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Accuracy of the Land Use/Cover classification in the Oueme Basin of Benin (West Africa)

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ABSTRACT
In the scope of the European Union water initiative for developing countries, the research programme RIVERTWIN (A Regional Model for Integrated Water Management in Twinned River Basins) was initiated for three river basins, Neckar in Germany, Ouémé in Benin Republic and Chirchik in Uzbekistan. Our contribution to development of the model at regional level was the establishment of a Soil and Land Resources Information System for the Ouémé basin (SLISYS-Ouémé). The objective of the SLISYS was to provide information about soil, climate and land use in the Ouémé basin. As well as data on soil and climate, it was essential to have information on land cover and land management practice. Therefore, a land use/cover map was established at the scale 1/200.000 from satellite images LANDSAT ETM Plus of 2003 from 3 scenes. After image treatment, imaged maps were established and an interpretation of keys was defined. For efficacy reasons, the interpretation was carried out at the scale of 1/50.000 in order to get the maximum amount of information. Field controls were done for one month and more than 650 observation points were checked during the ground check process. Finally, 17 land use/cover classes were defined. The subsequent accuracy check showed that the overall interpretation precision was high (87 %). The land use unit "mosaic of cropland and fallow" had the most precision in its interpretation, and the classification of the unit "humid and dry dense forest" had the least precision.

***Keywords*:** Accuracy, land use/cover classification, Satellite images, RIVERTWIN project, Benin

1. INTRODUCTION
Land use/cover data are a valuable source of information to assess natural resources in a country and provide a basis for environmental planning. The land resources information system SLISYS-Ouémé was created to provide data about soil, climate and land use. A land use/cover map was therefore established at a scale of 1/200.000 from satellite images LANDSAT ETM Plus of the year 2003, taken from three scenes.

2. MATERIAL AND METHODS
The Ouémé basin covers total land area of 48.000 km², but in Benin the area covers about 44.197 km² (upper and middle basins). Geologically, the basin is located on the northern part of the so-called Continental Terminal and on Precambrian crystalline rock (Figure 1).
The borders of the basin are at the following geographical location: in the south at 6°35' N and in the north at 10°12' N latitude. In the west the basin is bordered by the Republic of Togo and in the east by Nigeria.

The Ouémé basin entirely or partially encompasses 24 communes in 6 departments (Borgou: 5 communes, Donga: 3 communes, Collines: 6 communes, Plateau: 3 communes, Zou: 6 communes and Ouémé: 1 commune).

The climate was bimodal to monomodal with a mean annual rainfall between 1000 and 1200 mm. The mean annual temperature was 27° C with March being the hottest month (35°C).

Land cover was derived from a LANDSAT ETM PLUS interpretation of the year 2003 using 3 scenes (Igué, 2005, Igué et *al*., 2006; Figure 2). Radiometric data were taken from 7 bands and the resolution was 30 m. The data was digitally processed using ERDAS version 8.3.1 software.

The three LANDSAT scenes were rectified to Universal Transverse Mercator (UTM) projection, Zone 31 North Spheroid (WGS1984) using control points from topographic maps at the scale 1/200.000 (IGN 1969).

ARCVIEW version 3 was used for mapping. After image treatment, the imaged maps were established and interpretation keys were defined. For efficacy reasons, the interpretation scale was 1/50.000 (IGN, 1954) in order to get maximum information. Field controls were done for one month using GPS (Garmin GPSMAP 76C). More than 650 observation points were checked during ground checks of the map. Out of the total number of observation points, 291 points were used for image interpretation and land cover classification.

For validation of the land use/cover map, a methodology was employed that consisted of the selection of several control axes, the content of the observation points, the scale of observations and an interpretation of the observations to evaluate the quality of the land cover map. On the control axes (20), the determination of land cover categories was done every two kilometres using GPS. In total, 359 points were checked. The collected data were content and the limits of the land units. These data were compared to those on the land use/cover map. For each observation point the information on the land cover map was classified as "correct" (C) if it conformed with the observed land cover or "incorrect" (I) if it did not conform or was mixed. The total A of all checked points was equal to the sum of the "good" check points and the "bad" check points. Precision of the classification (P) was given by the equation P = C/A and error (E) was calculated with the equation E = I/A. The precision must be greater than or equal to 70% for a high map quality (Houndagba et al., 2006), It was necessary to discuss precision by a control axis and land category. For the five major land units one matrix was established, which indicated any errors of the satellite image interpretation. The percentage of land units in the map (% C: Ratio or proportion of the map unit compared to the total area) and the percentage of the error (%E: Ratio or proportion of error per land unit compared to the total number of errors) were calculated.

3. RESULTS AND DISCUSSION

3.1 Land use/cover map

In general**,** 17 land use/cover classes were defined (Igué, 2005, Figure 1, Table 1)**.** Tree and shrub savannah (Sa) was the most important land cover type in the Ouémé basin and covered about 38% of the study area (Photo 1).

Mosaics of cropland and bush fallow (MC) occupied the second position (31% of the area) and at the third position woodland and woodland savannah was ranked (FC, about 17% of the area) (Figure 3, table 2). These three land classes covered about 86% of the study area.

