Trans. Inst. Indian Geographers
Vol. 12, No. 2, July 1990

IMPACT OF IRRIGATION ON CROPPING INTENSITY IN WEST BENGAL

Sm. NANDINI CHATTERJEE, Calcutta

ABSTRACT : The success of irrigated agriculture in West Bengal is best reflected in cropping intensity rather than net sown area. This may be attributed to the overpopulated nature of this State, which limits the scope for extension of cultivable lands. Both gross irrigated area as well as the seasonal nature of irrigation have been considered and statistical techniques applied to correlate them with cropping intensity. It has been observed that cropping intensity is not highly related to gross irrigated area but rather, it has been considerably influenced by ecological settings and seasonal nature of functioning of the different irrigation types. Percent gross irrigated area is high along canal irrigated tracts followed by STW irrigation in the Damodar-Hughli riverine plains. In contrast percent GIA under rabi and summer season irrigation records high values along the RLI irrigated 'a'l and 'dara' lands of Maldah as well as northern foothills and saline coastal plains. Maximum CI is recorded along the humid, Damodar-Hughli riverine plains with their conjunctive use of canal and STW irrigation. Values of regression between variables also testify to this fact. The overall increase in CI has been considerable as evidenced by the Wilcoxon ranked pair test.

An assessment of the efficiency of irrigation should necessarily consider winter ('rabi') and summer ('boro') season crops as their cultivation is mostly dependent upon the availability of irrigation water. Moreover, returns from such crops like potato, wheat and the highly water consuming 'boro' rice are more remunerative than the rainfed 'aman' rice. The cultivation of such crops is best manifested by Cropping Intensity (CI) values

$$CI = \frac{\text{Gross Cropped Area (GCA)}}{\text{Net Sown Area (NSA)}} \times 100$$

Although it has been postulated that irrigation has had considerable impact upon the extent of the area under double or multiple cropping in West Bengal, yet the correlation coefficient 'r' between Gross Irrigated Area (GIA) and CI fails to bring this into perspective. It amounts to only + 0.274 at .001 significance level. However, it would be erroneous to draw conclusive evidence from this purely statistical test. CI has been considerably influenced by the ecological setting and irrigation types (Fig. 1). A prior analysis of GIA is essential to highlight these facts.

GROSS CROPPED AREA IRRIGATED, 1986

In general, the pattern of Gross Irrigated Area (GIA) remains essentially similar to that of net irrigated area. The districts of Bardhaman, Birbhum emerge as the leading ones followed by Hughli, Nadia and Bankura (Fig. 2).

