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WATERSHED MANAGEMENT IN THE UPPER GAMBIA RIVER BASIN

report on a planning consultancy
to the River Basin Development Office
AID/Senegal

Peter H. Freeman
February, 1987

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Report on a Planning Consultancy to the OMVG

February, 1987

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Introduction

This report presents the results of a consultancy on the subject of watershed management in the Gambia River Basin, carried out in the context of AID's technical assistance to the Gambia River Basin Development Organization (OMVG) (Project 625-0012).

The purpose of the consultancy was to outline an approach or strategy for the OMVG in watershed management and develop an action plan suitable to the OMVG's institutional mandate. The terms of reference called for a review of existing watershed management or watershed management planning, of existing data on sedimentation in proposed impoundments, of current plans for environmental monitoring in the basin, and an assessment of the contribution watershed management could make in the river basin's development program.

The focus is on the management of water, land and vegetation in catchment areas according to the hydrological function of the catchment. In practice, that hydrological function may be ensured through development projects as well as through conservation of natural vegetative cover. However, such projects would be shaped according to the primacy of the hydrological function.

The consultancy was carried out in Senegal and Guinea during January 16 to February 7, 1987, however preparatory and follow-up work in Washington, D.C., was also entailed. An itinerary and list of persons interviewed is appended.

During the time I spent in Dakar, the entire OMVG staff was occupied for over a week in joint programming work with UNDP representatives, and during the last week of my stay, the 7th meeting of OMVG heads of state took place in Banjul. Consequently, interaction with OMVG staff was somewhat limited.

I wish to extend my thanks to AID's River Basin Development Office Staff and the AID technical assistance team at the OMVG for their hospitality and cooperation. Special thanks are due Paul Andre de Georges for camaraderie and daily logistics. Also, I was received courteously in telephone interviews as well as visits with a number of individuals in Washington D.C. and elsewhere in the USA, in the course of preparing for the mission. Their names are listed in the Appendix.

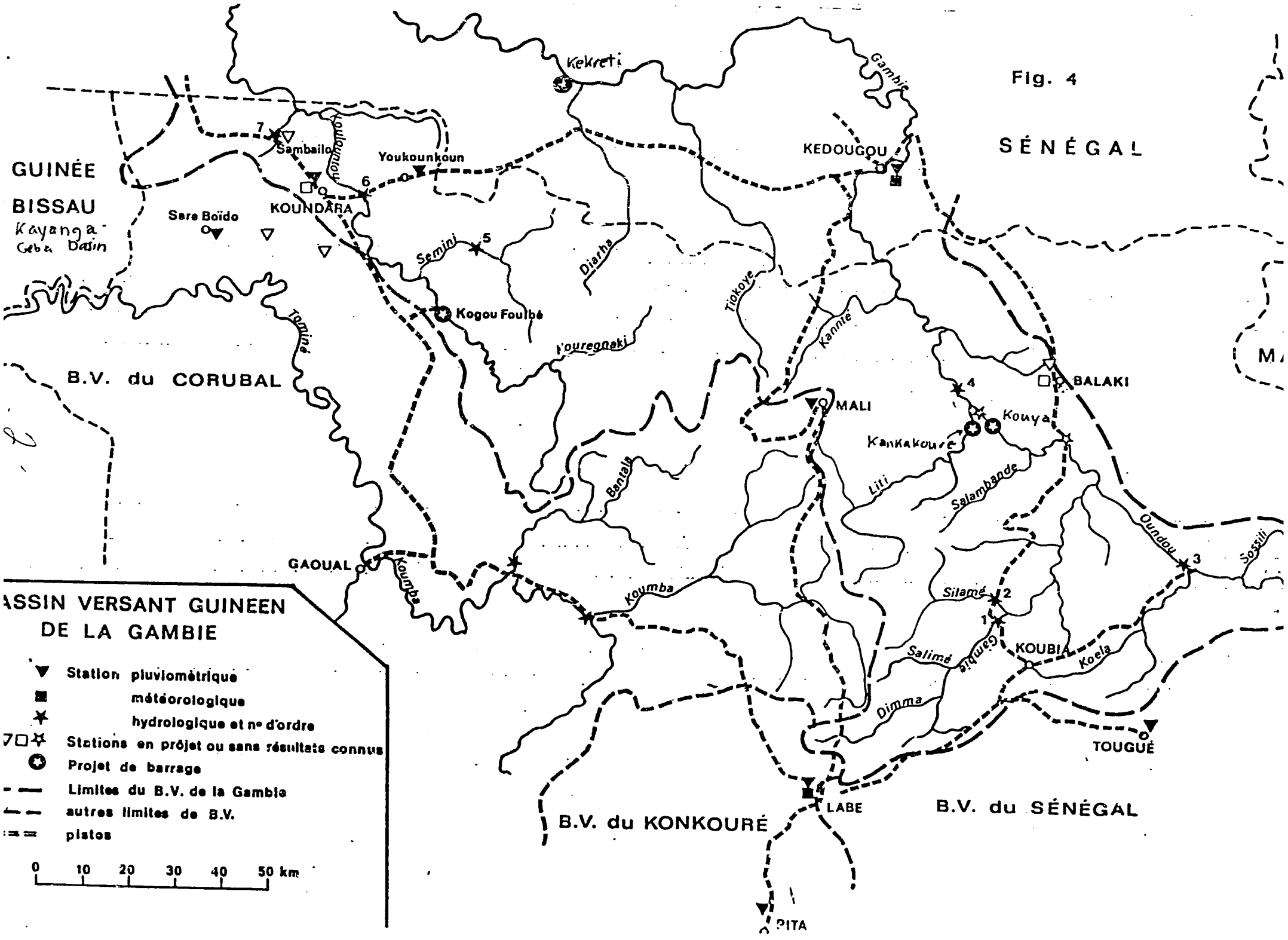


Fig. 4
SÉNÉGAL
GUINÉE
BISSAU
Kayanga
Geba Dasin
Kekreti
Gambie
KEDOUGOU
Sambailo
Youkounkoun
KOUNDARA
Sare Boïdo
Semini
Diarha
Kogou Foulbé
Kouregnaki
Tiokoye
Kannté
Tominé
B.V. du CORUBAL
MALI
BALAKI
Kouya
Kankakoure
Liti
Salambande
Bantala
Oundou
Sossili
GAOUAL
Koumba
Silamé
Salimé
Gambie
KOUBIA
Koela
Dimma
TOUGUÉ
LABE
B.V. du KONKOURÉ
B.V. du SÉNÉGAL
PITA
ASSIN VERSANT GUINEEN
DE LA GAMBIE
Station pluviométrique
météorologique
hydrologique et n° d'ordre
Stations en projet ou sans résultats connus
Projet de barrage
Limites du B.V. de la Gambie
autres limites de B.V.
pistes
0 10 20 30 40 50 km

Watershed management in the OMVG program

Watershed management does not figure in the OMVG's present program, which is essentially that set forth in the 1985 Schema Directeur d'Amenagement du Bassin du Fleuve Gambie. The focus of that master plan is control of saline intrusion up the Gambia River by means of the Balingo barrage, water storage and hydropower production from the Kekreti dam near Kedougou, and irrigation development of 70,000 ha of irrigable soils in a 50-year period. With the association of Guinea-Bissau to the OMVG, an added goal is the integrated development of the Kayanga-Geba and Corubal-Koliba basins, for which planning is needed. Financing was also being sought for a feasibility study of the Kouya dam in Guinea.

Also, development in Guinea is being studied in the OMVG, i.e. "amenagement des bassin versants", in the context of proposed "mini-barrages" for small scale irrigation development.

The OMVG has not yet defined for itself an institutional role and related program in matters not related to the financing of these various developments. For instance, the OMVG does not operate a hydrological and meteorological station network, or pilot research and development projects.

AID and UNDP financed technical advisors to the OMVG, and their African counterparts, have generated studies and analyses of potential use to watershed management planning, which are cited elsewhere in this report. However, there exists no programmatic context for watershed management planning. Also, given the policy focus on financing dams first(for which much of the feasibility and design work has already been done), a dynamic planning context for incorporation of watershed management has been lacking.

