Management Arrangements for Accommodating Nonrice Crops in Rice-Based Irrigation Systems in Bangladesh

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INTRODUCTION

AGROCLIMATIC CONDITIONS AND agronomic factors remain extremely favorable for rice cultivation during the wet season in Bangladesh. Furthermore, people's extreme dietary bias to rice as the staple food favors the dominance of rice-based farming systems in the country. Rice receives major support from government programs in terms of input distribution. price support and technological development. Seventy-two percent of the current total cropped area of the country is put to rice cultivation and 83 percent of the total irrigated land is covered by rice. A recent estimate based on field surveys in four different agro-ecological regions of Bangladesh reveals that 92 percent of total pumped water is consumed by rice alone. the remainder being used for irrigating nonrice crops (Biswas 1990). Rice also receives most of the agricultural loans. In 1988-89, 67 percent of the total loan from the Bangladesh Krishi Bank was disbursed for rice production.

Extent and Conditions of Crop Diversification

Agriculture in the country is highly diversified as it encompasses crops, livestock, fisheries and forestry in an interrelated fashion. The crop sector alone includes about one hundred crops grown in different seasons of the year. The agricultural census of 1983-84documented 85 crops, which included 11 cereals, 10 pulses, 7 oilseeds, 7 cash crops, 31 vegetables and 9 spices. But cereals (rice, wheat and minor cereals) occupy about 77 percent of cropped land, the remainder is devoted to pulses, oilseeds, cash crops, vegetables and other crops (Table 1).

Table 1. Distribution of cropped area by crop, 1988-89.

Crop	Total cropped area ('000 ha)	% of total area	% of irrigated area	Irrigated area as % of total cropped area
Rice	10,225	72.4	83.3	19.3
Wheat	560	4.0	8.4	35.0
Other Cereals	115	0.8	–	–
Pulses	535	3.8	–	–
Oilseeds	562	4.0	0.8	3.1
Cash Crops	808	5.7	0.5	9.2
Vegetables	459	3.3	3.8	7.3
Others	853	6.0	3.2	5.6
Total	14,117	100.0	100.0	16.7(27.0)[a]

[a]Indicates, irrigated area as proportion of 8.9 M ha net cropped area in 1987-88.

Source: Bangladesh Bureau of Statistics (1990).

The rate of adoption of a few nonrice crops such as vegetables and banana is increasing, as these are being commercially grown in different locations of the country. For example, in areas such as Bogra Sadar, Gabtoli, Shibgonj, Khetlal, Kalai. Dhaka Sadar, Mithapukur, Rangpur, Dinajpur Sadar, Rajshahi, Paba, Putia, Natore, Chandina, Comilla, and Feni, farmers have taken up commercial production of vegetables, especially potato, cabbage, cauliflower, cucubit, tomato, and aroid. Onion and tomato are grown widely in Iswardi, Pabna, while banana is adopted as a commercial crop in areas such as Shibgonj, Narshingdi, and Kaligonj, Jhenaidah. These vegetables and fruits are mainly disposed of through domestic markets all over the country. Some vegetables and fruits are exported.

Diversification of crops in different locations of the country is possible mainly because a number of high-yielding varieties of vegetables are available and also because the versatile use of minor irrigation equipment is spreading. Current research on irrigated crop diversification at Bangladesh Agricultural University (BAU) reveals that the extent of irrigated crop diversification was larger in shallow tubewell (STW) and hand tubewell (HTW) schemes than in deep tubewell (DTW) schemes. This is because STWs and HTWs have smaller command areas and have more flexibility to adjust to variable water application required for accommodating both rice and various nonrice crops in the same commands. There are also areas where other forms of manually operated devices such as treadle pumps, rower pumps, dug wells, and swing baskets are also used extensively for irrigating crops such as vegetables and fruits.

