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TABLE OF CONTENTS

From the Editor
Syed S. Andaleeb iv

ARTICLES

Reflections on Governance and Development
Nurul Islam *1*

Decentralization, Pro-poor Growth and Political Economy:
An Example from Markets and Highways
Salim Rashid *10*
A.K.M. Riaz Uddin

The North East and Adjoining Bangladesh Districts:
Exploring Development Possibilities through Economic Linkages
Muhammad Masum *19*

The Dynamics of Refugee-Related Violence in South Asia
Navine Murshid *30*

Papermaking from Jute:
A Win-Win Solution for Bangladesh
Bernhard Gunter *46*
M. Sarwar Jahan
A. F. M. Ataur Rahman

TABLE OF CONTENTS

From the Editor	**Syed S. Andaleeb**	**iv**
ARTICLES		
Reflections on Governance and Development	**Nurul Islam**	**1**
Decentralization, Pro-poor Growth and Political Economy: An Example from Markets and Highways	**Salim Rashid** **A.K.M. Riaz Uddin**	**10**
The North East and Adjoining Bangladesh Districts: Exploring Development Possibilities through Economic Linkages	**Muhammad Masum**	**19**
The Dynamics of Refugee-Related Violence in South Asia	**Navine Murshid**	**30**
Papermaking from Jute: A Win-Win Solution for Bangladesh	**Bernhard Gunter** **M. Sarwar Jahan** **A. F. M. Ataur Rahman**	**46**

Papermaking from Jute:
A Win-Win Solution for Bangladesh

Bernhard G. Gunter
M. Sarwar Jahan
and
A. F. M. Ataur Rahman

Abstract

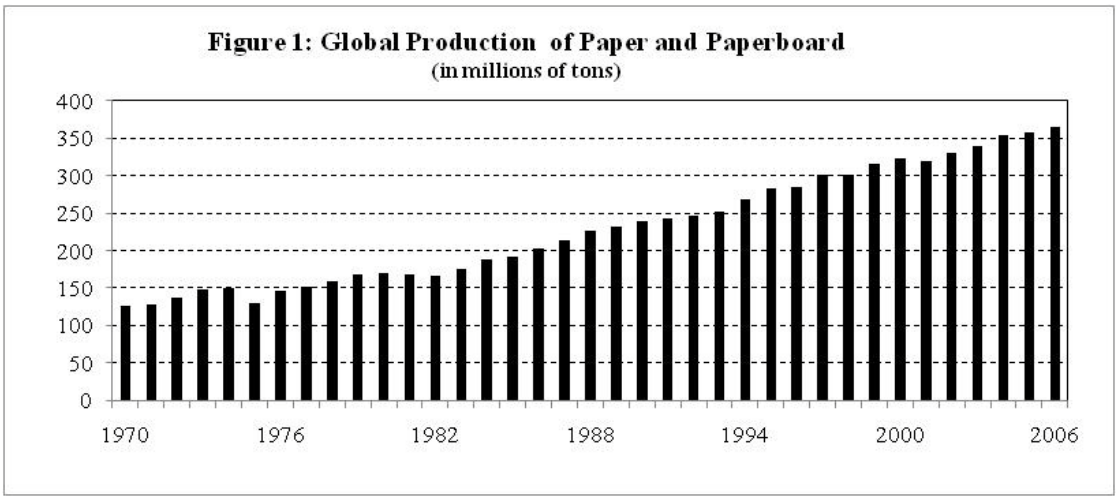
This paper reviews the availability and suitability of nonwood fibers for papermaking in Bangladesh and analyzes the economic, developmental and environmental implications of using jute for this purpose. It summarizes the literature on the availability and suitability of nonwood fibers for papermaking and then analyzes the economic viability of this process in Bangladesh by comparing the costs of jute pulp with those of imported paper pulp. It then summarizes broader economic and environmental aspects of using jute for papermaking in Bangladesh. Bangladesh is facing an acute shortage of fibrous raw materials for the production of pulp and paper while the demand for paper and paper products is increasing day by day. On the other hand, Bangladesh has a huge amount of unused jute fiber, which is highly suitable for papermaking in the country. It also finds that jute is economically viable for papermaking in Bangladesh and would contribute to Bangladesh's urgently needed economic diversification. It finally shows that there are no intrinsically negative implications on the environment from using jute for papermaking in Bangladesh. In short, using jute for papermaking constitutes a win-win solution for the country.

