

Mosaico de imágenes de radar de la Depresión Momposina /Radar images mosaic from the Mompos Depression (IGAC, 1974)

**Región de Mompox: síntesis de estudios de
evaluación ambiental regional para el sector transporte**
***Mompox Region: synthesis of regional environmental evaluation
studies for the transportation sector***

Resumen/Summary

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1 Introduction

By the end of 1998, the Colombian National Road Institute (INVIAS) had completed feasibility studies for a major highway that would interconnect the West and East national road network through the north of the Mompox Depression, a large, low lying region in the lower flood plain of the Magdalena river where its largest tributaries -Cauca, San Jorge and Cesar rivers- come together.

Although the region was settled since the early colonial period (1500's) and utilised the extensive natural navigation network, it is presently rather isolated and largely underdeveloped. The difficulties of building and maintaining roads in the large expanse of wetlands that encompasses over 50% of the area, are thought to be a major obstacle for the development of the region. The road project -*Momposina Highway*- would make improvements to a 150 km long existing road including a number of long bridges and viaducts (see table 1. and cover illustration.).

Tabla 1. Tramos y obras de la Transversal Momposina¹
Table 1. Momposina Highway main components

tramo/sector	longitud/length (km)
Magangué -Yatí	3,5
puente /bridge Yatí - boca río Chicagua	0,8
viaducto/viaduct boca río Chicagua - Bodega	5,4
puente/bridge Chicagua - Bodega	0,2
puente/bridge caño Violo	0,2
Bodega - Sandoval	68,6
puente/bridge Sandoval - Guamal	0,5
Guamal - El Banco	36,2
El Banco - Chimichagua	35,1
Σ	150,5

¹ Fuentes/Sources: Consultoría Colombiana S. A., 2000.
mediciones sobre cartografía realizada para esta síntesis
measurements taken from map done for synthesis

In 1998 INVÍAS contracted a Regional Environmental Assessment (REA) to identify the most convenient road and transportation systems that would bring about regional development and satisfy local needs, without exerting pressure on critical ecosystems and resources and its patterns of current utilisation, and while maintaining the highly regarded cultural heritage of the region. The following alternative scenarios should be considered by the REA: (i) zero additional infrastructure (ii) a major highway to interconnect the East and West national highways,(iii) development of multimodal systems that integrate improvements to the existing regional all-weather small roads an dry-season roads networks, rehabilitation of the navigation network, together with the construction of new roads to reach the poorest and most isolated areas.

The REA, concluded in 2000, formulated several alternatives to interconnect the western and eastern highways, together with a series of recommendations about improvements to the navigation system and investments in conservation, institutional strengthening and cultural heritage protection.

A social valuation study (SV) was contracted by the World Bank in 2000 and a second phase by INVIAS in 2001, in order to gather the perception and opinions of the rural population about: (i) the development of the region, (ii) the role of transportation systems, (iii) the alternatives identified by the REA study, and (iv) to formulate complementary projects. In 2001 INVIAS contracted an economic valuation (EV) of several alternatives for the Momposina Highway based largely upon the REA recommendations.

This summary is concerned with the REA mainly, but makes extensive reference of the SV and integrates relevant information from the EV study.

2. Characterisation of the Mompox Region

The size of the study region differs in the various studies. This summary considers a smaller *Mompox Region* than the ones analysed by the REA, which covers areas related to another road project not dealt with in this synthesis, and by the EV, but larger than the one studied by the SV. The Mompox Region covers 13.174 km² in 23 municipalities that belong to three Departments, has a total population of 519.872 inhabitants, 58% in the rural areas.

Upon the basis of their common physical, ecological and social -economic features related to the transportation sector, the Mompox Region could be divided into four zones (see figure 1. and table 2.).



Figura 1. Sectorización de la Región Momposina desde el punto de vista del sector transporte/*Environmental zonification from the stand point of transportation*

The Mompox Region is one of the most underdeveloped of the country, the adult illiteracy rate is over 25%; the poverty indices for households: *misery index* (ca. 54%) and *UBN index* (ca. 76%)¹ are amongst the highest of the country. This is contrast with a rich resource base that sustains only extensive cattle ranching, mostly on natural grasses, and subsistence economies, based mainly upon fisheries and wildlife utilisation in communally owned wetland habitats, amongst the large rural population. It has been traditionally considered that the lack of a modern highway system that integrates the region to the more developed areas of the country is one of the main factors for this underdevelopment, thereby the interest of INVIAS in assessing the environmental advantages and limitations for the improvement of the regional transportation sector.

¹ The *UNB* (Unsatisfied Basic Needs Index, NBI in Spanish) is one of the methodologies utilised to measure poverty in households. It includes indicators of attributes that demonstrate the absence of basic consumption of goods and services or the low capacity to generate income. The most severe situation occurs when more than one indicator is present, the index is termed *misery*. http://www.dnp.gov.co/01_CONT/INDICADO/DOCU_SISD_COMPUESTOS.htm#1

Table 2. Zonification of the Mompox Region

municipality ¹	area km ²	population (2001)			characteristics	social indicators (%)		
		urban	rural	% rural growth		literacy	misery	UBN
<i>planicie aluvial/flood plain</i>								
Cicuco	132				- interfluvial area between Mompox and Loba arms of Magdalena			
Hatillo	196				- high density of communal resources, declining rural population			
Margarita	263	1.418	5.703	-1,75	- high dependency on fluvial system along which most of the urban and rural nucleated population is settled	66	55	84
Mompox	630	21.946	16.438	-1,43	- outside road connections by ferryboat only	77	38	64
Pinillos	723	2.449	32.548	0,78	- traffic on inner roads severely restricted in rainy season	67	64	83
San Fernando	288	1.538	7.267	-0,59	- Mompox arm small-boat navigation restricted to high water season	67	63	82
Talaigua	261	4.854	19.863	1,87		77	55	64
<i>serranía de San Lucas/San Lucas range</i>								
Altos del Rosario	304				- territory partly on flood plain zone, with high density of comunal resources			
Barranco	416	4.485	20.995	4,13	- intensive use of fluvial system	67	63	81
El Peñón	155				- growing rural population, mostly recently settled, exploits rich forest resources of range areas			
Regidor	140				- lowest inner road density in region			
Río Viejo	1.414	6.423	48.726	10,63				
San Martín	742	7.631	24.997	0,96		69	63	79
Tiquisio	758							
<i>margen derecha brazo de Mompox/Mompox arm right bank</i>								
Guamal	565	6.530	11.034	-2,92	- narrow flood plain with ample quaternary terrasses, where all main townships are located	74	37	71
Pijiño					- most of rural population settled on tertiary terrasses			
San Sebastián	421	4.748	10.173	-1,46	- low density of communal resources, rural population declining	76	54	79
San Zenón	238	4.605	3.431	-4,11	- rural road density highest in the region	75	62	83
Santa Ana	2.222	24.932	19.021	-0,81		68	41	69
<i>periferia/peripheral areas</i>								
El Banco	816	45.492	15.899	-1,67	- disjunct zone (eastern and western sectors) fully integrated to national road networks	77	43	64
La Gloria	789	4.496	13.788	2,28	- townships are river ports of national and regional importance	75	38	63
Tamalameque	599	3.772	8.234	-1,74	- growing urban areas, with most regional industry and commerce	65	43	69
Magangué	1.102	75.163	41.275	0,17		77	43	65
Σ región	13.174	220.480	299.392	0,03		71,2	54,1	76,3

¹ The municipalities without information were segregated from other municipalities within the Mompox Region in 1994, after the last population census in 1993.

2.1 Climate and hydrology

The Mompox Region is tropical, monthly mean temperatures are over 25°C year around, daily minima are rarely under 20°C while daily maxima often exceed 32°C. Mean annual rainfall decreases from 2.200 mm/year in the south and south-east to less than 1.000 in the north. Precipitation follows a bimodal pattern, a first moderate peak around May and a second, sharper one, in October. The first dry season lasts from December through February in the South and through March in the North.

Four large rivers come together in the Mompox Region: the Magdalena, which at the region's entrance has a mean flow of 4.121 m³/s, the Cauca (2.372 m³/s), the San Jorge (266 m³/s) and the Cesar (212 m³/s); at the exit of the region Magdalena's mean flow is 7.448 m³/s. The gentle slopes (0,3 - 0,4%), the large load of sediments carried (0,5 - 0,9 g/l) and the cyclic changes in water levels allow the formation of *levees* along the rivers and arms banks and large shallow lakes -*ciénagas*- that store water and trap sediments, nutrients and contaminants.

The pattern of flows and of water levels in the flood plain follows the precipitation bimodal regime, although with about a month lag. The first flood (ca. 2,6 m over mean water level) occurs towards the end of May and the second around the end of October or beginning of November (ca. 5 m over mean water level). These mean values are rather meaningless, as the year to year variations in *magnitude*, *timing* and *duration* of the high and low water seasons are quite large.

2.2 Geomorphology

The low Magdalena river valley is geomorphologically young, due to the large sediment load it has not fully developed the classic meandering pattern. It presents braided stretches and great river bed instability, lateral migration of the main channel, closing of arms and reinvasion of old channels. The most significant event in this regards is the avulsion of the Mompox arm and the subsequent development of the Quitasol-Loba arm, a process that commenced ca. 150 years ago and is still underway. Besides the ecological implications for the flood plain habitats, the event has had particular importance for the isolation during the dry season of the towns and rural settlements along the Mompox arm. Human manipulation of the flow and drainage regime with improvised works have certainly exacerbated these consequences.

The Mompox Depression is undergoing a subsidence process -thereby its name- which is in equilibrium with the large sedimentation rates. Between 40 to 50 m of sediment have been deposited in the area during the last 11.000 years.

2.3 Landscapes and biotopes

Climate, hydrology and geomorphology together contribute to the formation of a very dynamic mosaic of aquatic, amphibian and terrestrial habitats, that house a very large floral and faunal diversity. The location of the area between the foot hills of the Central Andean range to south and west and of the Eastern Andean Range to the east makes it a transitional zone between the floral and faunal assemblages typical of the pluvial Choco-Magdalena formations and the peri-Caribbean xeric belt, this biogeographical factor contributes greatly to the species richness of the Mompox Region. There are two major natural landscapes in the Mompox Region, both are also associated to the two main patterns of resource utilisation:

On the one hand the *uplands* which are either orogenic (San Lucas and Perijá exterior ranges in the south and south-east respectively) or alluvial terraces (tertiary and quaternary paleoplains with differences in substrate and drainage). The key ecological factors are rainfall amount and dry season duration and soil drainage. All settlements, urban and rural, are located in the uplands; extensive grazing areas that replaced the original vegetation, managed with fire is the main use of land.

