to 6,000 ha., increasing at an average annual rate of 1,100 ha. However, the total area of aerially seeded plantations soared to 65,000 ha. in the seven years from 1959 to 1965. Man-made forests would take 60 years to cover the same amount of acreage.

### Establish large-sized timber bases

50. Trees that were aerially sown in the early times have now become forests covering two million ha. In Guangxi Zhuang Autonomous Region there are 4 pieces of forested land which were seeded by aerial sowing that cover 70,000 ha. each, and 7 pieces of forested land with 30,000 ha. each. It is measured that the volume of the ten-year-old stand of *Pinus massoniana* is 120-150 cubic meters per ha., of which the best ones aerially seeded in 1967 can have 270 cubic meters per ha.

### Ecological effects

51. Aerial sowing plays a very important role in water and soil conservation, catchment protection, soil improvement, climate adjustment etc. For example, there are 5,300 ha. of aerially seeded forests in Daxian County, Sichuan Province. According to the measurements made by the local hydrometric sation, in the 1970's the Mingyue River annually carried away 1.14 million tons of sand. This was reduced to 320,000 tons in 1981, by which time the aerially seeded trees had become forests. In Longan Country, Guangxi Zhuang Autonomous Region, 60 square kilometers of catchment around Nalong Reservoir have been afforested by aerial sowing. The usual flow of the main watercourse was 0.032 cubic meters per second, before the aerial sowing. Now the normal flow of the main watercourse has increased to 0.2 cubic meters per second since the aerially seeded trees have grown up. The water storage of the reservoir in dry seasons increased by 17% when the aerialy seeded plantations were still young.

### Economic and social benefits

52. The aerially seeded plantations have not only provided society with timber, but have also supplied farmers with fodder, fertilizer and forest by-products. In particular, the supply of fuelwood from the plantations has effectively alleviated the rural energy crisis. For example, since 1961, Wuzhou Prefecture, Guangxi Zhuang Autonomous Region has afforested 165,800 ha. of *Pinus massoniana* by aerial sowing, of which 25,300 ha. was thinned from 1978-1984; 164,000 cubic meters of timber were yielded from thinning. The sum earned by selling the thinned timber was 5.9 times as much as that of the investment in aerial sowing in the whole area.

53. Another example comes from Wugi County, Shaanxi Province. The species chosen for aerial sowing was *Astragalus adsurgens*, which is a nice fodder and green manure plant. In the year that aerial sowing was carried out, the germinating rate was 20-30% with 45,000 – 195,000 seedlings per ha. Each ha. yielded 13.5 tons of fresh fodder in the second year and 72.5 tons in the third year. Therefore, the aerial sowing of *Astragalus adsurgens* has

promoted the development of local animal husbandry.

54. The first tending of the 86,700 ha. of aerially seeded plantations in Huidong County, Guangdong Province, was conducted in the sixth year after aerial sowing was done and the income from selling the fuelwood amounted to one million RMB yuan.

**Training a large number of specialized technicians in aerial sowing**

55. After many years of aerial sowing practice, a considerable number of technicians have been well-trained, who have not only mastered the theoretical knowledge, but also have gained rich experiences in practical operations. The Ministry of Forestry has transferred suitable technicians from provinces and regions to be trained. These trained technicians then go back to their own provinces or regions to hold short-term training courses to improve the skills of the people involved in aerial sowing. Working brigades at the three levels (provincial, prefectural and county) have been organized in the key provinces and regions to undertake the whole process of aerial sowing operations including planning, designing, organizing and inspection, etc.

56. The achievements made in aerial sowing in China are closely connected with the long-term assistance from the Civil Aviation Administration of China and the Chinese Air Force of P.L.A., and the close cooperation between the forestry departments concerned and research institutes and forestry colleges. Due to the combination of scientific research, teaching and production, great achievements have been made in the past twenty years and more. Many aerial sowing projects have won prizes variously awarded by the Ministry of Forestry, Ministry of Agriculture, Animal Husbandry and Fisheries, the State Commission of Agriculture, the State Commission of Sciences and the State Commission of Economy.

## PROSPECTS FOR AERIAL SOWING IN AFFORESTATION IN CHINA

57. China is vast in territory but poor in forest resources. Mountains and hills account for 67% of the total land area and the forest coverage is only 12%, with the per capita forest land of less than 0.3 ha. The problem of water and soil erosion is very serious because of the shortage of forest resources. Therefore, it is quite essential to mobilize all initiatives to plant trees and pastures for the purpose of increasing the coverage of vegetation in the whole country. The task facing the Chinese foresters is, on the one hand, to develop fast-growing and high-yielding forests, timber purpose forests and shelterbelts in the areas where the transportation is easy and the manpower can be employed, and on the other hand, to take the advantage of aerial sowing on the upper reaches of big rivers and remote areas in order to make the country green and to realize a healthy rotation of the ecological system as quickly as possible.

58. In the future, aerial sowing will be employed mainly in the sub-tropical and humid areas of the ten southern provinces. These provinces are very experienced in aerial sowing from earlier practice, such as the early aerially sown plantations which have become mature and now function as shelterbelts, which is tangible and convincing to the people. Furthermore, the local governments at different levels attach great importance to the acceleration of afforestation and the local people are eager to afforest the barren hills to improve the environment.

59. In the northern semi-humid and temperate areas where there is serious water and soil erosion, the main job is to establish shelterbelts and protective forests. Aerial sowing in these areas must be steadily developed drawing on past experiences gained and the according to the local weather conditions in order to make it successful.

60. In the semi-arid areas, the experiments on afforestation and grass planting by aerial sowing should be continued and the experiences on sand control by aerial sowing should be specially summarized.

61. The 5,000 km. sand dune running along the "Three North" (northeast, northwest and north of China) is seriously imperiling the production activities of about 100 million ha. of farmland and pastures, and any successful experience in sand control by aerial sowing is of strategical importance. However, this area suffers from bad natural conditions and the aerial sowing will have to be performed in a step-by-step manner, i.e. starting from the area with about 400 mm. of precipitation, and the careful selection of proper species and correct timing of sowing. Data

and rules of aerial sowing must be accumulated to enhance any future large scale aerial sowing.