Introduction

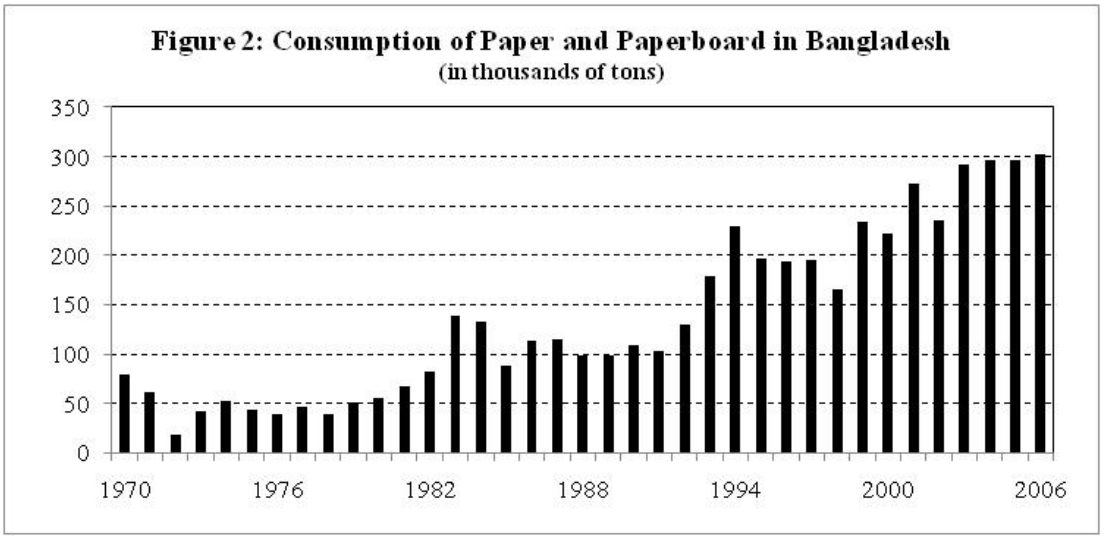
Papermaking (defined as being made of pulped cellulose) was invented from nonwood materials in China almost 2000 years ago. Textile rags, cereal straw, reeds, grasses, and sugar cane bagasse have been used in pulping and papermaking ever since, especially in Asia. The invention of industrial printing in the 15th century implied a rapid increase in demand for paper. Yet, it was not until 400 years later, that the use of wood to make pulp had been invented in Germany by Friedrich Gottlob Keller in 1840. The annual production of paper from wood pulp has grown since to a multi-billion dollar industry, concentrated mostly in a few industrialized countries. Today, about 90 percent of all pulps are being produced from wood.

As Figure 1 shows, the global production of paper and board increased—with two exceptions (1975 and 1982)—continuously over the last few decades from 125 million tons in 1970 to 365 million tons in 2006.[1] It is projected that the market for paper and paper board will continue to grow globally at 2.3 percent per year until 2030,[2] with particularly sharp increases in developing countries (due to increases in population, literacy rates, and quality of life) and a slight decline in the most advanced industrialized countries (due to advances in electronic communication).

The continued growth in paper consumption as well as the emergence of bio-fuel will lead to an increased demand for wood; creating additional pressure on the world's diminishing forest resources. Some efforts at the national and international levels are ongoing to find suitable substitutes, commonly called nonwoods. Some of these nonwoods are already used for papermaking, accounting for about 10 percent of the world's pulp production. Most nonwood pulp is produced from wheat straw in China and India. These two countries account for about 80 percent of the total nonwood pulp production. Pande (1998) provides a useful table with information on non-wood paper fibers in the 18 countries that account for nearly 98 percent of world supply of non-wood paper. Atchison (1995) showed that during the early 1990s, China produced 86.9 percent of its paper pulp from nonwood plant fibers, while at least 47 countries in the world produced some nonwood plant fiber pulp, with some of them producing 100 percent of their pulp and some 10 countries more than 50 percent of their pulp from nonwood plant fibers. Over the last three decades, the share of nonwoods for papermaking has also increased considerably in India. As the President of the Indian Paper Manufacturers' Association, Vederah (2006) has shown, the share of nonwoods has increased in the Indian paper industry from 9 percent in 1970 to 31 percent in 2000. Other nonwood fibers have been identified and used, but have not reached yet efficient industrial production levels.



Source: FAO-STAT Forestry Database (http://www.fao.org/corp/statistics/en/)