The second landscape is the present *flood plain* (52% of the area), whose dynamics is governed by the hydrology (flood magnitude, duration and periodicity) and the geofluviomorphological processes associated to channel bed stability, sediment load and sediment size. Low lying areas with impermeable clayish substrates, form shallow lakes (*ciénagas*) that store runoff and overflow, lack woody rooted vegetation but have extensive herbaceous (*taruya*) or woody (*firme*) floating communities, are surrounded by extensive areas (*playones*) exposed to floods of different duration, depending on topographical position and substrate, which also determine the vegetation cover, from swamp or seasonal savannah to forest. Ciénagas and playones are flooded and drained through natural bi-directional channels (*caños*), which also inter-connect ciénagas isolated from one another during low water periods.

River channels, arms and caños form natural levees; the larger abandoned deposits constitute the quaternary alluvial terraces, both are strictly part of the present flood plain, but their topographical position restricts floods, therefore they constitute uplands.

The spatial distribution of these biotopes are shown in map 1. a description of them, in regards to their natural and anthropogenic features can be seen in table 3.²

The complex of flood plain aquatic, amphibious and terrestrial biotopes house the largest diversity of the region, over 450 species of terrestrial vertebrates, ca. 60 species of fishes and more than 500 species of woody plants³. Water bodies, fishes, rich sediment-laden soils, natural grasslands, forests and wildlife comprise an enormous resource base which by tradition and law is communal property (with the exception of levees and terraces), and has been utilised by subsistence peasant economies since the early colonial times. The proportion of the different biotopes per municipality and zone are shown in table 4.

² García Lozano, L. C., P. de Greiff G. y A. Etter R. 2001. Mapa preliminar de unidades de paisaje de la Depresión Momposina. (Preliminary map of landscape units and biotopes from the Mompox Depression). Based on interpretation from radar images from IGAC (1974), complemented with interpretation from aerial photographs (1975-1991) and field evaluation. Neotrópicos, Medellín, unpublished.

³ Estimate based on scanty documentaion and limited field work in Margarita Island. It does not include San Lucas range where species richness of woody plants is probably greater.

Preliminary map of landscapes and biotopes from the Mompox Depression

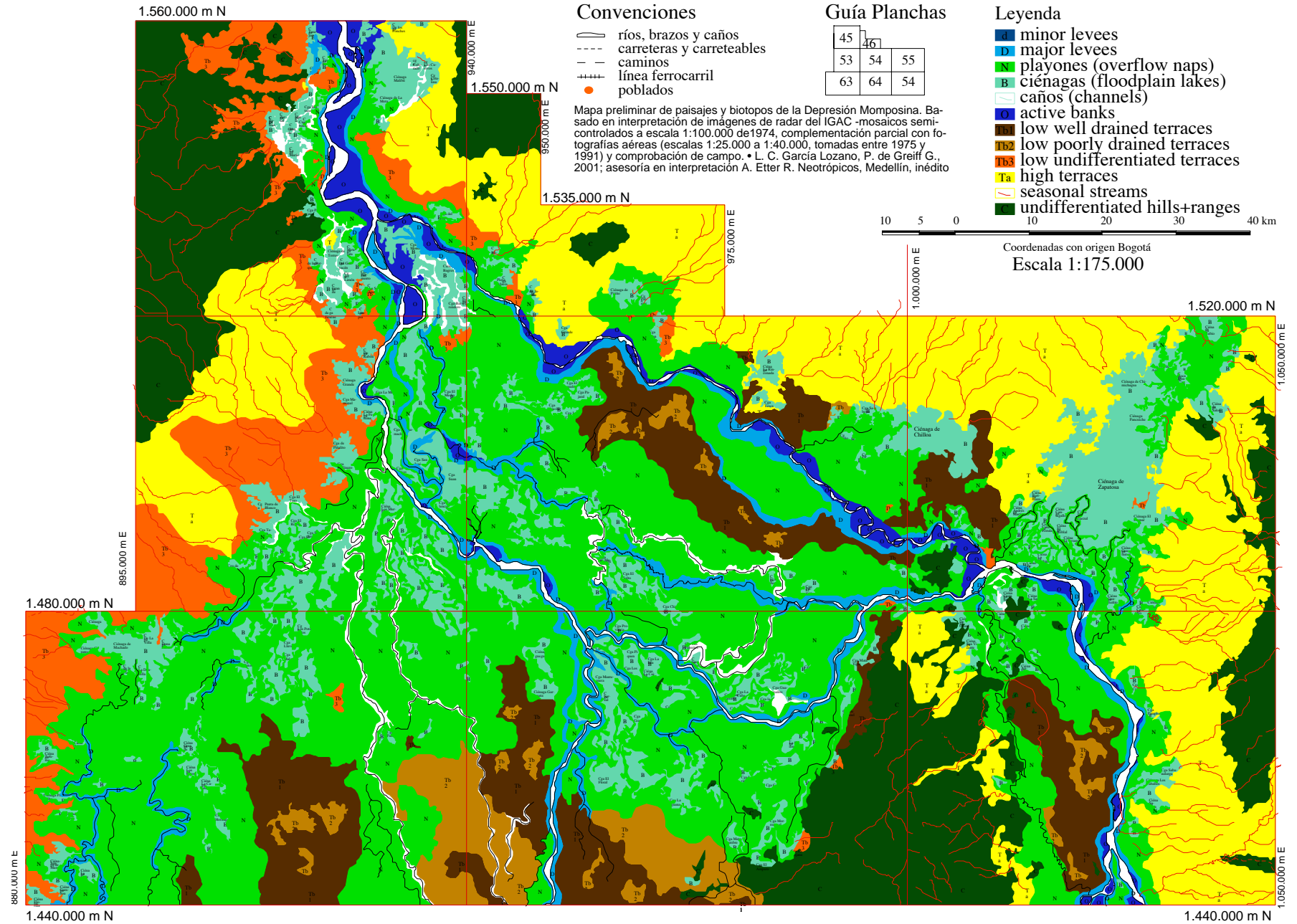


Table 3. Legend, map of landscapes and biotopes from Mompox Depression (map 1. ex folia)¹

biotope	relief	drainage	parental material	vegetation	uses and alteration factors
D major natural levees	plane-convex, 0,2 to 1 km long stripes, height < 3-4 m along major rivers: Magdalena, Cauca y San Jorge	internal drainage good; exposed to laminar overflow from major channels, without water logging during high water events	coarse-medium sandy to silty substrate	well developed ombrophilous alluvial forests with closed canopies, diverse, with many species from pluvial biomes and from deciduous forests in high levees to the north and north-west	- highly altered by: a. urban and nucleated rural settlements, favoured by location along water ways and prolonged dry periods. b. intensive use for subsistence crops and pastures. c. dikes and embankments for roads and flood protection; bridge-culverts often poorly located and insufficient in number and capacity, generate conflicts between property owners on both sides of works - Zenu culture <i>ridged fields</i> in Cauca-San Jorge inter-fluvial areas, abandoned since pre-Columbian times
d minor natural levees	plane-convex, along minor arms and channels, < 0,1 a < 0,5 km long, < 3 m high stripes, due to lower transport capacity of sediments		fine sandy to silty substrate		
O active river banks	convex-concave, irregular, unstable, very dynamic; alternated narrow, elongated ridges and depressions along major rivers, formed by aggradation - degradation during meander migration	variable, from good (ridges) to poor (depressions)	sandy to silty substrate	poorly to moderately developed alluvial forests; mosaic from several pioneer and early successional stages, rarely climactic, from river's edge inland	- extensive grazing, subsistence farming - building materials extraction (sand, gravels) - poorly designed and built flood protection and erosion control works
N playones overflow napes	- plane, slightly tilted towards <i>ciénagas</i> (B), adjacent to levees, receive overflow from both during high water events	drainage gradient from moderately good in highest parts near levees to imperfect towards <i>ciénagas</i>	- silty to silty-clayish	- transition from well developed ombrophilous alluvial forest in upper parts to dwarf forest with open canopies and herbaceous swamp towards <i>ciénagas</i> - contrasting physiognomies between low and high water periods	communal utilisation by tradition and regulations: hunting, grazing, subsistence farming, fire wood, timber... severely intervened by: a. private appropriation by large cattle ranchers b. extensive grazing with yearly dry season fires c. dikes and high water dams to minimise flood and to prolong low water period
B ciénagas flood plain lakes	plane-concave, shallow lakes located at the lowest sector of the flood plain, store runoff and overflow from high water events (<i>potamophase</i>); release them during low waters (<i>limnophase</i>)	- without free drainage, water evacuation through <i>caños</i> (Cñ) and by evaporation, - form complexes inter-connected by <i>caños</i> (Cñ)	clayish substrate, benthic accumulation form organic matter (detritus, silt and contaminants)	- herbaceous swamp - floating communities: herbaceous (<i>taruya</i>) + woody (<i>firme</i>) - rooted communities in <i>ciénagas</i> distal from rivers	- fishing, resource deteriorated by: over-exploitation, natural and induced siltation, and by introduction of species from other biogeographical areas - altered by <i>abonamiento</i> (induced siltation), drainage, artificial avulsion of <i>caños</i> (Cñ) and pollution
Cñ caños	- plane-concave, long, narrow, shallow meandering channels, interconnect <i>ciénagas</i> with rivers - form <i>minor levees</i> permanent or submerged during high water season	natural channels, flow river-wards in dry season and <i>ciénaga</i> -wards during flood; transport sediments, floating vegetation, fishes and other organisms	- silty to silty-clayish	- herbaceous swamp in channel banks and seasonal levees - floating communities in channel - ombrophilous alluvial forest in permanent levees	- navigation - fishing, hunting - drinking water, altered by: avulsion, channel rectification, dredging, hydraulic control works and pollution
TERRACES Tb1 low well drained (montaña)	paleoplains, relief levelled by erosion and siltation: low lying <i>quaternary</i> (Tb1-3) and higher lying <i>tertiary</i> (Ta), latter with quaternary deposits in drainage network.	slow runoff, water logging in still plane-concave sectors (ancient <i>ciénagas</i>) (Tb1); ground water high; imperfect to poor drainage (Tb2)	inherited substrates: -coarse sandy - silty (Tb1, Ta) -fine sandy-clayish (Tb2)	dense, diverse, well developed, slow growing deciduous forests	severely altered by: - logging of slow growing, fine wood spp during 19th and 20th centuries - extensive grazing with yearly fires - modern mechanised agriculture - forest plantations with exotic spp - numerous nucleated rural settlements
Tb2 low poorly drained (bajos)	- ancient levees, banks and upper parts of <i>playones</i> (Tb1)	Ta, Tb1 dissected by incision of drainage network: torrential, seasonal streams			- embankments for roads across and along <i>bajos</i> ; bridge-culverts often poorly located and insufficient in number and capacity
Tb3 undifferentiated	- ancient <i>ciénagas</i> and lower parts of <i>playones</i> (Tb2)				
Ta high terraces					
C undifferentiated hills and ranges	<i>interior</i> : isolated promontories up to ca. 100 m over plain; <i>exterior</i> foothills from San Lucas (SE) and Perijá (E) ranges	<i>interior</i> : drainage good to excessive, dissected by seasonal torrential streams	<i>interior</i> : gneises+up-wellings from crystalline basement from de San Lucas range	<i>interior</i> : dense,, diverse, well developed, deciduous forest, transition to thorn forest in N and NE	<i>interior</i> : altered by extensive grazing (dry season pastures); yearly fires - firewood, timber - construction materials (gravels)