Agencies Involved in Crop Diversification

A number of government and nongovernment agencies have taken up research and extension programs in order to promote diversified cropping. The most notable of them are: Multicrop Demonstration Programme of the Directorate of Agricultural Extension (DAE) for popularizing 49 noncereal crops; Bangladesh Agricultural Development Corporation (BADC)-sponsored Agro-Service Center for promoting vegetables, fruits, seeds/seedlings, fish and poultry; Horticultural Development Project of DAE-BADC-BAN; BRRI-BWDB-IRRI-IIMI Project for improving irrigation effectiveness and diversified cropping; On-farm Research and Development Programme of BARI for diversified cropping; Crop Diversification research for improving irrigation water market, and Farming System Research and Development Project at BAU; Continuous Cropping System Management Programme of Bangladesh Rural Development Board and German Technical Assistance-sponsored Tangail Rural Development Project for demonstrating vegetables and fruits in the upland district of Shokhipur; Improved Vegetable Cultivation Program of Mennonite Central Committee in Feni; Changing cropping patterns with Treadle pumps under Rangpur-Dinajpur Rural Service; and Canadian International Development Agency (CIDA)-sponsored Crop Diversification Program using mostly manually operated shallow tubewells for irrigation.

IRRIGATION PLANNING AND OPERATION FOR RICE-BASED SYSTEM

Practices in Rice Irrigation-Systems

Irrigation is applied for high yielding variety (HYV) rice production during the dry months of January/February to April/May, but in areas where winter vegetables or short-duration oilseeds are grown, irrigation may start in February/March and continue up to May/June.

Planning for rice irrigation varies between lift-irrigation systems and large-scale gravity-cum-lift irrigation systems. For DTWs (usually 2 cfs capacity) and STWs (usually 0.5 cfs capacity) which are used for intermittent or continuous flood irrigation in the small-sized fragmented plots surrounded by dikes, major planning activities include decision making as to when to start pumps, which canal to be repaired and to what extent, who will put how much land for what crop, how much land to be covered in the command area, how much to charge for water, how much diesel/Mobil to buy, who will collect water fees in how many installments, and which mechanic to be contracted for pump repair in case of breakdowns and at what mode of payment. The dominant form of payment for water is cash at a fixed rate per unit of irrigated land for the whole season, but the rates vary depending on whether water suppliers or water users provide fuel. The other important form of payment is sharecropping with water. where one-fourth share of the crop is charged for water. In a normal year, on average, the full requirements for DTW and STW are about 3,000 and 600 liters of diesel, respectively, aiid the tubewell owners/managers have to purchase these with cash or on credit in several installments.

A recent field study at BAU shows that in the case of HYV rice, irrigation water is usually applied at 2-10 day interval with 30-50 mm average net depth per application, depending on variations in soil type, climate and irrigation plan. There are canal-wise rotations, and also management flexibilities to allow water to rice fields on demand from farmers. But the water sellers always prefer low-lying clay dominant plots which have high water holding capacity. Plots with light textured sandy soils, which require frequent irrigation or those plots where water delivery with the existing kutcha canals is difficult or result in huge conveyance losses, are gradually "screened out" of rice irrigatioii and put to wheat or other low-water-coiisumiiig nonrice crops. This is one of the reasons why tubewell commands in highly competitive areas undergo contraction or expansion every year, resulting in increase or decrease in profits from the sale of water.

As far as irrigation planning is concerned, increased command area means increased hours of pumping and increased cash requirement for meeting energy costs; but, there are areas where increased pumping may not produce enough water for all the command-area plots because of reduced discharges, especially in the hottest months of March and April. A recent field research study in four sites in the country reveals that overall irrigation canal system efficiencies were 63 aiid 54 percent, respectively, for STW and DTW (Duna 1990). The same study also found that most of the irrigated rice and nonrice crops were underirrigated.

The Ganges-Kobadak (G-K) irrigation system, a large gravity-cum-lift irrigatioii system, was designed for providing supplemental irrigation to aman rice grown in the wet season, but nowadays farmers in the G-K irrigatioii system produce two rice crops, HYV aus and HYV aman, and most land remains either fallow or is used to grow low-value low-yielding pulses. The major planning elements involved in such projects are annual repair and maintenance of pumps, repair and dredging of intake channels aiid irrigation canals, selection of date of initiation of pump operation aiid pump suspension. aiid collection of water fees which is very negligible at present.

Modified Practices to Accommodate Nonrice Crops

Canal network facilities of well-functioning rice irrigation systems can adequately support the water delivery needs of both rice arid nonrice crops in the dry season without any major redesign or upgrading specifically for that purpose (Bhuiyan 1989). At the farm level. water application and drainage functions for nonrice crops may require some additional facilities. mostly in the form of channels, but these can be nonnally handled by the farmers adequately.