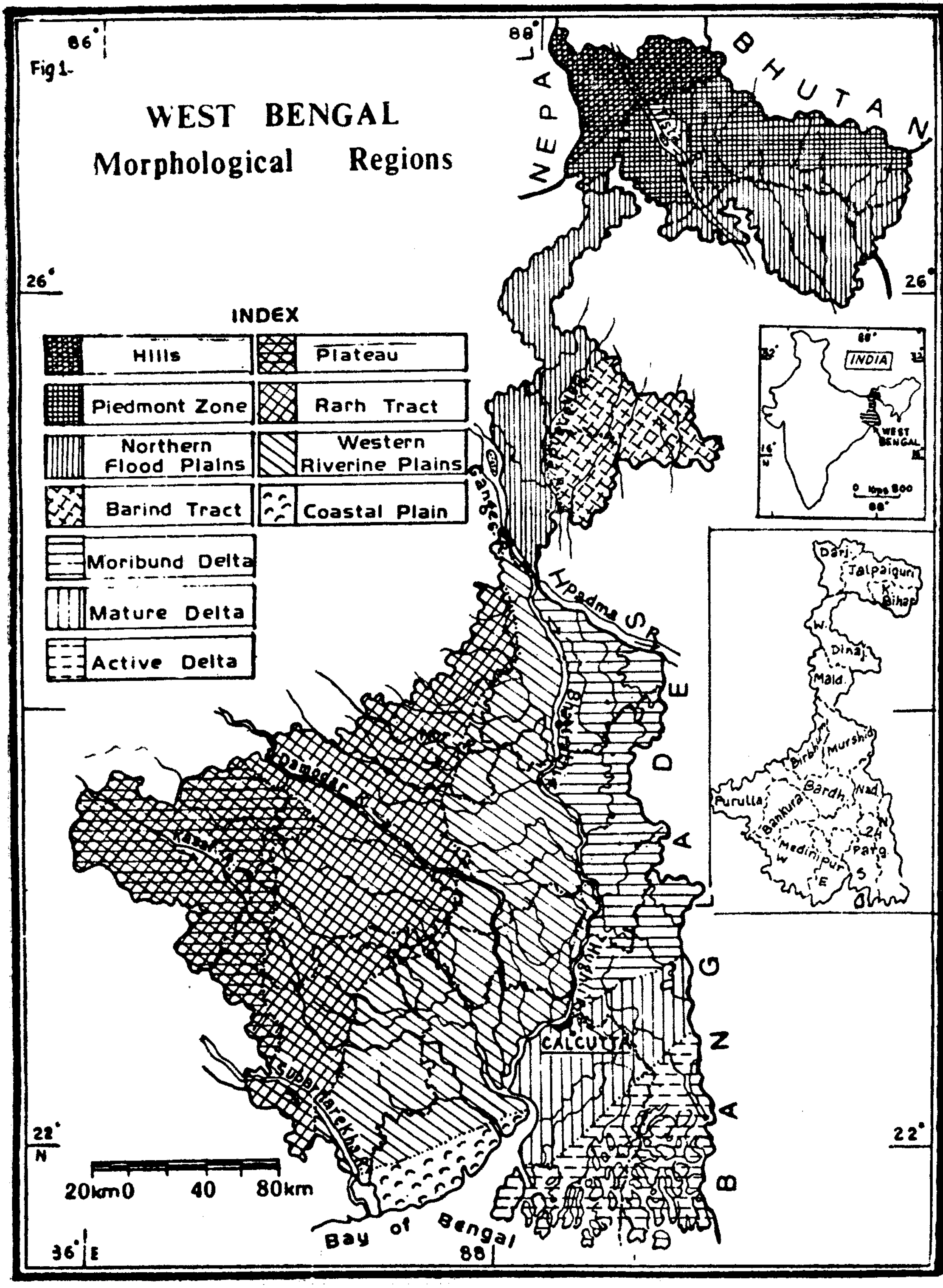
Fig 1.
WEST BENGAL
Morphological Regions
INDEX
Hills
Plateau
Piedmont Zone
Rarh Tract
Northern Flood Plains
Western Riverine Plains
Barind Tract
Coastal Plain
Moribund Delta
Mature Delta
Active Delta
NEPAL
BHUTAN
BANGLADESH
INDIA
WEST BENGAL
Darj.
Jalpaiguri
Bihar
Dinaj
Mald.
Murshid
Birbhum
Purulia
Bankura
Bardh.
Nad
24 Parg.
Medinipur
Ganges
Padma R.
Damodar
Kasai
Subarnarekha
CALCUTTA
Bay of Bengal
20km 0 40 80km
86°
88°
26°
22° N
86° E

