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URBAN SYSTEMS AND RIVER SYSTEMS - A NEGLECTED RELATIONSHIP

G. C. DICKINSON

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School of Geography
University of Leeds

ABSTRACT: Suggestions of a strong spatial correlation between the distribution of towns and rivers are plentiful in maps and literature. This paper formally tests and measures the strength of that correlation in the portion of southern Germany studied by Christaller in 1933. A 92% town/river coincidence generally is obtained, as well as confirmation of the hypothesis that larger towns tend to be more usually associated with larger rivers. An examination of the history of German urbanisation suggests that this correlation can be explained through the influence, in historic times, of the three factors of stronghold, route and human territorial organisation, together with the later influences of inertia and ease of adaptation to technological developments. The idea that the same correlation may occur more widely than in Germany is briefly considered, as is the manner in which riverine influences might be incorporated into more general explanations of Central Place systems. Some potential riverine effects on intraurban distributions are also suggested.

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INTRODUCTION

Subjective evidence that a strong spatial correlation exists between urban systems and river systems can be found on almost any topographical map or atlas page. Most inland towns lie on a river of some sort, and large towns are often on larger-than-average rivers. The same idea of a basic town/river relationship can also be encountered in a wide variety of literature, for example:

> "The steady growth of small towns" (in Bedfordshire and Huntingdonshire) "before the nineteenth century can be clearly related to the main rivers and the trade they engendered" (Bigmore, 1979).

> "The great rivers of India ... were the first attractive natural factors for the siting of Indian cities" (Taneja, 1971)

> "Only eight towns out of 165" (with more than 20,000 population, in France) "are not tied to a river or a canal" (Carriere and Pinchmel, 1963)

> "The most distinctive feature of Regina's physical character is the absence of a river. Practically every other large Canadian city is located on navigable water" (Naden, 1976)

> "Water was probably the most important single factor influencing the site selection of hsien" ('county') "capitals. Most ... were 'river towns' in character" (Chang, 1961)

Yet oddly enough, and despite some tangential approaches to the idea, eg Burghardt (1959), Dacey (1960) and Woldenberg & Berry (1967), this relationship appears to have been little studied formally, in recent years, with the notable exception of Blache's "Sites Urbains et Rivieres Francaises" (Blache, 1959).

Blache's work confirmed the general validity of the relationship in France - a 61% town/river coincidence nationally (for non-coastal towns) with regional variations ranging from 48% (Midi Mediterraneen) to 76% (Paris Basin) - but was not without certain shortcomings. Cartographic bias, for example, may well be present within the results, since Blache considered only towns and rivers marked on the 1:3,800,000 scale map "France Administrative" in the Atlas Vidal-Lablache, and he made no attempt to look for any variation in the relationship at different size levels of towns or rivers.

A more rigorous investigation of the town/river relationship seems long overdue, therefore, and the concern of the first part of this paper is to provide one, using the context of Southern Germany. Possible explanations for the relationship revealed are then considered, followed by the implications of these explanations for Central Place Theory and some possible wider ramifications.

DEFINITION OF SYSTEMS AND SELECTION OF STUDY AREA

In theory, examination of the spatial correlation between urban and river systems in any area demands no more than simple definition and comparison. In practice matters are not so easily resolved. Since neither system is naturally finite both allow the introduction into their definition of the kind of subjective bias already envisaged in Blache's work, and this is particularly so with urban systems where a very wide

range of criteria have been used for definition and subdivision (see for example Dickinson, 1964; Beavon, 1977). Adoption of an urban system already rigorously defined in previous research is perhaps the best way of minimising this potential effect, though the likelihood of finding a parallel pre-defined river system for the same area is remote.

In fact very few river systems have been defined at all, most obviously because of the lack of quantitative data, eg mean annual discharge, on which to base a definition. Even in countries where gauging stations are relatively plentiful (the USA and France were considered) their occurrences on the smaller rivers are too few to allow adequate classification, and the same smaller rivers and streams, which number literally thousands at topographical map scales, also inhibit the adoption of Strahler's classification as an alternative (Strahler, 1960; 376).

For river system definition, therefore, some easily measured surrogate for discharge is needed, and in this paper river length is used. In many areas the correlation between length and discharge, though admittedly crude, is adequate enough for the classificatory needs of a study such as this. Moreover the simple adoption of an appropriate cut-off level allows the elimination of the troublesome tiniest components whilst permitting, through the interval nature of the measurement, complete freedom of subdivision and classification.

It was in the light of considerations and constraints such as those just described that the area of southern Germany was selected for study. Classification of the urban system there, into a seven-fold hierarchy of L-, P-, G-, B-, K-, A- and M-centres, had already been devised by Christaller in 1933, and listing of these centres, down to B-level generally and K-level around Munich, was available in Christaller (1966). The remaining K-centres proved readily identifiable by comparing the system map

(Christaller, 1966, Dickinson, 1964, Berry, 1967) with topographical maps, though the same was not true of the still lower A- and H-centres. In view of this difficulty of identification, the sheer numbers involved and the extremely small size of these centres (approximate populations of only 2,000 and 1,000 respectively were suggested by Christaller in 1933) it was decided to omit them from the subsequent analysis.

Although no parallel pre-defined river system existed in the area examination and measurement of rivers was much facilitated by the existence of the excellent orohydrographic edition of the German Topographische Ubersichtskarte at 1:200,000 scale, and definition was ultimately achieved using the following criteria:-

(1) all components whose total length exceeded 15 km were regarded as "rivers", irrespective of local terminology. In Britain, under relatively similar climatic conditions, this appears very roughly to be the sort of size at which the term 'river' begins to be applied to drainage components.

(2) measurement was by dividers set at a 2 km chord, thus increasing speed of measurement whilst preserving crude comparability.

(3) both <u>total</u> length and length within the study area were recorded for each river. The former is the standard classificatory value but the latter has applications to calculations of percentage composition, centre frequency etc.

(4) length was taken to include, if necessary, the longest of two unnamed headstreams, or of two named ones where <u>neither</u> bore the name of the main river.

(5) where straightening had occurred (eg the Dreisam) measurement along the former course (if obvious) was used, to maintain comparability. The complex former channels of the Rhine were, however, ignored.

(6) measurement continued through lakes, eg L. Constance, and towns on their shores were regarded as lying 'on' the river.