The OMVG appears to be following the example set by the OMVS. It proceeded from an indicative development plan to feasibility and design studies of the Diama salt barrier dam at the river's mouth and the Manantali dam upstream, built for hydropower and irrigation waters storage. Both have been financed. The Diama dam has been completed; the Manantali is in advanced stages of construction. Meanwhile, small scale pumped irrigation is being pursued. Notably, there is no watershed management aspect in the OMVS program. The Senegal River also arises in the Guinean Fouta Djallon highlands, where the Gambia River has its headwaters.

The Permanent Water Committee of the OMVG, which would be empowered to consider and propose an action program concerning watershed management, has never met and exists only on paper.

Watershed management could be seen an an environmental concern. The environmental advisor and his counterpart have initiated the formation of a Subcommittee on the Environment, which has met twice to consider and react to a proposed environmental monitoring and surveillance activity, centered at regional field laboratories in Gambia, for the lower basin, and Labe, Guinea,

for the upper basin.

(I made a detailed critique of this plan to Paul Andre deGeorges, with written commentary on the draft.)

The OMVG had not taken a strong official stand on this proposal. However, a measure of official endorsement of the proposed monitoring and surveillance activity was contained in a speech by Senegal's President Abdou Diouf, at a meeting of the OMVG heads of state in Banjul, during February, 1987(Le Soleil, Feb. 5, 1987).

(With regard to the OMVS as a model, it is noteworthy that the OMVS is not doing any monitoring or surveillance of environmental changes(except for the AID-financed groundwater monitoring effort), and has therefore missed the opportunity to measure changes caused by the Diama salt barrier on estuarine and river ecology and productivity.)

During 1987, several opportunities exist for pursuing an initiative in watershed management within the OMVG's program.

1. The planned installation of "environmental monitoring laboratories" in Gambia and Guinea.The field laboratory at Labe, Guinea, could well become a focal point for watershed management actions in the upper Gambia River Basin. Its genesis and prospects are discussed in detail in a later section.

2. The broad planning study to be carried out by the years' end as part of AID's technical assistance to the OMVG. (Mr. Songthara Omkar arrived in Febrtuary, 1987, to initiate this work).

3. The development of small dams and irrigation at two sites in Guinea(Sambailo and Dougel Sigon).

These possibilities are examined following a review of watershed management issues in the the Fouta Djallon.

The Fouta Djallon Watershed.

Seventy percent of the Gambia River's flow originates in the Fouta Djallon massif, in Guinea(Risely, personal communication). Its headwaters in Guinea total apprpxomately 12,000 sq. km.

The massif is also the headwaters of the Senegal and Niger rivers, and a number of lesser rivers, including the Koumba River which flows into Guinea-Bissau(see map).

All these rivers share the characteristic of steep gradients in their Guinean headwaters, abruptly changing to shallow gradients once they flow out of the highlands onto the semi-arid, flat Continental Terminal erosion surface. The essential hydrological catchment of these rivers is the Fouta Djallon massif, contained entirely within the Republic of Guinea.

Physical geography of the Fouta Djallon

The unique geography of the Fouta Djallon as well as its mineral resources have attracted the attention of travellers and researchers since many years ago, and more recently a regional program for the "Projet de Restauration et d'Amenagement Integree du Fouta Djallon" under the aegis of the Organization for African Unity, now beginning its third year of field work. That effort is described later.

Of particular relevance to this consultancy are various studies by foreign and African researchers on the geomorphology, soils, hydrology and landuse in the Fouta Djallon, including studies commissioned by the OMVG. Only some of this work was seen.

The Fouta Djallon's geomorphology has been studied by Michel(1967)(not seen) and more recently reviewed by Lo(1984), who also measured suspended and dissolved sediments in the Gambia River at Gouloumbou during the 1983 rainy season. Numerous earlier works on its physical geography are cited by Pascual(1986) in a brief but informative description of the geomorphological aspects of laterization in the massif.

The massif is ancient and tectonically quite stable. Millions of years of tropical weathering apparently dominated by alternating wet and dry seasons have reduced rocks or sediments to laterite and bauxitic earth, over large surfaces. Vertical faulting has controlled the stream courses in many places.

Major questions are still unanswered concerning the evolution of the various erosion surfaces of the Fouta Djallon. Within the Gambia River portion of the Fouta Djallon, at least three erosion surfaces are discerned (Lo, 1984). All three are capped with laterite.

(1) The "Labe surface" - 1200 m elevation post Paleozoic remnants.

(2) The Dongel Sigon surface - 850 - 900 m elevation

(3) The Fantofa surface - a well preserved lateritic plateau at 550 to 600 m elevation

The predominance of lateritic earth or ironstone cuirass(crust) greatly influences the hydrological behaviour of the Fouta Djallon, and imposes important limitations on crops and landuses.

Laterite is a highly weathered material rich in secondary oxides of iron, aluminum, or both. It is nearly devoid of bases and primary silicates, but it may contain large amounts of quartz and kaolinite. It is either hard or capable of hardening on exposure to wetting and drying(Alexander and Cady, 1962). Layers of doughy laterite often occur underneath a leached upper soil. Upon exposure to wetting and drying, through erosion or deforestation, these layers harden irreversibly.The ferruginous crusted, or hardened, form is termed "cuirasse" in the French language and ironstone in English.

Laterite in different concentrations and stages of induration occurs on steep slopes as well as flat or gently sloping terrain in the Fouta Djallon. Cuestas and cliff forming sandstones are capped by ironstone crusts and deeply incised by streams.

Among other peculiarities, termites appear to play a beneficial ecological role in maintaining a measure of fertility in soils underlain by laterite, e.g. the flat or undulating "bowe" surfaces(Pascual, 1986). McGauhey also reports the absence of laterite under forest cover, and the possibility of reclaiming areas with hardened laterite through tree plantings(McGauhey, 1984).

On-going research on the laterization process is especially germane to any consideration of soil erosion and its control. In 1985, the Direction de Recherche Scientifique et Technique of Guinea undertook field studies of the geomorphological aspects of cuirass formation in the Fouta Djallon(Pascual, 1986), with co-financing from the French Centre National de la Recherche Scientifique.

For a number of years researchers working out of ORSTOM/Dakar(Hann) have been studying geomorphological degradation of the entire massif, largely through analyses of sediments and dissolved solids in the various rivers arising in the massif. The object of the research program, which is headed by Dr. J. Y. Gac, is to model soil erosion processes in the Fouta Djallon. This work is now part of an international research effort(PIRAT) begun in 1986 and headquartered in Florida which is seeking relationships between plate tectonics and laterization.

Any future work by the OMVG in the Fouta Djallon should entail complete familiarity with past and on-going research on the massif's geomorphology and related pedology(soils formation) and hydrology.

The OAU Fouta Djallon Project

The Organization of African Unity has served as the political coordinating body for a program for "the restoration and integrated development of the Fouta Djallon", the need for which was first enunciated in the 1960's, in recognition of the regional importance of the massif's hydrological function.

With UNDP and UNSO financing and technical assistance, a program of reconnaissance studies and mapping of the entire Fouta Djallon was initiated in 1984. A series of thematic maps was undertaken (bioclimate, geomorphology, soils, landuse and vegetation, land use potentials) at the 1:250,000 scale. (Cueto and Khoumba's soils mapping work done through the OMVG, and described above, is included in the series.) A preliminary zonation of the massif was carried out, according to environmental and resource management similarities. These maps or mapping materials were not yet generally available; they can be seen at the project's headquarters in Labe, however.

The next phase of the OAU project pursues a strategy of working with small watersheds on a pilot basis in the different zones of the massif. Twelve representative watersheds or "bassins representatifs" have been identified throughout the massif for more detailed studies and actual development.

Earlier, AID had funded a pilot project in Pita involving reforestation and range management, in which Peace Corps volunteers were involved. These and other development experiences in the Fouta Djallon comprise the technological point of departure for the efforts to be undertaken in the representative basins.