62. Aerial sowing in China has a history of 30 years and proved that it is one of the major ways to make the country green. With the development of economic construction, the modernization of aerial sowing will be fostered. It is expected that by the end of this century aerial sowing in China will make a great leap forward and the achievements will exceed those of the past thirty years as long as continual and effective efforts are made by the people who are in charge of the aerial sowing activities. Technical cooperation on aerial sowing between China and rest of the world will be strengthened and experts from various countries are welcome to organise study tours in China. In the meantime, the Chinese experts are ready to go to the developing countries to assist afforestation efforts with advice on aerial sowing operations.

## *NGOS AND FORESTRY*

*Several Non-Governmental Organizations (NGOs) in Asia are taking an increasing interest in promoting environmental awareness and encouraging local level afforestation. They play a crucial role to represent local interests and often act as intermediaries between the governments and local communities. Although NGOs have proliferated in recent years, there is a lack of information about the precise nature of their activities. This section is devoted to their activities. The first installment published in the first issue of Forest News concerned Thailand. The second covered Indonesia, and the third India. In this issue Mr. Shanta Pandey reports on Jarajuri, a small voluntary NGO in Nepal which is encouraging community initiative in development work.*

### JARAJURI – A NEPAL NGO WITH A DIFFERENCE

1. Sometimes all local people need is merely recognition or someone to pat their backs for what they have been doing on their own initiative. This can be illustrated by an effort of "Jarajuri" in some villages of Nepal. Jarajuri is a small voluntary organization formed by a few environmentally–conscious people of Nepal in response to recognizing local community's initiative to protect forest. The founder of this organization, Dr. K.K. Panday, recognizing that there are pockets of local communities in Nepal who are planting and protecting trees in their communities reflecting their environmental consciousness, decided to contribute a royalty received from the sales of his book "Fodder Trees and Tree Fodder in Nepal", as an individual venture to boost their morale. Villagers of four villages in Ward No. 2, Nalang Panchayat, Dhading District of the Central Development Region of Nepal (where this author did a study on the traditional community forestry management system), received one of the six Jarajuri Awards for protecting a forest (Hattisunde Forest) in government-owned land. Villagers of 53 households (who are mostly illiterate, poor and politically powerless) of these four villages had been protecting this forest since 1979 without any external support (financial or otherwise). The forest has neither a fence nor a forest guard. All 53 households protect this forest by obediently following a self-imposed protection system. No one else, including the Forest Department of Nepal, had noted the environmental awareness of the people of these villages until one day when they were recognized by a Jarajuri Award of Rs 1,000.00. The award not only served as a morale boost to the people for what they had been doing for almost a decade, but also gave them prestige among the neighbouring villagers. Neighbouring villages in turn began to emulate the work of these villagers by beginning to protect denuded government land around their own villages as a spread over effect of the Jarajuri Award received by the Hattisunde forest protectors.

2. It was one of the best steps Jarajuri could have taken for the villagers of these four villages because their community-based efforts to protect Hattisunde forest had not yet been recognized by the Forestry Department. The current (1980 amended) Forestry Legislation of Nepal states four categories of forest which could be transferred to local communities for control and management: 1) Panchayat Protected (PF); 2) Panchayat Forest (PPF); 3) Religious Forests; and 4) Contract Forests.

3. Hattisunde Forest does not fall under any of the above categories of forest. This is probably because not much experience of this kind has been brought to the notice of the planners and policy-makers. Hattisunde forest is neither a Panchayat Forest nor a Panchayat Protected Forest. It is a forest protected by four villages of Ward No. 2 of Nalang Panchayat (a Panchayat is divided into nine political wards). It does not even involve all the people of that ward. Most importantly, the villagers of these four villages have neither applied for, nor have they received any legal document from the forestry department that shows that it is they who have on their own initiative protected this forest. The existing legal forest policy does not have a provision to accomodate this kind of forest.

4. Hattisunde Forest is a result of the total participation of both men and women. It is being protected by the local people, on government land, at the expense of the villagers' time, energy, food and livestock as a step towards achieving a sense of independence and self-reliance.

5. A community is composed of men and women, older people and children where a groups functions together to achieve a certain common goal. The composition of a community may vary from a few households of a village to several villages. A community could be composed of a homogenous or a heterogenous caste, ethnic or economic group. The four villages around Hattisunde Forest, for example, represent a true community unit in terms of managing this forest.

6. These villagers have made significant sacrifices in bringing up this forest. They will continue this trend as long as they are sure that the decision to manage and use this forest will rest with them. The moment there is any doubt in trust that they are no longer the only users or managers of this forest, the villagers might begin harvesting it indiscriminately. The responsibility of the forestry-related experts here is to make sure that these people continue to feel the same, if not a better, sense of trust and ownership for this forest.

7. Any action of the forestry department or forest-related projects that discourages these villagers from what they are doing would not only mean the destruction of this forest, but would also be a step towards moving the villagers towards dependence on external help. Further, it might erode their confidence that they can take community initiative to solve other similar problems. In addition, such activities would also destroy the inspiration this forest has generated among neighbouring villages. Today, the people of Hattisunde Forest do not stand alone in this venture, although they seem to be the first people to have initiated a forest management project in Dhading District. Several patches of land are being protected by people in Nil Kantha Panchayat of Dhading District. Similarly, villagers around Hattisunde Mahadevsthan have also begun protecting the forest on their own initiative. This kind of venture costs less to the forest department of Nepal. In addition, how better could participation in development be than for the villagers themselves to begin initiating development? What better way could there be to enhance their sense of self-reliance than by approving their self-motivated development work? If the purpose of rural development is to promote self-reliance, why not make an effort to understand and approve programmes that are already self-reliant? It is, therefore, time for the policy-makers and planners to recognize the existence of such types of local level forests that are truly community – based.