¹ Fuente: L. C. García Lozano, P. de Greiff G., A. Etter R. 2001

Table 4. Distribution of biotopes in the zones and municipalities of the Mompox Region (areas in km²)

municipality	levees		playones	cienagas	banks	terraces				hills+ranges		Σ area	
	minor	major				low			high	interior	San Lucas	habitable	flooded/floodable
						well drained	poorly drained	undifferentiated					
alluvial plain													
Cicuco		30,5	85,0	95,0	9,6							30,5	189,6
Hatillo		20,1	72,0	18,7	20,0	7,0				23,4		50,5	110,7
Margarita	8,8	43,1	123,8	12,2	20,3	50,0	5,2					101,9	161,5
Mompox		38,4	196,6	65,9	9,0	87,2	39,4					125,6	310,9
Pinillos	25,9	68,6	450,0	132,8	2,5							94,5	585,3
San Fernando	19,0	21,5	211,9	7,0	3,5	110,9	7,3					151,4	229,7
Talaigua	21,5	31,0	189,0	85,0	36,0			8,1				56,6	314,1
San Lucas range													
Altos del Rosario		9,4	103,8	20,3						1,8	6,4	17,6	124,1
Barranco	15,5	28,0	170,0	62,0		35,0		3,3	28,2		246,9	355,3	233,7
Regidor		16,1	66,0	0,9	7,0	107,6	30,0		24,0	6,7	196,0	350,4	103,9
Río Viejo		3,7	7,7									3,7	7,7
San Martín+El Peñón	9,2	17,8	224,3	54,2	7,7	81,4	14,8		85,2	59,1	246,6	499,3	301,0
Tiquisio			62,8	22,0			43,0	3,7		11,6	121,7	135,2	129,7
Mompox arm right bank													
Guamal		3,1	67,6	34,0	6,4	52,6	4,4					55,7	112,4
San Sebastián			43,0	7,8	20,0	2,7		41,4	69,6			93,0	91,5
San Zenón			58,8	17,3				10,8	60,4			65,8	81,5
Santa Ana+Pijiño		6,9	94,5	27,5	44,9			67,4	486,6			527,2	200,6
peripheral areas													
El Banco		10,2	163,0	222,0	26,0	113,6		4,5	273,2			399,3	413,3
La Gloria		7,2	33,1	8,2	1,3				148,0			155,2	42,6
Magangué	26,0	45,0	254,0	157,0	25,5	10,0		190,0	234,0	2,1		412,1	531,5
Tamalameque		12,5	120,0	38,0	10,5				416,0			428,5	168,5
Σ	125,9	413,1	2.796,9	1.087,8	250,2	658,0	144,1	329,2	1.825,2	104,8	817,6	4.109,2	4.443,6

2.4 Ecological status

The functioning of the alluvial plain and the associated resources in the Mompox Region are in an advance stage of deterioration. There are no relicts of primary forests of any size in the flood plain, the small patches of secondary forest are subjected to intense selective extraction of fire wood, and timber for fences, house and furniture construction. Forested areas are also subjected to cattle browsing that diverts secondary succession and damages soils, and are exposed to wild fires; fire is extensively utilised to manage pastures and for subsistence hunting.

There are practically no *ciénaga-playón-caño* complexes in natural conditions. Playones are yearly burned to stimulate green grasses growth. Most caños are obstructed with floating aquatic vegetation which is only removed to install small mesh fish nets across them during the upstream reproductive migrations that take place in the dry season. Quite often the caño-ciénaga and the caño-river mouths are diverted to open directly, counter current, cutting meanders and levees in order to accelerate siltation and thus expand pasture areas. In other occasions caños are subjected to avulsion to impede the free flow of water into a ciénaga, this slowly leads to a general impoverishment of fish species richness and fish resources. During the last 50-60 years cattle ranchers have built an extensive network of roads over dikes and embankments; bridges and culverts are purposely fewer than needed and with lower capacity in order to diminish the flood height and retard its occurrence. The pulse flood-drainage is thus altered beyond the immediate vicinity of the works: on the wet side of embankments (proximal to the river) a small increment in water level causes prolonged floods and on the dry side (flood plain side, distal from the river) water, nutrients and organisms can only reach the ciénagas and playones during extreme events, the drainage during the subsequent limnophase is thus impeded.

The main cause of this condition is the expansion of the cattle ranching activities that incorporate communal land and the partly subsequent construction of roads: This expansion brings besides a reduction of communal areas and resources, and to compensate, a more intensive utilisation of the remnants. In this sense, the *ciénaga-caño-playón* complexes are the more sensitive habitats, the

ones which manifest more widespread deterioration and are likely to withstand further deleterious processes in the near future. However, the highly dynamic physical and ecological processes of these habitats allow their readily recuperation and restoration once the alteration factors are stopped or controlled.

There is very little utilisation of biocides and fertilisers to manage pastures and agricultural land in the Mompox Region; however, waters and sediments in Mompox, Loba arms of the Magdalena as well as in many ciénagas, present high concentrations of heavy metals and probably of other pollutants as well. They are still under critical levels, but likely on the increase as a consequence of population growth and industrial expansion in the upper Cauca and Magdalena watersheds.

2.5 Social and economic status

The ecological situation underlined above is both cause and reflection of the social-economic status of the population. This is mostly comprised of poor, uneducated, landless peasants. Most of the agricultural land is owned by very few absentee cattle ranchers; the plots owned by the peasantry are too small to sustain their families, therefore they ought to complement incomes in a variety of ways:

- grazing of small herds of cattle (< 50 heads/family), short cycle crop agriculture and hunting in playones
- fishing in ciénagas, caños and rivers, is the most widespread activity, subjected to year to year variations, associated to the magnitude of the difference between high and low waters during previous years, and within-year variation associated to the up-stream reproductive migration of many species
- out hiring of work force in large cattle ranches, and labour exchanges
- door to door commerce of agricultural, fishing and hunting surpluses and of home made products (cheese, corn and cassava bread, handicrafts, etc.)
- cash transfers from family members who work elsewhere

The most important resources for the majority of the population are housed in the communal areas: fishing, hunting, firewood, timber, grasslands, cropland, wild fruits, seeds, fibres, and so on. It is estimated that from 50 to 60% of families incomes proceed from their exploitation. These values are similar to those of isolated aboriginal populations in Choco, Amazonia and elsewhere in the country and higher than those of new settlers in those regions.

However, the large rural population growth, the loss of accessibility and the deterioration of communal areas, and the widespread rural unemployment associated to the cattle ranching activity, have forced the emigration of rural population to urban areas within the region, to cities on the Caribbean coast and the interior of the country and to Venezuela. This process started more than 50 years ago and still continues. In the last 30 years, and more recently with the support from guerrilla groups, migration to the San Lucas range areas is taking place. Indeed, the municipalities in this zone are the only ones that show positive rural population growth rates in the Mompox Region (see table 2.). Presumably, the increased deterioration of the San Lucas range habitats is absorbing the pressure that the emigration from flood plain habitats release.

The communal areas are subjected to appropriation by large land owners and peasantry; the process is usually accompanied by improvised works for flood control and to accelerate siltation of cienagas, these two processes displace the traditional extractive and productive activities, but do not incite an explicit response from the affected population. Partly this lack of response is due to widespread appreciated social model role that the large cattle rancher represents. Cattle ranching is more an activity of commerce of lands and animals and one that gives large social prestige, its economic considerations are rather secondary.

There are no communal organisations for production and commerce; state supported credit and technical assistance for productive activities are very limited and require land ownership.

2.5.1 Transportation systems in the Mompox Region

The settlement of the Mompox Region was conditioned by two fundamental factors: (i) availability of non floodable areas and (ii) access to transportation ways. Settlement took place since the early colonial period, by the time of the independence war against the Spanish Crown, at the beginning of the 19th century, all the townships have been founded. These settlements made intensive use of channels -rivers, arms, caños and ciénagas- for short distance navigation; i. e., the transportation network was exclusively fluvial. Figure 1. shows the spatial distribution of population; settlements -urban as well as nucleated rural- are restricted to non floodable areas.

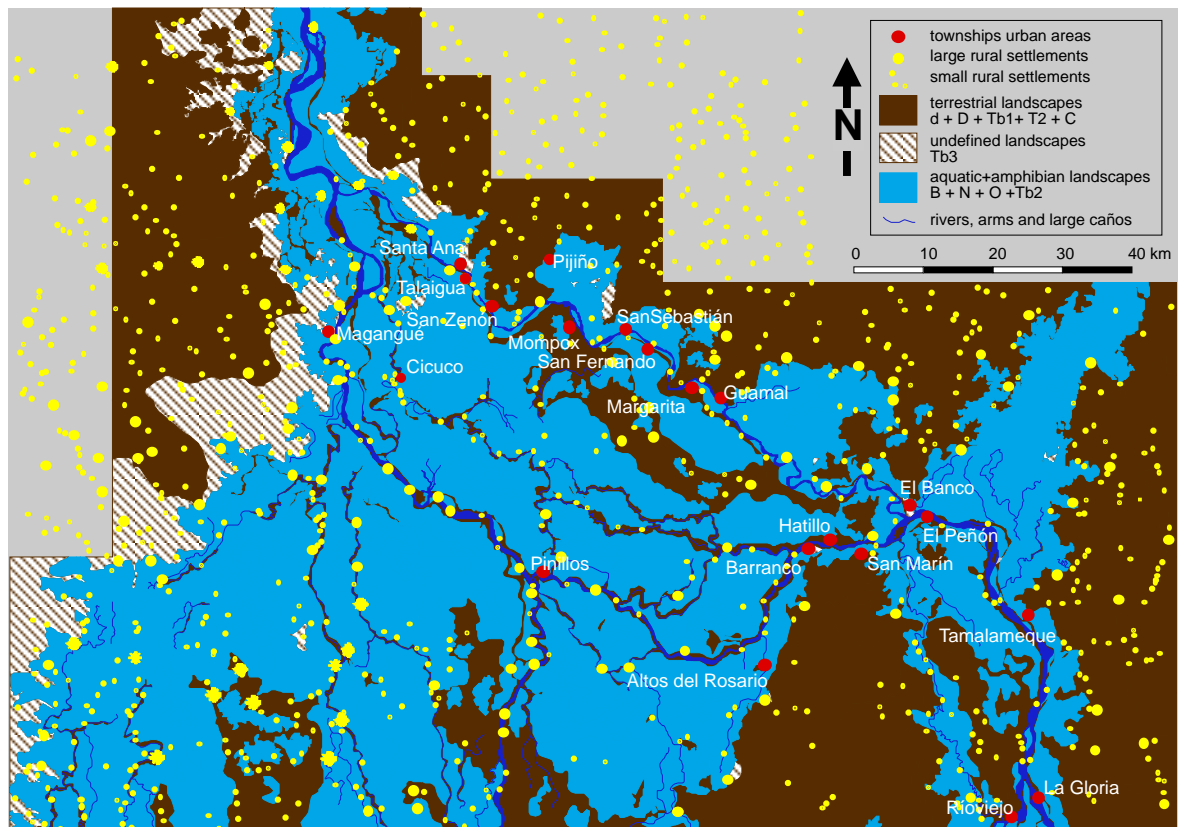


Figura 1. Spatial distribution of terrestrial (brown), aquatic and amphibian landscapes (blue) and of urban and rural settlements in the Mompox Region