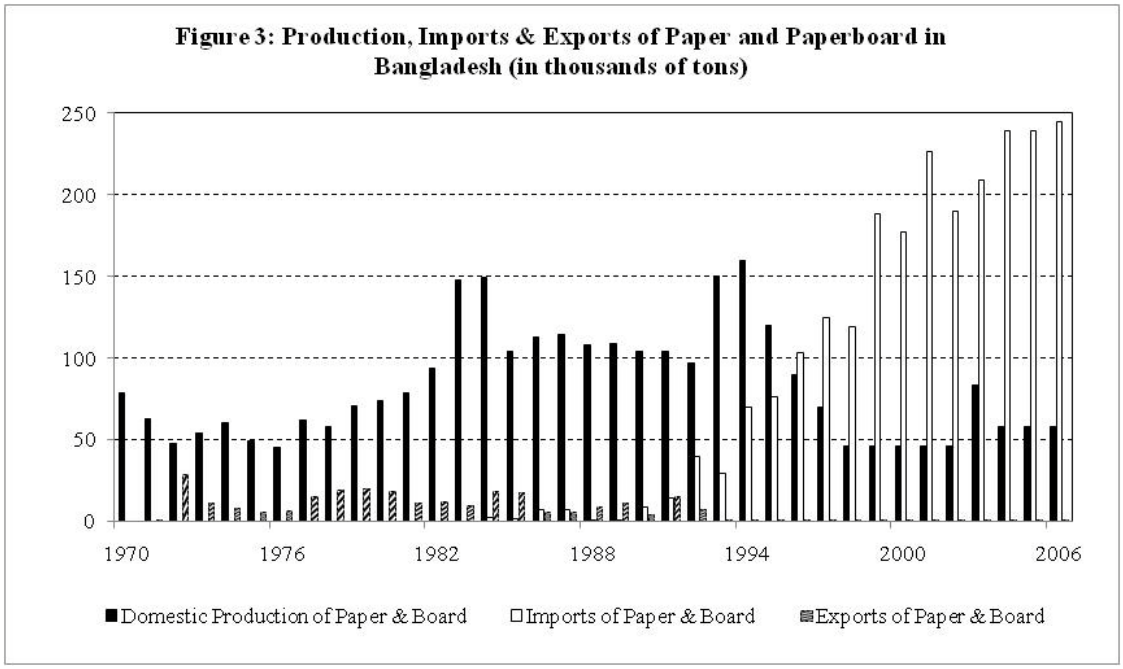


Source: FAO-STAT Forestry Database (http://www.fao.org/corp/statistics/en/)

Bangladesh is facing an acute shortage of fibrous raw materials for its pulp and paper industry. On the other hand, the demand for paper and paper products is increasing day by day in Bangladesh. Following this introduction, this paper provides an overview of Bangladesh's paper industry in the next section, followed by a summary of the availability and suitability of jute and other nonwood fibers for papermaking in Bangladesh (section III). The economic feasibility of using jute pulp for papermaking in Bangladesh is then analyzed in Section IV, followed by some developmental and environmental implications, discussed respectively in Sections V and VI, before Section VII provides some concluding remarks.

Overview of the Bangladesh paper industry

As Figure 2 shows, Bangladesh's consumption of paper and paperboard has been slightly more volatile than consumption at the global level shown in Figure 1, but still shows a clearly increasing trend. In Bangladesh, the paper industry uses mostly bamboo and mixed hardwood. Both of these raw materials come from Bangladesh's forests,[3] though the supply of these raw materials could not keep up with the growing demand for paper in Bangladesh. Hence, as shown in Figure 3, beginning in the mid-1980s, Bangladesh has imported increasing amounts of pulp and paper. Today, Bangladesh imports about 250 thousand tons of paper and paperboard a year, which



Source: FAO-STAT Forestry Database (http://www.fao.org/corp/statistics/en/)

costs Bangladesh about US$300 million a year.

With increasing imports, the domestic production of paper and paperboard has decreased drastically in Bangladesh. Today, Bangladesh produces less than 20 percent of its paper and paperboard consumption. As documented by FAO (2002), Bangladesh's capacity to produce paper and paperboard has remained constant at 121,000 tons during 1997-2001, which implies that Bangladesh's paper mills are producing paper and paperboard at only half of their capacities. Though Bangladesh continues to export some paper and paperboard, the current amounts exported are so small (about 100 tons a year) that they do not even show up in Figure 3. In practical terms, the export of paper and paperboard from Bangladesh has ceased in 1992.

According to Saha et al. (1997, p. 165) these developments are mostly due to the increasing shortages of wood fiber in Bangladesh: "The government sector pulp and paper mills are highly dependent on forest based fiber resources and private sector paper and board mills depend on imported pulps. Uneven distribution of fiber resources has limited the raw material availability of the pulp and paper mills. Shortage of raw materials, irregular procurements, and low installed capacity are the main reasons for low paper production." Gupta (1999) has pointed out that the Bangladeshi paper industry is also grappling with a number of other challenges, like natural disasters, out-dated equipment, and a shortage of investment capital. On the other hand, it should not be overseen that these developments in Bangladesh's paper industry were influenced by falling paper prices at the global level, resulting from an oversupply of paper and paperboard that built up at the global level mostly during the 1990s. In any case, these changes in the Bangladeshi and global paper industry had (and continue to have) considerable economic implications for Bangladesh, especially in terms of losses of employment.

Availability and suitability of nonwood fibers in Bangladesh

As shown in Tables 1 and 2 below, nonwood fibers available and suitable for papermaking in Bangladesh are jute, straw, golpata fronds, dhanicha, bagasse, corn stalks, cotton stalks, and kash. While the following paragraphs of this section are non-technical summaries of details and references provided in Jahan et al. (2009), the important point is that it is often the case in papermaking that more than one type (or grade) of pulp is used to develop paper sheet properties necessary for both machine runnability and end user's requirement. In many paper grades, long

Table 1

Current Production, Yields, and some Chemical/Morphological Characteristics of Nonwoods in Bangladesh

