Preferred citation: M. Judt. Research problems in developing countries using non-woody fibres, as seen by UNIDO. In **The role of fundamental research in paper-making**, *Trans. of the VIIth Fund. Res. Symp. Cambridge, 1981*, (Fundamental Research Committee, ed.), pp 829–850, FRC, Manchester, 2018. DOI: 10.15376/frc.1981.2.829.

RESEARCH PROBLEMS IN DEVELOPING COUNTRIES USING NON-WOODY FIBRES, AS SEEN BY UNIDO

M. Judt,
United Nations Industrial Development Organisation
(UNIDO), Vienna, Austria.

Thank you very much for inviting UNIDO (United Nations Industrial Development Organisation) to attend this conference and for giving our organisation a platform to discuss with you how the pulp and paper research situation in the developing countries might be improved with your help.

UNIDO, a member organisation of the United Nations Organisations, is 14 years old and started operations in Vienna on 1 January, 1967. Its mandate, according to the United Nations General Assembly resolution 2152 (XXXI) of 17 November 1966, is to promote and accelerate the industrialisation of the developing countries.

With regard to its functions, UNIDO shall, among other things:

- Encourage and extend, as appropriate, assistance to the developing countries for the development, expansion, and modernisation of their industries;
- Assist developing countries in establishing and operating industries to achieve full utilisation of locally available natural and human resources, and contribute to self-reliance;
- Provide a forum and act as an instrument to serve the developing and industrialised countries in their contacts, consultations, and negotiations;
- Develop special measures designed to promote co-operation among developing countries and between developed and developing countries.

To co-ordinate the work within the UN family, also in the pulp and paper field, there is an "Agreement setting out guidelines for co-operation between the Food and Agriculture Organisation of the United Nations (FAO) and UNIDO in the field of industrial development". According to the spirit of this agreement it is UNIDO's responsibility to care for the existing pulp and paper industries in the developing countries and to help to promote the usage of non-woody fibrous materials world-wide. On the other hand, it is FAO's responsibility to care for the forestry sector and to promote the usage of softwood and hardwood in green-field pulp mills in the developing world.

The responsibility of the pulp and paper department within UNIDO is to work through the governments of the respective countries and provide the following services upon request.

UNIDO shall

- Supply governments, mills, and institutions, with experts who, through their experience, will assist in increasing the production and usage of more pulp and paper;
- Carry out opportunity and pre-feasibility studies for new pulp and paper mills using non-woody fibrous materials;
- Advise, through experts, existing mills on how to produce more efficiently and also how to diversify their production using more indigenous fibrous raw materials and waste paper;
- Provide general information on all phases of pulp and paper-making supported by a data bank;
- Help to finance and operate plant units where specialised technologies will be developed, such as newsprint bagasse and bagasse pulp dissolving plant in Cuba, fibre fractionation of waste paper in Egypt, and desilification of bamboo black liquor in India, and disseminate the results to other developing countries;
- Help to train and educate nationals from developing countries in appropriate and new technologies and in scientific research of interest to those countries;

- Invite experts from developing countries to attend international conferences or arrange such conferences in specialised fields for such experts, to make them better acquainted with developments in pulp and paper-making, and help them to apply this knowledge in their home countries, thereby also creating partnerships between mills and research and training institutions amongst developing countries.

The future of non-wood plant fibre usage in pulp and paper-making in developing countries

It should be remembered that up to 90 years ago the only fibres used for paper-making were from non-wood agricultural products such as wool, linen, flax, cotton, straw, etc., and to a large extent from recycled rags. Only recently have softwoods and hardwoods begun to be used for pulp and paper-making. Today these fibres have taken over 93% of the market.

There are large areas in the world, like the Middle East, North Africa, and Central Asia, which do not possess indigenous supplies of wood, but have plenty of agricultural residues. These are also the areas where the demand for paper, due to population growth and education programmes, will increase faster than in the industrialised countries. Here it will be imperative to find supplies of paper-making fibrous material other than wood.

That there is no shortage of non-wood plant fibrous raw material in the world[1] is shown in Table 1. Rags, textile waste, cotton linters, etc. were not considered in it, so that another 1 million tons per annum could be added to the yearly figure of 5.4 million tons of non-wood plant pulps. Recent information from the People's Republic of China indicates that 60% of the fibres used for the production of 5,000,000 tons/year of paper in the 1,000 mills there are also non-wood fibres. So there is plenty of unused non-wood plant fibre material available in the world. About 500 million tons per year of fibres could theoretically be produced.