These additional facilities are seasonal and disappear at the beginning of the wet season as the land is released for rice cultivation (Tabbal et al. 1990)

A recent field research at BAU reveals that farmers of an intensive lube-well irrigated area of Chandina, Comilla could successfully adapt the kutcha channels used for flood irrigation to rice fields for the purpose of providing furrow irrigation to vegetable fields. Fanners delivered irrigation water intermittently from kutcha farm ditches lo furrows in plots in which potato was grown either as the sole crop or as an intercrop with other vegetables such as brinjal, yard-long bean, and bitter gourd. After the harvesting of potato, the ridges or furrows were leveled off through deeper plowing by tractor or country plows to allow land soaking and puddling for transplanting of HYV boro rice which could then be irrigated without difficulty by applying the usual flooding method. Such modifications of water conveyance structures and necessary adjustments of water delivery schedules were also observed in Jhenaidoh, a relatively dry zone where irrigated nonrice crops such as potato, tobacco, papaya, tomato, brinjal and banana are grown simultaneously with HYV boro rice which is however grown on other plots of the same tubewell commands (Mandal 1990).

Constraints/Opportunities in Management Changes

In Bangladesh, most soils are well-drained and groundwater is well beyond the root zone of most crops grown during the dry season. Therefore, land suitability and drainage are not major problems for crop diversification, except that temporary drainage congestion problems arc artificially created by the unplanned construction of roads and embankments. Such congestion restricts or delays planting of Rabi crops such as pulses or oilseeds in many areas, because lands remain too wet to be planted. This is particularly the case in the G-K irrigation system where delayed suspension of pumps in mid-November is reported to be responsible for delayed seeding of Rabi crops and hence damage of these crops at mature stage because of early pumping in February (Ghani et al. 1990).

One of the agronomic opportunities for changing irrigation management for crop diversification is that a number of quick-growing high-yielding varieties of vegetables and oilseeds are available in Bangladesh. With the presently available cultivars, an opportunity for expanding cultivation of nonrice crops exists mostly in the winter and partly in the summer seasons. But to release land early in the winter months to facilitate timely seeding of the succeeding nonrice crops, presently grown photosensitive rice varieties need to be replaced by day-neutral to weakly photosensitive rice varieties in the wet season (Huq 1990). Besides, the very low yield potential of some nonrice crops, especially pulses and oilseeds, results in lower returns to farmers, compared to irrigated HYV boro rice. Both yields and profitability have been declining in recent years. This implies that more and more land is diverted to boro cultivatiori pushing nonrice crops out of cultivation or to cultivation in poor quality soils.

From a technical point of view, different crops need different methods and different intensities of irrigation. Biswas and Sarker (1987), in a pioneering paper, illustrated the physical and technical potentials and constraints of irrigating nonrice crops commonly grown in Bangladesh and indicated that the existing rice-based irrigation distribution systems are not appropriate for irrigating nonrice crops. But the level of technical adjustments needed to accommodate nonrice crops in the existing rice-based irrigation water distribution system is within the fanners' ability. The major input required for altering rice basin irrigation to furrow irrigation to suit line planted vegetables, and then for leveling off the furrows again for rice cultivation at the beginning of the wet season is human labor, which is adequately available in most areas during the early winter months. Whatever extra costs incurred in making such structural alterations are more than compensated for by savings made in terms of reduced costs of pumping water for nonrice crop irrigation.

A number of food items such as pulses (mostly lentils), spices (onion, ginger, turmeric, etc.) and edible oils are currently imported, although some of these imports are not officially recorded. These crops have been pushed out of cultivation by the singular emphasis on dry-seas011rice production with mechanized irrigation. The prices of these crops may have risen recently so that the cultivation of these crops appear lo be profitable, temporarily. compared to irrigated rice production. But inter-year price fluctuations and inadequate transport, communication. storage and marketing facilities, restrict the expansion of these crops on a commercial scale. Furthermore, the farmgate prices which the growers receive during the harvest are much lower than market prices consumers actually pay. This is especially true for potato and vegetables which are perishable and need cold storage facilities.