Plant	Current Production (thousands of tons)	Annual fiber yield (tons/hectare)	Annual pulp yield (tons/hectare)	Fiber length (mm)	Fiber diameter (mm)	Ash (percent)
Jute	963	15	7	2.5	20	0.5-2.0
Rice straw	34,020	3	1.2	1 - 3.5	n.a.	n.a.
Wheat straw	25.8	4	1.9	1.4	13	4.5-9.0
Golpata fronds	60	n.a.	n.a.	1.73	10	7.0
Dhanicha	50	15-18	7-9	n.a.	n.a.	n.a.
Bagasse	700	9	4.2	1.7	20	1.5-5.0
Corn stalks	128	8-10	3.2-4.3	1.0-1.5	18	6.0-6.9
Cotton stalks	36	8-10	3.5-4.3	1.3	20-30	3.1
Kash	20	7-9 (est.)	2-4 (est.)	1.52	16	3.9

Source: Compiled by authors based on information provided in Jahan et al. (2009)

Table 2

Pulping Properties of Nonwood Raw Materials (Physical properties at oSR 35-45)

Nonwood	Pulp yield, %	Kappa number	Breaking length, m	Burst index $kPa.m^2/g$	Tear index $mN.m^2/g$	Initial oSR
Bamboo	45.9	24.6	5,511	4.9	18.1	12
Jute fiber	64.9	18.7	8,393	7.6	15.2	12-15
Whole jute plant	55.6	30.3	7,336	7	9.8	15-17
Rice straw	38.8	13.6	6,590	3.8	6.7	n.a.
Wheat straw	46.7	16	8,680	3.9	5.79	28
Bagasse	50.5	13.3	5,600	3.6	6.8	n.a.
Golpata fronds	37.2	27.2	7,228	4.5	11.6	45
Dhanicha	43.3	29	9,745	7	9.8	15
Corn stalks	50.5	23.4	7,307	5.1	4.7	23
Cotton stalks	44.5	33	5,500	5.4	7.1	15
Kash	57.9	20	5,536	3.2	6.5	23

Source: Compiled by authors based on information provided in Jahan et al. (2009)

fiber from softwood bleached kraft pulp is used in combination with short fiber from hardwood bleached kraft pulp. In this combination, the long fiber component provides the strength (especially tear resistance) to the paper sheet, while the short fiber helps to improve the functional properties of paper, such as sheet smoothness and formation. With regards to nonwood fibers, jute fiber provides long fiber furnish, where cotton stalks, corn stalks, straw and other nonwood fibers provide short fiber furnish. Especially the combination of jute and cotton fibers is highly suitable for papermaking.

Jute

Jute (*Corchorus capsularis/olitorius*) is abundantly grown in Bangladesh, amounting currently to about 1 million tons a year, and constitutes nearly 40 percent of the world's jute production. Jute has a long historical role in the socioeconomic development of Bangladesh. Once, jute was known as the golden fiber of Bangladesh. It provided considerable employment opportunities to the country's work

force as well as foreign currency. For example, based on annual data provided in the Bangladesh Bank's *Economic Trends*, exports of jute and jute-products accounted for 73 percent of Bangladesh's total exports during 1975-1979. Over the last two decades, the traditional uses of jute have—due to the emergence of synthetic fibers—declined drastically. Today, jute and jute products amount to less than 5 percent of Bangladesh's total exports. Jute fiber, which is coming from the bark of the jute plant, produces pulp of good quality pulp with a yield above 60 percent. If instead of jute fiber the whole jute plant (stick and bark) is used in pulping, pulp yield is about 45-55 percent. As shown in more details in Jahan et al. (2009), the pulping properties differ between pulp made from jute fiber and pulp made from the whole jute plant. Yet, as shown in the literature,[4] there are by now various processes and techniques which make jute highly suitable for papermaking.

Straw

As mentioned, wheat straw is a major source of pulp for paper production in some Asian countries. The average yield of straw is 1.3-1.4 kg per kg of grain. In North America and Europe, nearly 300 million tons of wheat straw are produced yearly and used for a variety of agricultural purposes, though not for papermaking. In Bangladesh, the availability of wheat straw is currently very limited (about 26,000 tons/year). On the other hand, rice straw is abundantly available in Bangladesh (though it is used extensively as animal food), amounting to about 34 million tons annually. While the very limited amount of wheat straw Bangladesh has is suitable for some papermaking, the high silica content (amounting to 9-14 percent) in Bangladesh's abundant rice straw currently prohibits its economic use as pulping raw material. The silica causes problems in the recovery of chemicals used in the pulping process. Other shortcomings with the use of all kinds of straw for pulp are the higher water retention capacity of straw, the lower yield per ton of raw material compared to wood, and the low bulk density of straw. It is generally accepted that fibers such as straw are currently not optimal to be used on a 100 percent basis for paper manufacturing, as their poor drainability and low tearing strength make it necessary to add a certain amount of long fibers from other sources.