The last-named point touches an issue of more general significance in any potential town/river relationship, namely when may a town be deemed to be 'on' a particular river? Considerations of flooding or defence for example may place a town at some distance from a river without in any sense reducing its dependence on it. Nottingham, England, lies 1.8 km north of the R. Trent, though there is no doubt that the 'juxtaposition' of castle-rock, major route (the Domesday 'Great North Road'; Barley and Straw, 1972) and the largest water-barrier between London and York were crucial factors in its early rise to importance. In this study a similar tolerance of 2 km has been judged necessary to allow for considerations of this sort, and all towns whose centres lie within this distance of a river are deemed to lie 'on' it.

One further definition used in the study needs mention. On the system map, referred to above, urban centres seem to be noticeably less dense in the eastern half of the area than in the west, and calculation of the appropriate figures, after division using a line drawn through Ulm and Wurzburg, confirms that this is indeed so (Table I). Presentation of much of the data that follows in half-system, as well as whole-system, form allows this important dichotomy, and any associated characteristics, to be kept in view. The appropriate areas, along with their urban and river systems are illustrated in Figure 1; quantitative aspects of the same

features are summarised in Table I.

THE RELATIONSHIP BETWEEN URBAN SYSTEMS AND RIVER SYSTEMS

As Figure 1 suggests, and Table II confirms, a close spatial relationship does exist, within the study area, between the elements of the urban and river systems, 92% of all centres lying on a river more than 15 km long. Nor is this relationship seriously undermined if larger river minima are demanded. 83% coincidence still remains at 25 km and 71% at 40 km minimum; the 15 largest rivers alone (ie those exceeding 200 km) provide sites for 26% of all urban centres.

In reality, of course, these are measurements of coincidence within 'riverine bands', potentially 4 km wide, but even when allowance is made for this the results are still impressive. Assuming the area of such bands, in square kilometres, to be four times the total of all appropriate river lengths (almost certainly a slight overestimate due to sinuosity and overlap) there are still far more towns within them than would be expected by chance. With 92% of all towns occurring within the 65% of the area which the bands contain a null hypothesis, based on actual counts, that this could occur by chance can be rejected at a confidence level of 99.9%. Moreover as measured by the ratio of percentage of towns to percentage of area within appropriate bands, the relationship gets stronger as river length increases, the ratio rising from 1.42 at 15 km level to 3.25 at 200 km (Table II). When half-areas are considered figures for the eastern half are more impressive still, but even in the western half crude centre/river coincidence is 65% at 40 km length and the percentage towns/percentage area ratio never falls below 1.20, indicating a distribution differential still significant at 99.9% level (Table II).

If towns and rivers generally are closely associated within the study

area do more important towns also tend to occur on larger rivers? The evidence of Figure 2 and Table III suggests that they do, both showing that, for those towns that do lie on rivers, as urban status increases a decreasing proportion will be associated with rivers of length below any given value. Furthermore as towns become scarcer this tendency may become stronger, a smaller proportion of centres being characteristically associated with any given river length or less in the more sparsely urbanised eastern half than in the west. Differences in river composition, which is remarkably similar in the two halves (Figure 3, inset), do not appear to be the cause, and in any case this effect can be removed by standardisation to percentages, as in Figure 3. As Figures 2 and 3 show there is a clear tendency for those larger centres which are riverine to be relatively few until quite large river sizes are reached. Once again the contribution of rivers more than 200 km long is striking, their ultimate inclusion in Table III usually adding 20, 30 or more percentage points to the cumulative totals found there.

A final, rather curious, aspect of the town/river relationship is illustrated in Figure 4 which shows the average number of kilometres of river per centre of given grade and below (ie G-centres are also counted as B- and K-centres) when rivers are grouped into broad size classes to eliminate the declining totals and zero frequencies which occur with the larger rivers when 5 km classes (used in other figures) are employed. The most intriguing factor here is the tendency for centres in the G-, B-, and K-classes to generate crudely characteristic average spacings once the 40 km river length is passed (Table IV), albeit with a consistent tendency for that average to decline slightly with increasing river size. Consistency is noticeably best, eg in K-centres generally, B-centres for the whole area, where centre size-groups are large enough to damp down the effects of any marked variations from the norm; conversely where groups are small, eg G-centres in the eastern half - only 19 in all, the pattern is esily

disrupted.

Even so the actual distribution of centres along rivers (Figure 1) shows little tendency to exhibit any recognisable regularity and it is difficult to know whether the situation revealed in Figure 4 has any real significance beyond demonstrating that larger rivers characteristically attract urban centres rather more powerfully than do smaller ones. Even the apparent importance of the threshold value of 40 km may owe more to the chance effects of grouping than to any intrinsic importance. There are some indications that noticeable changes occur at the 40 km point, however, on Figures 2 and 3 for example, though the urban centre classes used there are differently defined to those in Figure 4 (see captions).

EVOLUTION OF THE URBAN SYSTEM OF GERMANY

The close correlation demonstrated above, between urban and river systems in Southern Germany, demands explanation. But since it is obvious that historic quite as much as contemporary linkages may underlie it it seems sensible briefly to examine the temporal development of towns in Germany before attemtping any causal explanation.

Accounts of German urbanisation (Dickinson, 1961; Gutkind, 1964; Smith, 1967; Sagarra, 1977; Leuschner, 1980) suggest that it can be summarised as passing through three main phases. In the first of these, from Merovingian times to about 1150, town development was relatively slow and limited, occurring principally where strongholds (burgen, pfalz, konigshofen[1]) of the Emperors or their major legatees, the dukes and bishops, offered protection and custom to merchants trading along long distance routes in luxury/exotic goods and specialised manufacturers. Of about 120 towns in Germany in the eleventh century 40 were associated with bishop's seats 20 with monasteries and 60 with royal foundations, including

12 palaces (Smith, 1967, 333), and it seems likely that at the end of this phase the total number of towns in Germany was perhaps no more than 200. Many of these towns, particularly the bishop's seats, occupied sites of earlier Roman or Frankish centres and since most of them had military or ecclesiastical territorial associations (or both) it is not surprising that these regional linkages, plus an early start, usually earned for them a later position in the higher echelons of the urban system.