The available institutional credit for nonrice crop production is inadequate, despite the fact that crops such as potato and leafy vegetables need considerably more cash inputs as well as timely cultural operations and timely processing, and transport and marketing facilities than rice. A three-country study by Miranda (1989) also corroborates this view. Another major institutional constraint is that the irrigation support services such as supply of fuel oil, electricity, machine spare parts and repair services are virtually not available for irrigating crops other than HYV boro rice grown in the dry season (Mandal 1988). This turns out to be a formidable problem for irrigation managers/tubewell owners to undertake canal repair or pump operation in the wet season to provide supplemental irrigation to aman rice, which is the major rice crop in terms of acreage and output. But a significant improvement in yield of this major rice crop appears to be a prerequisite for diverting lands from dry season boro rice lo nonrice crop production.

The type of crops grown by neighboring farmers in adjacent plots is also an important consideration for growing nonrice crops in rice-based irrigation systems. For example, the D-N-D Irrigation Project of BWDB is very close to Dhaka City with a good market for vegetables, but the farmers in the farming system research block of the project did not respond to suggestions of growing vegetables. The main reason farmers reported was that they were unable to protect one or two plots of vegetables from theft (Huq 1990).

STRATEGIES TO ADDRESS CONSTRAINTS/OPPORTUNITIES

Improvement of Irrigation Facilities

The Fourth Five-Year Plan of Bangladesh has put increased emphasis on the improvement of irrigation facilities. It is expected that by 199495, the terminal year of the plan, 4.8 M ha (54%) of the country's 8.85 M ha net cropped area, will be under irrigation. While surface water irrigation will cover more than one-third of the area, groundwater lift devices such as DTWs, STWs and HTWs will be the dominant forms of irrigation in the future (Table 2).

Table 2. Irrigation achievement and targets in Bangladesh.

Source of irrigation	Estimated achievement (1989-90) ('000 ha)	Target for FFYP* (1990-95) ('000 ha)
Surface water irrigation:	1,295	1,788
Gravity flow	212	500
Low-lift flow pumps	783	1,088
Traditional lift	300	200
Groundwater irrigation:	1,805	3,017
STW	1,251	2,200
DTW	500	700
HTW	54	54
FMTW	–	63
Total	3,100	4,805

'Fourth Five-Year Plan.

Source: Planning Commission (1990)

One encouraging feature of the proposed irrigation development is that greater emphasis has been put to small-scale lift irrigation devices, which offer better management opportunities for crop diversification. Therefore, it is also not surprising that the crop diversification prograins of government and nongovernment organizations give preference to locations where farmers have more access to these flexible small-scale technologies, compared to large-scale irrigation projects.

Improvement in Procedures and Practices

While there will be horizontal expansion of irrigation facilities by installing additional capacities, there are also pronounced intentions to improve irrigation performance through improved water conveyance systems, improved canal layout and alignment, and motivation and training of farmers on appropriate water application methods. One of the improved water distribution systems currently being experimented is buried pipe irrigation, which allows greater flexibility in water management for growing rice and nonrice crops on fragmented plots simultaneously. Another experiment with respect to improved water distribution system is the rotational irrigation practices in the G-K irrigation system and the North Baugladesh Tubewell Project, which demonstrated feasible cropping patterns allowing growing of rice in the wet season and nonrice crops in the dry season. One of the encouraging aspects of irrigated cropping patterns is that these promise higher levels of grain output prr hectare (Tables 3 and 4).

Growing nonrice crops in the winter season in sequence with aman rice in the wet season may be accomplished by selecting or developing rice varieties which are day-neutral to weakly photosensitive rice varieties so that lands put to these varieties can be released in early October and adequately dried to allow early seeding of nonrice crops. Another opportunity exists with the Flood Control and Drainage (FCD) projects which are expected to drain out land to the advantage of nonrice crop production (but to the obvious disadvantage of natural fisheries). Intercropping of pulses with wet-season aman rice provides another good opportunity; it is practiced in several parts of the country. In this case, pulse seeds are sown by draining out excess water after flowering of aman rice and the pulse seeds germinate and grow within the rice fields using residual moisture. Khesari (Lathyrus Sativus) is mostly grown in such intercropping systems.