8. Further, villagers have a lot to offer to the community forestry programme of Nepal, especially in terms of enabling people's participation in forestry activities.

**What Can Be Learned from People of Hattisunde-Mahadvesthan in Development?**

9. People involved in Hattisunde forest protection have demonstrated that:

- Development can be purely village-based.
- Participation in development can

happen in an informal setting and that formal organization is not a crucial factor necessary for the success of participation.

- Even though local people may not be aware of various government policies and know how to go about using them, they do not always need support from the government or a project in development.
- Monetary expenditure is not always necessary to produce a good result and that development can take place even without any financial support.
- Educated people are not always required to provide a knowledge source in rural development. Even illiterate villagers can come up with excellent ways of handling the problem of decreasing resources.
- Even uneducated, poor and politically powerless people are aware of the decreasing forest resources of Nepal.
- Local people are not always the users and exploiters of natural resources. Many also share a sense of responsibility towards reversing the current trend of decreasing forestry resources.

10. To sum up, they have shown that development can take place even without the intervention of development projects, external stimulation or monetary help. They have shown that local people can get stimulated or energized from within the villages and demonstrate their sensitivity to the disaster of decreasing natural resources in their neighbourhood, if not in the whole of Nepal. The people of these four villages should be allowed to harvest the products of Hattisunde forest without having to pay a royalty or should be charged a minimum amount of royalty, especially when the time to harvest the timber comes. This view would be shared by many other community forestry experts as well. The protection system of Hattisunde Forest does not involve any financial expenditure. In other words, it is based on faith and trust. It is community-based and not panchayat-based. It would be interesting to watch them from the outside and learn the type of system they will come up with when the time to use the forest arises. The community forestry division of Nepal may be able to learn a lesson on how to go about developing a more user-suitable management system from these people.

11. The Nepal Forum of Environmental Journalists (NFET), an NGO whose members include some environmentally conscious people of Nepal, has, among other things, made visits to various environmentally deteriorated places of Nepal and have disseminated their concern about the threat to the environment through media coverage. NFET mainly aims at promoting greater public awareness and sensitizing the planners and policymakers regarding environment-related problems of Nepal.

## *SAARC SCIENTISTS ON FORESTRY MEET AT KATHMANDU, APRIL 10–12, 1988*

**By V.R. Nanayakkara, Chief Conservator of Forests, Sri Lanka**

1. The Second Meeting of SAARC Counterpart Scientists on Forestry was inaugurated by Mr. B.N. Khunjeli, Secretary to the Ministry of Forests and Soil Conservation on 10th April 1988. The meeting was attended by the delegates from: Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. Country reports were presented by respective delegates. Delegates from all the participating countries unanimously felt that forestry deserves higher priority than assigned to it in the Technical Committee on Agriculture.

2. Discussions were held on items identified at the first meeting of SAARC held at Thimphu,

Bhutan in September 1987. (Reported in Tigerpaper Vol. XIV: No. 4). The second meeting made the following recommendations:

**Separate Technical Committee for Forestry**

3. Forests constitute the most important natural resource in a majority of SAARC countries. They contribute substantially to the economy of the people in these countries. Their conservation and proper management is essential for environmental stability and for sustained agricultural production. The committee therefore unanimously and very strongly recommended that a separate Technical Committee should be constituted for Forestry.

**Creation of Data Base and a System for Exchange of Scientific Information**

4. In order to create a data base and a system for exchanging scientific information among SAARC countries, it was recommended that:

i) Each member country identify an institution as a focal point in the country to be charged with the responsibility of collection, compilation and publication of scientific information.

ii) Scientific information should be exchanged through the SAARC Secretariat.

iii) Information may be compiled on a priority basis in respect of the following:

- Forest resources: their management, production of various forest products and their marketing and processing;
- Forest research and training facilities in each country and a directory of research workers and specialists in different disciplines of forestry.
- Annotated bibliography on the following should be prepared:

a) Silviculture and management of the following natural forests: spruce and silver fir forest; chir pine forests; blue pine forests; oak forests; sal forests; and humid evergreen forests.

b) Nursery and planting techniques of the following species: chir pine; tropical pines; important fodder and fuelwood species including shrubs; Causarina; Eucalyptus; *Dalbergia sissoo;* Teak; *Acacia catechu; Azadirachta indica;* Poplars; and Dipterocarps.

c) Biomass production and utilization for energy.

d) Wood properties and recommended uses of species including lesser known species.

- List of important medicinal plants and endangered species of plants and wildlife.

**Study Tours and Symposia**

5. The delegates unanimously felt that a large volume of useful work in forestry has been done by SAARC countries but very little is known about the same in other member countries. It was realised that arranging workshops and study tours will be extremely useful for dissemination of useful information to the member countries. Keeping this in view, the delegates felt that definite areas may be identified and a plan be drawn up for the study tours and symposia to be arranged within one year.

6. It was agreed to hold symposia, workshop and study tours in the following probable areas, which were assigned first priority for the purpose:

| Topic of Symposia | Host Country |
|---|---|
| i) Community Forestry | Nepal |
| ii) Integrated Forest Management in Catchment Areas and Agro-forestry | Sri Lanka |
| iii) Wildlife Habitat Mangement | India |
| iv) Forest Research Mangement and Priorities | India |

7. The Bangladesh and Pakistan delegations agreed in principle to host workshop and study tours, but added that they will be consulting their experts and will report later on to the SAARC Secretariat.

8. Dates convenient to the host countries should be communicated in the next TCA meeting.

**Exchange of Seeds/Germplasm and Other Planting Materials**

9. The delegates realised the importance and agreed to exchange these materials. To facilitate the exchange of materials, it was decided to identify institutions to be made responsible for collection and exchange of the materials, and also to arrange for the necessary Phytosanitary Certification. The following institutions were identified for the purpose:

| **Country** | **Institutions** |
|---|---|
| Bhutan | Research Division, Forest Dept. Thimphu |
| India | Forest Research Institute, P.O. New Forest, Dehradun |
| Nepal | National Tree Seed Unit, Hattisar, Naxal, Kathmandu |
| Pakistan | Pakistan Forest Research Institute, Peshawar |
| Sri Lanka | Forest Research Branch, Forest Dept. P.O. Box 509, Colombo |

# *EXPERTS DISCUSS FORESTRY AND FOOD PRODUCTION/SECURITY*

The FAO-organized Expert Consultation on Forestry and Food Production/Security held at Bangalore, India from February 14 to 20 was attended by 48 participants/observers from Latin America, the Middle East, Africa and Asia.