The UNDP proposes to focus on one of selected watersheds(Batinguel, not in the Gambia Basin), in a proposed four-year, $4.0 million project, that will be a country project, as opposed to the effort to date which has been a regional project. (In February, 1987, UNDP was preparing projects and programs for the next funding cycle).

Two of the pilot watersheds fall within the Gambia River Basin. and therefore would be of potential interest to the OMVG.

Organization of Guinean government services in the region

The Fouta Djallon region corresponds to the administrative region

of Moyenne Guinee. The on-going decentralization of governmental functions is auspicious for the regional focus on the Fouta Djallon that has been pursued in the OAU project, begun in 1984.

A special office, the Service National de Restauration et d'Amenagement Integree du Massif de Fouta Djallon, has been set up to coordinate efforts. The Service is located within the Ministere de Ressources Naturels et de l'Energie, specifically in the office of the Secretariat d'Etat des Eaux et Forets. A National Technical Coordinating Committee was set up to coordinate governmental services, while a National Coordinator ensures coordination of neighboring states and international donors, as well as regional organizations such as the OMVS, OMVG and the NBA.

The Service oversees the various projects underway in the Fouta Djallon such as those of UNDP and ORSTOM.

Financing was being actively sought to fund pilot management and development activities in the various representative catchments in the massif, identified during the OAU project. Contact had been made and expressions of interest elicited from the EEC, the Canadian Centre des Etudes et de Cooperation Internationale(CECI), GTZ, FAC and CIDA. Also Euro Action Accord (representing various European NGO's), Volontiers Francais and the Peace Corps have been approached.

The Peace Corps is preparing an expanded program in the Fouta Djallon as a part of its Accelerated Food Production in Africa program, initiated in 1986.

Watershed management in the Fouta Djallon

The Fouta Djallon massif has been called the "water tower" (chateau d'eau) of West Africa. The three most important rivers of semi-arid West Africa arise in the Fouta Djallon, namely the Niger, Senegal and Gambia rivers. Almost the entire flow of these rivers is run-off from the Fouta Djallon massif. Its role as a critical catchment is well established.

"Chateau d'eau" is a somewhat misleading metaphor, however. In fact the "water tower" is empty or almost so for four months out of the year on average: February to May. Rainfall is markedly seasonal but variability in the massif is less than in the lower valley in Senegal and Gambia. Labe's mean of 1670 mm has a standard deviation of 246 mm; at Pita the s.d. is 327 for a mean of 1719 mm.(Webb, 1986).

The large extent of ironstone(cuirass), either exposed or with a shallow covering of soil, renders much of the massif quite impermeable(Lo, 1984). The markedly seasonal rainfall over the Fouta Djallon, the general impermeability of its rocks and lateritic surfaces, and the aridity of its dry season(heightened by the Harmattan wind) combine to severely limit the massif's potential to store rainfall and release it following the rainy season.

This is evidenced by the precipitous drop in flow at the end of the rainy season. The Gambia River may dry up entirely; the minimum monthly flow during 1972-1980 averaged 0.4 cubic meters/second in May at Kedougou(Harza, 1984).

Notwithstanding these peculiarities, at least two, more or less classical objectives of watershed management can be posited.

(1) soil erosion control and stabilization of stream courses in order to limit sedimentation in reservoirs and irrigation canals, and,

(2) retardation of run-off by means of biological and structural measures so as to buffer extreme flows(and limit stormflow damage) and enhance percolation to the subsurface.

The OMVG could well pursue these two objectives in any future watershed management program, since they are related to the issue of sedimentation of reservoirs, both large and small, in the upper basin.

The degradation of the Fouta Djallon massif(erosion, loss or pauperization of forest and other natural vegetation, uncontrolled burning) has been of general concern for many years. Degradation of the massif could jeapordize dams and related land development, especially with regard to shortening reservoir life due to sedimentation. However, not until 1984 were concrete actions taken to address degradation on a regional scale, namely the OAU's Regional Project for the Rehabilitation and Integrated Development of the Fouta Djallon, described later.

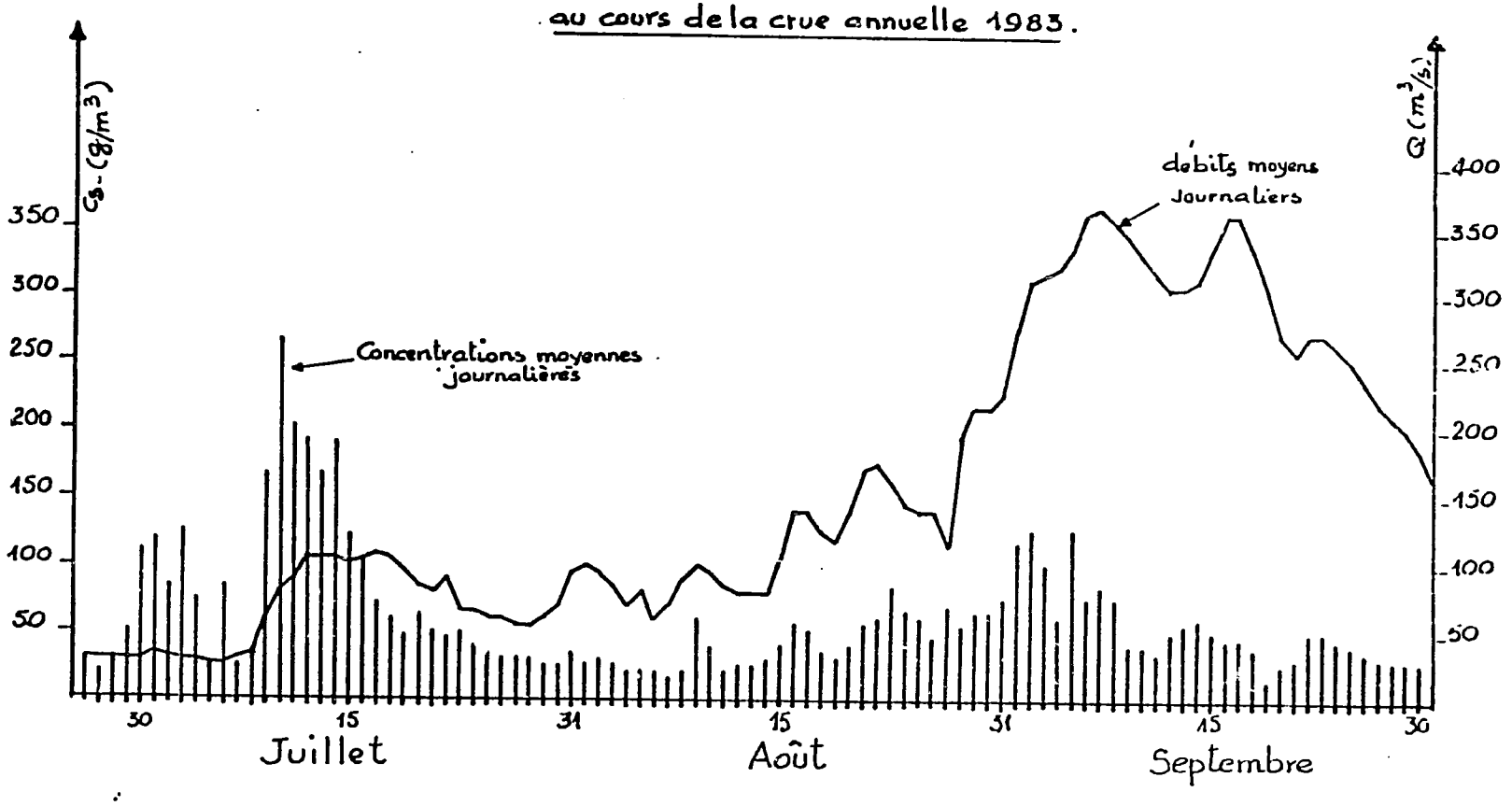
It appears that little can be done with vegetative cover to alter the seasonality of the river's flow, although storm flow peaks can be attentuated with vegetation. In particular, further deforestation of areas prone to cuirass formation should be controlled, not only to prevent faster run-off but also to preserve site potential.