	Potential Worldwide bdmt	Pulp/Paper Production Worldwide tons	Percent of total at 50% yield
Straw (wheat, oats, rye barley)	705,000,000	1,500,000	0.43
Rice straw	180,000,000	700,000	0.78
Bagasse	55,000,000	1,300,000	4.7
Bamboo	30,000,000	1,400,000	9.3
Reeds	35,000,000	270,000	1.5
Jute/Kenaf	6,000,000	60,000	2.0
Leaf fibre	900,000	130,000	29
Grasses	500,000	60,000	24
Totals	1,012,400,000	5,420,000	

Table 1
Estimated availability of specific non-wood plant fibrous raw materials(1)

Technologies do exist for pulping non-wood plant fibres for paper-making. Most of these technologies are not applied anywhere any more in the industrialised world, but exist in many developing countries in Europe, Asia and Africa, in a number of more or less modernised variations in existing mills. The pulp industry in a number of countries such as Algeria, Morocco, Tunisia, Egypt, Iran, Burma, Cuba, and Sri Lanka is based on non-wood plant fibre materials. Pulp production in many other countries, such as India, the People's Republic of China, Colombia, Peru, Turkey, Romania, Hungary, and Indonesia, is partly based on these fibres.

Let us look at the fibre characteristics of the non-wood plant fibres and compare them with softwood and hardwood fibres. See Table 2.

Fibrous Material	Length (mm)		Diameter (μm)		
	Range	Average	Range	Average	Reference
Bagasse	0.8- 2.8	1.7	10-64	20	18
Bamboo	1.5- 4.4	2.7	7-27	14	18
Cotton lint*	10.0-40.0	18.0	12-38	20	20
Esparto	0.5- 1.6	1.1	7-14	9	18
Kenaf, Bast	2.0- 6.0	5.0	14-33	21	20
Woody	-	0.5	-	38	17
Jute	1.5- 5.0	2.0	-	20	8
Manila Hemp	2.0-12.0	6.0	16-32	24	20
Reeds	0.3- 4.0	1.2	3-32	12	2,3
Sisal	0.8- 8.0	3.0	8-41	20	20
Straw, Cereal	0.7- 3.0	1.5	7-27	13	18
Rice	0.6- 3.5	1.5	5-14	8.5	20
Temperate Woods					
Coniferous					
Tracheids	2.7- 4.6	-	32-43	-	9
Deciduous					
Fibres	0.7- 1.6	-	20-40	-	9

*Linters are shorter (6mm), more cylindrical, and have thicker walls than lint fibres.

Table 2

Approximate dimensions of various wood and non-wood fibres used in paper-making.[2]

McGovern[2] collected data from which it can be seen that most non-wood fibres have fibre dimensions which are longer and thinner than the fibres in northern hemisphere hardwoods. These characteristics are valued by paper-makers. Fischer[3] recently did some similar work (See Table 3).

Fibre Species	Length (mm)	
	Range	Average
Bamboo	0.4 - 4.66	1.5
Wheat straw	0.1 - 3.3	0.65
Rye straw	0.1 - 2.3	0.74
Corn stalks	0.1 - 1.9	0.71
Arundo donax (from Greece)	0.1 - 5.1	1.42
Bagasse	0.1 - 3.0	1.1
Sabai grass	0.1 - 3.8	1.1
Papyrus	0.1 - 2.5	1.0
Banana	0.2 - 7.5	3.6
Cotton (linters)	0.2 - 7.0	2.12
Sisal	0.2 - 6.5	3.2
Temperate Woods		
Coniferous (fir)	1.7 - 3.7	3.1
Deciduous (birch)	0.8 - 1.6	1.1

Table 3
Dimensions of various wood and non-wood fibres used in paper making[3]

Some plants have fibres with even better dimensions than softwood fibres, for example, cotton linters, kenaf bast, jute, hemp and sisal.

How is pulp and paper production distributed in the world?

The following[4] statistics are based on the figures for 141 nations, 20 of which are developed nations according to UN definitions. Out of a total world pulp and paper production of

127 million tons of pulp
167 million tons of paper

these 20 nations produce

102 million tons of pulp
128 million tons of paper.

Or in other words, 121 countries produce only

25 million tons of pulp
39 million tons of paper.