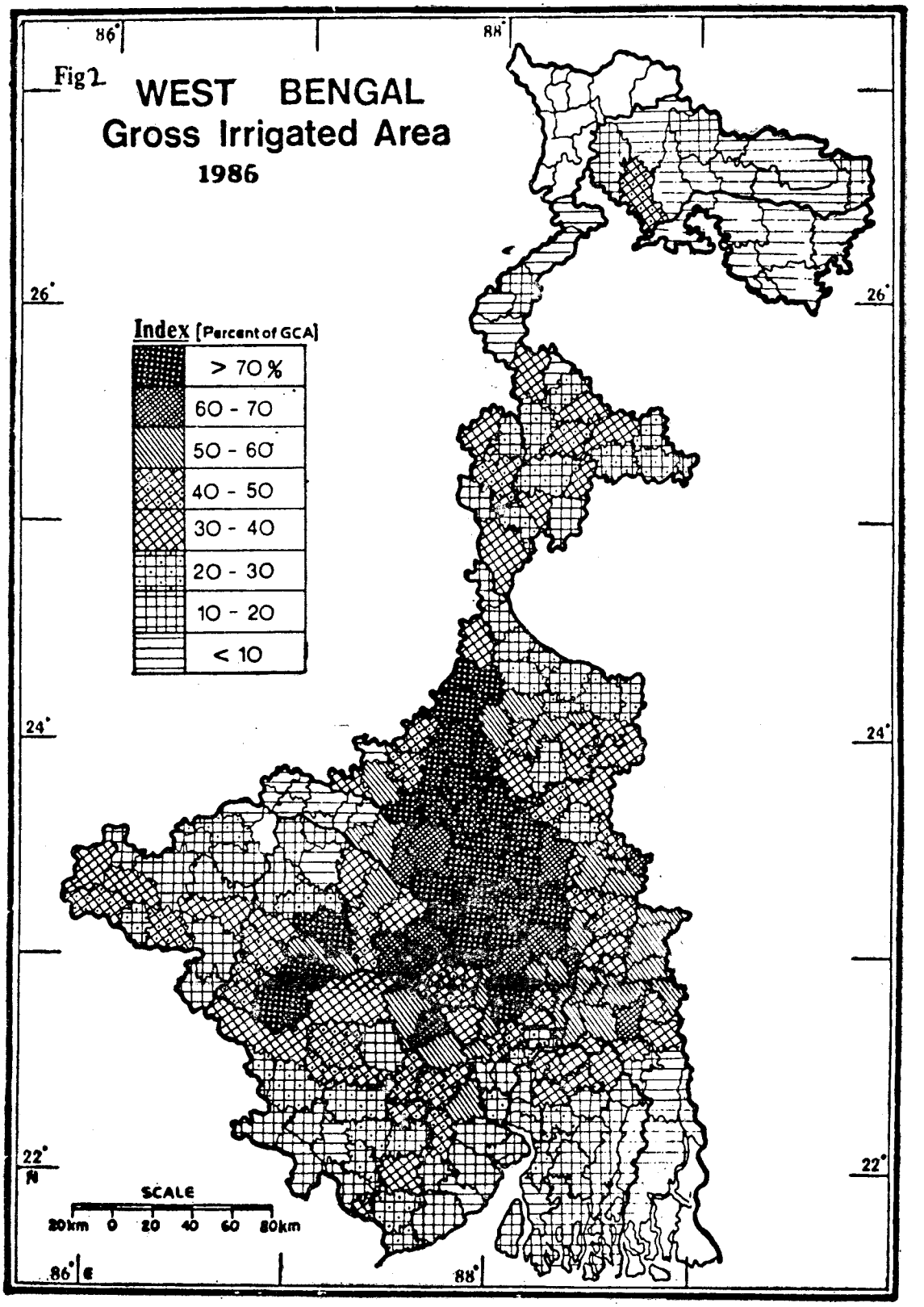
Fig 2
WEST BENGAL
Gross Irrigated Area
1986
86°
88°
26°
24°
22°
Index (Percent of GCA)
> 70 %
60 - 70
50 - 60
40 - 50
30 - 40
20 - 30
10 - 20
< 10
SCALE
20km 0 20 40 60 80km

Very Dense Irrigated Areas (> 60% GIA) : As in case of net irrigated area, this zone is confined to central and south-eastern Birbhum, south-western Murshidabad, central and south-eastern Bardhaman districts as well as the DVC irrigated areas of Hughli district such as Haripal, Tarakeswar, Dhaniakhali and Pandua P. S. In addition, south-eastern part of Bankura district also lies in this category, due to the operation of the Kangsabati irrigation project. Hence the percentage of gross irrigated area is evidently high in the canal irrigated tracts.

Dense Irrigated Areas (40-60% GIA): The beneficial role of groundwater irrigation is brought into perspective when one considers gross irrigated area. Parts of western Hughli (Arambagh and Pursurah P. S.), eastern Hughli (Balagarh, Polba-Dadpur P. S.) as well as Nadia district and parts of 24 Parganas North emerge as dense irrigated areas due to the progressive development of STW irrigation since the 1970s. In recent years DTW irrigation has also contributed to this pattern but its role is secondary to the former as it is influenced by erratic supply of electricity and as it requires costly set up.

Moderate Irrigated Area (20-40% GIA) :These usually surround the former zones. However, some of the regions which were poorly irrigated with respect to 1971 now fall in this category. This is best exemplified by the eastern part of Murshidabad district (Naoda, Jalangi P. S.) where both STW and DTW irrigation have played important roles. This also accounts for parts of Medinipur East. In Medinipur West, areas within the Kangsabati command area record medium values as in Medinipur, Salboni P. S. The southern part of West Dinajpur and large areas of Maldah register similar values due to the prevalence of RLI schemes, which have been recently introduced. Parts of K. Bihar district, where STW's are a recent introduction, also fall in this category. However, the role of dugwells should not be ignored as they are the major source of irrigation.