Sedimentation

Although as yet the OMVG's program does not include sedimentation as a potential problem or issue, the question has not gone unnoticed, as the work reviewed next attests. The review finds that sedimentation is not a serious potential problem for large dams but could be for smaller dams in the upper tributaries.

Sediment transport and erosion are related but are not equivalent quantitatively. The amount of sediments actually moved into streams and transported in suspension is only a fraction of the total or gross erosion that takes place in a watershed. This fraction, known as sediment yield is estimated to be 20 percent of total erosion in the United States. (In the French language sediment yield, computed from suspended sediment measurements, is

Fig. 40 Variations des concentrations moyennes journalières de matières en suspension avec les débits à Goulouinbou au cours de la crue annuelle 1983.



Source : Lo 1984.

termed "degradation specifique")

While erosion may be locally severe in the Fouta Djallon, the amount of sediments transported into the Gambia River is quite low. Although various estimates of sedimentation rates and sediment yields from watersheds show little agreement, many tend towards an overestimation of sediment yield, compared to the rates indicated by actual measurements of suspended sediment.

Sediment transport and sediment yield in the Gambia River Basin

The amount of suspended sediment in the Gambia River and its tributaries will determine the useful life of reservoirs that may be built.

Although suspended sediments in the Gambia R. and its tributaries are nowhere routinely monitored, sediment transport has been measured and estimated in the upper basin by ORSTOM(Lerique, 1975, cited in Olivry(1983)) and by Lo(1984) in his doctoral dissertation on the Upper Gambia basin (above Gouloumbou).

Measurements of suspended sediments reviewed by Olivry, indicate a low concentration in the different tributaries, and a low sediment yield from the watersheds, when concentrations are converted to metric tons per square kilometer. Concentrations at Gouloumbou reach maximum values in the range of 200 to 300 g/m3, but average 50 to 75 g/m3 during the July to September peak flow period(Olivry, 1983).

Lo measured somewhat lower values in 1983(see diagram), which was an exceptionally dry year. Total flow was only 34% of the 1971-1980 average for Gouloumbou. The average concentration of suspended sediments was 45.8 g/m3. giving an average yield from the catchment above that station of only 2.1 mt/sq km for the period. By comparison, during the statistically average year of 1974/1975, the sediment yield was 15.7 mt/sq km.

A field survey of suspended sediments, sampled daily at Kedougou, and of dissolved sediments in "all the tributary streams of the Gambia R." was carried out during the 1985 rainy season -- June to November(Gac, ORSTOM/Dakar, pers. comm., 1987). The data were still being analyzed in February, 1987.

Olivry reviewed sediment yield computations which varied between 16 mt and 70 mt/sq km per year. In the course of the U. of Michigan/Harza Eng. environmental assessment of the OMVG's development plan, Jasinski computed yield rates varying from 18 mt to 27 mt/sq km per year(cited by deGeorges and Samba, 1986).

Values of suspended sediments in the Senegal River are also low. ORSTOM's Dr. J.Y.Gac points out that in the Senegal River Basin, measurements of suspended sediments indicate a low rate of sediment transport, wtihin the same range as those found in the Gambian tributaries.

Olivry notes the incredulity of some authors at the low yield rates indicated by suspended sediment(Olivry, 1983, p. 65 cf). Many chose to add a safety margin to estimates by increasing them by an order of magnitude or more, to between 1000 and 1500 mt/sq km/yr. In a recent work for example, Fofana(1986) computed a yield of 1740 mt/sq km/yr in the Fouta Djallon.

A reservation has been voiced about the accuracy of low concentrations of suspended sediment. Measurements in some cases have been made not during peak rainfall months but before or after the maximum rainy periods(Fofana, 1986). However, daily samples throughout the maximum flow season were taken by Lo in the summer of 1983 at Gouloumbou, and by Bamba in 1985 at Kedougou. Their findings confirm the lower values measured at less frequent intervals.

I find the empirical studies by ORSTOM and/or supervised by ORSTOM scientists to be more convincing than various theoretical estimates which increase sediment yield from the catchment surfaces by a factor of 10 or more, over that indicated by actual sediment transport. Nevertheless, it is to be expected that sediment yields from smaller, steep catchments in the upper headwaters will be greater.

Reservoir sedimentation estimates

Sedimentation rates of various possible reservoirs have been estimated by Howard Humphreys Inc. and by GERSAR and SOGREAH in studies of potential small dam and irrigation developments in the upper basin. Jaskinski(Harza Engineering, 1984) estimated sedimentation in the proposed Kekreti, Kankakoure, Koungou Foulbe and Kouya reservoirs, in the course of the AID-financed study of the environmental and socio-economic impacts of the proposed dams and other develoments. The results of these studies are summarized in the tables below.

Idrissa Samba attempted to apply the modified USLE to an estimate of erosion and sediment transport in the Kouya watershed, above the proposed Kouya damsite, for his thesis at the University of Arizona(which was supported by the AID/OMVG project). More recently(November, 1986) Idrissa Samba and Paul Andre DeGeorges reviewed Olivry's work and recent sedimentation studies in order to estimate the reservoir life of various proposed dams -- the Kekreti dam, and the two "mini-barrages" at Sambailo on the Koulountou tributary and at Dongel Sigon, in the uppermost portions of the catchment.

It appears that the proposed large dams are not seriously threatened by sedimentation. Even at the highest estimates of 1.47 million cubic meters per year, the dead storage of the Kekreti reservoir would not be filled until year 170. Jasinski, using lower rates based on measurements of suspended sediments, esti-

TABLEAU XXIV : COMPARAISON DES EXPORTATIONS EN SUSPENSION DE QUELQUES GRANDS FLEUVES (D'APRES J.Y. GAC, 1980)

	Longueur en Km	Surface du b v ($\times 10^6$ Km^2)	Module en $L/s/Km^2$	Tonnages en suspension ($\times 10^6$)	Dégradation spécifique en $t.Km^2.an^{-1}$	Concentration moyenne en g/m^3
GRANDS FLEUVES						
Amazone	7 025	6.30	28	490	78	83.8
Congo	4 700	3.83	10.1	50.0	12.9	42.3
Yang-Tsé-Kiang	5 980	1.95	11.2	955	174.4	1380.
Mékong	4 023	0.80	22.8	345	430	600.0
Branmapoutre	-	0.58	33	795	1435	1310.
FLEUVES AFRICAINS						
Zambèze	2 575	1.34	5.3	42.0	31.3	324.0
Niger	4 184	1.13	5.4	28.0	24.7	127.0
Nil	6 700	2.87	0.98	67.0	23.3	755.0
Sénégal	1 800	0.27	2.8	1.40	5.2	58.0
Mbam	-	0.042	16.9	3.60	85.0	160.0
Gambie *	1 180	0.0042	6.4	0.66	15.7	77.5
**	"	"	7.8	≃ 0.30	≃ 7.1	≃62.0
FLEUVES EUROPEENS						
Volga	3 700	1.38	6.1	27.0	19.6	105.0
Rhin	1 300	0.224	9.8	0.45	2.0	6.5
Loire	1 012	0.115	2.8	4.0	35.0	145.0

* Valeurs moyennes de l'année hydrologique 1974/1975

** Valeurs moyennes interannuelles

Source: Lo, 1984

mated the total deposition for 50 year intervals for a number of reservoirs, as follows:

Jasinski's estimates of sedimentation in large reservoirs after 50 years

Reservoir	Sediment volume (hectometers)	% capacity filled at 50 years
Kekreti	3.7	0.3
Kankakoure	1.45	1.1
Kongou-Foulbe	1.78	0.8
Kouya	3.56	0.1

Source: Harza Engineering Co., 1984.