In the 20th century, gasoline and diesel engines and motor vehicles changed the mode of transportation -long distance travel by road or motor boat was made readily accessible- and offered besides the possibility of large scale manipulation of the terrain -construction of dikes, embankments, diversion of channels, etc.; together, they permitted the expansion of the large cattle ranching land holdings and allowed livestock to be maintained year around in floodable areas. The development of roads as the preferred means of transportation -partly associated to the higher costs of motorboat transport- has induced the abandonment of the fluvial network, particularly of the smaller arms and caños; this, paradoxically, further increases the demand for more and better roads.

The roadways. Figure 2. shows the extent of the road and navigation networks, as expected, the areas covered by the two networks and the distribution of settlements fully coincide. Population would not settle where there are no possibilities of transportation and these would not be built unless the areas are inhabitable and have plenty of resources.

The road networks from the Mompox Region are integrated to the western and eastern national highway systems, the first one from Magangué and the second one from El Banco, Tamalameque and La Gloria. The communication however is not an expedient one, the following interference and difficulties are encountered:

1. There are no bridges over the main rivers, arms and caños, to cross these gaps, ferryboats or powered floating rafts or platforms (*balsas*) are needed; the eastern highway connection requires crosses over the Mompox arm (5 different possibilities, see figure 2.) and over the Cesar river in El Banco. All crosses are short (< 600 m), the services are privately provided, take less than 10 minutes, there is practically no waiting time. All Mompox arm balsas are capable of crossing over medium size trucks (15-20 Tm) and buses, they operate during day light hours. There are no limitations in the Cesar river cross, the service operates around the clock.

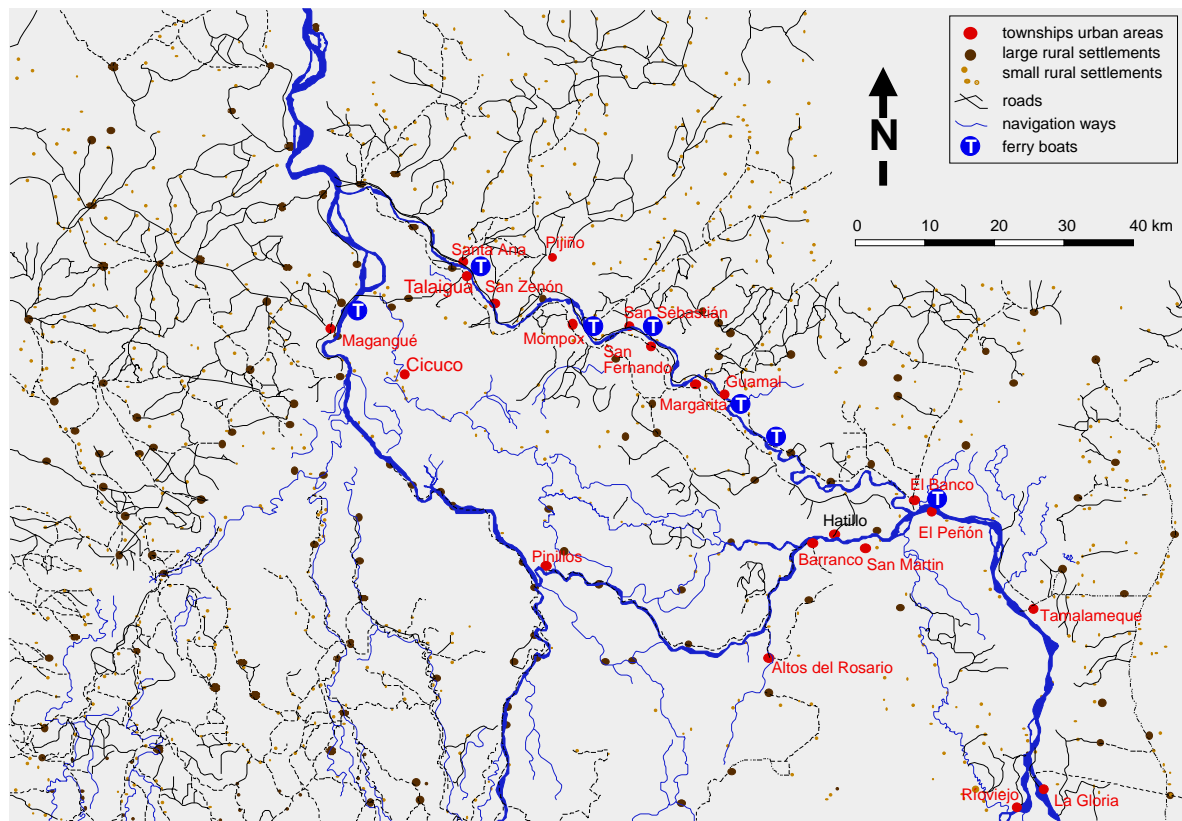


Figura 2. Spacial distribución of urban and rural population and fluvial and road networks in the Mompox Region

The western highway cross is somewhat more complicated, a large ferryboat departs from Yatí on the left bank of Loba arm, navigates downstream to the mouth of the Chicagua arm and upstream this to Bodega, where the Margarita island road network ends. The service is government owned, fairly reliable, operates three times daily; Yatí-Bodega takes 45 minutes and 60 minutes in the opposite direction; loading and unloading can take up to 30 minutes and waiting times are normally more than two hours. All access roads to the ferryboats and balsas are narrow, unpaved, without hard topping and because the services are private, there is no maintenance in any of them.

2. All interior roads in the Mompox Region (excluding the roads to Magangué and La Gloria from localities external to the region) are unpaved; except the 45 km long Bodega-Mompox road. All minor and most secondary roads (see table 5.) are simply built with compacted earth and have no hard riding surface. They become very difficult to use with the first rains and by the end of the rainy season a 30 km ride could take up to 4 hours. Road maintenance is minimal, given the reduced departmental and municipal budgets and the high costs of hauling road materials, which are scarce in the flood plain areas.

3. culverts and drains are often insufficient or are poorly placed (either too high or too low), they are regularly obstructed by neighbours to impede floods from reaching the playones, which incidentally is a source of conflict with owners of land on the wet side of embankments. This factors accelerate the deterioration of embankments, dikes, culverts and bridges during the rainy season.

4. practically all roads in the flood plain (Margarita island and Loba arm) and in the tertiary terraces of the right bank of Mompox arm are only useful during the dry season, 6 to 8 months per year at the most. Similarly to access roads for ferryboats and balsas, dry season roads are constructed with private efforts, therefore no state funds for maintenance -which is needed at least once a year- are available.

5. besides the financial difficulties mentioned for road maintenance, this is difficult to accomplished given the scarcity of appropriate materials, especially in the flood plain areas.

Table 6. summarises the extent of the road networks for the 4 zones within the Mompox Region; while there are differences in the extent of habitable areas, the indicators of road development (i) *road density* measured in km of road per km² of habitable area and (ii) km of road per settlement do not change very much from one zone to another, even when the peripheral areas are taken into account.

Table 6. Road networks in the Mompox Region

municipality	main roads	2ndary roads	other roads	Σ	habitable area	density (km/km ²)	urban areas	rural settlements	km/settlement
flood plain	172	107	132	411	611	0,7	8	92	4,1
San Lucas range	132	51	87	270	1.361	0,2	6	80	3,1
peripheral areas	224	164	253	641	1.395	0,5	4	149	4,2
Mompox arm right bank	136	323	546	1.005	742	1,4	5	193	5,1
Σ	664	645	1.018	2.327	4.109	0,8	23	514	5,2

This indicates clearly that the *isolation* from the Mompox Region is related more to the *quality of the transportation networks* and to the *lack of public means* to use them, than to the extent and coverage of the networks.

The waterways. The navigation network of the Mompox Region is 2.257 km long; 59% is major caños, arms and rivers, the rest is smaller caños. This does not include numerous large ciénagas inter-connected to the system by the caños network. All together the fluvial network is at least 1,7 times longer than the roadways, if only the primary and secondary roads are considered and only comparable if the dry season small roads are taken into account. All settlements located on the banks of rivers, arms and caños (urban areas, major and small rural nucleated settlements) have some sort of quay or docking facility for canoes, motorcanoes and outboard motor boats. Larger townships and main urban areas (Magangué, Bodega, Mompox, San Sebastián, El Banco, San Martín de Loba, etc.) have concrete or piled wharves that permit mooring of tugboats and other large boats for cattle, timber, cement transport and many other types of bulk cargo. Market places are usually located near the quays and wharves. Quays, docking facilities and wharves have poorly maintained access roads, in precarious state.

In principle the fluvial network should operate year around; nevertheless, in the case of the Mompox arm and other smaller arms and caños (Pijiño, Guataca), their use is severely restricted during the dry season; the reasons are:

1. the low water levels expose sediment banks and distributes the smaller water volume amongst several arms (furcation), which prevents the mobilisation of even small boats and leaves away from the channel the banks and quays of many towns and dwellings
2. the type of boats utilised for minor navigation (fibber glass canoes and boats of high keel) and the type of engines used (outboard with long propeller shaft) require water depths over 1 m, not available in the Mompox arm during extreme dry seasons nor in many caños and smaller arms
3. increase, during the last decades, of the sediment load of the Mompox arm, which is deposited in the slower stretches of low slope of the Mompox Depression
4. obstruction of caños river mouths that isolates ciénagas, prevents access to them and interferences with the flow of water to the arm, which further increases the low water problems.