Sparse Irrigated Areas (> 20% GIA): The dry western plateau zones and saline coastal tracts, the northern hills and fothills with their exessively coarse textured alluvium are poorly irrigated. (Fig. 1).

GROSS IRRIGATED AREA UNDER RABI & SUMMER SEASON IRRIGATION

This aspect of irrigation intensity depicts the economic significance of irrigation types. Kharif season irrigation usually applies to the rainfed crop 'aman' during the sowing and maturing stages when rainfall variability is high. However, to increase the gross cropped area through irrigated farming, rabi and summer season irrigation are more remunerative as they allow the cultivation of 'boro' rice, oilseeds and vegetables.

With reference to rabi season irrgation, a totally contradictory pattern emerges; not conforming to that of either net irrigated area or gross irrigated area. The leading districts are Maldah, West Dinajpur, Medinipur East, 24 Parganas South in respective order hence no single reason can be offered as the causative factor. These areas however, record widely varying ecological setting Fig. 3).

Very Dense Irrigated Areas (> 70% rabi irrigation): Two major continuous zones may be identified. One lies tn the old alluvium tracts as well as parts of the northern mature moribund plains

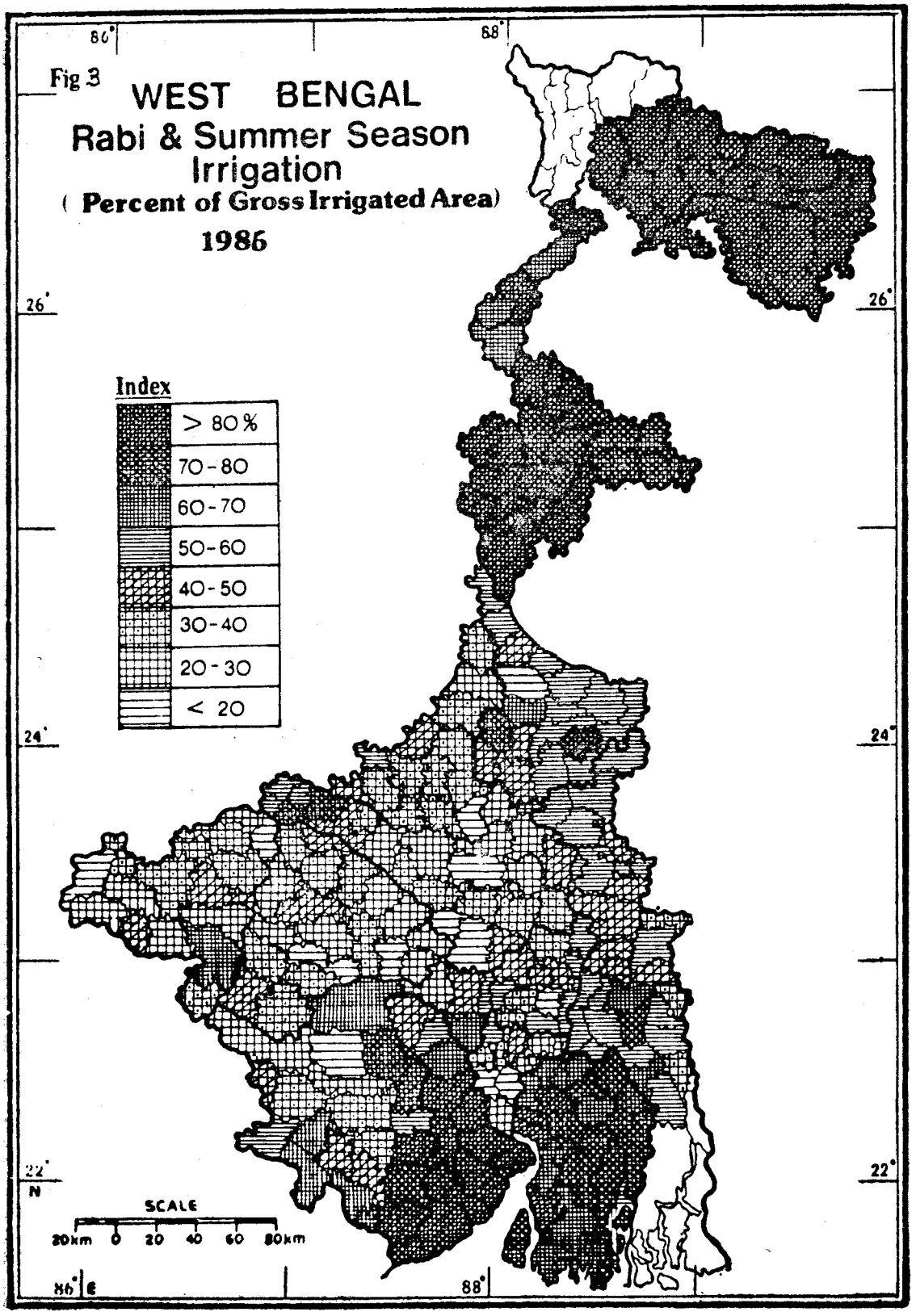
Fig 3
WEST BENGAL
Rabi & Summer Season
Irrigation
(Percent of Gross Irrigated Area)
1986
Index
> 80 %
70 - 80
60 - 70
50 - 60
40 - 50
30 - 40
20 - 30
< 20
SCALE
20km 0 20 40 60 80km
86° E
88°
26°
24°
22°
N