Small dams in the steeper, upper valleys will experience a higher rate of sediment deposition. However, once again estimates diverge widely. The high and low estimates of ORSTOM and of GERSAR/SOGREAH of the Dougel Sigon reservoir and the Sambailo reservoirs are shown below.

Estimated sedimentation in two small reservoirs

	Sediment yield (mt/sq km/yr)	Life in years of dead storage	
		Dougel Sigon	Sambailo
GERSAR high	2000	13	9
GERSAR low	200	125	93
ORSTOM high	100	250	186
ORSTOM low	50	500	348

Source: OMVG internal memorandum by P.A. deGeorges and I.Samba, October, 1986.

The discrepancies arise in widely differing assumptions about the nature of local rainfall, especially the intensity of storm events. Rainfall intensity is of particular importance in assessing erosion and sedimentation in West Africa, where erosion is largely a function of rainfall erosivity rather than the erodability of soils(Roose, 1976).

Lack of data on rainfall intensity is thus an important data gap, and a common problem in remote upper valleys of catchments. Intensity data requires a recording rain guage (or alternatively a

Best Available Document

conscientious manual recording of every rainfall event). Indirect indicators of peak storm flows can be used to estimate their past occurence and magnitude(Benson and Dalrymple, 1967. Note: this reference work was given to the OMVS watershed and environment technicians). However, such work does not yield probabilistic estimates.

A caveat to the veracity of the lower range of sedimentation estimates concerns the nature of gross erosion and sediment transport in a sub-humid to semi-arid tropical climate. Sediments tend to accumulate on slopes to be dislodged and swept into the drainage system by the occasional, very high intensity storm, if such is the rainfall pattern. Exceptionally intense storms can move enormous amounts of sediment, with serious consequences for smaller reservoirs in particular. In the southwestern United States, the 50-year storms are those that have shaped the land.

Similarly in northern Africa and the Sahel, the exceptional 50- or 100-year rain is that which transforms the landscape(Roose, 1978). However, in the dry to humid tropical environments of West Africa, Roose notes the level of erosion to depend upon the sum of the 10 or 20 most severe rains in a year, rather than the exceptional rainfall.

On the Casamance plateau, disastrous erosion on relatively flat (less than 3%) terrain cleared in 1949 for mechanized cultivation of groundnuts was caused by rainfall intensity, rather than soil fragility. The Casamance climate is judged to be 30 times more erosive than a comparable temperate zone climate, and at Sefa, up to 3000 mt/sq km/yr of soil loss are possible(WMO, 1983, p 107 cf.).

Given the location of the Gambia River catchment in the Fouta Djallon, it is possible that both types of rainfall events may affect erosion and sediment transport.

As regards the possibility of historically exceptional storms, older inhabitants of watersheds in the Fouta Djallon can be queried. Fluvial morphological and other geomorphological traits can also indicate such possibilities, e.g. layers of large cobbles occuring within a profile of finer alluvium, or colluvial fans.

Recommendations

1. Sediment monitoring.

The OMVS should sponsor(help plan and finance) and assist to carry out a multi-year program of measurements of suspended sediments at locations chosen according to the proposed large and small dams.

2. Rainfall monitoring.

Rainfall intensity should be measured at carefully chosen sites within the important tributary catchments, in order to permit correlation of this factor with sediment transport. The possibility of recording rain gauges, powered by batteries should be considered, for remote locations as well as locations in settlements. Several such gauges which record data on cassettes have been installed by ORSTOM in the Fouta Djallon. (See M. Bouchez, ORSTOM Hann meteorologist)

Considerations regarding implementation:

The actual installation, operation, maintenance and data collection would be done not by the OMVG directly but by field crews (brigades) of the Direction d'Hidraulique, Ministere de Energie, Ressources Naturels et l'Environnement, of Guinea.

Existing streamflow stations in Guinea are reported to be in bad shape, poorly maintained, and with data gaps and data discrepancies (Olivry, 1983; Gac, ORSTOM, personal communication; Risely, OMVG, personal communication). Rain gauges and records are better maintained and the records more reliable, but rainfall intensity is not measured, nor are stations sited to provide data on rainfall within the upper catchments of various tributaries.

Consequently, the recommendations made above raise the general question of the adequacy of the stream and rain gauging networks in this part of Guinea.

It appears that OMVG cannot assume that Guinea's exising stream gauging stations and operations in the upper Basin constitute an adequate program, to which would be added the additional data collection and monitoring tasks of particular interest to OMVG, specifically sediment transport and rainfall intensity. This brings me to the next recommendation.

4. Assessment of field stations in Guinea.

Assuming that the OMVG undertakes to sponsor additional hydrological and meteorological data collection in the upper basin, it appears that a general assessment of the adequacy and functioning of existing stations operated by the Direction de l'Hidraulique should be undertaken as a first step. The assessment must be carried out by an experienced field hydrologist and the work should be based upon a prior definition of OMVG's data requirements and priorities. This, in turn, should be based upon an articulation by the OMVG of its objectives with regard to hydrological and meteorological data networks, collection, studies, analyses, etc. in the Upper Basin.

5. OMVG's role in hydrological and meteorological monitoring

At the minimum OMVG's role could be "to assist the member states to improve and supplement existing stations and operations so as to permit a more accurate analysis of the basin's hydrology, and more accurate analyses of dams and other water and related land development." Coordination and data collection and dissemination would be important program elements, which are generic to the OMVG's work in all domains, of course, including the one suggested here.

Immediate next steps:

Preparatory technical planning work can be undertaken by the OMVG technical staff. In particular, detailed knowledge of the current work on erosion modelling and related sediment transport in the Fouta Djallon under ORSTOM sponsorship should be obtained. A series of meetings in Dakar with Dr. Jean Yves Gac, Mr. Bamba (from Cote d'Ivoire , one of Dr. Gac's students who is presently analyzing sediment data collected at Kedougou during June to October, 1986); Dr. Lamagat, meteorologist, and Mr. Bouchez, meteorologist. Mr. Bouchez has installed several battery powered recording rain guages in the Upper Gambia Basin, in connection with the ORSTOM studies.

It is noteworthy that the ORSTOM studies do not figure with any prominence, in fact are hardly mentioned, in the documents from the November, 1986, seminar in Labe on the first two years of the OAU Projet de Restauration and d'Amenagement Integree du Fouta Djallon(OAU, 1986). Also, in our discussions in Conakry of the possible program of the Labe "Laboratory" and the field studies that could be undertaken in the "bassins representatifs", on-going ORSTOM work was only mentioned in passing, whereas it could play a central research role in these pilot watersheds. Nevertheless, Dr. Gac assured me that the Guineans are fully informed of the ORSTOM work. The apparent discrepancy suggests the need for coordination, particularly in regard to instrumentation, data collection and analysis, and perhaps field missions. This could be readily accomplished in Dakar, where the ORTSOM offices are located a short ten minute drive from OMVG offices.

Erosion

Actual measurements of erosion losses have not yet been carried out anywhere in the Fouta Djallon massif(OAU, 1986). This fact is presented at the onset, in order to establish the speculative and subjective nature of the commonly held view that the Fouta Djallon is undergoing a serious, accelerated process of degradation, i.e. soil erosion and laterization, as well as deforestation, and excessive burning of natural pastures and brushland.

A second useful fact to keep in mind is the inherently poor quality of the soils in the massif. Large surfaces are bereft of soils altogether, consisting of exposed ironstone. Elsewhere ironstone may be covered by only a thin layer of soils capable of sustaining only grassy or herbaceous cover, e.g. the "bowals" which are grazed by the trypano-tolerant Ndama cattle herds in the region. Soils are generally acidic or very porous.

In fact, degradation has been occuring on a geological time frame and has produced a massif with poor productivity even for natural vegetation, given the limitations of the soil resources. Man-induced degradation is all the more serious, especially if the result is greater lateriation. At the same time, however, the desired regeneration of the massif is limited by poor soils, largely suited to non-agricultural uses, and in many instances, irretrievably degraded to bare or only thinly covered ironstone.