Conclusions and recommendations of the Consultation focussed on the following aspects:

**Production**

Agroforestry: In certain situations agroforestry is clearly an improved and preferred land use for increasing food production without endangering the environment. It can serve to rehabilitate degraded lands as well as produce the food and fodder requirements of local communities.

Fodder production: Where possible, fodder production in forest areas should be enhanced through projects meant for raising either fodder grasses or fodder trees in blocks to be financed by the Government in the same way as for other forestry operations.

Fuelwood production: Sources of domestic fuel extend beyond fuelwood and include agricultural residues and animal dung. Methods for estimating the availability of biomass useful as fuel have not yet been perfected and more work is needed in this area.

Food production from mangroves ecosystems: Joint production of fishery and forest products is possible in mangrove ecosystems.

Production and supply of food from forests: Inventories are needed of the kinds of food available in forest areas from wild and some domesticated species and steps should be taken to ensure their collection and distribution to the needy communities.

Wildlife for food: Captive breeding of wildlife for food and economic products has potential in some areas, to be incorporated in an overall food production strategy.

**Environment**

Effects of forests: There is considerable controversy about the global effects of forests on precipitation, floods and droughts. The Consultation expressed reservations about conclusions based on hypotheses, computerised models and data from specific and dispersed locations, without relating them to the actual field situations. Whereas an understanding of the state of knowledge is important, environmental dimensions should not be looked at in isolation. Evaluation of environmental impacts of other kinds of land use, particularly those that follow deforestation, was emphasized.

Effects of shelterbelts: Shelterbelts have both negative and positive impacts on crop production. Shelterbelts are undoubtedly beneficial in those places where strong, harmful winds prevail. Some negative effects on crops in the immediate vicinity of shelterbelts have also been reported. However, where appropriate, culturally compatible and technically sound, shelterbelt systems including the right species and design should be put in place to increase the overall productivity.

Shifting cultivation: In countries where shifting cultivation is practiced as an unsustainable form of agriculture, a package of measures which include population planning, health, housing, education, crop diversification and market support should be developed. Inmediate results are difficult to obtain, but durable long-tern changes will be achieved. Development plans concerning shifting cultivation should span over a long period, say a quarter century or more.

Effects of genetic resources: While *ex-situ* conservation of genetic resources is necessary, the Consultation stressed that *in-situ* conservation is an even more important method since it offers scope for conserving a wider range of species.

**Socio-economic Aspects**

Contribution of forest foods: Forest foods are often important in bridging seasonal "hunger gaps" and periods of work stress. Medicines generated from forest areas enable the upkeep of the health of the local communities.

Forestry's contribution to income: Gathering, processing, and sale of various forestry products such as fodder, fuelwood, and minor forest products contribute to food security by enhancing the purchasing power of rural households and enabling them to buy food.

People's participation: People's participation in all aspects of planning, developing and utilising the forest resource should be ensured. These should take the form of consultation with communities on the basic needs and their perspectives of approaches to meet these needs.

Promoting forest-based small-scale enterprises (FBSSEs): Promotion of FBSSEs needs the establishment of a total supportive environment in which these enterprises can flourish.

Women as beneficiaries of forestry activities: To enhance forestry benefits to women, surveys of the forest and tree species utilized by women in different socio-economic groups should be undertaken. A sufficient number of women should be incorporated into agricultural and forestry extension services and informal women's groups and other local organizations should be utilized in the planning and implementation of forestry strategies and actions.

**Institutional Aspects**

Policy issues: There is a clear linkage between forest policies and land use policies at the interface between forestry and food security. The vulnerable rural groups in relation to food security are particularly dependent on common property resources (CPR) and on public lands. In situations where common resources are unavoidably diverted to other more productive uses, managers of CPR should find alternative ways of ensuring the livelihood of those groups who originally had open access to CPR.

NGOs: NGOs can often play a useful role as brokers, facilitators, clearing groups and advocates of the interests of rural communities. Whereas the strength of NGOs lies in their capacity to organise people and their easy access to local communities, their ability to give specific advise on technical aspects is often limited. Training of staff of NGOs in tree growing and management and in forest products utilization at the local level is frequently needed. Financial resources of NGOs also need to be augmented to make them more effective.

Research and extension: Inter-disciplinary research in support of forestry for food security should be encouraged and the teams carrying out such research might include universities' staff, NGOs and government personnel such as extension workers.

*FOREST NEWS is issued by the FAO Regional Office for Asia and the Pacific as part of TIGERPAPER. This issue of FOREST NEWS was compiled by Dr. Y.S. Rao, Regional Forestry Officer.*

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SPECIAL ISSUE OF CLIMATIC CHANGE

THEME OF TROPICAL FORESTS AND CLIMATE

Outline by Guest Editor, Norman Myers

1. Background Rationale

There has been much discussion in recent years about whether tropical forests affect climate, and hence whether the removal of the forests will change climate. Despite the extensive debate on this contentious topic, there is little concensus about what we know and understand, still less about the implications for development policy. A good deal of research has been undertaken, but it has been little coordinated for the most part, and the findings have not been assembled into an overview assessment of where we stand. The time is ripe for a collation of research results, with integrative analysis of what they reveal on this significant issue.