Table 7. Passengers and cargo mobilisation in Magangué and El Banco

item	Magangué	El Banco
number of regional origins and destinations	14	29
mean regional distances (km)	57	42
number of extra-regional origins and destinations	16	11
mean extra-regional distances (km)	246	198
passengers		
monthly mean	21.822	32.783
anual total	261.867	393.391
cargo (Tm)		
anual mean	33.591	55.331

It is not possible to know the volume of cargo or passengers mobilised in the region nor what percentage of the total cargo generated in the region or with destination to it, is mobilised by the fluvial network. Nevertheless, data provided by Fluvial Intendances of Magangué and El Banco -the two major peripheral cities in the Mompox Region- displayed in table 7. gives a perception of its importance.

Transportation systems. Regional production (crops, livestock and fish) is mobilised through the two regional networks fluvial and roads, both within the region and to external localities; however, there is no information to define their relative importance. Trade of livestock is probably the most important, given the percentage of area dedicated to it; it utilises a combination of fluvial and road stretches, from its origins and to its destinations. The data displayed in table 8. are from limited time periods of different length in the three localities, but are qualitatively important because, in the case of Mompox -a city that exemplifies or questions the regional isolation- underlines the fact that the trade is of comparable magnitudes to the one from peripheral cities, where the isolation is not a major issue. Fish is the only product that utilises almost exclusively the regional fluvial network.

Tabla 8. Monthly mobilisation of livestock (number of animals) in the Mompox Region

locality	cattle	other spp	# of regional origenes		# of extra-regional destinations	
			fluvial	road	fluvial	road
Magangué	1.075	593	8	4	9	11
Mompox	798	63	9	3	19	11
El Banco	749	0	4	2	4	6

Public transportation. Over this complementary component of the transportation system there is practically no information in the studies carried out for Invias. Public transportation is privately managed with state control through different agencies for fluvial and road components. Although there are differences between the various zones and between the fluvial and road systems, in general the public transportation is characterised by: (i) the low reliability of the service, related to external factors such as recurrent descent of water levels (fluvial system) and precarious condition of the roadways; (ii) the low level of entrepreneurship of transportation activity; companies are co-operative ventures of owners of motorboats and all terrain vehicles with very little supervision and control; (iii) high costs of transportation, particularly fluvial, that affect mostly the low income peasant producers (iv) old age and poor operating condition of vehicles and equipment (v) seasonal changes in prices of perishable agricultural production and fisheries, caused by seasonality of production; during high production seasons, total expected revenues of production from a peasant family could be less than the transportation costs, thus production is lost.

Due to the lower costs of transportation, the development of roadways induces an abandonment of the navigation channels and of the associated infrastructure (quays and access roads). Guataca caño -a 45 km long old arm of the Mompox arm, located in the Margarita island- exemplifies this situation: it was until the 1960s a water way that connected no less than 6 settlements from Mompox, San Fernando and Margarita with a population ca. 15.000 people. A road built in the late 1950s over the natural levee induced: (i) its slow avulsion and abandonment as a waterway; (ii) permanent obstruction of the upper mouth and seasonal obstruction of the lower one; (iii) prolonged isolation of the ciénagas in the inter-fluvial area caño Guataca-Mompox arm (iv) expansion of grasslands in large neighbouring livestock land holdings.

3 Environment - development - transportation issues in the Mompox Region

3.1 Population dynamics and spatial distribution

The Mompox Region population (from the 23 municipalities analysed in the REA) is still mostly rural (58%); nevertheless, the ongoing migration to urban areas and to areas outside the region will decrease the proportion and eventually the absolute size of rural population. An exception to this tendency occurs in the San Lucas range municipalities, where new settlements exploit yet large intact resources, it is believed that this zone is partly absorbing the migrant population from flood plain areas.

Urban and rural population in the region is settled in non floodable biotopes that are located near the navigation network. In the tertiary plain from the right bank of the Mompox arm the population is sparser, rural nucleated, and is located near the roadways network.

3.2 Resources

47% from the area is not habitable, i. e., does not permit the construction of permanent settlements, but it is by law and tradition communal property and houses -in the cienagas, caños, playones and unstable river banks- the fundamental resources for the peasant population subsistence economies: grazing areas, land for short cycle crops, fish and game resources, firewood, timber, fibres, wild fruits, seeds, etc.

Cropland is restricted to the scarce non floodable biotopes (terraces, levees, hills), it is privately held in large absentee owner land-holdings, mostly dedicated to livestock feeding on natural grasses maintained by fire. As of recent, there is a tendency to reconcentration of rural property, even incorporating small land holdings, that further forces emigration of peasants. The lack of cropland for the peasant population further increases the reliance on wildlife resources from communal areas and induces over-exploitation.

3.3 Dynamics of the deterioration processes

Everywhere in the Mompox Region there is a growing tendency of deterioration of the resources upon which the peasant economies are based. This is caused by a constellation of factors: natural, induced, exogenous and endogenous:

- alteration of the cycle flood - drainage with improvised works for expansion of livestock feeding grasslands, roadway development, and flood protection of rural nucleated and urban areas
- siltation of cienagas by excessive sediment load, associated to intensive deforestation processes and gold mining upstream from the region.
- over-exploitation of fisheries and wildlife resources without replacement and zero reinvestment in conservation and restoration
- growing population in urban areas and in nucleated rural settlements
- introduction of foreign species, accidental as well as purposeful, which displace and even drive to extinction, by competition and predation, the native species.
- caño avulsion and reinvasion of old channels, obstruction of caños mouths and induced siltation of cienagas
- toxic and organic contamination of water bodies by : uncontrolled sewage and garbage disposal, runoff from livestock and agriculture areas, oil spills by vandalism of pipelines and trapping in flood plain of heavy metals and organic pollutants transported by rivers

3.4 Limitations imposed by present transportation systems

Urban and rural population in the Mompox Region is not isolated; the inadequacy of the navigation and roadways systems is qualitative rather than quantitative. There are extensive networks of waterways and roads but both are deteriorated, are not fully useful year around, and lack adequate, inexpensive and efficient public means of transportation.

The road network is articulated to the eastern and western highway systems, but rivers and arms are unabridged gaps; the ferryboat and balsas service is relatively reliable and efficient, but the access roads are in precarious condition and receive little or no maintenance.

Neither the roadway system nor the associated infrastructure of the navigation system have an adequate maintenance program, public investment from Departments and municipalities is minimal, sporadic and without due continuity.

National, departmental and municipal roads were built in the past without proper management of the local hydrology.; earth fills, embankments and dikes are essentially flood control structures. The situation is no better with the newer projects, although there are national and regional environmental authorities in Magangué.

The extensive network of dry weather roads, derived from the expansion of the livestock economy, has had an enormous deleterious effect on the flood plain habitats. It has stimulated sedentarity in rural population and induced abandonment of the navigation channels and their associated infrastructure.

3.5 Community perception

According to the opinions of the communities consulted during the SV, the status of transportation system constitutes an obstacle for the development of the region, however, other factors play a more important role. Perceptions of problems were grouped in three categories:

1. related to the transportation systems:
 - recurrent deterioration of roads and waterways,
 - road and fluvial public transportation with low coverage and high costs and
 - lack of roadways to some production areas
2. related to other factors of development:
 - concentration of ownership of rural land
 - limited availability of credit to small producers for production, commercialisation, and housing
 - high levels of rural unemployment
 - deficient technical assistance to small producers
 - limited capacity for community organisation
 - inadequate health and education services
 - low cover of rural public services
 - corruption and opportunism of politicians
3. mixed issues of 1. and 2.:
 - frequency and severity of floods
 - deterioration of ciénagas and caños by production activities and urban growth.

3.6 Causal relationships

It has been stressed in this summary the causal relationships between (i) the physical and ecological limitations of the Mompox Region, (ii) the two main uses of the territory and (iii) the role of transportation systems. These could be seen as two simultaneous cycles which lead to an expansion of the livestock activity, general depletion of resources, larger towns, generalised impoverishment of population and outward migration.

Two distinctive features complement this picture: (i) on the one hand the systematic lack of private or public (social or institutional) mechanisms for natural capital replacement and reinvestment in the system; natural resources are transformed either in cattle or in people and both emigrate. (ii) On the other hand there is no state induced control nor investment in conservation and restoration of the severely predated natural capital. The only control mechanism comes from the natural functioning of the flood plain which is neither predictable nor immediately effective, the ecological time lags of natural restoration are longer than the perturbation cycles and rather than induce prudence in resource utilisation they are considered *natural catastrophes* and further stimulate the artificial management of the flood plain, even with the tacit or explicit, opportunistic support of the state agencies.

4 Transportation investment options

The investment options identified in the three studies carried out for *Invias* can be classified in two groups: (i) those oriented towards the solution of development problems by means of articulating the western and eastern highways systems, is the type of option analysed by the REA and by the EV (ii) those options oriented to the strengthening of regional transportation systems independently of their national interest, this type is favoured by the communities and institutions consulted by the SV.

4.1 Regional Environmental Assessment options

The REA assumed that *the articulation of the western and eastern highways would generate regional development* and did not question the role that transportation development has played in the determination of the present status of natural resources and social conditions within the region. The REA proposes a series of options of articulation which classifies by means of a multiple factor subjective weighting scheme. The plan recommended consists of two principal and one complementary components:

1. Roadway component. Articulation of the western and eastern highway systems by a major 205 km long road: From Bodega to Hatillo, ferryboat to cross the Loba arm to Barranco, a road to Regidor through the flood plain fringes, ferry boat to cross the Mag-

dalena river to La Gloria. The option also includes a bridge over the Mompox arm at Guamal, but the bridges over Loba arm in Yatí and over the Chicagua arm in Bogega are not recommended, instead an undefined plan to improve and modernise the ferry-boat services is recommended. This option is complemented with a minor 5 year plan for maintenance of secondary roads throughout the region, without indicating where are the critical areas. Total cost US\$ 94.680.000

2. Navigation component. It is not clearly defined, 4 from 6 items are proposals for studying what and where ought to be done to improve the performance and utilisation of the system. The largest item is improvement of quays, wharves and hub stations at 9 localities, but no clarifications of concrete needs is given. A small budget is also included for *maintenance* of cienagas, caños, and rivers, without details of needs or location of works. Total cost US\$7.000.000

3. Complementary component. Includes investments in environmental, social and institutional development, mostly short to medium duration studies; over 70 projects for Mompox and another region simultaneously analysed. Within these, two institutional strengthening projects are worth mentioning: (i) for regional environmental authorities to improve environmental control and conservation and (ii) for Mompox private and state institutions to improve cultural heritage conservation and to promote tourism. Total cost US\$1.176.000

4.2 Economic Valuation Options

The EV terms of reference clearly indicated that alternatives of connection of eastern and western main highways through the Mompox Region ought to be analysed; two purposes should be taken into consideration: economic feasibility as national interest projects and economic and social benefits to the Mompox Region. The EV contemplated 7 options of inter-connection, including 4 also analysed by the REA. All options include Bodega - Mompox - Sandoval - bridge over the Mompox arm - Guamal. Differences were in the points of connection and on the number of bridges to be built. The analysis is based upon: (i) travel costs and travel times of different alternatives as compared with an existing route (ii) investment costs, (iii) regional traffic generated and (iv) benefits to Mompox Region derived from investments and from roadways improvement.