Landuse

Current landuses and trends are reported to be increasing erosion. Agricultural soils are scarce in the Guinean portion of the basin -- ranging from 0.16 ha to 0.87 ha per person(U. of Michigan Harza, 1985). Steeper soils on slopes adjoining valley farms are being cleared and farmed. Also fallow periods are shortening on soils where shifting cultivation is practiced. Fallow periods have been shortened to 4 to 7 years(Pascual, 1986; Keita, pers. communication), where previously a 12 to 15 year forest fallow was allowed to develop. Only the local grain, fonio, (Digitaria exilis) can tolerate the acidic low fertility soils(McGahuey, 1985).

The flat or undulating "Bowe" soils are burned every year by Peul herders, who are blamed for the consequent exposure and hardening of the layer of lateritic earth which characteristically occurs very near the surface of the Bowe's.

Luxuriant forests are found only along stream edges and at the heads of narrow ravines, i.e. in sites with moist, deep soils. Elsewhere the natural vegetation is of limited stature, corresponding to the treed savannan vegetative type. It has been steadily degraded by burning, which also encourages erosion and further exposure of lateritic layers, and eventual formation of ironstone. Deforestation alone can also trigger hardening of underlying lateritic earth, even before exposure, since the result of deforestation is an alternation of wetting and drying in the soil horizon, which causes hardening.

The recent drought period in the adjacent Sahel extended into the Fouta Djallon, resulting in rainfall values at the lower range of probable variation from the norm. The resulting abnormal aridity has undoubtedly exacerbated vegetative degradation, stunted fallow regrowth, and perhaps has speeded the hardening of lateritic earth.

Land potentials

A reconnaissance land evaluation (1:200,000) of the entire river basin has been carried out, as part of the UNDP-financed soils mapping program being done within the OMVG (Cueto and Khouma, 1986).

The use potential ("aptitude potentielle") of the 1.2 million hectares within the territory of Guinea, is distributed as shown in the table.

Although undertaken under the auspices of the OMVG, the reconnaissance land evaluation has not resulted in the definition of an OMVG policy or recommendation concerning the adjustment of landuses to land potentials in the upper basin.

Land potentials in the Upper Gambia River Basin

Use potential	000's has	%
A agriculture, no limitations, irrigable lands	22	1.8
B agriculture, with moderate to severe limitations, mainly rainfed farming.	27	2.2
AB mosaic	59	4.8
P mainly grazing, or high technology farming.	0	
BP mosaic	109	9.0
F mainly forest lands, but also grazing uses.	346	28.6
FP mosaic	12	0.1
X no use, protection only	509	42.1
FX mosaic	124	10.2
total	1208	99.0

Source: Cueto and Khoumba, 1986.

Almost 1.0 million of the 1.2 million hectares, or 83% of the upper Gambia River watershed in Guinea, are classed as non-agricultural. Most of these non-agricultural lands are concentrated in the upper elevations of the basin. Many are farmed or grazed, nevertheless. Adjustments of uses to potentials will have to be planned at a much more detailed scale, of course. For the present a reconnaissance scale landuse map is being prepared by the OAU project, headquartered in Labe (Westinga, 1986). It will permit a preliminary comparison of uses with potentials.

OMVG's role regarding erosion

OMVG's role with respect to soil erosion in the upper watersheds is less clear than in the case of sedimentation. The burden of any institutional effort required to measure and to control erosion through various conservation measures, rests on the shoulders of the Guinean government ser vices, and of the farmers o. the region who must carry out the actual work.

OMVG's role needs to be defined pragmatically, in terms of what actions would contribute to on-going work and local actions concerning soil erosion. In particular, activities begun under the OAU project, as well as preparations underway for an environmental laboratory at Labe must be taken into account.

Recommendations specific to soil erosion

1. Sponsor, plan and supervise experimental plots for measuring erosion in the representative basins.

This work would allow the adjustment of various parameters of the Universal Soil Loss Equation to local conditions.

2. Sponsor and supervise applied research to measure the effectiveness and assess the economic benefits of erosion control works.

Again this work could be undertaken in the context of the proposed representative basins program.

3. Promote the use of a standard methodology in the experimental basins for researching and evaluating erosion and conservation of soils, water and vegetation.

This would permit harmonization on a basin-wide level of studies on soil erosion and conservation.

4. Include watershed management in the planned pilot projects for small dams and related irrigation at Sambailo and Dongel Sigon.

This recommendation would entail field surveys and plans for the catchment portions of the valleys in question.

The laboratory at Labe

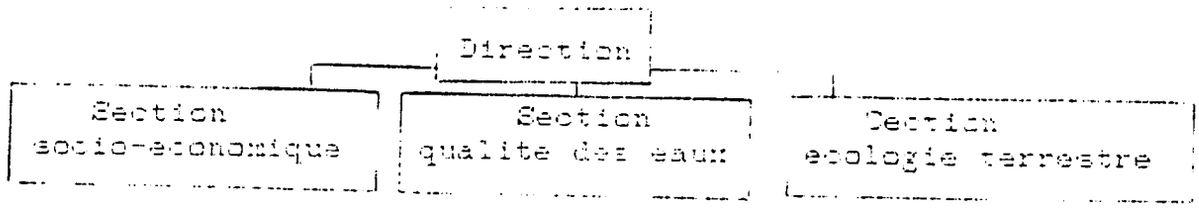
This field laboratory is an initiative of the Guinean government's Direction de l'Hidraulique, which is also the agency that represents the government in the CMVG. AID support for such a laboratory was not envisioned in the OMVG project, however AID has agreed in principle finance laboratory equipment through the project.

In AID/Conakry, furthermore, 93 million Guinean francs have been programmed out of the PL 480, Title III account, to underwrite operational and personnel expenses over the period 1986-1991. 13 million francs had been approved for 1986-87, but not yet received as of Feb. 1987. With the problem of recurrent costs out of the way, an unparalleled opportunity exists, as a result, for undertaking field research and monitoring of various facets of the physical environment in the Fouta Djallon.

The town of Labe is situated just south of the uppermost headwaters of the Gambia River. It is the center of regional activities, including the UNDP assistance to the OAU project. Labe sits on a 1,000-meter high plateau precisely at the headwaters of all the major rivers and streams that drain the Fouta Djallon. Consequently, the proposed environmental monitoring laboratory is seen as a regional facility, rather than one that would focus exclusively on the Gambia and Koliba river basins. It was described as playing a central research and coordinating role in the entire Moyenne Guinee adminstrative region by Mr. Aliou Kankalabe Diallo, Director, Direction de l'Hidraluique and Mr. Balde, Director of the Direction National de la Nature et de l'Environnement,

Within the Guinean government, overall planning for the laboratory is centered in the Direction National de l'Hidralique, which is pursuing preparations for the facility. A building in Labe that will house the laboratory and offices was in the process of rennovation in February. The laboratory will apparently enjoy a semi-autonomous status and staff will be seconded from other government offices. The head of the laboratory had been named (Cheikh Omar Diallo, chemist, from the Direction National de l'Hidraulique) and other technicians were being identified for secondment from the various national services. It was expected that by May, 1987, the renovation would be complete and the staff could move to Labe.

Its structure was described as shown below.



With regard to various types of analyses, the Direction de l'Hidraulique anticipated considerable demand from other government offices and field workers, and was contemplating offering free analytical work as a public service function, as well as access to the laboratory itself.

Issues

A number of unresolved questions and related needs were discerned with respect to the preparations for and planning of the environmental laboratory in Labe.

1) The new facility has not been formerly named. It is referred to as the "laboratory". I perceive that this has handicapped communication, by evoking an image of white smocked technicians and test tubes, or a facility devoted to basic research. In fact a wide range of field surveys, applied research, monitoring and analytical work has been set forth in a preliminary document prepared by the OMVG, which proposed the content of a basin wide monitoring and surveillance program, including actions at Labe. Also, in the course of interviews it became evident that the laboratory was seen as playing a supportive role in the representative basins program, initiated by the OAU project.