2. Central Issue

The basic question to be addressed is, How far, if at all, does tropical deforestation lead to climatic change? If there is such a connection (rather than a mere association of phenomena), what are the main manifestations? Does it arise primarily through changes in the composition, chemistry and behavior of the atmosphere over tropical forests? More specifically, does it occur significantly in the form of an enhanced greenhouse effect through release of carbon dioxide, nitrous oxide, methane and other relevant trace gases? Can it also arise via increased albedo? Does it occur too through hydrological disruptions of Salati-esque sort? Can it arise through still other effects? And if it occurs through a combination of two or more effects, is there any synergistic compounding of impacts?

To the extent that deforestation-climate linkages exist, what could be some likely impacts at local, national, regional and even global levels? What feedback effects could emerge, both positive and negative? What time horizons are in question? How much unrealized climatic change might be "in the pipeline" due to deforestation that has already taken place?

Note: This conceptual approach deliberately omits consideration of further climatic consequences through e.g. reduction of soil moisture, or increase in flood-and-drought regimes, in the wake of deforestation. There have to be some limits to the scope of the Special Issue.

3. Significant Repercussions

If deforestation indeed causes climatic change of whatever sort (temperature, precipitation; depletion or disruption), how far is this significant? How might it affect forest productivity? What might it do to major agricultural crops of the humid tropics? Could it

6. Other Trace Gases

How far does deforestation serve as a source of nitrous oxide, methane, carbon monoxide and other trace gases in the atmosphere? How does this compare with emissions from undisturbed forests? What are some repercussions of buildup of these other trace gases?

7. The Albedo Effect

To what extent does deforestation increase albedo? What are the climatic consequences, and on what scale?

8. Macro-scale Hydrological Systems

How does deforestation affect hydrological systems, especially moisture recycling, in large-scope regional ecosystems such as Amazonia? What are the mechanisms involved, and how far might they be disrupted and depleted by deforestation patterns on various scales? Can the Amazonia model yet be applied to other regional forests such as the Zaire basin and Borneo?

9. Localized Changes in Rainfall

What evidence is available that deforestation can lead to irregularities and/or declines in rainfall at local level, as witness the apparent cases in the Panama Canal zone, Guanacaste Province in Costa Rica, southwestern Ivory Coast, northwestern Peninsular Malaysia and various localities in the Philippines? What could be some mechanisms at work in addition to evapotranspiration processes and cloud formation? What is our understanding of surface roughness?

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PART III: WHAT DO WE DO ABOUT IT?

10. Why Deforestation-Climate Linkages Matter

If tropical deforestation indeed leads to climatic change, what repercussions can we anticipate for major agricultural crops in the humid tropics, whether rain-fed or irrigated? And for other forms of agriculture, such as stock raising? What consequences could there be for still other salient sectors of development, e.g. hydropower, or even water supplies for industrial and domestic use? Which could prove the more adverse, shifts in the amount or in the timing of rainfall? What human communities are likely to be affected, in which regions, and how large might they be? Can the repercussions, such as they might be, be quantified in economic terms, however preliminary and approximate at this exploratory stage?

11. Policy Implications

To the extent that the deforestation-climate case can be demonstrated, what are the principal implications for development policy? How are policy makers to confront the substantial risks that may be inherent in the situation? Can they/should they build in some "safety first" precautions, perhaps treating this form of putative climatic change as a contingent variable? What parallels can they draw from other areas of public policy vis-a-vis climatic change (the greenhouse effect generally, ozone-layer depletion) where they must operate within a context of considerable uncertainty? What payoffs might become available from e.g. an insurance-policy approach? What other institutional constraints are pertinent?

12. A Management Response

With respect to one of the major linkages, viz. buildup of carbon dioxide in the atmosphere, what scope is there for a sizeable response through broadscale reforestation? How could it be mounted as part of an eventual global-level program to counter the greenhouse effect? What deforested areas, notably those constituting "wasted lands" (viz. unoccupied lands such as the extensive alangalang grasslands of Southeast Asia), could become available for reforestation? What new tree species could play a substantive part, perhaps through genetically-engineered provenances with ultra-rapid growth? How much carbon could be absorbed? How could the timber be sequestered to form a permanent carbon sink? What would be some costs involved, and how could they be shared among the community of nations in equitable fashion?

These synopses indicate that authors need not feel they must present new data and analyses. State-of-the-art review papers will be fine, provided they conform to the conceptual framework of the Special Issue, thus enabling the Issue to present a single coherent evaluation of what we currently know and understand about tropical deforestation and climatic change.

July 20th 1988 Norman Myers

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Paper for Conference on Climate and the Geo-Sciences, Session on Climate, Environment and International Security, Louvain-la-Neuve, Belgium, May 1988

# TROPICAL DEFORESTATION AND CLIMATIC CHANGE

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Keywords/Abstract: Tropical forests as the single greatest stock of biomass on Earth. Rates of deforestation; impending demise of most tropical forests. Putative linkages with climate via rainfall regimes, hydrological mechanisms, surface albedo, carbon dioxide among trace gases, and the greenhouse effect, among other biogeophysical feedbacks. Repercussions for biotas; potential synergistic interactions. Implications for public policy; dealing with uncertainty; risk-reduction analysis.

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## Introduction: the Putative Linkages

So far as we can discern, tropical forests play a significant role in atmospheric patterns, whether at local, regional or global levels. In turn, this means they contribute to the workings of climate, notably via their impact on rainfall regimes among other repercussions (for some overview treatments, see Dickinson, 1987; Houghton, 1984; Lawson, 1986; Prance, 1986; Rosenzweig and Dickinson, 1986; Reynolds and Thompson, 1987). This raises important implications for development in the humid tropics with their two billion people--especially for agriculture and hence for the capacity of human communities to feed themselves. A number of tropical crops are climatically more vulnerable than is usually the case with temperate-zone crops; and in many parts of the humid tropics, a marginal shortfall in precipitation can cause a substantial shortfall in the outputs of several staple crops (Oram, 1986; Parry and Carter, 1985). In addition, tropical deforestation may eventually prove disruptive for climatic patterns in regions far outside the humid tropics.