In total contrast to this first phase the next three centuries saw the rapid expansion of the German urban system to something surprisingly close to its ultimate extent. Increases in population, agricultural production and specialisation now offered increased potential for local exchange, leading to the development of hundreds of new market centres. But whether older villages newly exalted, or new towns speculatively founded, these market centres did not develop freely. Instead their selection or creation was rigidly controlled by feudal lords, greater and lesser, who followed the established custom of offering protection and regulation of trading activities, receiving in return profits from market tolls, or the rents of the newly established urban artisans. The same feudal controls could also be used (and apparently often were) to compel attendance at a particular market, so that "peasants were forced to give up, or at least reduce, their own home industry to buy industrial requirements in the town, and to sell their agricultural produce only to 'their' town" (Gutkind, 1964, 148; Vance, 1977, 91).

In various ways, therefore, the system of market towns became closely enmeshed with the territorial units of the German feudal system, though this did not prevent towns, once established, seeking to free themselves from Imperial or feudal controls. The earlier or more important centres were noticeably successful in this respect, ultimately obtaining the status of "Free Cities of the German Empire", the more freely to develop their

role as centres of trade and specialised manufacture.

With so fully developed an urban system - different estimates suggest between 2000 and 3000 towns in Germany as a whole by about 1400 (Dickinson, 1964, 91-2, 162; Leuschner, 1980) - there was little scope for the addition of many new centres in the third phase of urbanisation which lasted from the fifteenth century to the present. Moreover system-growth was still further restrained by the devastating impact and aftermath of the Thirty Years War (1618-1648) and the late arrival of the Industrial Revolution, which occurred in Germany generally after the construction of a railway network and so favoured the growth of existing towns rather than the development of new ones (Dickinson, 1964, 55; Sagarra, 1977).

But if system growth was largely absent in this third phase change was not. Changes in power, transport and technology were important here, but so too were less obvious processes, most notably the increasing general sophistication of urban life and the gradual replacement of local organisations and institutions by those of the centralised state. In Germany, of course, following the waning of Imperial power, the 'centralised state' was, for a long time, one of 300 or more units whose convoluted and interlocking territories, large and small, left traces on the administrative map of Germany until its redrafting by the National Socialists in 1933[2]. But within the larger of these units at least spatial allocation of centralised activities, which could range from justice through postal systems to (eventually) schools, began to have important consequence for urban status, ultimately creating a more formalised urban hierarchy than had hitherto been the case.

The increasing needs of the state, for defence, as at Mannheim, industrialisation, as at Freudenstadt, or simply prestige, as in the new or enlarged capitals at Karlsruhe and Darmstadt, could also be seen in several

of the important additions to the urban system during this phase, though increased sophistication and leisure also added, rather later, a class of resort towns, some old, some new, and mostly spas.

Perhaps it is not altogether surprising that some of these autocratic creations, where powerful forces were at work, should provide several of the more striking anomalies in the "normal" town/river relationship, though individually they also illustrate how difficult it is to define exactly the presence or absence of riverine influences. Stuttgart for example, one of only 6 L-centres in the study area, and originally selected as a 'refuge capital' in 1320 after defeat (Gutkind, 1964, 287) has no river larger than 15 km, but the important artery of the Neckar only 3 km away undoubtedly greatly assisted its later development. The same is true of Wiesbaden, a P-centre, an important spa since Roman times and a capital city from 1355; it too, however, lies only 3 km from the Rhine. Karlsruhe, another P-centre, stands on a rather unimportant river, the Alb. In fact Karlsruhe virtually ignored its river, merely lying within the 2 km tolerance band, but it owes much to the Rhine only 6 km away, and linked to it by a major canal. Most curious of all is the 'river-less' B-centre of Ludwigsburg some 10 km from Stuttgart. Created in 1709 by Duke Lewis "to gratify the caprice of an extravagant mistress, and to revenge himelf upon his wife and the estates of Wurttemburg with whom he had quarrelled, intending to make it his capital instead of Stuttgart" (Murray, 1877) it serves as a reminder that rational explanations can hardly accommodate all members of an urban system.

POSSIBLE ORIGINS OF THE TOWN/RIVER RELATIONSHIP

The description of German urbanisation just concluded reveals two very important characteristics which have relevance to any attempt at an explanation of town/river relationships. These are firstly that

urbanisation is inextricably enmeshed in the process of human territorial organisation in its widest sense, not simply in the provision of market-type services, and secondly that most of the sites where towns are found today had already been selected by the year 1400. What must be sought then are reasons why, initially, German urbanisation found in riverine sites advantages superior to those offered by almost all others, and why subsequently such sites continued to be able to accommodate urbanisation successfully, despite the very marked changes of the last 500 years. Such reasons are not hard to find and it is suggested here that in the initial period many of them are connected with the three major factors of stronghold, route and territory itself. The relationship of each of these factors to river systems will now be examined.

Strongholds and Rivers

Much the clearest relationship within the three factors is exhibited here. Defensive considerations were important in the local organisation of a feudal society and to this end riverine sites, with the potentially double asset of a natural moat and (often) steep river banks, possessed a decided advantage. A combination of such a site and an established river crossing was even better, for such crossings were often the limiting subset in an otherwise permutateable communications system - the ideal place from which to observe potentially hostile movements or to obstruct them.

Moreover from their residential as well as their defensive role such stronghold-sites would attract other nodal functions - the need to render service to a lord, or attend his court to obtain justice - even before a servile population, largely preoccupied with subsistence agriculture, had any need or opportunity to participate markedly in trade and exchange. When, at a later date, such exchanges were formalised into markets these

established "central places" were obvious choices for their location, offering convenience, familiarity, and the maximum opportunity to supervise and tax what went on.

Routes and Rivers

Unlike strongholds the relationship here is potentially more subtle, and does not necessarily lie in the obvious possibility that in some localities the use of water transport could transform river systems into route systems. Several commentators on urban development have stressed the importance of water transport in stimulating urban locations however, eg Bigmore and Nader (sup), Pinchmel (1969, 364), Chang (1963) and Leighton (1972). Leighton, in perhaps the most relevant definitive work, is emphatic, stating that "mediaeval man preferred to use water transport wherever possible ... every watercourse that could be used (authors italics) was brought into service" (p 125). Nash (1976) sees the relationship as even older, with Celtic oppida in parts of France located near rivers (not necessarily large ones) to take advantage of and control river transport; Blache (1959) too refers to the astonishment of classical writers, "mediterranean men" of course, at finding in Gaul a network of river routes.