Recommendation:

A more descriptive and accurate title for the laboratory should be adopted, e.g. Centre d'Etudes et de la Recherche Applique Environnementaux. Whatever the title, however, it should follow the goal and program definition.

2) The Direction de l'Hidraulique had not yet begun to plan the laboratory's program. Rather, attention had focussed on the actual physical plant, its equipment and staffing. This lack should be remedied as soon as possible.

The coordinating mechanisms already exist for undertaking planning with the various government services and donors, hence the work to be done revolves around the scheduling, preparation of background documents and carrying out the planning work.

Recommendation:

The OMVG should take an active role in planning the laboratory's program, to the extent that its sponsorship and institutional identity and work program are involved in the laboratory's prog-

ram. OMVG should be prepared to advance its priority interests as they might be served by the laboratory, specifically with regard to work in the Gambian and Kolika basins.

A short term, at least one year program and work plan should be drawn up, taking into account the research and monitoring needs entailed in the pilot watershed project initiated by the OAU as well as proposed small scale dam and irrigation developments in the Gambian headwaters at Samballo and Dongel Sigon. Also program goals and content for the longer term need to be sketched out.

Constraints on OMVG work in watershed management

The lack of a policy or program objective concerned with watershed management has been mentioned. It is of course the most important limitation. The definition of an OMVG role in watershed management must necessarily evolve from internal staff work, as well as proposals by member states.

Watershed management requires considerable sophistication in terms of organization, technical interventions, and institutional arrangements. To be effective, the OMVG must carefully analyse the way in which it can contribute to watershed management , e.g. as a catalyst, facilitator, co-sponsor, or planner. This will entail a well considered internal decision as to its institutional commitment to this aspect of river basin development. There was no evidence that such a decision was being planned.

The two African staff members most qualified to work in this area had recently rejoined the OMVG office, after completing graduate studies in the USA(U. of Arizona and U. of Colorado). However, they were not being paid salaries for lack of funds. An answer was pending from AID for a request for interim funding. Uncertainty over their professional futures within OMVG obviously does not favor long term planning by these individuals. It is a disincentive to the considerable investment of personal energy that may be needed to promote and fund a core technical program concerned with watershed and natural resources management.

An important constraint concerns the geographic distance and corresponding communication difficulties between OMVG offices in Dakar and offices in Conakry or Labe. There is presently no telephone link between Dakar and Conakry. Telegrams are sent first to Paris and then relayed to Conakry, resulting in a four to five day lag that may be increased by delays in local delivery. Clearly, this situation greatly handicaps the potential role of the OMVG Secretariat in Dakar as a coordinator, facilitator or catalyst.

Thus, an active role in watershed management in the Guinean portion would almost by definition require the posting in Guinea

of OMVG staff, or alternatively frequent trips to Guinea to oversee work. Also, preparatory work will entail frequent trips to Conakry and Labe.

A final constraint concerns the fact that AID's support to the OMVG through the OMVG project terminates at the end of 1987. UNDP support was being sought by the OMVG, and a program proposal was being drafted during the period of this consultancy. It was not seen, however support for watershed management was not requested of the UNDP, apparently.

Conclusions

A major OMVG initiative in watershed management is not readily justified on the basis of sedimentation threats to large dams, given existing low rates of sediment transport. Unofficially, OMVG staff are considering small scale works as alternatives or supplements to the two dams that officially constitute the focus of OMVG program. Small scale works in upper reaches of the river, where gradients are steeper, are more susceptible to sedimentation. A strong rationale exists for the management of landuses and for conservation in the respective catchments. And correspondingly, if OMVG co-sponsors these "mini-barrages", it should take an active role in the management their catchments.

Little objective information exists on soil erosion in the Upper Basin. It could be a factor in the longevity of smaller reservoirs. OMVG should sponsor and plan applied research on erosion and erosion control.

International support seems to be the only avenue for undertaking certain studies or pilot developments not related to the two big dams. Thus, some form of international assistance will be necessary for watershed management initiatives that the OMVG may wish to take.

In view of the various constraints to initiating work in watershed management, it appears that not only must initial work be modestly scaled but also carefully designed so as to contribute to or complement on-going initiatives.

In my judgement the most appropriate and viable role that OMVG could play is that of coordinator and sponsor of watershed management research, and perhaps field management, or co-management of this research. This could include research on erosion and run-off, on the technical and economic aspects of various land treatments for controlling erosion and slowing run-off, on instrumentation for data collection and field methods of data collection suited to the specific conditions of the watersheds. Clearly, such activities cannot be carried out from a base in Dakar. However, they could be directed from Dakar, and to the extent that ORSTOM or IDRC were involved, OMVG's Dakar location is ideal for coordination.

Thus, OMVG staff would manage (or co-manage, e.g. with ORSTOM) research contracts or grants, carried out by entities in Guinea, either public or private.

As regards the Sambailo and Dougel Sigon pilot developments, watershed management -- e.g. catchment landuse and conservation, data collection and analysis, community education and the corresponding field mapping and surveys for planning these actions -- should be designed and included in these developments.

Recommended Approach for OMVG Actions in Watershed Management

A pragmatic, gradual approach to defining and developing a watershed management program is proposed. It is assumed that the OMVG is willing to consider the adoption of an institutional program in watershed management, based upon the findings of this consultancy as well as other indications.

A definition of OMVG's role in watershed management would best be started internally by OMVG staff. Working elements would include this report, the CAU Labe seminar papers, UNDP documents concerning proposed actions in the Fouta Djallon (collected in Conakry), and detailed information on work sponsored or supervised by ORSTOM in the Fouta Djallon.

An internal OMVG goal and program statement on its role in watershed management should be prepared for presentation to the member states' consideration and reaction, and, eventually, approval.

A watershed management initiative must use as its point of departure on-going or planned actions that involve watershed management or landuse in some measure. Specifically, the planned small scale dams at Sambailo and Dongel Signon; the laboratory at Labe, Guinea, and the proposed representative basins in the Fouta Djallon.

The focal point for field interventions and development actions in the Fouta Djallon is in Labe. Hence, it would not be reasonable to look to the OMVG as a source of unique expertise in technologies or approaches needed in the massif. However, the OMVG, working with ORSTOM and perhaps other research centers, including the Dakar base of the IDRC (International Development Research Center), could assist in the design of applied research and data collection.

ORSTOM-Hann scientists and staff would be logical technical partners, given the antecedent and on-going work in the Fouta Djallon. The possibility of a formal arrangement for advisory and perhaps collaborative work should be explored, especially with respect to hydrological and meteorological research.

IDRC's association with an OMVG involvement in the representative watersheds would be attractive. IDRC sponsorship of applied research in the watersheds could perhaps be fashioned so as to bring additional international technical perspectives to the efforts and so as to complement OMVG's technical staff. IDRC responds to research proposals from nation states but it could well entertain a joint proposal from the OMVG's member states, coordinated through the OMVG secretariat.

OMVG technical staff should take an active, participatory role in the shaping of the laboratory program at Labe, consistent with OMVG's sponsorship of certain laboratory expenses. OMVG could do this by convening a series of program planning meetings: the first in Conakry to set an agenda and identify participants, the second to initiate planning and a third to finalize a plan for the laboratory's program. Specific recommendations on the laboratory's organization, on erosion and sediment monitoring, and rainfall intensity measurements, could be raised by the OMVG as elements of the program. (See sections above on these topics

Assuming an active OMVG role in obtaining financing for the Dougel Sigon and Sambailo small scale dam and irrigation projects, a total watershed management component should be included in these developments, with a primary OMVG role in project planning and a continuing technical advisory role during implementation.

The accomplishment of these various tasks and steps will constitute an experiential basis for evolving a viable OMVG role in watershed management. Other possibilities will certainly emerge as experience is gained, and there will need to be a continuous process of reflection and reiteration of what it is that the OMVG as an organization can effectively do in the field of watershed management.

Assistance that AID may wish to provide through the OMVG project could follow two lines. First, it could be oriented to the preparation of plans and proposals for watershed management research, keyed to proposed developments in the Fouta Djallon, and to the identification of potential sponsors.