Golpata Fronds

Golpata (*Nypa fruticans*) is a regal palm that grows abundantly in monotypic stands along the banks of the numerous rivers and canals that bisect the dense mangrove forests of the Sundarban. Every December to May, thousands of *bawalis* (traditional forest users) collect an average of 60,000 tons of golpata fronds (palm leaves) from throughout the Sundarban reserve forest. This number, however, could be a fraction of the actual amount harvested. While the pulp yield of golpata fronds is very low, the chemical and morphological properties of golpata fronds are comparable to some common nonwood and hardwood raw materials. The anatomical properties showed that the vascular bundles in golpata fronds are very low. The observed fiber length of 1.73 mm is a little bit shorter than the length of softwood fiber, though longer than that of hardwood fiber.

Dhaincha

Dhaincha (*Sesbania aculeate / Fussbnia rostata*) is a jute-like crop of which some species are known for their large showy flowers. It grows throughout Bangladesh, especially in the sandy region, where it protects land from erosion. It also fixes nitrogen to the soil and is therefore a very useful annual plant for Bangladesh's agricultural system. It is cultivated during the monsoon season almost throughout Bangladesh It is an ideal green manure crop as it is quick-growing, succulent, easily decomposable with low moisture requirements and produces maximum amount of organic matter and nitrogen in the soil. The plant is extremely fast growing and can produce yields in excess of 20 bone dry tons per hectare during its short life. It has presently no industrial use, though it is occasionally used for the production of rope. The chemical and morphological properties of dhaincha favor it as pulping raw material. The higher slender ratio of dhaincha fiber produces pulp of better tear strength than the other similar fiber length raw material. The pulp yield (42-44 percent) and most papermaking properties of dhaincha pulp are similar to hardwood. Unbleached dhaincha pulp is highly suitable for packing paper.

Bagasse

Bagasse is the outer stalk of sugar cane, a by-product of sugar mills. About 0.7 million tons of bagasse are produced in Bangladesh annually. Sugar mills in Bangladesh use bagasse as fuel for steam generation. Therefore, sugar mills consume almost all bagasse. Pith is the main problem for bagasse pulping as it creates problems during pulp washing, clogging in machine wire, etc. Adequate removal of pith is essential to produce a satisfactory pulp and to avoid wastage of chemicals. De-pithing is possible with dry, moist or wet bagasse. The strength of bagasse pulp is slightly lower than that of hardwood pulp. Bagasse pulps are generally smooth and soft. Bagasse

has been used in many grades where local factors limit the availability of better pulp. Paper grades in which bagasse have proven to be particularly suitable include writing, printing, tissue grades, corrugating medium and newsprint.

Corn Stalks

Bangladesh produces 64,000 tons of corn a year, which is estimated to come with about 128,000 tons of corn stalks. The chemical and morphological characteristics of corn stalks are comparable to hardwood species. Corn stalks are easier to delignify than wood. Corn stalks also require lower temperatures for pulping. The pulp yield is about 50 percent and the papermaking properties are with exception of tear strength very good.

Cotton Stalks

Cotton stalks need to be removed after the collection of cotton. They have besides some very limited use as fuel in some rural areas no use and are considered to be agricultural waste. The chemical and morphological properties of cotton stalks are comparable to hardwoods. Anatomically, cotton stalks are similar to hardwood. The pulp yield is about 40-45 percent and the papermaking properties are acceptable for some papermaking.

Kash

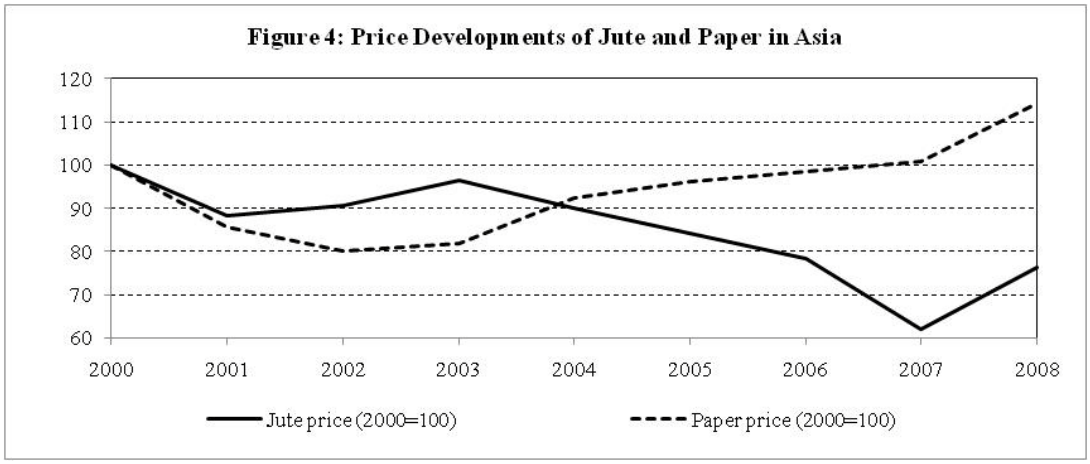
Kash (*Saccharum spontaneum*), which is the Bangladeshi term of what is called Kan in India, grows in the wet and sandy lands of Bangladesh and some parts of India. It is currently used in a limited extent as fencing in rural areas. Its production may increase to a few folds if proper planning is taken. Pulp yield from kash is very high and its papermaking properties are comparable to that of tropical hardwood. Kash pulp provides very good bleachability and is suitable for newsprint.