Yet direct evidence is surprisingly lacking. Apart from reference to larger rivers, where the connection is never in doubt, Leighton for example quotes only two other supporting illustrations of water transport, on the Fulda and Regnitz, neither of them particularly small. Contrariwise one can envisage, particularly on small rivers, growing numbers of obstructions which would impede navigation - milldams and primitive bridges for example. Thus whilst it is known that within the study area the Rhine, Danube, Main and Neckar carried river transport (Naval Intelligence Division, 1945) whether, when and how the rest of the

river system was so used is not certain.

The idea that river valleys may have generated early land routes is less obvious but not impossible. Such routes could have developed from "wet" origins, such as the canoe-portage-canoe type routes encountered in the river valleys of the Ohio-Great Lakes area (Brown, 1948, 266-9), or from 'dry' ones where pioneer traders used river valleys as markers to guide them through little known territory. Certainly both types of approach were frequently used in historic times by explorers faced with not dissimilar circumstances. Support for the 'route marker' idea is suggested by mediaeval routes in Britain which, though they follow valley features such as the Aire and Tyne Gaps do not "use" them but climb onto shoulders and interfluves (Brigg, 1927; Ogilby, 1675).

Within the study area itself the evidence of the relationship between valleys and routes is not easily evaluated. Whereas the very generalised representations of early routes, found in atlases such as Barraclough (1978) and Stier (1972), often suggest a strong connection with major river valleys or corridors such as the Kinzig-Brigach link (Barraclough, 1978, 120-1), the most detailed map of mediaeval trade routes within the area, at 1:1,000,000 scale (Gradmann, 1956), is much more equivocal. The routes shown often follow valleys for notable sections of their length, where there is directional coincidence, but rarely do so in their entirety. In this connection it is interesting to note that Blache (1959) points to the importance, as town sites, of "fluvial elbows" where routes tend to leave or join a valley (eg at Orleans, Toulouse, Basel). But in any case by mediaeval times something of a chicken-and-egg situation must have arisen in town/route relationships, including the generation (between important centres) of routes which, perforce, might be completely across the grain of the county, eg Ulm-Augsburg, Nuremberg-Prague.

Whether or not one accepts the basic idea of such a proto-generic relationship between route system and river system it is difficult to deny that whenever route and river intersected a point of unusual importance was created in the landscape. If circumstances prompted town growth or creation independently of a stronghold, for example, such a location was ideal. Established traffic along the route could swell local exchange, and artisans who might have to be tempted from afar to occupy newly created burgage plots would see more favourable prospects in such a "thoroughfare" location. To these advantages, admittedly inherent anywhere along a route, an established river crossing added ease and convenience of access from all directions, with bridge, ferry or ford acting as a focus for local routes on either bank (Beresford, 1967, 114). In addition the river itself offered process water and power for any potential urban industries. If established (or potential) nodality was a prerequisite for urban success then established, or indeed newly and deliberately created, river crossings had much to commend them, even more so when the route at the crossing was an important one. The foundation of Munich in 1158 on an established salt-route provides a classic example (Gutkind, 1964, 337).

Territorial Systems and River Systems

The link suggested earlier between urban systems and territorial units, whether feudal or later administrative ones, prompts one further line of speculation. Might there ever have been - pace the subsequent vagaries of factors such as war, inheritance, marriage, gift, even debt - a crude relationship between territorial units and river-system units? Both the basic idea, and its application in the "kaleidoscope" of southern Germany, have too complex implications to be given detailed consideration here, though one might note, in passing, certain features which suggest that it is not entirely fanciful. Valleys are easily accepted as

'natural' units in rugged terrain; several ancient British counties, eg Derbyshire, Leicestershire, Herefordshire, Breconshire, Selkirkshire, have extensive "core areas" lying within one drainage system. Rather pertinently too the German term gau, referring to a basic, early tribal territorial unit, had the original meaning of 'land by water' or 'the surroundings of water' (Grebe, 1963, 199; Kluge, 1963, 235).

Whatever the reality (or otherwise) of such a proto-generic relationship between territorial sytems and river systems, other aspects of territoriality have potential relevance to any consideration of urban distribution, and two will be mentioned here. The first of these is that a town need not necessarily be located centrally within a feudal territory. If an English lord contemplating town creation could see that "if an important artery of road or water touched only at the edge of his estate there was no choice at all but to lay out the town at the point of tangency" (Beresford, 1967, 111) would a German one view the situation differently? Whilst solutions which were totally impractical for mass convenience were unlikely we are a long way here from the kind of solutions which more "democratic" or market-oriented approaches to territorial thinking would suggest and which, for example, could influence the siting of such new state capitals as Indianapolis in the USA several hundred years later (Reps, 1965, 272).

The second point, a more general one, may also partly explain the considerable variation in urban density noted within the study area (see Table I). The idea is simple. When towns are formally related to discrete territorial units then the greater the number of units the greater the number of towns which they will require. In France, for example, Pinchmel, has pointed out that as a result of the highly formalised devolution of central power via prefects in departmental capitals, there are 95 'small big towns' rather than a few large ones (Pinchmel, 1969,

189). In the same way the high density of urban centres in the western part of the study area may be envisaged as being at least partly influenced by the political fragmentation which existed and persisted there to a degree quite unequalled elsewhere in Europe (see, for example Stier, 1972, 120). In contrast, from the eighth century onwards, the greater part of the study area lying east of the Ulm-Wurzburg line has been occupied by only two units, the Dukedom/Kingdom of Bavaria and the Nordgau, later Oberpfalz. Dickinson (1964) and Walker (1971) have both commented on the impact of this duality on developing urban systems. Dickinson describes the smaller size and often founded and planted, rather than defensive, origins of the small towns on the Bavarian Plateau (p 164); Walker contrasts the 'centralised' country of Prussia, Austria and Bavaria - with characteristic open landscape and great towns - and the "individualised" country of Middle Germany from Westphalia to the Danube characterised by rolling landscape dotted with middle-sized communities.

Continuation of Initial Riverine Locations over time

The foregoing three sections provide several reasons for suggesting why, when spatial locations for an urban system were first being selected, riverine locations were so often seen as offering several advantages. Furthermore, differentials within these same advantages - greater potential for water transport, more frequent coincidence with important land routes, more restricted crossings conveying enhanced nodality, even a more decisive potential role in defining units of "territorial thinking" - might also go some way to explain why larger rivers could often generate greater urban development than smaller ones. What is rather more surprising is that since the fifteenth century only rarely, and sometimes for very obvious reasons, eg resort towns, have forces contributing to urbanisation not been able to find their expression in these already selected riverine sites. The ability of such sites easily to accommodate major changes in industrial

and transport technology - water powered factories, canal and early railway development - must surely be important here but it would also be foolish to underestimate the importance also of 'initial advantage', of simply being there as a ready-made source of influence and centrality whenever new developments had to be incorporated within the system. Inertia, it would appear, is a powerful force in the development of many urban systems during the last 400 years or so, the occasional new prestige-capital or resource-based creation notwithstanding.