Out of these 121 developing countries only 71 nations actually have producing pulp and paper mills. There are still 50 non-producing countries in the world and they import about 1.1 million tons of paper/board for their 200 million inhabitants.

Excluding the countries with central economies (there are 11 of them), then 60 developing countries produce only

12 million tons of pulp
26 million tons of paper

So only 10% of the pulp and 15% of paper are produced in 60 countries with a population of 2.6 milliard out of a total world population of 4.2 milliard.

How big are the pulp and paper mills in the developing countries, many of them using non-wood plant fibres?

To make a comparison, Table 4 shows the annual production and average daily production of pulp and paper mills in Europe and North America, in Table 5 of Africa, Table 6 of South and Central America, and in Table 7 of Asia.

In summary, the average pulp mill size at present in developing countries varies between 15 and 112 tons/day of production in Africa, Asia and even in South America. The average paper mill size varies between 30 and 55 tons/day.

	Paper mills	Pulp mills
EUROPE		
Number of mills	2,109	625
Annual production (tons)	56,139,000	38,733,000
Annual production/mill (tons)	26,618	61,972
Daily production/mill (tons)	81	188
NORTH AMERICA		
Number of mills	835	390
Annual production (tons)	68,138,000	65,437,000
Annual production/mill (tons)	85,500	168,000
Daily production/mill (tons)	260	509

Table 4
Average mill sizes in Europe and North America

	Paper mills	Pulp mills
Number of mills	46	16
Annual production (tons)	483,000	382,000
Annual production/mill (tons)	10,500	23,875
Daily production/mill (tons)	32	72

Table 5
Average mill size in Africa

	Paper mills	Pulp mills
Number of mills	399	128
Annual production (tons)	7,269,000	4,761,000
Annual production/mill (ton)	18,218	37,215
Daily production/mill (tons)	55	112

Table 6
Average mill size in South and Central America

	Paper mills	Pulp mills
Number of mills	601	328
Total production (tons)	5,971,000	1,907,000
Annual production/mill (tons)	9,935	5,814
Daily production/mill (tons)	30	17
People's Republic of China		
Number of mills	1,000	
Total production (tons)	5,000,000	
Annual production/mill (tons)	5,000	
Daily production/mill (tons)	15.2	

Table 7
Average mill size in Asia (excluding Australia, Japan, and New Zealand)

Mills using non-wood plant materials are small and should not be bigger, because the collection and storage of such materials is a problem, and very often the infrastructure of the country makes the collection of larger quantities impossible.

On-going UNIDO research projects

1. Waste paper fractionation in Egypt

Waste paper is a widely used, low-cost fibre material for the Egyptian paper industry. It is usually a mixture of papers with varying percentages of long and short fibres and fillers. If it were possible to separate the long from the short fibres, an upgrading of paper or board production would be possible.

Stock screens[5-10] have been developed by machine manufacturers which are claimed to be able to effect such separation of long and short fibres. The Chairman of the Board of the Rakta (General Company for Paper Industry) mill, Mr. M.A. El Ebiary, is aware of this new development and has volunteered to have the stock screen tested in the Rakta board mill. All

test results and new possibilities for up-grading waste paper furnishes and paper-board qualities by this new technology will be made available to UNIDO and to other developing countries.

The project will be carried out this year. Results should be published by the end of 1981. The funds were provided by the Government of the Federal Republic of Germany.

2. Bamboo fibre fractionation in India

Agricultural fibrous material and grass (gramen) materials like bamboo contain in their plant structures long and short fibres to varying percentages. The fibre length distribution in bamboo is from 0.4 to 4.2 mm with an average length of 2.4 mm. About 10 to 15% of the bamboo fibres have a fibre length comparable with soft wood fibres.

Stock screening machines[5-10] are now on the market whereby long and short fibre fractions can be separated from a mixture of long and short fibres. Application of this technology for bamboo pulp could produce two different fibre fractions, of which the long fibre fraction, when separated, could help to produce high tear packaging papers in developing countries. The long fibre fraction of the bamboo pulp could also act as a softwood substitute.

The Asholk Pulp and Paper Mill in India volunteered during the Forum on Appropriate Industrial Technology in New Delhi, 1978, to test this new screening technology in their mill and apply the results to existing paper grades.

The project will be carried out this year and results should be published in 1982. The money was provided by the Government of the Federal Republic of Germany.