The key question is this: "How far can tropical deforestation change climate?" The question is increasingly asked. Yet climatologists are far from being able to supply substantive answers, let alone definitive answers. The best they can offer is some insights into some linkages. According to a number of observers (Dickinson and Henderson-Sellers, 1988; Hansen and Takahashi, 1984; Hare, 1985; Henderson-Sellers and Robinson, 1986; Hutchison and Hicks, 1985; Moore, 1986; and Shukla and Mintz, 1982), the putative interactions amount to this: Forests of all kinds exchange moisture and energy with the atmosphere more intensively than do other types of land-surface cover. The main mechanism lies with evapotranspiration, which in turn depends on three requirements: moisture in the soil; vegetation that transfers moisture from the soil to the atmosphere; and energy that converts the moisture into water vapour. Most of the energy in question comes from radiational heating of the land surface,

Link of the Indian monsoon with pressure parameters! (Walker's approach! See my article on climatic variability in Trop. Ecol.

If present exploitation patterns and land-use trends persist (for the most part they are accelerating), we shall find that by shortly into the next century there will be little forest left outside of two large blocs in the Zaire basin and western Brazilian Amazonia, plus some outlier portions in New Guinea and the Guyana highlands. Even these remnant tracts appear little likely to survive beyond a further few decades (Myers, 1985).

**Impacts at Local Level**

At local level there are some alleged linkages between decline in forest cover and decline in rainfall regimes. This has long been a contentious issue, and certain observers (notably Pereira, 1973; Lee, 1978; Lockwood, 1980; and Thompson, 1980) assert there is not, and cannot be, any connection between the two. But some recently emergent evidence suggests otherwise, based on findings from localities in widely different parts of the humid tropics.

1. PANAMA CANAL AREA

Deforestation in the Panama Canal area from the start of this century has resulted in the loss of most of the forest cover in the Canal area. At the same time there has been a steady decline in rainfall as measured at Barro Colorado Island in the middle of the Canal. The decline has occured at an average rate of 6.1 mm. per year (and 9.6 mm. at a site 8 kms. further north), until it has fallen to the mid-1980s level of 2650 mm. per year (Windsor et al., 1986). Yet this trend observed from stations in mid-Isthmus is not observed at stations on or near the Atlantic and Pacific coasts. Thus the process of convection--the daily heating and subsequent rise of moist air, followed by turbulence and thunderstorms (which is the principal source of mid-Canal rainfall)--has weakened over the middle of the area, but there has been no change in the supply of moisture advected from adjacent areas by prevailing winds along the coasts. Theoretically convection should be weakened by a reduction in local stocks of moisture; and the change in vegetation from forest cover to grassland diminishes the amount of moisture stored in the soil-vegetation layer.

2. IVORY COAST

In the southern half of Ivory Coast there has been progressive replacement of forest with croplands during the past 30 years. There has also been a steady dropoff in evapotranspiration rates, from 60 to 35 percent, i.e. from a level typical of forests to a level typical of savannah (while runoff has increased eight-fold). True, climate in the Ivory Coast is more affected by nearby oceanic influences than is the case with Amazonia. Nonetheless there seems to have been an association between deforestation and drying-out of formerly forested lands during a period of 30 years. Areas that were formerly excellent and thus it depends on surface albedo (or reflectivity of the surface). In turn, the albedo depends on the vegetation, which in turn again depends on the soil moisture. As vegetation is eliminated, so there is less scope for evapotranspiration, and less moisture is dispatched into the atmosphere for recycling as rain. In addition, forests tend to increase the cloudiness of the atmosphere above them, and clouds alter the climate of forest regions in terms of both temperature and rainfall.

Within this analytic framework, tropical forests are exceptionally important. They receive a maximum of visible and especially of photochemically active, ultraviolet solar radiation. They comprise a large fraction of the Earth's biomass, and an even larger proportion of global productivity. As human disruption of these biomass stocks increases, so tropical forest ecosystems will become still more significant for climate change. Thus tropical forests, and human modification of their ecosystem workings, bear significantly on climate--all the more so if the tracts in question are large. Of course the exact response will be subject to a good deal of variation in accord with local conditions, depending too on how the largescale atmospheric circulation is altered.

In this paper, we shall explore some of the purported linkages between tropical deforestation and climatic change. But first, a couple of qualifications are in order. This is an unusually complex, under-researched and controversial issue. Second, and more important, we shall not gain a conclusive understanding of the linkages for quite a time to come. So policy makers will have to respond while in the semi-dark--a prospect from which many policy makers tend to shrink. But let us remind ourselves that decisions on the future of tropical forests will be made willy-nilly: if not by policy makers with the backing of systematized science, then by commercial loggers, cattle ranchers, slash-and-burn farmers and other agents of forest depletion who will take their decisions in light of such limited information as they have to guide their "planning processes."

**Review of Tropical Deforestation Rates**

Before we look at some empirical studies, let us briefly remind ourselves how fast tropical forests are being depleted. The amount of forest remaining in the humid tropics is now about 8 million sq. kms., or roughly half of what once existed (according to bioclimatic data). Almost 100,000 sq. kms. are being eliminated each year in complete and permanent fashion, mainly through conversion to agriculture for largescale ranching and smallscale cultivation; and at least another 100,000 sq. kms. are being grossly disrupted each year by heavy logging and intensive slash-and-burn farming (FAO and UNEP, 1982; Melillo et al., 1985; Molofsky et al., 1986; and Myers, 1980 and 1984). This means that 2.5 percent of the biome is being accounted for each year in terms of viable forest cover with full biomass and ecological complexity. Some regions are being affected more rapidly than others.

for cocoa growing are being abandoned because of less rainfall, less humidity, and longer and harsher dry seasons, plus lowering of water tables and drying up of wells (Spears, 1986).

3. SEVERAL PARTS OF INDIA

See Curr. Sci. 5-1-88.