in Maldah and West Dinajpur districts. The areas are mainly covered by river lift irrigation system. The absence of canal irrigation and lack of groundwater potential are the primary factors for RLI to be in vogue. Sufficient water remains in the rivers and marshy pockets to sustain less water demanding crops during rabi season. In case of the saline coastal tracts of Medinipur East and 24 Parganas South, tank irrigation prevails during winter season. As the soils are moisture retentive vegetables like lady's finger spinach, cabbage etc. can be successfully cultivated with little water. As these regions are very humid, rainfall variability does not have detrimental effects on 'aman' cultivation. As such Kharif irrigation is negligible.

In Jalpaiguri and K. Bihar districts, the area of gross cropped area irrigated is low, being concentrated during rabi season ($>80\%$). As in the case of the coastal tracts, these regions are excessively humid not requiring Kharif season irrigation. Moreover enough soil moisture is retained, even in these sandy soils, to cultivate crops like tobacco with slight additional irrigation from dugwells and STWs.

Dense Irrigated Area (50 - 70% rabi irrigation) : The major area of occurrence of this type is along STW and DTW irrigated parts of eastern Murshidabad and Nadia district. Such sources of irrigation being more assured are capable of supplying water during winter and summer seasons. The same reason pertains to such high values in eastern Hughli, 24 Parganas North and Western parts of Medinipur East districts.

Moderate (20-50% to Sparse ($<20\%$ rabi irrigation) Irrigated Tracts : These have been considered together as they are both confined along the dry western districts as well as in the canal irrigated tracts of Hughli district.

In Purulia and parts of western Bankura, above the canal commanded areas, the climate and soils do not render winter and summer season irrigation economically feasible. Considering the canal irrigated areas, rabi, season irrigation acounts for less than 50% of GIA, reflecting its benefits upon 'aman' crop in these less humid regions. The canals dry up during the critical rabi and summer seasons. As observed during field surveys, this is true in the case of the Mayurakshi and Kangsabati command areas. In the DVC command area, water is available even during rabi and summer season to sustain 'boro' rice cultivation.

SPATIAL PATTERN OF CROPPING INTENSITY (1986)

Very High values of CI ($>180\%$) are confined mostly to the eastern districts along the marshy 'diara', river lift (RLI) irrigated lands of south-western Maldah dist., most of eastern Murshidabad, eastern Bardhaman (Kalna, etc.), and Nadia districts, all forming the moribund riverine-deltaic tracts, parts of western Hughli and Birbhum districts as well as the urban fringe areas around Calcutta Metropolitan District (CMDA). One fact which comes into prominence is that, with the exclusion of Birbhum district, all these areas are moderately to poorly irrigated with respect to Gross Irrigated Area (GIA) but very intesely irrigated during 'rabi' and summer seasons as they are under RLI, Shallow Tube well, Deep Tube well irrigation. A close observation also reveals that these regions are humid, with moisture retentive fine texture alluvial soils cheiefly clay-silt loams, besides the presence of innumerable marshy de-

pressions and discarded water bodies. The residual soil moisture is enough to sustain the cultivation of a few winter and summer season crops with low consumptive water use. Wherever irrigation facilities are available CI values increase, thus perpetuating this pattern. The same reason applies to some of the lowlying parts of the Mayurakshi commad area (Mayureswar, Sainthia P. S.) in Birbhum district. They form effective sites for tapping canal water. The hilly Baghmundi P. S. (Puruliya dt) registers a detached occurrence of nearly 200% CI. This could be due to its function as the chief supplier of crops to the nearby industrial centres of Bihar (Fig. 4).