3. Desilification of black liquors in pulp mills using non-wood fibres[11-19]

Many pulp and paper mills in developing countries using agricultural residues as fibrous raw material are built without chemical recovery systems. Materials like rice straw, bamboo,

jute, and bagasse, contain silica which dissolves during digestion, mostly in the alkali, and remains as an undesirable constituent in the black liquor. This creates many problems at various stages of its flow in the chemical recovery plant, for example:

- scale formation in the evaporator tubes;
- hard smelt desposits on the furnace walls of recovery boilers;
- formation of over- and under-burnt lime in the lime sludge reburning kilns and formation of glass lining in such kilns.

Anticipating these difficulties, these mills dump all pulping chemicals, and the organic matter dissolved from the agricultural material in the process of obtaining cellulose, with the effluent, thus causing pollution and creating many environmental problems.

Some kraft pulp mills using straw, bamboo, jute sticks, reeds, etc. as fibrous raw materials, which have installed chemical recovery systems, can only run them with moderate success by not returning and reburning the lime needed in the causticising reaction for reclaiming the alkali in the chemical recovery plant. About 220 kg of burnt lime (CaO) per ton of pulp produced is needed for this reaction.

In many parts of the world huge quantities of lime mud, which contains most of the silica, is removed from these pulp mills to be dumped and used for land-filling.

Universal interest therefore exists for attacking the silica problem scientifically and to help find a final solution to it. Such a solution will serve to increase the efficiency of the mills, considerably reduce their chemical costs for pulping, provide extra steam and energy for the plants by burning the organic matter in recovery boilers, and avoid the large water pollution problems and environmental dangers.

UNIDO received US$ 604,000 from the Swedish government to design, erect and run a pilot plant in the Ashok bamboo mill in

India to develop a technology for removing the silica from the bamboo black liquor. It is hoped that a successful solution will make it possible for many small mills in developing countries to recover their cooking chemicals with standard technology, thereby reducing the effluent loads in rivers tremendously.

We hope to have the plant operational in early 1982, and expect results in the middle of 1982.

4. Objective testing of the NH_4pulping process

In June, 1977, the description of a new pulping process for agricultural residues was published in the journal of the Technical Association of the Pulp and Paper Industry by Mr. Thillaimuthu[20]. The inventor claims that dilute aqueous ammonia solutions (2-7% NH_3) can digest straw and un-depithed bagasse under optimum conditions in 30-45 minutes. Recovery of ammonia after pulping is possible. The effluents of such a process have a fertilising effect on the soil. A thorough investigation of the possibilities and economics of this new pulping process has so far not been carried out in a well-equipped laboratory.

In July, 1978 Mr. Thillaimuthu wrote to the Executive Director of UNIDO and asked for UNIDO's assistance in evaluating his process for the benefit of developing countries. The pulp and paper unit of UNIDO strongly supports the testing and evaluation of the process in a developing country for non-wood fibrous raw materials for paper-making.

It was possible to obtain the services of the Indonesian Cellulose Research Institute, Bandung, to carry out a three months' research programme and evaluate this process in the presence of its inventor and a UNIDO cellulose pulping expert.

Besides studying the fibre characteristics, the properties of the lignin extracted during the process will be examined.

The project will be carried out this year. Funds have been provided by the Government of the Federal Republic of Germany.

Now follows a description of one research project under discussion with donor countries, or in the pipeline, as we say, which might be of interest.

5. Pulping process for the production of animal fodder, semi-mechanical and chemical pulp and fertiliser

During the UNIDO Conference on Appropriate Industrial Technology held in New Delhi in October 1978, a paper on a new pulping process was given by its inventor[21] who claimed that by using nitric acid or neutral nitrate salts and alkali, agricultural waste materials such as rice straw, bagasse, cotton stalks, grasses, jute sticks, and reeds could be converted into animal fodder or semi-chemical and chemical pulps. Such semi-chemical pulps are suited for the manufacture of packaging and fluting papers, and paper boards.

The process uses simple non-pressure equipment and is very low in energy input. Small units (5 to 10 tons/day) can be built. The process was tested in laboratory equipment and a very small pilot plant has been established at Messrs. Sieger K.G. Zulpich, FRG. The process chemistry is non-polluting and non-odoriferous.

It is further claimed that the black liquor of the process and the effluent of such a plant have good fertilising effects in agriculture. The black liquor also acts as a sizing agent in when added to, for example, corrugating medium stock furnishes.