There are parallel phenomena reported in several parts of India. In the Western Karnataka area of the Western Ghats, for instance, Meher-Homji (1985) has examined deforestation and rainfall records at 28 stations during the 1886-1982 period, and has evaluated them in terms of 12 rainfall criteria (6 related to rainfall overall, 6 to the number of rainy days). He has found that when deforestation has exceeded 15 percent within areas up to 16 kms of the stations, there has been some degree of decline in rainfall regimes. At the Ooty station, for instance, the number of rainy days outside the monsoon season (monsoonal rainfall derives from outside the area) totalled 416 days for the period 1886-1890, but steadily fell away throughout the following eight decades until it totalled only 271 days (a 35-percent decline) during the 1978-1982 period. At Chotanagpur there used to be sufficient convectional rainfall to support tea plantations, but in the wake of deforestation there is now so little such rainfall that the tea plantations have been abandoned.

Similar accounts and analyses are reported, albeit with less detail, from Assam (Sarmah, 1976), the Ranchi Plateau (Warren, 1974), and the Andaman and Nicobar Islands (Biswas, 1980).

4. PENINSULAR MALAYSIA

In the northwestern States of Penang and Kedah in Peninsular Malaysia, there has been not only a decline in rainfall associated with decline of forest cover, but a less predictable distribution of rainfall in both time and space. This has been documented throughout the past 75 years, and particularly since 1960 (Chan, 1986; Goh, 1980). As a result, some 20,000 hectares of paddy ricefields have been abandoned in this "rice bowl" of the Peninsula, and another 72,000 hectares have registered a marked dropoff in production, leading to an overall shortfall in the Peninsula's rice output of 27.5 percent in 1978.

5. PARTS OF THE PHILIPPINES

Several areas in the Philippines appear to feature a drop-off in rainfall associated with deforestation. On Mount Apo there used to be such dependable rainfall that the city of Davao installed no waterworks to ensure water supplies year-round. But during the 1960s' coffee boom there was much forest felling to make way for coffee plantations; and today there is an extended drought each year, to the extent that coconut plantations are drying out (Alfonso, 1987). Similar phenomena have been noted in Bicol, also in Mindanao; and in the Cagayan Valley of northeastern Luzon.

In addition to these five cases, there is a number of further instances reported, albeit with less documented detail. In southern

China, the 20,000-sq. km. Xishuangbanna area has lost more than half its tropical forest cover in the last 30 years. Data from three stations during the 1954-1980 period show that annual rainfall has dropped off by an average of 4 percent, and by 15 percent during the dry season. Overall the climate has become drier and hotter during the warm season, and drier and colder during the cool season (Zhang, 1986). Similarly in Guanacaste Province of northwestern Costa Rica there has been a decline in lowland rainfall extending over 40-50 years, and apparently associated with broadscale deforestation (Fleming, 1986). In the Western Ghats of southern India too there is reported to have been a parallel occurence (Green and Minkowski, 1977).

In the case of none of these areas is it possible to postulate a direct and/or causative linkage between changes in vegetation cover and shifts in rainfall patterns. All manner of other variables could well be at work. Very few problem-specific experiments have been carried out, largely by virtue of the scale and complexity of the processes involved. Nonetheless, in light of the severe repercussions that may arise from the putative linkages, there is urgent need for research of systematic scale.

Let us hypothesize, meantime, that an additional key factor could lie with land surface roughness (Garrat, 1978; Hare, 1985; Rowntree et al., 1985; Sud and Smith, 1985). Through its influence on horizontal water-vapour transport, land surface roughness can significantly affect the distribution of convective rainfall. The main determinant of surface roughness is generally vegetation cover, in the form of grass, bushes and trees (also buildings). This roughness exerts a "drag" on winds moving across them, dissipating some of the winds' energy. Since deforestation reduces the roughness of the surface, this change could well diminish rainfall in some areas. Indeed it is sometimes thought (Sud et al., 1985) that changes in local surface roughness can be as important an influence as changes in surface albedo.

**Impacts at Regional Level**

1. AMAZONIA'S HYDROLOGICAL CYCLE

According to research with water isotopes (Lettau et al., 1979; Salati and Vose, 1984; Salati et al,. 1988; Shuttleworth et al., 1984), much of the moisture in Amazonia--between half and four-fifths in central and western sectors--remains within the ecosystem. That is, it is constantly transpired by plants into the atmosphere, where it gathers in storm clouds before being precipitated back onto the forest (mean recycling time, 5.5 days). Thus much of the Amazonian forest represents a significant source of its own moisture: it does not have to depend on moisture imported from the ocean surrounds.

Were Amazonia to be widely deforested, there could be a pronounced decrease in the amount of moisture being evapotranspired into the atmosphere, leading to a significant decline in rainfall they appear to be a significant source of greenhouse gases.

First of all, consider carbon dioxide as a greenhouse gas. The buildup of carbon dioxide in the atmosphere stems primarily from combustion of fossil fuels, to an extent of some 5.2 gigatons a year. But there is also a sizeable contribution from burning of biomass, notably in tropical forests (Houghton et al., 1987; Woodwell et al., 1983). An acceptable figure for this biotic contribution to date is 1.9 gigatons a year, within a range of 0.9 to 2.7 gigatons.

In addition to carbon dioxide, there are a number of trace gases that molecule for molecule are far more efficient than carbon dioxide in absorbing infrared radiation from the planetary surface. These gases include nitrous oxide and methane, some of the main sources of which could well be tropical forests (Bolle et al., 1986; Goreau and de Mello, 1988; Harriss et al., 1988; McElroy and Wofsy, 1986; Keller et al., 1986; Mooney et al., 1987). Other sources include hydrocarbon fuels, farms and oceans, whose contributions are moderately well documented--by contrast with the case for tropical forests, which have been all-too little investigated.