High CI Value (160 - 180%) is mostly observed along the lower reaches of DVC canal irrigated areas in Hughli (Dhanakhali, Haripal, Singur, Chanditala P. S.) and Haorah district, where supplemental groundwater irrigation is available and very high values of GIA occur ($< 60\%$). Parts of river lift irrigated tracts along the Hughli river as in Balagarh P. S. and Deep tube well irrigated zones of Medinipur East (Ghatal, Chandrakona, P. S.) also fall in this category. These regions fall under highly irrigated areas (40-60% GIA). The presence of large markets of Calcutta, Haldia and Digha townships have provided strong incentives.

Moderate CI Values (120 - 140%) surround the former zones. In the north, entire K. Bihar and West Dinajpur district as well as the southern parts of Jalpaiguri district are included in this category. These constitute the active plains of the north, south of the 'bhabar' tract. Although these regions experience heavy rainfall, the comparatively coarse textured soils preclude multiple-cropping. In addition, ground-water extraction is difficult as STWs and DTWs face the simultaneous problem of choking. Moreover STWs are subject to high seasonal fluctuations. Dugwells are the major source of irrigation, with a few recently introduced RLI schemes. This explains the overall low values of GIA ($< 20\%$). As these regions experience excessively high rainfall during the 'Kharif' season, the meagre irrigation that is practised is confined during the 'rabi' summer season ($> 70\%$) providing a misleading picture. It is basically the residual moisture that is utilized for crops with low consumptive use as tobacco. Moreover, as tea constitutes a major perennial cash crop, it is not registered in CI. As some of these regions border Bangladesh, political problems become disincenties to costly multiple cropping.

The other zone of such moderate values occurs along the canal irrigated tracts with superficially very high values of gross irrigated area ($> 70\%$) as in Birbhum, central and eastern parts of Bardhaman, DVC irrigated tracts of Bankura district (Sonamukhi, Barjora, Patrasayer) and parts of Kangsabati irrigated areas of Medinipur West (Binpur, Garbeta; etc.). As canal waters are more vulnerable to seasonal fluctuations of rainfall, they remain practically dry during the non-monsoon seasons except for intermittent periods when water is supplied from reservoirs in limited amount. The intensities of rabi and summer season irrigation ($< 30\%$) testify to this fact. Nevertheless, they best reflect the benefits of irrigation by creating oases in ecologically hostile regions characterized by meagre rainfall, porous sandy soils, and undulating lateritic-stony terrain. Without canal irrigation one could hardly visualize any double cropping.