POSSIBLE URBAN SYSTEM/RIVER SYSTEM LINKAGES OUTSIDE SOUTHERN GERMANY

Might the important urban system/river system linkages shown here in southern Germany also be encountered in a much wider context, as the quotations in the Introduction seem to suggest? Several indications are promising. The German urban system has been shown to have three characteristic feature (1) an initial development under feudal or autocratic forces powerful enough if necessary to distort emergent market-type forces to suit other needs and conveniences (2) relatively early completion, with subsequent adaptation rather than general expansion of locations and (3) the provision within this system of outlets for centralised functions which were themselves often of an administrative/political rather than a "commercial-response" type, eg 1 outlet per administrative unit, irrespective of unit size or population.

The first and third characteristics appear to have widespread validity, not only in Europe but possibly in parts of the Middle and Far East also (eg Chang, 1963), though the strength, timing and "mix" of the two factors may vary considerably. England, France and Germany, for example, show quite dissimilar pictures of the emergence of the centralised state, but the functions which followed this emergence and lodged in urban locations are similar in all three. The widespread validity of the second

characteristic is perhaps worthy of further investigation, though Pinchmel has noted it in France (Pinchmel, 1969, 381) and it appears to be generally true over much of Europe as well. Late newcomers to European urban systems are hardly rare occurrences, of course, but when they do appear they are almost always responses to particular forces or needs - leisure, resources, national prestige - rather than to the inefficiency of the existing system in accommodating general market-type demands. Thus in Britain the most numerous and successful true "gatecrashers" of the urban system in recent times (ie places with no historic urban roots at all) have been holiday resorts such as Blackpool, Bournemouth; in contrast the emergent regional capitals of industrialised Britain, which were a response to the growing market needs of a developing region, were hardly urban upstarts. Glasgow had a bishop from the twelfth century and a university from 1450 (Kellett, 1969); as early as the 1530's, Leland described Manchester as "the quikkest and most populus tounne of all Lancastreshire" (Smith, 1909,m IV, 5).

Even so the evolutionary characteristics just described are not found in all urban systems, and particularly is this so in young systems where the first feudal phase at least is absent and where the consequent irrelevance of various potential water-based linkages - riverine strongholds, early water-oriented transport or ancient territorial units - should all weaken urban system/river system relationships. One such young system, evolving also in a physical setting completely different to that of southern Germany, is found in Kansas, USA, where virtually all urban development occurred post 1850 (Socolofsky and Self, 1972). Even here, however, preliminary investigations suggest that the town-river relationship, though weaker is far from inconsequential, with 69% of all major centres and 53% of all urban centres occurring on the 'major river network'. Despite the fact that in this preliminary study the river network was defined somewhat differently, using a discharge approach which

ultimately proved difficult to adapt elsewhere, it seems highly unlikely that any different definition would seriously alter the quantitative aspects of the relationship[3]. Somewhat as expected, it was found that the town/river relationship in Kansas was generally stronger in towns whose formal incorporation occurred early in the development of the system rather than later, but even so some noticeable town/river linkage apparently endured until a surprisingly late date.

RELEVANCE OF TOWN/RIVER RELATIONSHIPS TO CENTRAL PLACE THEORY

Acceptance of association with a river as an important spatial common factor, perhaps even the most important spatial common factor, of the components of the urban system of southern Germany does not, of course, define the pattern of that system. Other factors are at work here too, and the identification of these, and the direction of their influence, was the concern of Christaller's original study of the area in 1933. In these circumstances, however, it becomes pertinent to enquire how far so widespread a factor as the riverine linkages discovered here are incorporated in, or compatible with, those explanations which were offered by Christaller, and which were to form the basis of Central Place Theory.

Curiously enough Christaller himself was well aware of the need to accept the modifications to the regular pattern of market centres, (which his theory envisaged) caused by both the physical influences and the kind of historical influences described above - though it is equally arguable that this consideration has been less noticeably propounded in subsequent summaries and developments. Indeed it seems likely that the parallel existence of his original three models, based on the 'market', 'traffic', and 'administrative' principles, was an attempt to leave room for these factors within an overall model, for it is clear from Map 5 (Christaller, 1966, 226) that he envisaged all three types as able to co-exist within one

system. His acceptance of the interference of both physical and historical influences is quite unequivocal. Thus he writes "where orographic influences are determining (sic), we may say that a pseudo-traffic principle is at work .... The natural conditions determine the traffic routes as well as the location of the central places" (p 191); "all the deviations which are caused by natural factors of topography, etc must be included in the economic explanations: a highly important natural factor, then, has a high economic importance ..." (p 193). On the "historical dimension" he observes "Thus, the rule is that the older system, previously determined, always determines the more recent system developed under other economic laws and conditions with other types of central goods and other ranges of these central goods" (p 122).

In one sense, therefore, and to Christaller at least, there is no case to answer, and recognition and incorporation are already achieved. What might be argued further, however, is that the river system, with its many attractions, is powerful enough to subsume so many of what Christaller himself presumably saw as important but spatially indeterminate forces that it warrants inclusion, in its own right, in any explanation of an urban system or its subsequent development. Haggett has suggested that one difficulty in analysing integrated regional systems is that there is no single point of entry (Haggett, 1966, 31). In the case of urban systems, however, might not the river system, linked to so many of the factors involved in town creation and development, be regarded as providing a 'zone of entry' to the urban system at a time when it was still "open", giving to it a skeletal form around which the rest tended to crystallise? In this respect the role of the river system would be not unlike that of the initial coastal point of entry in Vance's mercantile model of settlement evolution (Vance, 1970, Haggett, 1979) and indeed a type of system development not vastly dissimilar to the Vance model may be suggested in southern Germany. What is envisaged is a system driven from both ends via

"national" and local forces with very different requirements. Because of their superior advantages the valleys of the largest rivers would often contain the locations selected for a powerful but irregular network of early, major centres related to political organisation or long distance trade. At the lower end of the system, at K-centre level where low order and very basic needs had to be met via ranges which might once have been restricted to a day's journey on foot (say 20 km), the distribution of rivers (as on Map 1 for example) would offer little impedence to the establishment of the kind of regularly distributed marketing oriented centres which Christaller claimed were characteristic of southern Germany (Christaller, 1966, 192). In between, in the middle order centres, the same marketing-oriented forces contended with more local politico-administrative ones, variable riverine advantages, growing industrialisation and the influence of the major centres to produce the rather confused pattern which, for all Christaller's claims, seems to characterise this level of the German urban system.