Economic Viability

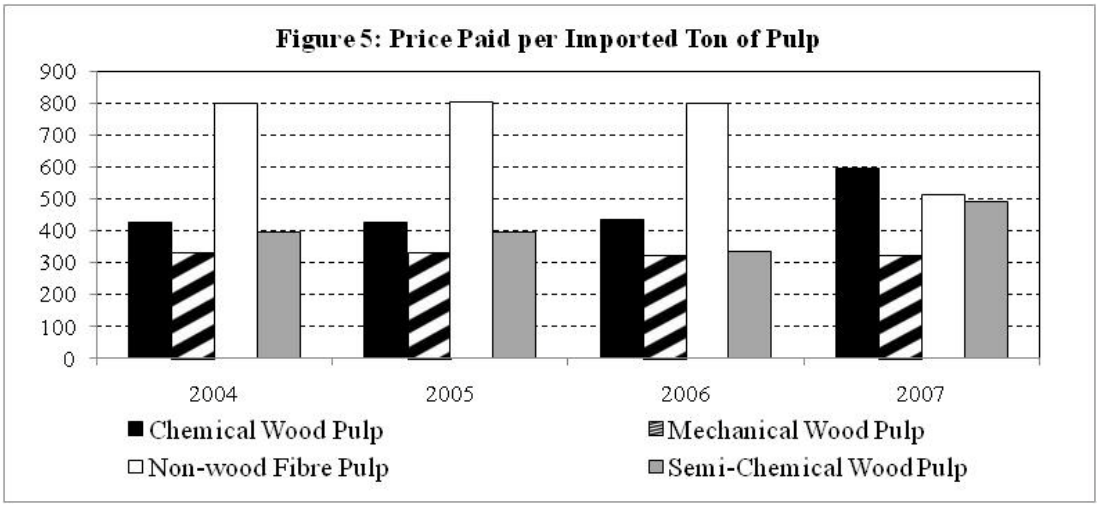
Availability and suitability do not necessarily guarantee the economic viability of nonwoods for papermaking in Bangladesh. For example, there was one bagasse-based pulp mill in Bangladesh that was shut down recently due to an increase in energy prices and the cheaper supply of other fibrous raw materials like imported pulp. The current use of bagasse for energy generation within the sugar mills make it less likely to be economically feasible for papermaking, unless cheaper energy sources can be found for the sugar mills. On the other hand, there are some nonwood fibers in Bangladesh that are currently non-valued agricultural waste. For example, despite negative environmental implications, most of the cotton stalks are typically burnt in the field to minimize removal costs of the non-valued cotton stalks. Beyond the clear-cut cases of bagasse (which is not economically viable) and cotton stalks (which are economically viable), most other available and suitable nonwood fibers have some uses beyond being used for pulp and therefore require a cost/price comparison to decide on their economic viability of being used for pulp. The following paragraphs provide such an analysis for jute.

As Figure 4 shows, the price of jute has fallen from 2000 to 2008, indicating a continued reduction in the demand for jute. There have been various efforts to find new uses for jute, especially in the textile sector that have however not yet resulted in an increase in demand for jute sufficiently large to compensate for the continued decline in the demand for jute from more traditional uses, including especially jute carpets. On the other hand, the price of paper from 2000 to 2008 (also shown in Figure 4) shows a clearly positive trend since 2002, largely due to the increase in demand for paper in Bangladesh and the global level. The difference in price trends between jute and paper support the economic rational to use pulp made from jute for papermaking.

The price trends shown in Figure 4 are useful to get some indication on the economic scarcity of a good over time but are not sufficient to determine if jute is an economically viable input for papermaking. We therefore compare the prices paid for imported pulp with the costs of domestically produced jute pulp. The prices for various imported pulps, shown in Figure 5, have been calculated by dividing the values of pulp imported into Bangladesh by the quantity of pulp imported. The price of domestically produced jute pulp has been estimated by dividing the actual average producer prices of jute in Bangladesh by the average pulp yield ratio for whole jute (0.50). Taking volatility of prices into account, we average these values from 2004 (which is the first year Bangladesh imported a significant amount of nonwood pulp) until 2007 (which is the last year for which such data is available). It turns out that the average raw material price for pulp produced from domestic jute would have been US$320 per ton of jute pulp, which looking at Figure 5 is marginally below the average price paid for imported mechanical wood pulp ($323) and significantly below the prices paid for the other kinds of imported pulp. Indeed, it is less than half the price that Bangladesh paid for imported non-wood fiber pulp. This simple price comparison indicates that domestically produced jute pulp is economically viable for papermaking.



Source: Calculations by authors based on FAOSTAT, updated by Paperloop and WorldJute.com



Source: Calculations by authors based on FAOSTAT.