The Government of Egypt has officially requested to establish a trial plant for this process at the pulp and paper mill at Alexandria, Egypt, and offered an existing 30 tons/day idle production line erected in 1968 to carry out pulping tests on a large scale.

Having confirmed that rice straw can be converted by this process into chemical pulp, UNIDO sees a great potential for applying this process, or variations of it, to convert often unused agricultural residues or materials undigestable by animals, such as rice straw, reeds, cotton stalks, etc., primarily into animal fodder products which can be stored without

deteriorating. When such materials are not required for feeding ruminants they can be treated and used in standard chemical pulp and paper mill equipment for the production of packaging paper, corrugated fluting, and paper board.

Small units in villages using this process could produce extra fodder for animals which would otherwise have to graze off the countryside, often creating soil erosion by overgrazing, and thus promoting the growth of badlands. Any surplus chemical fodder material could be supplied to local pulp and paper mills for conversion into packaging papers and paper board.

It is intended that besides evaluating the suitability of the universal pulping process for rice straw in the conditions of the pulp and paper industry in Egypt, its potential and adaptability to pulping the many different agricultural waste products available in the Nile Delta, will be investigated in trials at the 30 tons/day demonstration plant.

We hope to find a donor for this project this year, and by producing animal fodder, paper pulp, paper sizing material, and fertiliser, hope also to give small mills in developing countries a wider production base and greater profitability in the future.

Do we care about helping the developing countries to make more paper from their indigenous fibrous resources?

I went through the programmes of the last three Fundamental Research Symposia. There was no paper given by a researcher from a developing country in 1969, 1973 or 1977.

There was only one co-author, Dr. M.T. Htun, from Burma, who together with Mr. de Ruvo, gave a paper in 1977 on "Relations between drying stresses and internal stresses and the mechanical properties of paper".

In the indices of the publications in these three symposia no non-wood plant materials like bagasse, straw, bamboo, etc. were mentioned, though, of course, there are entries under wood, hardwood and softwood.

Does this mean that there are no worthwhile topics in the non-wood plant fibre field or good researchers in the developing countries? Does this prove that scientific research and development work in the industrialised countries is concentrated entirely on wood fibre behaviour? The answer could of course be: Why not! 93% of the production of pulp is from wood, why bother about the small 7% made from non-wood plant fibres.

For the last 50 years, R & D in the paper industry has been mainly concerned with the requirements of the basic wood pulping processes and innovations in machinery and equipment, particularly the change from batch to continuous operations, the introduction of computerised process control systems, the automation of various phases, the recovery and recycling of chemicals used, etc. The aims have been to improve product quality, eliminate losses, and increase production, if possible, at low costs.

There was a short revival of non-wood plant fibre research under Lathrop and Aronovsky[22] at the Northern Regional Research Laboratory, Peoria, USA in the fifties, and under Jayme[23-26] at the Technische Hochschule, Darmstadt in the fifties, and quite recently Giertz[27] carried out a thorough piece of research on newsprint made from bagasse pulp.

But I feel there is here a challenge and opportunity for many of you.

Which problems cry out for solutions and could be of interest to many researchers?

To apply the available understanding of softwood/hardwood fibre behaviour to describe the wet-strength characteristics of bagasse and bamboo pulp fibres, and how they compare with those of softwood/hardwood fibres, is very important for high-speed paper making, especially in connection with the transfer of wet paper webs from the wire to the presses, and so to the dryer section. Some work on this was started in Finland recently.

But perhaps it would be more useful to investigate the following problems.

What physical strength properties do the long fibre fractions from such chemical pulps made from straws, bamboo, bagasse and jute have?

How should these fibres be treated in stock preparation plant?

How should they be refined with a minimum of fibre shortening?

How can the brittleness of the fibres be changed?

How can the wettability of such fibres be improved?

How can their tendency to felt during sheet making be overcome?

Good research is needed on how pre-soaking in water and pre-steaming, or pre-impregnation with cooking liquors, and 2-stage cooking, can improve the overall performance of the chemical pulps from non-wood plant fibres.

In a number of new mills many difficulties have arisen recently because of the wrong pre-treatment of bulky materials like straw and bagasse. The materials either become too slippery to be handled in conventional equipment, or roped in screw conveyor systems, thereby causing the flow through continuous digesters to become irregular. By too vigorous remedial treatment e.g. by blowing out the fibres in pumps or screw presses, fibre strength losses have been caused and too many fines created, resulting in poor washing efficiency in the pulp departments.