SOME FURTHER IMPLICATIONS OF THE TOWN/RIVER RELATIONSHIP

It has just been suggested that one potential result of widespread town/river coincidence might be that it gives a hitherto missing spatial direction to forces and characteristics already acknowledged as present within urban systems. Curiously enough the same coincidence might also produce a somewhat similar effect in intra-urban orientations too, an unexpected parallel with Central Place Theory which also has both inter- and intra-urban applications (Beavon, 1977). Such an intra-urban effect derives from the idea that the presence of a river, or more pertinently here a 'water-barrier', might be regarded as a normal component of a town/city site given the extent of town/river relationships demonstrated earlier.

The simplest and most obvious effect of such a barrier on town growth would be to induce a degree of assymmetry into urban form, a characteristic which is clearly seen to be present, sometimes temporarily, often persistently, in a great many towns, perhaps even in the majority of towns. In some cases the effect is acute enough virtually to inhibit trans-river growth for long periods of time even in quite large towns, eg at Northampton, England until its recent town expansion scheme.

In a more complex form this water-barrier effect, strengthened by an industrial-barrier effect derived from the frequent existence of river-side industrial zones also, has been noted by Robson as influencing the social structure of Sunderland and possibly towns such as Belfast and New Haven as well (Robson, 1971, 128-130). A general characteristic of these towns, and possibly of many more too given the high degree of town/river coincidence, is that the good quality residential area lies beyond the Central Business District but on the same side of the river as it, interposing the Central Business District as a barrier between itself and riverside industry and giving a noticeable sectoral structure to that part of the city on the "near" side of the river. On the "far" side concentric characteristics appear as the better quality areas "allow" a lower status zone to develop as a buffer zone to riverside industry. One can also suggest that the trans-river area, often shrunken and late to develop, may acquire characteristics in some way related to its separateness, lateness, or both, eg in Britain a high proportion of local authority housing, as at Derby or Lancaster or a high concentration of an ethnic group, as with the French Canadians at Winnipeg (Nader, 1976, II, 282; Weir, 1978, 27) or the Jews in St Paul, Minnesota (Abler, Adams and Borchert, 1976, 24).

Whether such characteristics are, in fact, widespread enough to demand recognition and incorporation into any attempts at formulating a general model of city structure remains to be proved. What they do provide,

however, is even further reason to assert that, in our failure to recognise the pervasive role of riverine factors in urban activity, we have left between urban systems and river systems a truly neglected relationship.

Separate Sheet of Notes

NOTES

1. burg - fortress, stronghold generally; pfalz - royal palace Konigshof- imperial stronghold with accommodation for a garrison as well

2. Napoleon in particular brought about major simplification, compelling the absorption of many smaller units, including most of the former Free Cities, into the larger ones. The growth of Prussia brought further simplification but even so, by European standards, unusual complexities remained.

3. The method used was to construct a network of major rivers by identifying the most important river within a 'restricted area' roughly corresonding to the average area within the state served by (1) major centres (2) all centres. The 'restricted areas' used for selection were grids of squares of the appropriate size randomly imposed on a map of the state. Repeating each process three times for each grid size allowed two different networks of major rivers, each appropriate to a given urban level, to be identified. The resultant network did, in fact, coincide closely with those which simple, arbitrary, selection would have envisaged as 'the main rivers of Kansas'

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Captions of Figures

Figure 1. Components of the urban and river systems within southern Germany.

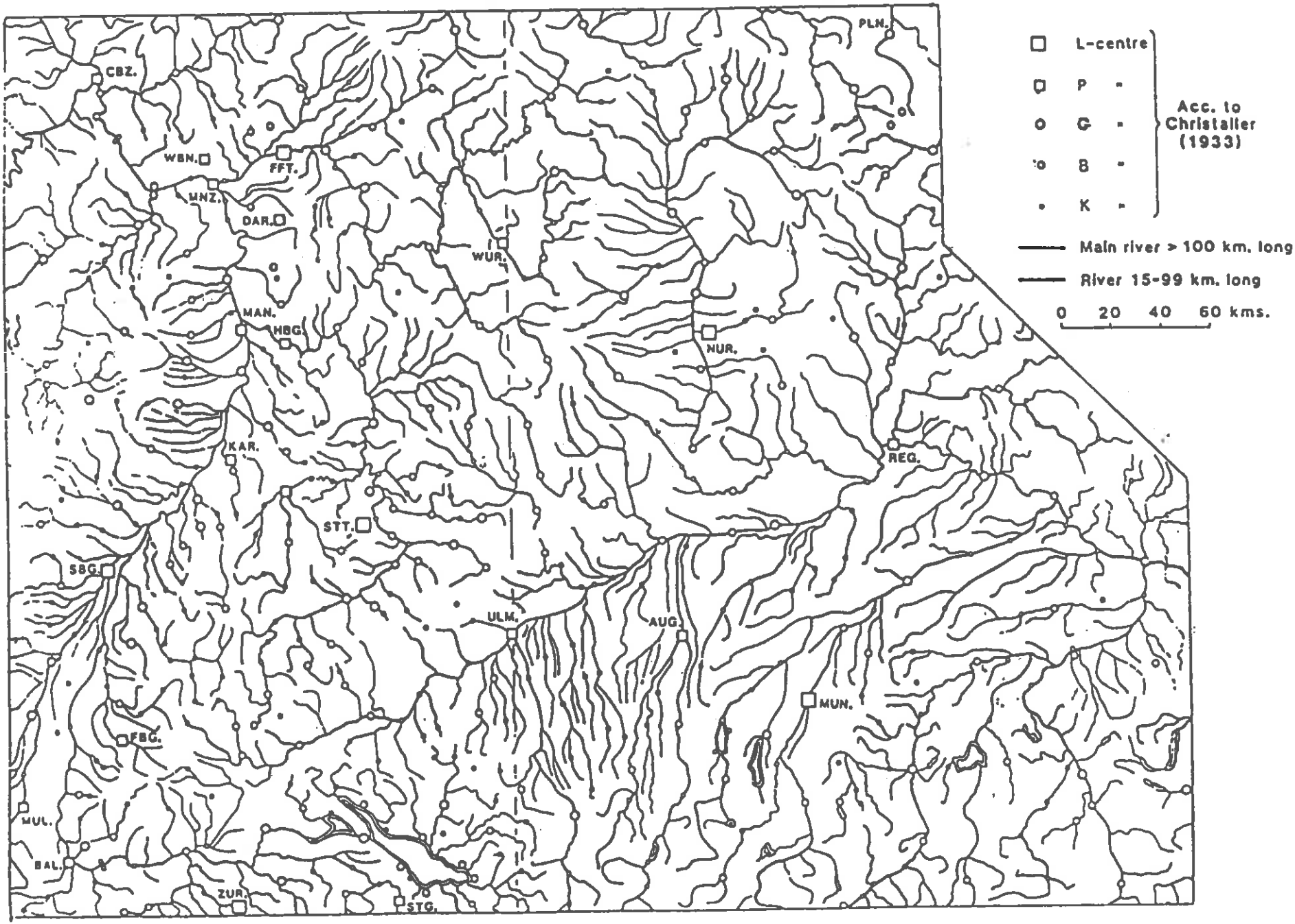
Figure 2. Cumulative percentage of centres in named categories only* on rivers of length greater than 15 km but less than the plotted value.