According to EV: (i) none of the options are economically feasible as national projects, eventhough at least two of them represent savings in travel costs and time (ii) the option recommended by the REA is not favoured on these basis (iii) the better alternatives as national interest projects are those that include *all* the bridges (at Yati, Bodega, Guamal, and El Banco) and are also the ones that imply higher benefits for the Mompox Region.

4.3 Social Valuation options

There are two major differences between the SV and other studies: (i) the region analysed excludes the peripheral areas (La Gloria, Tamalameque, El Banco and Magangué) and (ii) the interpretation of the objectives of the REA, given in the terms of reference. According to the SV these were:

"REA, should consider several alternative scenarios from the do nothing option to the development of regional and local multiple mode transportation systems that include improvement of the small and dry weather road network and of the infrastructure for fluvial transportation (rehabilitation of channels and fluvial connections, improvement of the service of ferryboats, docks and transfer stations). These studies should permit decision-making within a frame work of environmental sustainability, about the most adequate road and transportation systems needed in order to: (i) promote regional development, (ii) satisfy the needs and aspirations from the local communities, (iii) avoid exerting inadequate pressures over the fragile and already deteriorated ecosystem resources, (iv) preserve the local patterns of resource utilisation, and (v) promote the preservation of the historical and cultural heritage of the region, whose current status has been facilitated by the isolated conditions of the region."

The SV was developed in two phases; the first one in 2000 was basically a public consultation, during the second one in 2001 projects profiles were formulated based upon the recommendations from the public consultation. The total cost of the projects is US\$5.900.000. The recommended projects are:

1. Regional funds to repair and maintain secondary and tertiary roadways (150 km paved and 650 km hard top or earth roads)
2. Promotion of communal co-operative organisations to implement road and navigation public transportation
3. Hydraulic, hydrologic and ecological restoration of caño Guataca, left margin of Mompox arm, to control floods, to replace fishing resources and to allow small boat navigation.

4. Rehabilitation of caños mouths and ciénagas of the Central Depression (inter-fluvial area between Guataca caño and Mompox arm) to recover communal resources, and to re-establish dry season flows to the Mompox arm and to caño Guataca
- 5 Design of small boats adapted to flood plain conditions:
 - changes in boat type and sizes, engines and propulsion systems
 - construction of prototypes and
 - pilot evaluation
6. Evaluation of alternatives to increase low water level in Mompox arm (deviation of Cesar river flow and section narrowing with submerged dams), includes implementation of selected alternative.

5 Multi-objective evaluation of alternatives

Given the differences in interpretation of the terms of reference for the REA and in the scopes of each one of the studies, it is clear that individual options of investment in transport systems cannot fulfil by themselves the REA objectives. On the other hand, the diagnosis and the causal analysis demonstrate *contradictions between two objectives*: to *simultaneously* minimise changes on biotopes/resources and on current patterns of social utilisation, this contradiction is valid for the prevailing cattle system as well as for the subsistence economies. For the exposed reasons, it is considered necessary to conform alternatives by means of the grouping of complementary options. The investment options formulated by the different studies are shown in table 9. in three major groups: (i) options for the roadway network, (ii) options for the fluvial network and (iii) complementary options for the two networks. The location of fluvial and road options can be seen in map 2.

Table 9. Investment options in transportation systems in the Mompox Region

#	work or project	status	length (km)	benefitted zone
roadway network				
western access				
1	Magangué-Yatí	existing road, paved in 1996, narrow bank, localised fluvial erosion	3,8	flood plain (parcial) right bank of Mompox arm
2	bridge Yatí- Margarita island	new, would replace ferryboat	0,8	
3	viaduct Chicagua river		6,0	
4	bridge Chicagua river-Bodega		0,2	
stretches in Margarita island				
5	Bodega-Mompox	paved in 1995	37,3	flood plain (parcial)
6	Mompox-Sandoval	existing roads with hard top, recurrent deterioration during rainy season, narrow bank, culverts and bridges in poor condition	27,6	flood plain (parcial) right bank of Mompox arm
7	bridge Sandoval-Guamal		0,5	
8	Sandoval-Hatillo		39,5	
eastern access				
9	El Burro-Tamalameque	existing road, was once paved, presently with hard top,,damaged by large coal truck traffic	17,4	peripheral areas right bank of Mompox arm regional
10	Tamalameque-Zapatoza viaduct	existing road, hard top, narrow bank, recurrent deterioration during rainy season	32,9	
11	Zapatoza viaduct-Cesar river		12,3	
12	bridge Cesar river-El Banco	new, replaces balsas, indimensioned in studies	0,6	
stretches in right bank from Mompox arm				
13	El Banco-Guamal	existing road , hard top, recurrent deterioration during rainy season, narrow bank, culverts and bridges in poor condition	35,9	right bank of Mompox arm
14	Guamal-Santa Ana		57,5	
south access				
15	La Mata-bridge to Regidor	existing road, hard top,, access to oil pipeline	21,9	San Lucas range
16	bridge to Regidor	new,undimensioned in studies	0,7	
17	Regidor-Barranco (EE)	new along pipeline right of way	49,0	
18	Regidor-Barranco (EAR)	utilises a few existing stretches with narrow bank earth or hard top, poor drainage works	56,9	
19	bridge Barranco-Hatillo	new,undimensioned in studies	0,7	San Lucas range flood plain
northeastern accesses				
20	Chimichagua-El Banco	existing road, hard top,	35,1	right bank of Mompox arm
21	La Gloria-Santa Ana	existing road, hard top,	51,0	flood plain (parcial)

Table 9. Investment options in transportation systems in the Mompox Region

#	work or project	status	length (km)	benefitted zone
community interest roads				
22	in Margarita island (Bolívar)	32% are existing tertiary roads	82,9	flood plain (parcial)
23	in right bank of Mompox arm (Magdalena)	94% are existing tertiary roads	23,1	right bank of Mompox arm (parcial)
accesses not included in Mompox Region				
24	Regidor-Barrancabermeja	access options to Mompox Region considered by EV, without complementary information	w/o I	San Lucas range
25	Zambrano-Yatí		w/o I	peripheral areas
26	Apure (Plato)-Santa Ana		w/o I	periferia
fluvial network improvements				
27	Mompox arm navigability improvement	prefeasibility, includes pre-dimensioning of works	n. a.	flood plain (parcial) right bank of Mompox arm extra-regional
28	investments for fluvial infrastructure improvement	works and budgets undefined	n. a.	localised regional
29	rehabilitation of caños mouths in Central Depression	prefeasibility, includes pre-dimensioning of works and activities	n. a.	flood plain (parcial)
30	caño Guataca restoration	prefeasibility, includes pre-dimensioning of works and activities	44,5	flood plain (parcial)
31	small motorboat design improvement	pilot project, costs include: studies+designs+prototypes+evaluation	n. a.	regional
complementary projects				
32	institutional strengthening of environmental agencies	works and budgets undefined	n. a.	regional
33	institutional strengthening of Mompox private and public cultural organisations	works and budgets undefined	n. a.	flood plain (parcial)
34	regional funds for road maintenance and repair	prefeasibility, <i>annual costs</i> : 150 km paved roads+650 km hard top or earth roads	800	flood plain (parcial) right bank of Mompox arm regional
35	public transportation cooperatives	pilot project entrepreneurial building capacity	n. a.	regional

w/o I = without information n. a. = not applicable

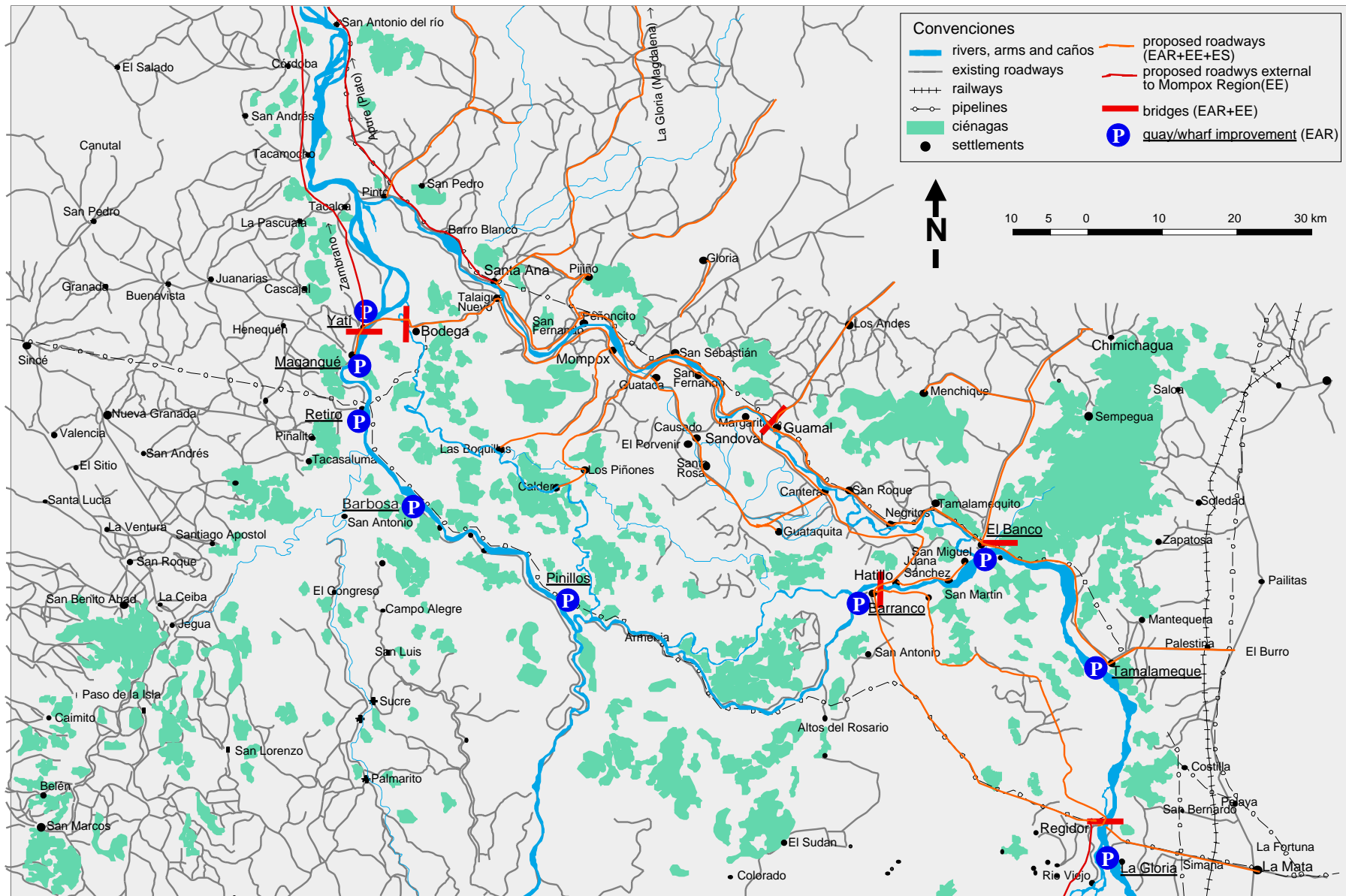
The steps for multi-objective analysis are: (i) definition of criteria for qualification of alternatives (ii) conformation of alternatives, (iii) calculation of payload (how each alternative performs with each criterion) and weight sets of criteria (iv) multi-objective analysis per se.