Furthermore, given that in the presence of externalities, economic prices may not reflect the true values of goods to society, other considerations will need to be taken into account. For example, the wood that comes from cutting down forests in countries that have huge reserves of forests may be priced cheaper in market values than some nonwood fibers available in Bangladesh, but would obviously not make sense when taking environmental aspects into account. Indeed, as the Paper Task Force (1996, p. 15) has pointed out: "Non-wood plants may provide an additional source of fiber to papermakers, and thus, reduce the harvesting of trees from natural forests or the conversion of natural forests into tree plantations."

Some Developmental Implications

The developmental implications for Bangladesh from not only producing its own paper but also using its abundantly available resources like jute for paper-pulp would be significant and complex. The following paragraphs discuss some of the more obvious economic implications in terms of Bangladesh's trade balance, Bangladesh's employment, and Bangladesh's economic diversification. While it is obvious that the economic impacts (like for example increased employment) would then have subsequent implications on income generation, living standards, poverty reduction, and human development, they would due to their

dynamics require a much more careful impact assessment than can be provided here.

The most obvious impact of using domestically available jute pulp for papermaking in Bangladesh instead of importing pulp and paper would be on Bangladesh's import bill. Given that Bangladesh currently imports about US$40 million of pulp and US$170 million in paper and paper products a year,[5] the domestic production of paper using domestic inputs would reduce the import bill by US$210 million a year. In relative terms, it would lower imports by slightly more than 2 percent, and hence, improve Bangladesh's trade balance by about 2 percentage points. These estimates do not take into account that jute pulp could be exported, hence, further improving the trade balance. On the other hand, these estimates do not take into account that there would be a considerable increase in imports of paper machinery as well as some increase in imports due to increased income increases, which have negative impacts on the trade balance. Yet, it is clear that the overall impact on Bangladesh's trade balance would be significantly positive.

The other important economic impact of using domestic jute pulp for papermaking in Bangladesh is with regard to the generation of jobs in Bangladesh. Bangladesh has a huge pool of underemployed people, most of whom would be available for formal jobs. Instead of importing pulp and paper in the amount of currently about US$210 million a year, the domestic production of Bangladesh's imported pulp and paper could create about 100,000 jobs in agriculture and industry.[6] This estimate of 100,000 jobs does not include the indirect employment that would be generated due to the construction of new paper mills and the subsequent employment that would be generated due to increased income and consumption.

Another important consideration is Bangladesh's urgent need to diversify its economy. The ready-made garments (RMG) industry, which started in the early 1980s, has become Bangladesh's most dominant sector. This is also reflected in Bangladesh's highly concentrated exports. As Raihan (2007, p. 16) has pointed out, "while export earnings from the RMG sector were as low as US$32 million in 1983/84, they increased to a staggering figure of around US$8 billion in 2006. Similarly, the share of RMG exports in total exports, which was merely around 4 percent in the early 1980s, is now around 75 percent." The lack of more diversified exports is not only an impediment to growth and development (see United Nations Economic and Social Commission for Asia and the Pacific (2004)), the high export concentration implies also a high risk for Bangladesh. As Raihan (2007) has pointed out, any negative shock to the RMG sector will have a profound impact on the economy and the human development status, including the gender development status of the country. Indeed, the current economic crisis is estimated to have significant implications on developing countries' exports. For example, the World Bank (2009) has estimated that in Cambodia, which has like Bangladesh its only significant export industry in garments, has lost 30,000 jobs in the garment industry due to the current economic crisis. For a useful overview of Asia's manufacturing sector, see Felipe and Estrada (2008).

While it is clear that the first-round impacts of using domestic jute pulp for papermaking in Bangladesh have unambiguously positive implications for Bangladesh's economy, one important question is the impact on Bangladesh's long-term development strategy. There are views that moving into an agriculturally-based industrialization, as the papermaking from domestic jute clearly is, might be a step backwards and therefore not serve Bangladesh's long-term goal of becoming a modern economy. Indeed, there is a growing popular view that information technology could be Bangladesh's superhighway to prosperity (see Yunus, 2000) and that anything related to using jute is basking in old days of jute's glory that have passed. While there is no doubt that a greater focus on information technology would be beneficial to Bangladesh, this does not imply that the country cannot also benefit, both in the short-run and in the long-run, from using domestic jute pulp for papermaking. Furthermore, using information technology to build up a competitive paper industry based on domestic jute would be an important step forward towards Bangladesh's urgently needed economic diversification.

Finally, given that land is scarce in Bangladesh, issues related to alternative uses of land and their distributional implications will need to be taken into considerations. For example, growing jute (for paper) instead of rice (for food) would have negative implications on already high food prices, benefitting food producers but hurting food consumers. While this is currently not a major concern as Bangladesh has currently a large abundance of jute, the long-term implications of increased jute demand on food production would need further investigation. There is some indication that with the majority of Bangladesh's poor concentrated in rural areas, the overall impact of using jute for papermaking in

Bangladesh and the possible competition between growing jute and food would benefit the rural population and therefore contribute overall to poverty reduction in Bangladesh, but here again, a more detailed analysis of the distributional implications would be needed.