* ie centres of higher grade are <u>not</u> treated as automatically forming centres of lower grade as well, eg G centres are <u>not</u> also included as B & K centres.

Figure 3. The relationship between K and G centres and increasing river length (as defined) in the eastern and western halves of the study area. The 40 km lines mark the point at which rivers of that length are reached in the increasing sequence.

Figure 4. Average numbers of kms of river (in specified river size-groups) per centre* in the whole, eastern and western halves of the study area.

* The number of centres in this case includes all centres in the category stated <u>and above</u> eg <u>all</u> centres are regarded as K-centres; G-centres are counted as including all L- and P-centres also.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FBG.
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ZUR.
STG.
L-centre
P "
C "
B "
K "
Acc. to Christaller (1933)
Main river > 100 km. long
River 15-99 km. long
0 20 40 60 kms.

Fig. 1

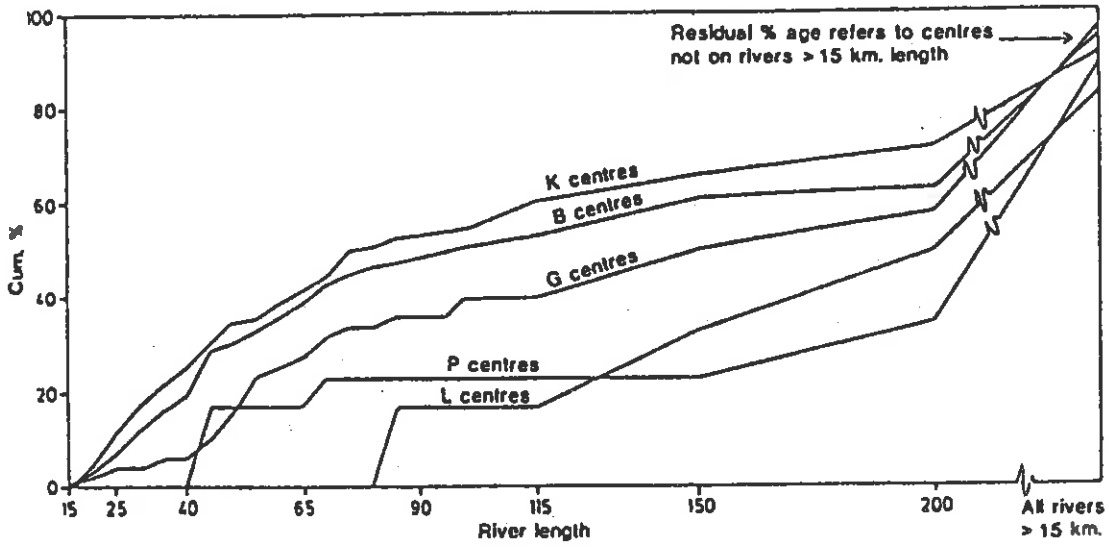

Fig. 2

Fig. 4

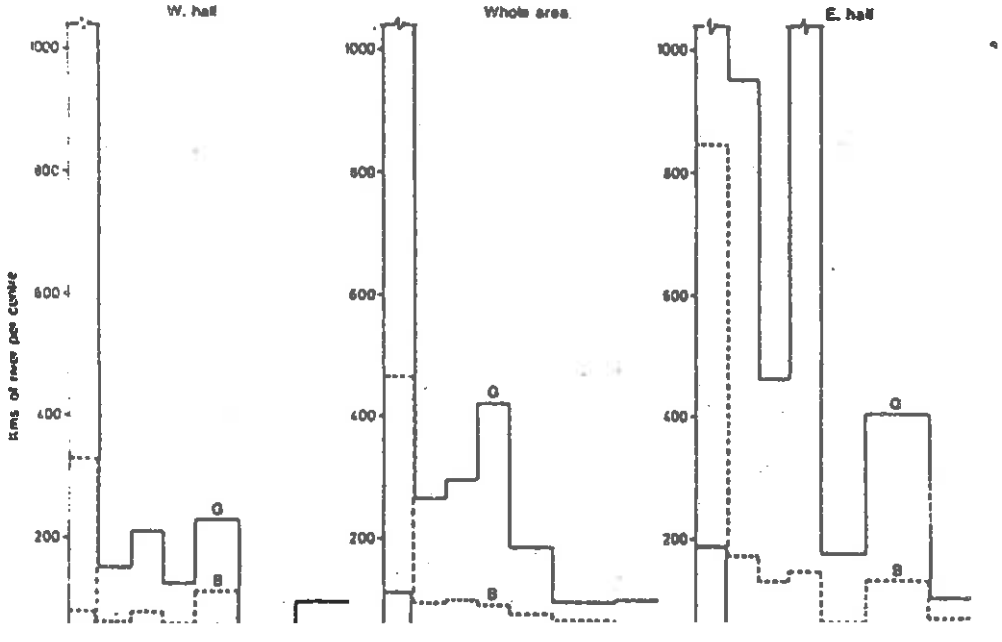

Fig.3

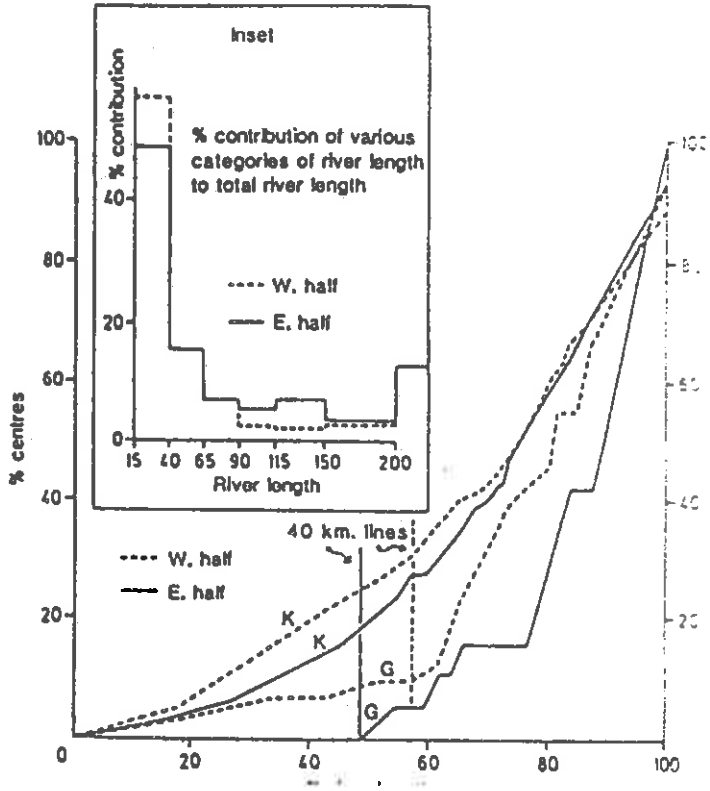

Table I Some basic characteristics of the urban[+] and river* systems of the study area and its component halves.

Feature	Whole Area	Eastern Half	Western Half
Area (sq kms)	147,200	85,440	61,760
Total no. of rivers x	737	-	-
River length within actual area (kms	23,806	12,240	11,566
River density (kms river/sq.km)	0.17	0.14	0.19
Urban centres (total)	515	210	305
Urban Centre density (sq.km/centre)	286	202	407

Urban Centre Category (Christaller)	No. f	Cum f	K§ ratio	Area/ centre (cum f)	No. f	Cum f	K ratio	Area/ centre (cum f)	No. f	Cum f	K ratio	Area/ centre (cum f
L	6	6		24,534	2	2		42,722	4	4		15,440
P	17	23	3.83	6,400	4	6	3.00	14,241	13	17	4.25	3,633
G	50	73	3.17	2,016	19	25	4.17	3,418	31	48	2.82	1,287
B	122	195	2.67	755	52	77	3.08	1,110	70	118	2.46	523
K	320	515	2.64	286	133	210	2.73	407	187	305	2.58	202

E half has 58% area 51% rivers 41% centres
W " " 42% " 49% " 59% "

Ratio overall centre density W half : E half = 2.01
" " river " W half : E half = 1.36

[+] defined as Christallers Central Place categories K to L

* " as all rivers and streams exceeding 15 km in length