## Potential Synergistic Interactions

While the individual sector linkages as set out above appear to be significant in themselves, their most potent repercussions could eventually lie with synergistic interactions. These have scarcely been identified to date, let alone defined and analysed. But we should surely consider what might happen, for instance, when certain tropical forests desiccate in the wake of hydrological disruptions (as per the Salati analysis for Amazonia above): this could lead to an increase in wild fires, thus compounding the emissions of trace gases. In a greenhouse-affected world, warmer temperatures may well upset albedo workings; and many plant species could suffer acutely if not terminally through respiratory losses of carbohydrates (though, conversely, increased concentrations of carbon dioxide could promote their survival). Greater warmth may also cause convective rainfall to become more intense and concentrated, possibly leading to greater flooding and erosion, while leaving less moisture in the soil and leading to more stressful dry seasons. Methano-genic production appears to expand with warmer temperature, so methane emissions could increase, thus strengthening the greenhouse-gas feedback. For further discussion, see Dickinson and Virgi (1987).

Many other synergistic responses could surely be at issue. They remain almost entirely uninvestigated.

## Policy Repercussions

How shall policymakers respond to a rapidly-changing situation? Clearly the deforestation issue carries profound implications for development questions of several sorts. Conversely of course, conservation of tropical forests, with their high metabolic and

(Henderson-Sellers and Gornitz, 1984; Shuttleworth, 1988). A decline of just this scale alone would entrain profound and irreversible ecological changes in many parts of the basin. But more important still, it could trigger a self-reinforcing process of growing desiccation for remaining forest cover, with declining moisture stocks followed by yet more desiccation, and so forth. Eventually the repercussions could extend outside Amazonia, even to southern Brazil with its major agricultural lands.

How far a similar drying-out phenomenon could arise in other large tracts of tropical forest, notably that of the Zaire basin, is scarcely considered to date, let alone researched.

2. THE ALBEDO EFFECT

Much of the energy that converts surface moisture into water vapour comes from the sun's radiational heating of the land surface. The energy thus depends on surface albedo, or reflectant "shininess" of the land surface. In turn, the albedo depends on vegetation, which absorbs more heat than bare soil. Over thick vegetation there are vigorous thermal upcurrents taking moisture (provided by the same plant cover) up into the atmosphere, where it condenses as rain. Because of its influence on convection patterns, wind currents and hence rainfall regimes, the albedo effect constitutes a basic factor in controlling climate. In tropical-forest zones, albedo appears to be, together with surface moisture, the most important factor by which the land surface can affect climate.

When vegetation is removed from the Earth's surface in large amounts, the result is often a self-promoting cycle of albedo enhancement, leading to a new stable state of less warm soil, lower rainfall and sparser vegetation. There ensues a significant decrease in rainfall and evapotranspiration, as in cloud cover. Were albedo-derived processes to become disrupted through tropical deforestation, the repercussions could well extend, via altered patterns of air circulation, throughout an entire region. If, say, the whole of Amazonia's almost 5 million sq. kms. were to be deforested during a period of 35-50 years, giving way to grasslands and crops, the surface albedo is estimated to increase from 0.11 to 0.19, and rainfall to decrease by 0.5-0.7 mm. per day, with both evapotranspiration and cloud cover being reduced (Henderson-Sellers and Gornitz, 1984).

**Impacts at Global Level: The Greenhouse Effect**

By the first quarter of the next century at latest, and perhaps even by the turn of this century, we shall surely be experiencing the climatic dislocations of a planetary warming, stemming from buildup of carbon dioxide and other "greenhouse gases" in the global atmosphere (Bolin et al., 1986; U.S. Department of Energy, 1985). Associated with this general warming will be some redistribution of precipitation patterns. The link-up with tropical forests is significant, insofar as biogeochemical recycling rates, could increase the ability of the biosphere overall to buffer all manner of changes in atmospheric chemistry arising from human activities--most notably the greenhouse effect.

Despite these key considerations, many long-range policy and planning decisions are being taken with respect to food production in the humid tropics, especially irrigation systems (plus many other broad-scope decisions as concerns, for example, hydropower facilities) on the assumption that climatic patterns of the future will be a simple extension of the past. Yet as we have seen, there is fast-gathering evidence that we face a major departure in rainfall regimes among other climatic patterns within the foreseeable future. Thus there is a growing premium on taking measures, especially preventative measures, while there is still a little time for manoeuver.

Two initiatives immediately arise for policymakers. The first is to generate mission-oriented research of a scope and scale that matches the issues. As tropical forests disappear, so humankind is witnessing an experiment with worldwide and presumably irreversible consequences. The repercussions for human welfare will be pervasive and profound. Yet we are conducting this superscale experiment in entirely unplanned manner. The amount of funding and other management resources that are allocated to the phenomenon is trifling as compared with some possible concealed costs of the experiment's outcome. Herein, then, lies a first and ultra-urgent recommendation: an emphatic expansion in research.

The second initiative available to policymakers is to adopt a risk-reduction approach toward the deforestation problem. In light of the broad-scope and adverse repercussions of tropical deforestation, the path of prudence dictates a safety-first response. That is to say, policymakers should pursue a strategy that seeks to respond to both the uncertainty inherent in the situation, and to the considerable risk factor (risk being defined here as the adverse outcome of a circumstance, multiplied by the likelihood of the unfortunate outcome actually coming to pass). Adopting a wait-and-see attitude--which is essentially what policymakers are doing right now--presumes that we shall sufficiently anticipate the amount and rate of tropical deforestation, plus its impacts, and that we are confident we can handle all the possible climatic repercussions.

The urgency of the issue is highlighted by recent evidence that a disruption of rainfall patterns on a hemispheric scale is already underway (Bradley et al., 1987). Over the past 20 to 30 years, a steady decline in rainfall over northern subtropical latitudes has been accompanied by a systematic increase in precipitation over higher latitudes. While the decline in rainfall has been most marked over northern Africa and the Sahel, it is also evident in Southeast Asia and around the Caribbean (Kelly, 1988).

In sum, even were the prospect of climatic dislocations to be considered slight, the repercussions could prove so disruptive, adverse and widespread that even a super-slight prospect of the dislocations actually occurring should be reckoned worth avoiding unless the costs of doing so prove prohibitively high. Under circumstances of risk associated with climatic dislocations (and as in other areas of public policy where the salient factor lies with uncertainty), it will be better for us to find we have been approximately right than precisely wrong.

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