Environmental Implications

Little information is available to compare the environmental releases associated with nonwood and wood pulping. Many existing nonwood pulping operations, both in the developing world (for commercial paper applications) and the developed world (for specialty paper applications), are technologically outdated. Because of their small scale, most of these mills use chemical pulping processes without chemical recovery, a practice, which is both economically and environmentally inefficient. Therefore, black liquor is either treated before discharge or transported to wood-based pulp mills for recovery. Based on their fiber properties, using nonwood fibers instead of wood chips may offer opportunities to reduce the magnitude of environmental releases generated by the pulping process. There also is some common misconception with regards to environmental standards of Bangladeshi paper mills. As Hartman et al. (1997, p. 26) have stated: "Clean production [of paper] is not uncommon, even in very poor countries such as Bangladesh."

Another question that has been raised is on the technical feasibility of nonwood pulp recyclability. In general, nonwood fibers are as recyclable as wood fibers (see Garg and Singh, 2004). The strength of pulp made from recovered fibers determines its usefulness. Fiber length as well as fiber bonding ability determines pulp strength. Recovered fibers on average are shorter than virgin fibers and lose strength with each reuse cycle (Jahan, 2003). For nonwood fibers that are generally shorter than wood fibers (such as wheat straw), issues such as slow drainage and low strength are a problem both in virgin production and recovered fiber paper production. On the other hand, nonwood fibers with greater fiber length can be used to compensate for losses in pulp strength from recycling. Depending on the strength of the nonwood fiber, more or less virgin pulp has to be added to the deinked pulp to produce high quality recycled paper.

Conclusion

Based on the above examination, we come to the conclusion that substituting wood pulp with jute pulp in papermaking implies a win-win solution for Bangladesh. Jute is not only abundantly available in Bangladesh, it is—based on its chemical and morphological characteristics—also highly suitable for papermaking. We have also shown that papermaking from jute would be economically viable and contribute positively to Bangladesh's urgently needed economic diversification as well as to poverty reduction. Furthermore, there are no intrinsically negative implications on the environment from using jute for papermaking in Bangladesh. Finally, in addition to physical, chemical, economic and environmental issues, we also need to take institutional issues into account. For example, though jute has been successfully tried as a raw material for pulp and paper in Bangladesh, China, India, Thailand and the United States, the global paper industry has been reacting very slowly in adopting it as a new pulping resource. Hence, there is an additional role for policy to encourage through price and non-price instruments the use of jute for papermaking in Bangladesh and other countries.

Endnotes

1. In this paper, ton and tons refer always to metric ton and metric tons (i.e., containing 1000 kg).

2. Organization for Economic Co-operation and Development (OECD) (2008), p. 401.

3. Presently, about 38,000 acres of forest are allocated and used for Bangladesh's pulp and paper industry. Most of these forests are occupied by tribal peoples, who traditionally apply a slash and burn (jhoom) cultivation, destroying huge amounts of forest, aggravating the increasing shortage of wood in Bangladesh.

4. See Akhtaruzzaman and Shafi (1995), Gupta et al. (1998), Hurter (2001), Jahan and Farouqui (2005), Jahan, et al. (2007), Jahan et al. (2008), Kulkarni (1999), Lutfar and Rahman (2008), and Nahar (1987).

5. Estimation by authors based on 2000-2004 data provided in the International Trade Centre (UNCTAD/WTO) Database as of December 12, 2008 (www.intracen.org/tradstat/sitc3-3d/ir050.htm) on imports of pulp and paper.

6. This is the authors' estimate based on the following consideration. Given that the Bangladeshi pulp and paper industry employed more than 15,000 people towards the end of the millennium (see Gupta, 1999, p. 93) but

produced less than 20 percent of the domestic consumption of pulp and paper (see Figure 3), the domestic production of all of Bangladesh's pulp and paper consumption would have implied the employment of an additional 60,000 people solely in Bangladesh's pulp and paper industry in 1999. Taking the growth in Bangladesh's pulp and paper consumption from 1999 to 2009 into account (which amounts to about 40 percent, see Figure 3), the potential new jobs from the domestic production of all of Bangladesh's pulp and paper consumption in 2009 would amount to 84,000 jobs. Another 16,000 jobs are estimated to be created in Bangladesh's jute sector due to the increased demand for Bangladeshi jute pulp.

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Bernhard G. Gunter, Ph.D.
Economics Department
American University
4400 Mass. Ave. NW
Washington, DC 20016-8029; and
Bangladesh Development Research Center
(BDRC), 2508 Fowler Street
Falls Church, VA 22046-2012
E-mail: president@bangladeshstudies.org

A. F. M. Ataur Rahman, Ph.D.
Department of Economics
North South University (NSU)
Dhaka 1229, Bangladesh
E-mail: ataur@northsouth.edu

Md. Sarwar Jahan, Ph.D.
Pulp and Paper Research Division
Bangladesh Council of Scientific &
Industrial Research (BCSIR) Laboratories
Dr. Qudrat-i-Khuda Road
Dhaka 1205, Bangladesh
E-mail: sarwar2065@yahoo.co.uk