§ " as ratio centres in given category : centres in category above (using cumulative frequencies in all counts)

x wholly or partially within study area

Table IL Association between urban centres and rivers in the study area

River Length km	Whole Area					Eastern Half					Western Half				
	Centres		Rivers			Centres		Rivers			Centres		Rivers		
	Total	%	Total length	% area	Ratio of %ages	Total	%	Total length	% area	Rates of %ages	Total	%	Total length	% area	Rat: of %ag
> 15	474	92	23806	65	1.42	199	95	12240	57	1.67	275	90	11566	75	1.2(
> 25	428	83	16556	45	1.84	189	90	8907	42	2.14	239	78	7649	50	1.5(
> 40	365	71	11283	31	2.29	168	80	6313	30	2.67	197	65	4970	32	2.0?
> 65	276	54	7546	21	2.57	137	65	4410	21	3.10	139	46	3136	20	2.3(
>115	191	37	4921	13	2.85	99	47	2890	14	3.36	92	30	2031	13	2.31
> 200	132	26	3107	8	3.25	59	28	1600	7	4.00	73	24	1507	10	2.4(
Area "outside" rivers	41	8		35		11	5		43		30	10		25	

Note: The figure for the % of the area occupied by riverine bands is calculated as (4 x appropriate river length) total area

Table III. Cumulative Percentage of centres in named categories only on rivers of various lengths

River length(kms)	Whole area					Eastern Half					Western Half				
	K	B	G	P	L	K	B	G	P	L	K	B	G	P	L
>15 -<25	11.3	6.6	4.0	-	-	6.0	3.8	-	-	-	15.0	8.6	6.5	-	-
>15 -<40	25.6	19.7	6.0	-	-	18.0	13.5	-	-	-	31.0	24.3	9.7	-	-
>15 -<65	41.6	39.3	28.0	17.6	-	33.1	30.8	10.5	-	-	47.6	45.7	38.7	23.1	-
>15 -<90	53.4	48.4	36.0	23.5	16.7	42.1	40.4	15.8	-	50.0	61.5	54.3	48.4	30.8	-
>15 -<115	60.3	53.3	40.0	23.5	16.7	53.3	48.1	15.8	-	50.0	65.2	57.1	54.8	30.8	-
>15 -<150	65.9	60.7	50.0	23.5	33.3	63.9	63.5	42.1	-	50.0	67.4	58.6	54.8	30.8	25.0
>15 -<200	70.9	63.1	58.0	35.3	50.0	71.4	67.3	42.1	25.0	50.0	70.6	60.0	67.7	38.5	-
All rivers >15 kms	90.6	95.1	96.0	88.2	83.3	93.2	96.2	100.0	100.0	100.0	88.8	94.3	93.5	84.6	75.0

Table IV. Average spacing tendency of centres in G, B and K classes along rivers of more than 40 km length

	whole area	Eastern half	Western half
K	25 - 40 kms	30 - 60 kms	25 - 35 kms
B	80 - 100 kms	70 - 150 kms	70 - 110 kms
G	180 - 300 kms	?400 - 900 ?kms	150 - 220 kms

Note: For rivers more than 150 kms long spacing tends to occur at or below the lower value given.