DIRECTION OF IRRIGATION MANAGEMENT FOR CROP DIVERSIFICATION

Research and Development

The promotion of crop diversification in Baugladesh involves research in two major directions: irrigation management and crop development. A number of researchable issues relating to crop diversification were suggested by Mandal (1988). Some of the on-farin research studies on improved water management practices are currently being conducted by the engineering divisions of the Bangladesh Rice Research Institute (BRRI) and thr Irrigation and Water Management Department at Bangladesh Agricultural University (BAU), Mymensingh. Rotational irrigation practices, improved conveyance systems, water quality, water balance studies of rice vis-a-vis nonrice crops, and improved water application methods are also on the current research agenda.

Research on improvement of crop varieties, to be included in crop diversification programs, is carried out by the Bangladesh Agricultural Research Institute (BARI), Bangladesh Institute of Nuclear Agriculture (BINA) and BAU. The Crop Diversification Program of the government envisages long-term, medium-term and short-term research strategies (Ministry of Agriculture 1989). Long-term research includes hybridization techniques while medium-tern research strategy involves collection of local varieties, and import and screening of advanced breeding lines. short-term strategies encompass collection of germplasm of vegetables, spices and fruits. Field research is needed for the adoption of improved technology packages for the improvement of local varieties such as ginger, turmeric, onion, garlic, chili, etc. Another urgent research is the development of high-yielding varieties of oilseeds and pulses.

Table 3. Average annual grain yield (t/ha) for selected cropping pattern in the Ganges-Kobadak Project (Phase I), Bangladesh, 1982-89.

Cropping pattern	Total yield under recommended management	Total yield under farmer management
Wheat-BR1-BR4[a]	11.41 (8.93)[b]	10.06 (7.63)
Wheat-BR1-BR11	11.80 (10.34)	10.41 (9.09)
Gram-BR3-BR11	11.77 (10.56)	9.94 (8.80)
Gram-BR1-BR10	11.81 (9.81)	10.44 (8.93)
Lentil-BR1-BR4	10.61 (9.88)	8.14 (7.76)
Kheshari-BR1-BR11	11.36 (10.15)	10.28 (9.23)
Dhaincha-BR3-BR11	10.26 (10.26)	8.53 (8.53)
Dhaicha-BR3-BR11	11.64 (11.64)	10.17 (10.17)
Sunhemp-BR1-BR11	11.65 (11.65)	9.25 (9.25)
Wheat-BR6-BR10	10.50 (9.50)	9.24 (8.14)
Wheat-BR1-BR11	11.25 (10.30)	10.65 (9.40)
Gram-BR1-BR11	10.47 (9.36)	9.54 (8.46)
Cowpea-BR1-BR11	11.51 (9.99)	10.80 (9.56)
Kheshari-BR1-BR10	10.84 (9.95)	9.52 (8.72)
Kheshari-BR1-BR4	10.85 (9.78)	9.74 (8.72)
Keshari-BR14-BR11	11.12 (10.10)	9.63 (8.75)

[a]Crops grown in rabi (winter), aus and aman seasons respectively, i.e., wheat is grown in rabi, BR1 in aus and BR4 in aman.
[b]Figures in parentheses are the rice yield (t/ha) for the pattern.

Source : Ghani et al. 1990.**Table 4. Average annual grain yield (t/ha) for selected cropping pattern in the North Bangladesh Tubewell Project, Thakurgaon.**

Table 4. Average annual grain yield (t/ha) for selected cropping pattern in the North Bangladesh Tubewell Project, Thakurgaon.