5.1 Criteria qualification

The criteria for qualification of the alternatives are based on the objectives explicit in the terms of reference of the REA. The alternatives, conformed by combination of options, will differ in their capacity to fulfil these pre-established objectives; some would favour certain objectives and would be disadvantageous for others; none would constitute an optimal solution. The strategy is to turn the objectives into variables to maximise and the restrictions and limitants into variables to minimise.

Satisfaction of local demands. Local demands are not well defined in any of the studies; the REA and the EV are biased in favour of the inter-connection of main highways, and the SV was limited to only two of the 4 zones of the Mompox Region. In order to account for this objective, *demand satisfaction was equated to maximisation of benefited population*. Criterion payload was measured by densities of rural and total population (inhabitants and settlements per habitable area) scaled over regional means of those parameters.

Maintenance of status of ecosystems and critical resources. In order to avoid the contradiction explicit in the terms of reference, given that the current status is an undesirable one, the objective was *changed from maintenance of status to improvement of status or reversal of current tendencies*. The criterion payload was measured by floodable area affected by each alternative, scaled over regional mean.



Map 2. Transport sector investment options de inversión analysed by the REA (Consultoría Colombiana, 2000) and the EV (Económica Consultores, et al., 2001) and citizen recommendations for complementary roadways (SV, Neotrópicos, 2001)

Maintenance of current patterns of resource utilisation. The second contradiction, this one implicit, in the terms of reference requires that two antagonistic systems be maintained: the large land owners livestock economy and the peasant subsistence economies are both to be maintained by the transportation development. Because in the Mompox Region the former one is expanding by displacing the second one the consideration was made that *alternatives are better if they favour subsistence economies and worse if they favour livestock economies*. Criterion payload was measured by densities of rural population and settlements benefited per communal area and by communal area affected within benefited zone, scaled over regional parameters.

Conservation of cultural heritage. Two different, not antagonistic but independent, aspects were considered (i) integrity of material culture from the city of Mompox and (ii) persistence of peasant culture (termed *amphibian culture* by anthropologists in attention to the multi-resource based utilised by their economies). Alternatives were qualitatively assessed as positive (1), negative (-1) or indifferent (0) in relation to their foreseen effects over each cultural aspect.

Other considerations for criteria qualification. The low availability of information or its low quality precluded the adoption of other indices to measure the criteria established. Indices considered but discarded for these reasons, included the following variables:

- costs of alternatives and significance as national projects; defined as alternative scenarios in the terms of reference, however the two variables should be decision criteria given the wide spectrum of costs and the fact that their financing is external
- level of complexity of environmental management and control required by alternative
- rural and urban demographic growth tendencies for each of the four zones
- actual production and expansive tendencies of livestock economy in each zone

5.2 Alternatives matrix

The complementary projects in themselves do not constitute alternatives of investment in the transportation sector to promote regional development; nevertheless, they are required in order to minimise deterioration (environmental, social or cultural) and to maximize benefits from the investments. Therefore, these projects must be associated to all the alternatives, but do not contribute to their discrimination, they were not included explicitly in the matrix and they were not part of the MOA. With the 35 options identified in table 9. an indefinite number of alternatives could be constructed, many of which would be trivial or meaningless; the 13 alternatives defined for the MOA are the ones closest to the options recommended by the three studies; these are identified in table 10., together with the values of the parametres needed to calculate the indices.

Table 10. Alternatives matrix

code	descripción	type	benefitted zone ²				area		population		# settle-ments	
			pM	pL	md	SL	pE	pO	habitable	total		rural
I	bridge Yatí+bridge Chicagua+viaduct	C	■					486	1.613	49.271	79.027	71
II	bridge Guamal	C			■			1.228	2.841	92.930	163.500	198
III	bridge río Cesar	C						399	813	15.899	61.390	46
IV	bridge Hatillo+road Barranco-Regidor-La Mata (EV)	C				■		818	818	94.718	113.257	86
V	puente Hatillo+vía Barranco-Regidor-La Mata (REA)	C		■		■		674	818	94.718	113.257	86
VI	Mompox-Sandoval-Hatillo	C	■					429	1.242	29.408	54.310	52
VII	Santa Ana-Guamal-El Banco	C			■			742	1.228	43.659	84.473	198
VIII	bridge Cesar river-viaduct Zapatoza-El Burro	C						399	813	15.899	61.390	46
IX	6+7+2 Mompox-Sandoval-Hatillo+bridge Guamal+ Santa Ana-Guamal-El Banco	C	■		■			1.228	2.841	92.930	163.500	269
X	9+3 Mompox-Sandoval-Hatillo+bridge Guamal+ Santa Ana-Guamal-El Banco+bridge Cesar river	C	■		■			1.627	3.653	108.829	224.891	315
XI	navigability Mompox arm+improvement small motor boats	F	■	■				2.555	4.792	130.851	255.181	375
XII	improvement small motor boats+quay/wharves infrastructure	F	■	■				3.622	7.936	299.392	519.872	533
XIII	caño Guataca restoration+rehabilitation ciénagas Depresión Central	F	■					379	1.081	29.408	54.310	44

regional rural population 299.392 total regional population 519.872

habitable regional area (km²) 4.109 total regional area (Σbiotopes areas, km²) 8.533

¹ C = road alternative

F = fluvial alternativa

² pM = floodplain Mompox arm
SL = San Lucas range

pL = floodplain Loba arm md = right bank Mompox arm
pE = eastern peripheral areas pO = western peripheral areas

Common elements to all alternatives are: (i) institutional strengthening of local and regional environmental agencies (CSB, COR-PAMAG and CORMAGDALENA) for improvement of environmental control, and planning in their jurisdictional areas; (ii) institutional strengthening of Mompox city private and state agencies to promote conservation of cultural heritage; (iii) regional funds for repair and maintenance of roadways and waterways; (iv) efficient, low cost, co-operative, road and fluvial public transportation systems.

5.3 Pay matrix

It is not included in this summary data were calculated according to algorithms defined above. Data are not useful to the reader as they do not permit alternative discrimination by inspection.

5.4 Weights of objectives and criteria

The terms of reference do not pre-define selection scheme of alternatives nor weight of criteria. Three sets of weights were utilised, each was constructed according to the following rules:

1. Weight of demand satisfaction = \sum restrictions weights
2. Social restrictions weights > ecological and cultural restriction weights
3. \sum indices weights = weight of criterion of objective or of restriction

5.5 multi-objective analysis⁴

It was carried out by means of three algorithms: (i) weighted averages; (ii) compromise programming and (iii) Electre IV. MOA is normally performed in two steps, the first one to eliminate inferior solutions and the second one to establish ranking of suboptimal alternatives (those not eliminated in the first step). However, the results from each of the algorithms for the different weight sets were not uniform and no particular alternative could be safely discarded. The results of the MOA are presented in table 10. It is clear that they were not conclusive. In general demands and restrictions are not well satisfied, which indicates that conflict cannot be easily solved, some interesting tendencies are worth commenting:

1. weighted averages and compromise programming show similar results and favour the following alternatives:
 - I (Yatí bridge-viaduct-Chicagua bridge)
 - V (articulation between San Lucas range and Margarita island)
 - IX (roadway circuit on both margins from Mompox arm, articulated with the bridge Sandoval - Guamal)
2. alternative XI (improvement of navigability of Mompox arm plus improvement of small boats) is consistently discarded by the three methods
3. ELECTRE favours alternatives XIII (rehabilitation of Guataca caño and cienagas from Central Depression) and X (Mompox arm circuit plus bridge over Cesar river at El Banco); to a lesser degree it favours also alternatives V and IX. and presents conflicting results for alternative XII (small boat improvement and quays and wharves improvement).
4. Alternative II (Sandoval-Guamal bridge) without other works is mediocre solution with all methods.
5. The two alternatives for articulating San Lucas range zone are equally favoured by the three methods and alternate their position according to the ecological or social emphasis of the weights.
- 6 All distances of compromise programming method are larger than two thirds of the rank (distance > 0,33) when all the criteria are considered, whereas if only the criteria for demand are considered (fundamental objective), the distances are all small; this emphasises the conflicts between the objective and the restrictions on the one hand and the limitations of the indices on the

⁴ MOA algorithms and methods are detailed in: Smith Q., Ricardo A., Germán Poveda J., Oscar J. Mesa S., Darío Valencia R., Isaac Dyer R. 1993. Decisiones con múltiples objetivos e incertidumbre. Universidad Nacional de Colombia, Facultad de Minas, publicación n° 5 del Postgrado en Aprovechamiento de Recursos Hidráulicos. v+231 pp. Medellín. Calculations were made with 4th Dimension application developed in Neotrópicos by M. M. Toro Uribe y L. C. García Lozano.

other..