Secondly, the planning activity could seek to define in greater detail and precision the hydrological behaviour of the upper basin, than is being accomplished in the current SSAR modelling activity. Of particular interest would be the correlation of land cover changes and streamflow.

Since the existing data is not likely to be adequate, the planning contribution could be that of diagnosing the need and benefits of establishing such a correlation (as a function of various planned downstream developments and related water control), and the design of the needed network. The planning work could entail an up-date of the evaluation done in 1968 by Olivry of the hydrological and meteorological stations in the upper watersheds, with the inclusion of the river basins flowing into Guinea-Bissau.

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Annexes

Schedule of interviews, Senegal, Guinea

Contacts made in the USA

Documents delivered to the OMVG

Documents collected in Conakry

Schedule of interviews, Senegal, Guinea

Jan.

16	David Hunsberger, AID/Dakar (OMVG project manager Paul Andre de Georges, OMVG project advisor
17	Review documents
18	Sunday
19	Review documents (AID holiday, Martin Luther King day)
20	Jean leBlond, OMVS advisor
21	review documents
22	M. Nassirou Diallo, Sec. Gen., OMVG M. M. Ndiaye, Dir. Technical Studies
23	M. Jean Yves Gac, ORSTOM, Hann
24	Gerard Sornier, IUCN rep in Dakart
25	Sunday
26	arrange travel to Guinea, review documents
27	Jim Webb, economist; John Risely, hydrologist, OMVG Idrissa Samba, OMVG
27	fly to Conakry with Idrissa Samba and P.A.de Georges joint interviews in Conakry with: Sheikh Omar Diallo, Dir. de l'Hidr. Aliou Kankalabe Diallo, Dir de l'Hidr.
28	Dir. de l'Hidraulique Robert Helyar, AID/Conakry, PL 480 coordinator
29	Aliou Diallo Dominique Obiaja, OAU Direction Eaux et Forets
30	Capt. Thiana Diallo, Sec. d'Etat, Eaux et Forets, Ministere Ress. Naturelles et Energie Sekou Camara, Service National des Sols (SENASOL)
31	Fode Keita, Sociologist, Institut de Planification M. Jules Frippiat, UNDP Res rep M. Kumbassa, Dir. de l'Environnement Djiba Kane, Biologist, " " Ijamilla B.Sow, " "

Feb.

1	Sunday
2 - 5	draft interim report, Dakar
3	Moctar Nyong, Dir. Reboisement et Conservation des Sols, Senegal Luis Cuesta, FAO pedologist, OMVG Koli Kouroumma, resource economist, OMVG
6	De-brief D. Hunsberger, J. Anderson, Mr. Carney, AID/Dakar
7	depart

Contacts made in USA

Roy Anderson, USGS, Information Management

Don Alfred, hydrologist, International Institute for Environment & Development, Washington, D.C.

Charles (Don) Clark, Soil Conservation Service, USDA.

Douglas Glysson, U.S. Geological Survey, Water Resources Branch, Reston, VA (648 4317)

Archie Shaw, Service Argos, Beltsville, MD. (985-4411)

Sam Kunkle, U.S. Park Service, Ft. Collins,Colo. (491-7857)

Sheryl Wilkins, Center for Global Studies, Arlington, VA.

Lawrence Lewis, Dept. of Geography, Clark U. (797-7291)

Richard Saunier, Organization of American States, Washington DC

Danny Schmidt, UNEP Clearing House, Nairobi

Documents delivered to OMVG

U.S. Dept. of the Interior, Geological Survey.

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Dalyrymple T. and M.A. Benson. 1976. **Measurement of Peak Discharge by the Slope-Area Method.**

Guy, Harold. P. 1977. **Laboratory Theory and Methods for Sediment Analysis.**

Porterfield, George. 1977. **Computation of Fluvial-sediment Discharge.**

Benson, M.A. and T.Dalyrymple. **General Field and Office Procedures for Indirect Discharge Measurements.**

Bodhaine, G.L. 1976. **Measurement of Peak Discharge at Culverts by Indirect Methods.**

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Chapter in looseleaf, as follows:

1 Introduction
2 Sediment properties
3 Erosion
4 Transmission of sediment by water
5 Deposition of sediment
6 Sediment sources, yields and delivery ratios
7 Field investigations and surveys
8 Sediment - storage design criteria
9 Units and equivalents

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Wischmeier, W.H. and D.D. Smith. 1978. **Predicting rainfall erosion losses - a guide to conservation planning.** Washington, D.C., U.S. Department of Agriculture. (Agriculture handbook No. 537)

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Temporarily loaned by P.H. Freeman to the OMVG:

FAO. 1977. **Guidelines for Watershed Management.** Rome, FAO. 293 p.

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Welcomme. R.L. 1979. **Fishery Management in Large Rivers.** Rome, FAO. 60 p. (FAO Fish.Tech. Pap. 194).

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I have also asked the American Farmland Trust to send the following to the OMVG:

American Farmland Trust. 1986. Survey of Geographic Information Systems. Washington D.C., American Farmland Trust.

Cost: $20.00. **The Trust will bill RBDO in AID/Dakar.**

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Documents collected in Conakry and left at OMVG

DAU. 1986. Numerous papers presented at the "Seminaire sur la Synthese des Resultats de La Premiere Etape des Activites du Projet Regional d'Amenagement Integre du Massif du Fouta-Djallon, Labe, Guinea, 30 July - 4 Aug., 1986), among which are the titles noted next. The entire collection is being edited for eventual publication by UNESCO.

Causes et effets de la degradation sur l'environement au Fouta Djallon. M Mathias R. Haba.

Unites physiographiques. E.Westinga.

Carte d'utilisation actuelle des terres et de la couverture vegetale. N. Conde and Aboubacar Oulare.

Etudes hydromorphologiques de Fouta Djallon. Alpha Bacar Bah.

Etat de l'erosion et susceptibilite des sols a l'erosion. Sekou II Camara and Nagoe Conde.

Etablissement et reamenagement des reseaux hydro-meteorologiques et analyse des donnees. Namady Fofana.

Carte des zones agro-ecologiques et potentialite des terres du massif du Fouta-Djallon. M. Westinga.

Analyse comparative de l'evolution milieu naturel et identification des zones echantillons. Aboubacar Oulare.

Choix des bassins represntatifs. Ousmane Diallo.

Quelques aspets geomorphologiques des cuirassements dans le massif du Fouta Djallon. Jean Francois Pascual.

Amenagement integre du massif de Fouta Djallon. J. Boulet and J.C. Talineau(ORSTOM and UNESCO consultants).

Analyse multitemporelle des images Landsat du Fouta Djallon. M. Westinga.

Resume du plan d'amenagement du massif du Fouta Djallon. Raj Gupta.

Communication de l'Association des Amis de la Nature et de l'Environnement(ASSOANE) a l'occasion du seminaire sur l'amenagement integre du massif du Fouta Djallon. ASSOANE-CNG.

Sécheresse, climat et reboisement dans les pays membres de l'O.M.V.G. Mamadou Khouma, OMVG.

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Abadiri-Soumaila, K.O. 1987. International Coordinator's Activities Report(1984-1986). Conakry, Guinea, Organization of African Unity, B.P. 1386. (Presented at the Forty-fifth Ordinary Session of the Council of Ministers of the OAU, Addis-Ababa, Ethiopia, 23-28 Feb., 1987).

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UNDP/Conakry. 1986. "Projet de programme 1987-1991 - Guinee". 23 p. manuscript with budget annexes.

UNDP/Conakry. no date. "Draft Projet du Gouvernement de la Republique de Guinee -- Restauration et Amenagement Integre du Bassin Representatif Pilote(BPR) de Guetoya(Batignel) dan le massif du Fouta-Djallon." 32 p. manuscript

UNDP/Conakry. 1986. "Programmation par pays et programmation multinationale. Quatrieme programme de la Guinee; note de l'Adminstrateur." 5 p. manuscript.