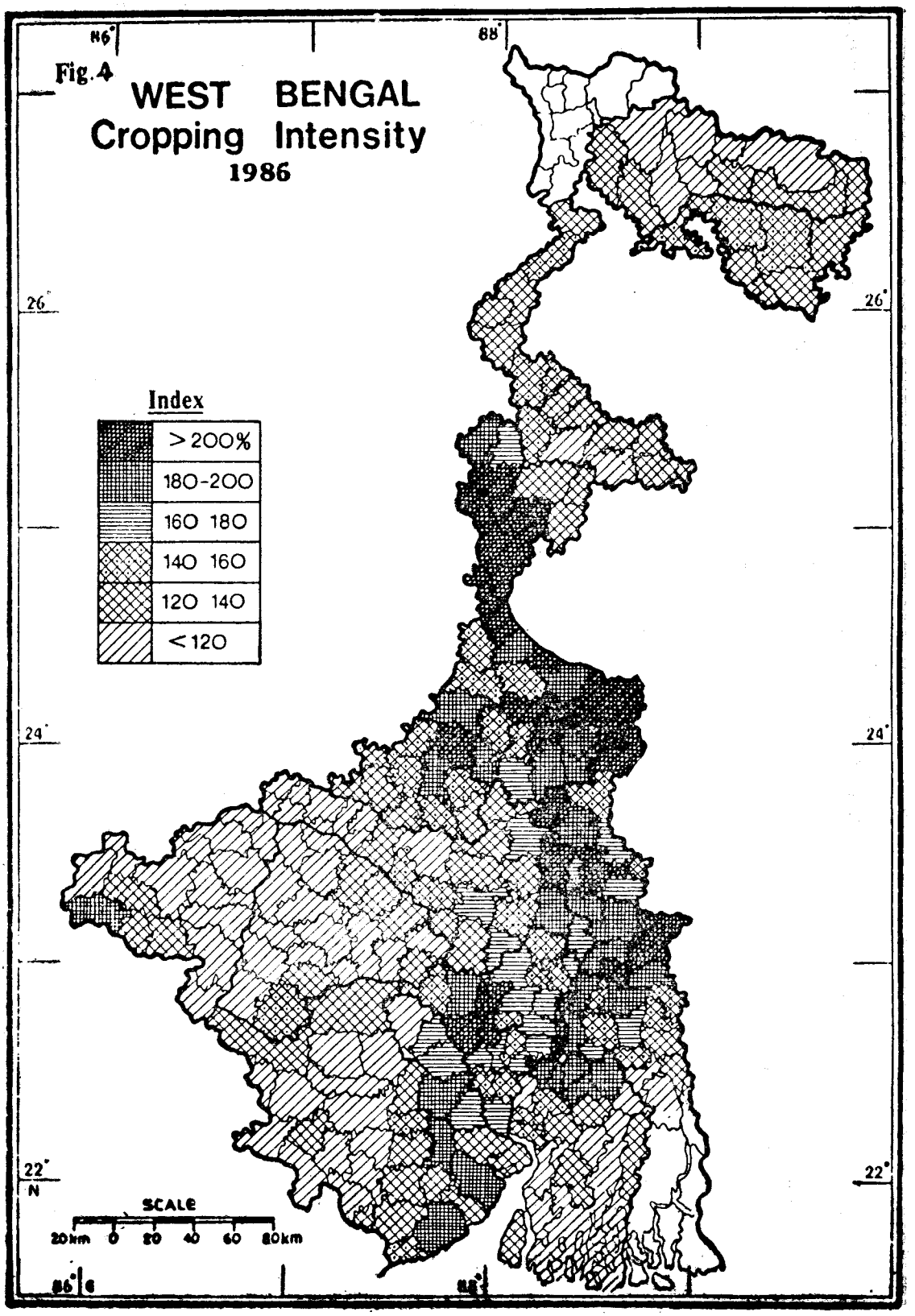
Fig.4
WEST BENGAL
Cropping Intensity
1986
86°
88°
26°
24°
22°
N
Index
>200%
180-200
160 180
140 160
120 140
<120
SCALE
20km 0 20 40 60 80km

Very Low CI Values (> 120%) are confined mainly to the dry, non-irrigated and tank irrigated western zones as well as in the saline coastal tracts in the south. In the former the percentage of GIA value is low (< 20%), as well as the percentage of the area under rabi and summer season irrigation is low (< 30%), as tanks constitute an ineffective source, nearly drying up during critical periods. They can be used only locally. In case of the saline tracts of the southern districts a discrepancy is recorded. Although the percentage of GIA value is low (< 20%, the percentage of the area under rabi and summer season irrigation record high values (50-60%) since these humid regions, with low rainfall variability as in case of the northern foothills, do not require 'Kharif' season irrigation. Double croping is basically dependent upon residual soil moisture. Considerable lands are also kept aside for saline water fisheries.

Residual Values of Regression between the GIA and CI
area.