Table 10. Mompox Region, MOA of transport solution alternatives. Ranking for identification of optimal alternative

weight set	13 criteria		13 weight		3	
	alternative	relative value	alternative	distance	alternative	ranking
I	1	6,14	1	0,43	13	1
	5	5,99	4	0,45	10	2
	9	5,39	9	0,46	9	3
	12	5,36	5	0,46	7	4
	13	5,36	13	0,47	5	5
	4	5,29	10	0,47	4	6
	10	5,02	2	0,48	2	7
	2	4,93	12	0,48	1	8
	3	4,35	7	0,52	12	9
	8	4,35	3	0,54	11	10
	7	4,19	8	0,54	8	11
	6	3,68	6	0,54	6	12
	11	3,46	11	0,55	3	13
II	1	6,05	1	0,44	13	1
	5	5,81	4	0,44	12	2
	9	5,49	9	0,45	10	3
	12	5,49	13	0,46	9	4
	13	5,37	12	0,47	7	5
	4	5,29	10	0,47	5	6
	10	5,08	5	0,47	4	7
	2	4,94	2	0,47	1	8
	7	4,45	7	0,50	11	9
	3	4,44	11	0,52	2	10
	8	4,44	3	0,53	8	11
	6	3,70	8	0,53	3	12
	11	3,68	6	0,53	6	13
III	1	6,23	1	0,43	13	1
	5	6,16	5	0,45	9	2
	13	5,34	4	0,45	5	3
	4	5,30	9	0,46	4	4
	9	5,29	13	0,48	2	5
	12	5,22	2	0,48	1	6
	10	4,96	10	0,48	12	7
	2	4,92	12	0,50	11	8
	3	4,25	7	0,53	10	9
	8	4,25	6	0,55	7	10
	7	3,94	3	0,55	8	11
	6	3,67	8	0,55	6	12
	11	3,25	11	0,57	3	13

5.6 Conclusions

The information on natural and cultural environments of the Mompox Region contained in the studies is very precarious, which limits the formulation of indices to evaluate alternatives of solution. The fundamental objective as well as the restrictions are evaluated with very few parameters and these -in particular data on resource utilisation, inferred from the spatial distribution of the population- are uncertain and aggregated for very large areas. This limitation is exacerbated by the contradiction between the fundamental objective and the ecological and social restrictions, given the lack of indices based on independent parameters to evalu-

ate each one.

The fluvial alternatives in general are very poorly formulated in the studies, particularly in the REA and they do not compete in the detail of the formulation with the roadway solutions. The alternatives formulated in this synthesis are based on the recommendations of Consultoría Colombiana (2000) and Neotrópicos (2001), but it is recognised that additional information on minor navigation in the Mompox Region is required in order to formulate more suitable alternatives of fluvial transport. No information is available on the routes (frequencies, volumes of cargo and passengers, costs and seasonal variations in those parameters); there is very little information available on wharves, accesses and conditions and on their operation costs.

The MOA of the considered alternatives outlines a combination of roadway and fluvial solutions to satisfy local necessities while maintaining ecological, social and cultural restrictions. The improvement of the circuit Bodega - Hatillo de Loba and Santa Ana - El Banco, plus the Guamal bridge is the best road alternative (alternative IX), whereas the restoration of the Guataca caño and ciénagas of the Central Depression of the Margarita island (XIII) is the best fluvial alternative. Alternative I (Yatí bridge-viaduct to Bodega) is favoured by its low ecological and social incidence and by its high satisfaction of the demand.

The analysed alternatives resembled as much as possible the original options formulated by the consultants but it is recognised that an ample spectrum of combinations could have analysed, v. gr., the several bridges (Yatí - Bodega, Sandoval-Guamal, Cesar river, Hatillo - Barranco, etc.) as road alternatives, or several road stretches within a given zone, etc. But the basic difficulty persists: Insufficient, detailed information for units smaller than the municipality to establish comparisons.

6 Recommendations

The complementary projects *subregional funds for road maintenance* and *public transport systems* must be better formulated and extended to allow to improvement and maintenance of the fluvial network and the improvement of the fluvial public transport system. The roadway options recommended by the community are evaluables by means of the criteria defined above with the MOA techniques, nevertheless by its strictly local character they cannot be considered as bona fide alternatives and therefore is not evaluated; nevertheless its implementation can be carried out by means of the application of the complementary project of subregional funds.

The regional environmental assessment associated to the transport sector in the Mompox Region suffers from important deficiencies that limit the formulation of clear recommendations for decision making. The fundamental one is the change of emphasis in the several studies and the importance that two of them (Consultoría Colombiana, 2000 and Económica Consultores et al., 2001) gave to the concept of *national interest highway that would articulate the two main western and eastern highways*, that the original terms of reference (INVÍAS, 1998) considered only an *alternative scenario of the solutions to formulate* and not a criterion of evaluation of them.

In the case of the second study (Económica Consultores et al., 2001) it is perfectly acceptable, its own terms of reference (INVÍAS, 2000) so demanded; but in the case of the REA it is questionable. This situation biased the search of solutions and prevented the formulation of alternatives nonrelated to the articulation of the national highway systems and of fluvial alternatives for minor navigation. Perhaps this could have been avoided if the REA had been carried out by an environmental planning organisation unrelated to the transport sector, such as the Ministry of the Environment, or the Unit of Environmental Planning of the National Direction of Planning or Plan Caribe from the same institution. It is easy to understand that throughout the process, *Invías* had biased to its interest towards emphases more in agreement with its mission and jurisdiction, i. e., and, roadways of national interest.

The analysis of the issues of regional development, the formulated in this synthesis, as well as the appreciation of the communities consulted by Neotrópicos (2000 and 2001) leaves clear that the limitations for regional development in the Mompox Region go beyond those that investment programs in the transport sector could solve. On the one hand, the Mompox Region is not isolated of the rest of the country, the deficiencies are more qualitative (quality of the components of the transport system) than quantitative (absolute magnitude of the fluvial and roadway networks), although large sectors can present deficiencies that limit their possibilities, such as the south of the Margarita island and extensive areas within the mountainous area of San Lucas range.

On the other hand, it is exactly the unplanned development of the regional road network, and the total lack of controls on the part of the environmental authorities, the fundamental reason of the present tendencies of resources deterioration and consequently of

rural migration. In this scenario, new developments that improve the accessibility to the region can exacerbate the present deterioration and cause, in the long term, graver damages than to contribute with positive changes.

Despite what it is said, it is clear that the regional qualitative deficiencies of the transport system are a major factor of the regional underdevelopment and INVÍAS, as well as CORMAGDALENA (which has jurisdiction over the fluvial network) can contribute widely to the regional development by means of carefully focused investments in the transport system.

The synthesis posed five basic questions that a REA would have to respond, each one is repeated here and commented upon.

1. Which are the environmental potentialities and limitations (even of cultural, social and economic nature) for the development of the Mompox Region?

The potentialities as well as the limitations are related to the natural supply of resources and the present patterns of utilisation. Resources are plentiful (fish, game, firewood, timber, fibres, pastures, seasonally available areas for short cycle crops, water for domestic consumption and animal care, etc.) and are associated to the *floodable communal areas*. The only limiting resource over large portions of the region is *nonfloodable areas*; its scarcity limits the establishment of perennial and long cycle crop plantations and population settlements. Nevertheless, the predominant utilisation patterns -extensive cattle ranching and subsistence peasant economies- are basically extractive, without replacement and without control and compete with each other. The hydrologic regime is the only control, but it is slow, unpredictable and it is socially considered catastrophic. On the other hand, the nonfloodable areas are concentrated in large cattle estates that not only expand over the communal areas, but generate very few jobs. The tendency to the depopulation of the rural areas is a reflection of the crisis of the peasant economies by depletion of resources.

2. How would be affected the potentialities and limitations with programs and projects of the transport sector?

The unplanned development, improvised and without control of the roadway network is simultaneously result and cause of the cattle economy expansion. In this sense, unless strict control is exerted on the present uses and the road developments adjust to clear restrictions basically related to the handling of the drainage to maintain the pulses of drainage and flood, the development of the road sector can be more cause of conflicts than of solutions. The essential ingredient is the strict control on the part of the environmental authority that does not have the human resources nor the financial means to attend this demand.

3. Which would be the characteristics of suitable transport developments?

The alternatives posed by the several consultants are based on the supply of existing infrastructure (road component) and on the natural conditions (fluvial component); in this sense, no additional direct deleterious consequences are expected. Nevertheless, the indirect consequences will persist unless the adopted alternatives, whichever they happen to be, are complemented with the following programs (i) institutional strengthening (CSB, CORPAMAG and CORMAGDALENA) for environmental control in their jurisdictions, (ii) institutional strengthening of Mompox organisations, to ensure the conservation of cultural heritage, (iii) subregional funds for roadway and waterway maintenance and (iv) co-operative systems for efficient fluvial and road public transport. These programs were roughly delineated in two studies (REA and SV) but, with the exception of the subregional fund for road maintenance, they were not adequately formulated. Activities were not detailed and realistic budgets were not included.

4. What ought to be done by the promoting organisation -INVÍAS- and by other organisations (CORMAGDALENA, CSB, CORPAMAG), to minimise the environmental disadvantages of transport projects and to optimise the benefits from them derived?

Neotróicos (2001) formulated two alternating schemes to implement the component of subregional funds for road maintenance. The first one as *compensations for deterioration associated to the developments* and a second one by means of an inter-administrative agreement between INVÍAS and associations of municipalities. INVÍAS in principle has considered the two options viable. It is recommended that the component be extended to include resources and activities destined to the fluvial network; this would imply similar inter-administrative agreements with the regional environmental authorities (CSB and Corpamag) and multiregional (Cormagdalena).

On the other hand, for the defence of the cultural heritage of Mompox a similar relation with the municipality could be considered. In any case, the complementary components require to be redefined as far as their objectives, scopes, activities, budgets and time horizon.

Finally it is recommended that financial and technical aid be given to the limited efforts from NGOs for restoration and conservation of the biodiversity of Mompox Region flood plain. These initiatives were identified in chapter 2. of the synthesis; the component was not formulated by any of the studies.

5. Could sustainable systems of transport in the region of Mompox be implemented? Sustainable because they contribute to - or at least they allow- the recovery and conservation of the base of resources and its social utilisation, and because the changes derived from the new transport system, generate the necessary financial resources for their continued operation?

It is perhaps simplest of the questions. Environmental sustainability in the present conditions is nonviable; still in absence of additional developments the cycle of impoverishment and deterioration will continue. Nevertheless, the great natural dynamics of the biotopes of the alluvial plain allows to glimpse a recovery scenario. As long as during a prolonged time, the transport sectors, road and fluvial, together with the environmental authorities join efforts to put forward whatever developments are finally agreed upon and that *these are complemented with the complementary projects repeatedly mentioned in this synthesis*. Up to here the first part of the question, a definite but conditional yes.

The predictions for the financial sustainability are another subject. Neotrópicos (2001) clearly stressed the impossibility that the developments of the transport sector could be financed within the region; not even the component of maintenance of the existing infrastructure could be financed. On the other hand, the practices of utilisation of resources, mediated by historical events and maintained by the unequal distribution throughout the region of a single limited resource -nonfloodable areas- precludes the possibility of glimpsing a new scenario that could generate the financial resources to compensate these developments. In other words, the development of the transport sector must be externally financed and in this sense, even the complementary components are financially unsustainable.