When a machinery company encounters such difficulties, it usually modifies the machinery or the process, often without doing prior research in pilot plants, and I feel there is a real need here for more scientific research.

It is still standard practice to return the primary screen rejects back into the pulp digester in many pulp mills. This affects operations and the final quality of the products (pulp or paper) to varying degrees.

Other researchers have found that such screen rejects from non-wood plant fibres from soda pulp mills have definitely a higher nutritional value than the untreated plants and therefore one should ask the question why such rejects are not used as additives to animal fodder in order to `stretch´ the often scarce resources in developing countries.

Here again I see a good opportunity for more research.

There have been repeated mechanical and chemical attempts to defibre such materials as bamboo, bagasse and even straw. Such research work should be supported with measurements into, for example:

- visco-elastic properties
- thermal softening of the bonds in the plant structure
- torsional properties of single fibres pulped with different chemicals, their torsional modulus and internal friction values.

Such data would definitely increase the scientific understanding of the defibering processes and provide a deeper appraisal of the potential of such fibres for making papers such as newsprint, corrugating medium, and packaging papers. The first thorough research was carried out by Giertz recently in Trondheim, Norway. But far more work is needed!

A lot of research work on cold soda pulping of hardwood has been carried out in Australia. This process will be applied to bamboo soon in India, but it is not known with what limitations . Perhaps there will be latency problems in the bamboo pulp. We need to know the guidelines on how to obtain the best pulp possible.

Clupac[28-29] claimed in 1969 that the compaction of non-wood plant fibres in the dryer section of the paper machine improves the stress/strain behaviour of the resulting paper, in the same way as is known to happen with conventional fibres. Several mills in developing countries now use such compacting machinery. It would be very interesting to have detailed scientific data to support such observations of characteristic improvements and learn from such investigations how non-wood plant fibres behave

and react under compaction forces. Here is a real challenge for Dr. Page, who does such excellent work on wood fibres.

Recently Mr. L Carlsson published a research paper on the flexural stiffness of multi-ply paper boards. Do his very interesting findings also apply to paper board made from non-wood fibres? Maybe under his supervision a student from an Asian developing country can observe and compare how boards made with such fibres behave.

What should be done?

Unfortunately UNIDO's possibilities for assisting the pulp and paper industry in developing countries are not yet well-known world-wide. Therefore we are grateful to be able to come to such meetings as yours and present our point of view and create new contacts and maybe partnerships.

May I stress that under the regulations of the United Nations, everybody in developing countries can obtain technical assistance in the fields mentioned earlier, but the condition is that all assistance must be supported by and requested through the governments, and the request should be passed through UN offices, which exist in almost all countries of the world.

We are confident that we have a great deal to offer especially in the field of non-wood fibres. These have the advantage that they grow yearly, even sometimes thrice yearly, like rice, and that often parts of the plant are converted into food. There is a world-wide rediscovery at present that the very first priority activities in developing countries must be in agriculture and in food production to meet the needs of the fast growing populations in these countries. Often industrialisation has fallen back to second priority.

What can be done in the field of pulp and paper research?

If we all care to discover more scientific facts on the understanding of non-wood plant fibres and their behaviour, I recommend

a. More scientific work for students from developing countries on subjects which are relevant to the conditions in their home countries, including raw materials like bagasse, bamboo, straw and so on in their research work;

b. Closer contacts among researchers in developed and developing countries, especially directly with former students and researchers;

c. More tests with such 'exotic' papers or boards like newsprint bagasse, kraft papers made from 100% bamboo or jute, bank note and tea bag papers made from abaca pulp, printing and writing papers made from 100% wheat or rice straw pulp;

d. More exchanges or correspondence with researchers among pulp and paper research institutions in the developed and developing countries. There is a number of well-known pulp and paper research institutes in developing countries, such as

- Institute Cubano de Investigaciones de los Derivados de la Cana de Azucar, (ICIDCA)
  Via Blanca y Carretera Central, Havana, Cuba

- Central America Research Institute for Industry (ICAITI)
  Avenida La Reforma 4-47, Zona 10, Guatemala

- Forest Products Research and Industries Development Commission (FORPRIDECOM)
  College, Laguna E-10, Phillipines.