Very High (> 60% to high (40-60%) positive residuals are concentrated along the intensely cropped but moderated-low irrigated zone in the 'diara' lands of Maldah, most of eastern Murshidabad and Nadia, parts of 24 Parganas North (Gaighata, Bagdah, Bangaon, Barasat P. S.), all located within the moribund deltaic tracts. Besides these, localized patches are observed at i) Mayureswar P. S. of Birbhum district with numerous 'bheels' or depressions effectively storing canal waters, ii) Khanakul P. S. of Hughli dist., due to similar conditions, iii) RLI irrigated Balagarh P. S. of the Hughli river and iv) Tarakeswar and Pursurah P. S. (Hughli dist.) where both canal and ground-water irrigation is prevalent. **Moderate positive values** (20 – 40% do not depict any distinct pattern, but usually tend to surround the former zones. **Low positive residuals** (> 20%) occur at the DTW irrigated parts of Medinipur East with its moisture-retentive soils, as well as the rest of canal irrigated humid, Hughli and Haorah districts. **The negative residuals** are confined to the dry western districts with both canal and tank irrigation. Although official records state high percentage of GIA, actually they remain without water during the winter and summer seasons. The various minor 'jhor' bundh irrigation schemes remain practically unutilized during the non-monsoon period. Within the canal irrigated tracts the police stations adjoining the main DVC branch canals (Galsi, Bardhaman P. S.) register slightly less negative values, as these provide adequate supply of water. Negative residuals are observed along the northern plains of West Dinajpur, and Jalpaiguri as well as the 'barind' tracts in Maldah. This could be due to the fact that officially recorded irrigation values have not yet been fully implemented in case of the Teesta Barrage command

Percent Change in CI, 1966 to 1986

The overall increase in cropping intensity for West Bengal has been considerable (+28.52%) implying the beneficial effects of irrigation. The **frequency distribution** depicts a concentration along the positive values, with 88.07% of all the police stations recording an increase in CI. About 60% of the P. S. lies in the category of 0 to 30%, steadily decreasing to 7% in the highest category (> 60%). Maximum negative change occurs between 0 to 20%.

The Wilcoxon Ranked Pair Test in this case shows a contrasting pattern to that of the overall insignificant percen-

tage change in NSA. Ten districts depict significant change in cropping intensity, two disricts moderate significance (K. Bihar and Bankura), one district low significance (Jalpaiguri) and only three districts record no significant change (Puruliya, Maldah and W. Dinajpur). Hence, the Wilcoxon ranked pair test supports the frequency distribution table.

The **spatial pattern of percent change** in cropping intensity depicts an overall orientation of high positive values towards the south-eastern and central districts, mostly below the Ganga. Negative changes are highly dispersed, influenced by local factors.

Very high ($> 60\%$) **to high** (40-60%) **positive changes** are perceived along the Mayurakshi canal command area of Birbhum district, the police stations directly impinging upon the main DVC branch canals in Bardhaman district (Budbud, Galsi, Bardhaman), parts of the moribund STW irrigated riverine-deltaic tracts of eastern Bardhaman (Kalna P. S.), Nadia (Hanskhali P. S.), 24 Parganas North (Bagdah, Bangaon, etc.), the canal and STW/DTW irrigated parts of Hughli district and the DTW irrigated parts of Medinipur East district. In addition the urban fringe areas also record high positive changes. Here, pressure of population has reduced net sown area but available irrigation facilities have made an increase in CI feasible, whereas in the former areas canal and ground water irrigation along with the heavy rainfall and moisture retentive soils have played deterministic roles.

Moderate positive values (20 to 40%) are recorded in the peripheries of former zones. Detached occurrences are observed along the northern part of West Dinajpur and parts of the northern plains as well as north-western Maldah district. It can be partly ascribed to increased tapping of ground water for irrigation during the recent decades. The Raipur and Simlapal P. S. of Bankura district, where on a localized scale such high values are due to the recent large scale allocation of Kangsabati canal water for 'boro' (summer rice cultivation on an experimental basis.

Low positive values ($> 20\%$) occur mostly along the dry, non-irrigated to tank irrigated zones of Puruliya, Bankura, Medinipur West and western parts of Bardhaman district. The Kangsabati canal irrigated tracts and parts of the DVC canal command areas of Bardhaman district, as canal waters are less available during the rabi season. The next major occurrence lies along the northern active plains where recent small scale functioning of minor irrigation schemes has resulted in slight increase.

OVERALL VIEW

It could thus be conceded that irrigation has had a direct bearing upon cropping intensity, enhanced further by the presence of favourable ecological settings. Its role, however, is best brought into perspective in the relatively irrigated, dry, plateau fringe areas as in the canal irrigated districts of Birbhum and Bardhaman. However maximum values are recorded in the fertile alluvial riverine-deltaic plains of Bardhaman, Hughli and Nadia districts.

ACKNOWLEDGEMENT : The research worker is grateful to professor Bireswar Banerjee, M.A., D.Litt. for his suggtstions in the preparation of this paper. She is thankful to Mr. Niranjan Ray, Directorate of Agriculture, Govt. of West Bengal for providing her with the data.