Year	DTW No.	Cropping pattern	Yield (t/ha)	
			RM	FM
1984	63	Sonalika-Sunhemp-BR11	8.08 (5.28)	7.40 (4.70)
		Sonalika-Millet-BR11	8.08 (5.28)	7.40 (4.70)
		Balaka-Mungbean-BR10	8.48 (5.28)	7.79 (4.79)
		Pavon-Dhaincha-BR4	7.38 (5.00)	6.27 (3.77)
	118	Sonalika-Sunhemp-BR11	8.30 (5.60)	8.33 (5.43)
		Sonalika-Millet-BR11	9.30 (5.60)	9.43 (5.43)
		Balaka-Mungbean-BR10	8.07 (5.80)	7.08 (4.12)
		Pavon-Dhaincha-BR4	7.78 (5.58)	6.45 (4.45)
	126	Sonalika-Sunhemp-BR11	9.18 (5.78)	8.78 (5.78)
		Balaka-Mungbean-BR10	8.00 (5.00)	8.01 (4.81)
		Pavon-Dhaincha-BR4	8.02 (5.02)	7.04 (4.64)
1987	126	Sonalika-Purbachi-BR11	12.21 (10.33)	11.09 (9.21)
1988	89	Kanchan-Millet-BR11	8.34 (5.52)	7.71 (4.89)
	118	Kanchan-Sesame-BR10	7.33 (4.89)	5.30 (3.95)
		Fallow-Purbachi-local rice	7.95 (7.95)	7.40 (7.40)
	120	Sonalika-Sesame-BR11	6.64 (4.59)	5.20 (3.15)
	126	Fallow-Purbachi-BR11	11.44 (11.44)	10.89 (10.89)
		Kanchan-Millet-Pajam	8.44 (3.67)	7.21 (3.67)
	142	Fallow-Purbachi-BR11	9.90 (9.90)	8.83 (8.83)
1989	89	Kanchan-Millet-BR11	10.02 (6.91)	8.46 (5.35)
	118	Kanchan-Sesame-BR11	6.63 (4.64)	6.39 (4.40)
	126	Mustard-Fallow-BR11	6.61 (6.04)	5.66 (5.09)

Notes: Sonalika, Balaka, Pavon and Kanchan are wheat varieties.
BR stands for rice variety.
Figures in parentheses are the rice yield for the pattern
RM = Recommended management
FM = Fanners' management

Source: Ghani et al. 1990.

Information Dissemination and Exchange

One major area of weakness is the poor dissemination and exchange of information about on-station research findings. No doubt, the occasional newsletter published by the Bangladesh Agricultural Research Council and research institutes act as a medium of exchange of ideas among the researchers, but there is no infonnation dissemination media for farmers. There are many innovative technologies evolved locally by farmers but in the absence of communication and dissemination media these remain unknown to farmers elsewhere. The Crop Diversification Program (CDP) Committee report mentions a number of examples such as year-round string bean production in Ramgarh, off-set production of kachu (aroid) in Barisal, multi-harvest of potato in Bogra and *mukhikachu* production with leaf mulching in Moulavibazar and Madhupur tracts. Another example of local innovativeness is the highly intensive production of vegetables under relay cropping, intercropping, mixed cropping and catch cropping under tubewell irrigation schemes in Chandina, Comilla. Farming system research also gathers many interesting local experiences and occasionally organizes field workshops with the participationoflocal farmers. The CDP committee report rightly suggests the need for interlocation fanner visits and orientation as a means to popularizing improved methods of nonrice crop production. The current BAU research project on crop diversification is planning to incorporate a farmer training and orientation component in the second phase in which suggested technological interventions with respect to improved irrigation management for diversified cropping will be tested in farmers' fields.

Funding

A number of collaborative research and extension programs for crop diversification are underway at different institutes/locations mainly with assistance from various funding sources. More research and development programs towards crop diversification will require funds from national and international sources.

SUMMARY

Agroclimatic conditions in Bangladesh have favored a rice-based farming system. Rice is the staple food and fanners will continue to grow rice to meet consumption demand. But continuous monoculture of rice has already started showing symptoms of micronutrient deficiencies of soils and consequently. declines in yield levels. Irrigated rice production is also becoming less profitable to farmers. So, a more logical approach would be to concentrate on growing nonrice crops in the winter season in sequence with rice crops grown with supplemental irrigation in the wet season. In other words, providing options to fanners to grow nonrice crops such as pulses, oilseeds and vegetables with partial or full irrigation in the dry season and to grow rice crops in the wet season should be a major strategy in increasing fanner income and improving soil fertility.

The most important factor that influences crop diversification is the economic incentives for farmers to grow nonrice crops. The production of most nonrice crops such as potato, onion, spices and leafy vegetables does involve high cash inputs and intensive agronomic practices but returns to farmers from these crops in most years are lower than returns from competing HYV boro rice production. Therefore, to promote crop diversification. institutional support in terms of credit, price support for nonrice crops, and backup services from irrigation-related agencies for storage, processing and marketing are needed. To improve performance of irrigated nonrice crop production, more research and development are needed in the field of irrigation water management and varietal development of both rice and nonrice crops.

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