- Cellulose Research Institute
  J.I. Mokh. Toha Km., 7.4., P.O. Box 194, Bandung, Indonesia

- Forest Research Institute and Colleges
  P.O. New Forest, Dehra Dun, India

- Centro Tecnico em Celulose e Papel Instituto de Pesquisas Tecnologicas Cidade Universitaria - 05508 - St. Paulo Sp, Caixa Postal 7141, (CEP 01000), Brazil

- Universidad de Guadalajara, Instituto de Madera, Celulosa y Papel, Apartado 4-120, Guadalajara, Jal, Mexico

- National Research Centre, Dokki-Cairo, Egypt

all of which would welcome such contacts.

It is recommended that during your trips some of you attending this conference may say hello to researchers in these institutions and create better understanding and a closer and friendlier relationship with some of them over the coming years.

UNIDO's function in this process is to act as a catalyst, helping in establishing such contacts, and in providing you with addresses of pulp and paper mills producing `exotic' boards or papers made from non-wood plant fibres exclusively. We have a world-wide fellowship and training programme and often we ask for hosts where mill personnel or researchers in pulp and paper from developing countries can be trained in your institutions or in your mills in the developed countries, and again your good co-operation, when we request such posts, would be very welcome.

Mr. Chairman I thank you very much for this opportunity to present UNIDO's point of view at this conference.

REFERENCES

1 Atchison, J.E., Symposium Internacional, EUCEPA, Madrid, May 1974.
2 McGovern, J.N., Tappi, January 1975, **58**(1), 82-86.
3 Fischer, S., das Papier, 1980, **34**, 280-285.
4 Pulp and Paper International, 1979 Annual Review, **21**(8), Review Number, 25 July, 1979.
5 Seifert, P., and Long, K.J., Tappi, 1974, **57**(1), 69-72.
6 Brewer, J.L., and Bolton, J.A., Tappi, 1974, **57**(1), 121-122.
7 Szwarcsztajn, E., and Przybysz, K., Das Papier, 1975, **29**, 295-300
8 Blechschmidt, J., and Strauss, J., Zellstoff and Papier, 1980 **29**, 62-66.
9 Musselmann, W., Wochenblatt fur Papierfabrikation, 1978, (6)
10 LeBlanc, P., and Harrison, R., Tappi, 1975, **58**, 85-87.
11 Franzreb, H., Diplomarbeit, Technische Hochschule Darmstadt, 1955
12 Franzreb, J.P., Dissertation, Technische Hochschule Darmstadt, 1958
13 Veeramani, H., Indian Institute of Technology, India, IPTA, 1977.
14 Murali, P.S., et al, Indian Institute of Technology, Kanpur, India.
15 Baba, M.A., Indian Institute of Technology, Kanpur, India.
16 Sadawarte, N.S., et al, Parkhe Research Institute, Poona, India, 1978.
17 Singh, S.V., and Guha, S.R.D., Forest Research Institute, Dehra Dun, 1975.
18 Misra, D.K., Tappi, CA Report No. 4 119-168.
19 Misra, D.K., Greek patent No. 63513, 1979.
20 Thillaimuthu, J., Tappi, 1977, **60**(6), p.112
21 Prior, E., EP patent No. 11/0012775/A1, 1978.
22 Lathrop, E.C., and Aronovsky, S.I., Tappi, 1954, **37**(12) A24-58

23 Jayme, G., Hindenburg, K-G., and Harders-Steinhauser, M., Paper, 1948, **2**(3/4), p.45-56; **2**(5/6), p.95-105, (German); BIPC 19.39.

24 Jayme, G., and Rosenstock, K.-H., Paper, 1957, **11**(1/2), p.7-14, (German); BIPC 27.781

25 Jayme, G., and Harders-Steinhauser, M., Papier-Fabr., 1942 **40**, 89-98. Paper Makers' Assoc. Gt. Brit., + Ireland, Tech. Sect., Tech. Bull., 1942, **19**, p36; CA 27.1865.

26 Jayme, G., Branscheid, F., Harders-Steinhauser, M., Papier 1953, **7**(23/24), p.459-66. BIPC 24.475.

27 Giertz, H.W., Dissertation, University of Trondheim, Norway.

28 Burrow, E.M., Paper Technology, 1965, **6**, pp.423-434.

29 Burrow, E.M., Tappi, Non-wood plant fibre pulping, progress report No.6., Committee Assignment Report (CAR) No. 58, 1975.