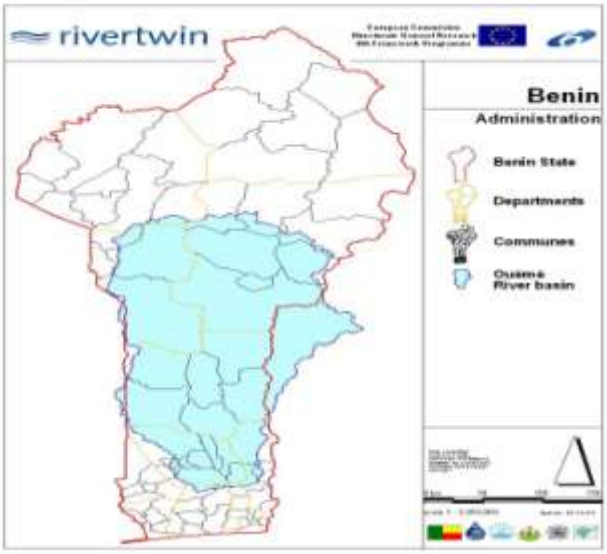

Fig. 1. Location of Ouémé Basin in Benin and in Nigeria

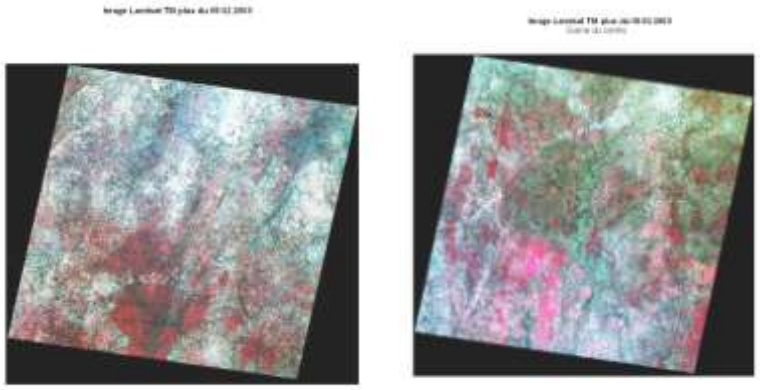

Fig. 2. Satellite images of northern and central part of the Oueme basin

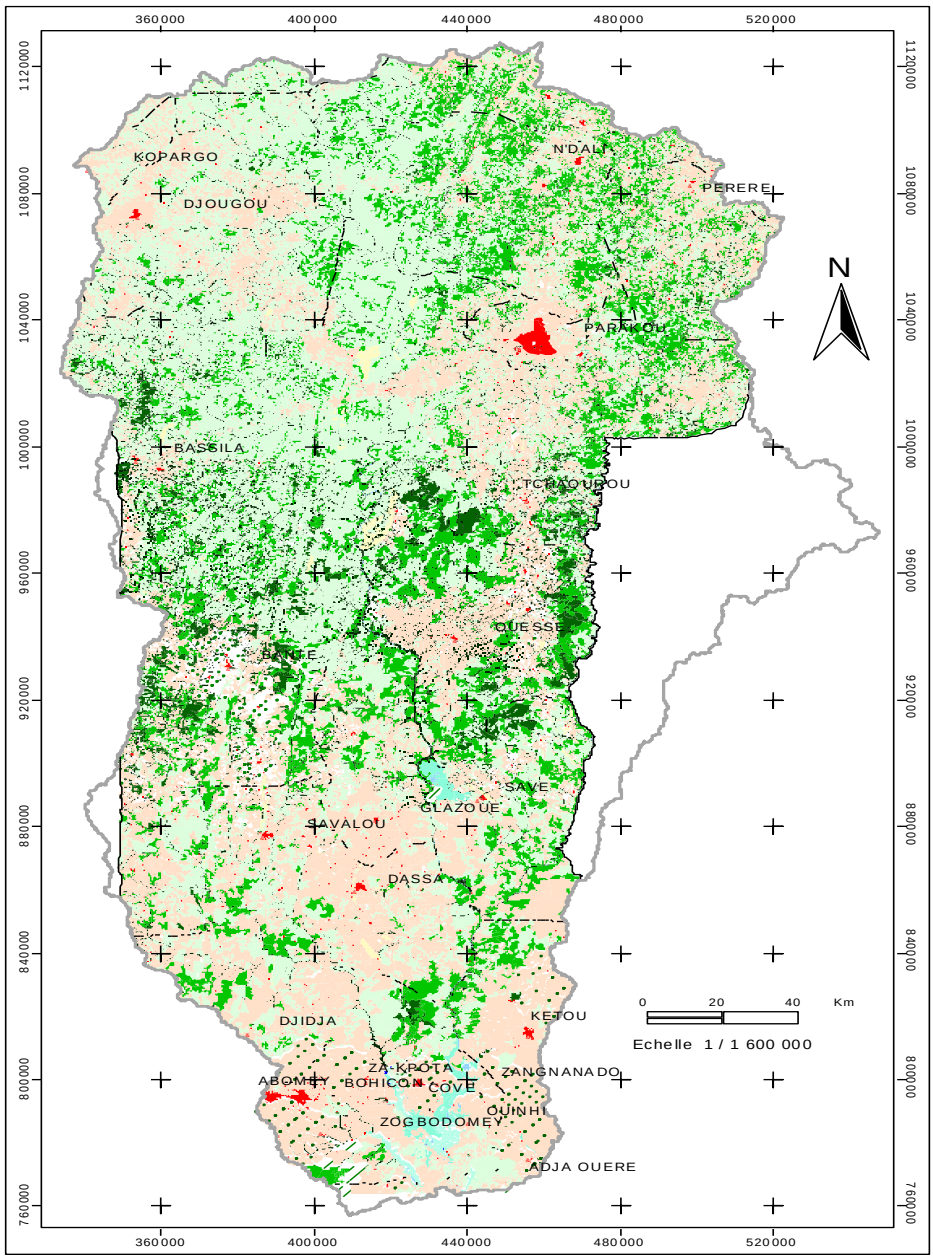

Fig 3. Land use/cover of the Oueme basin

Table 1. Legend of land use/cover map

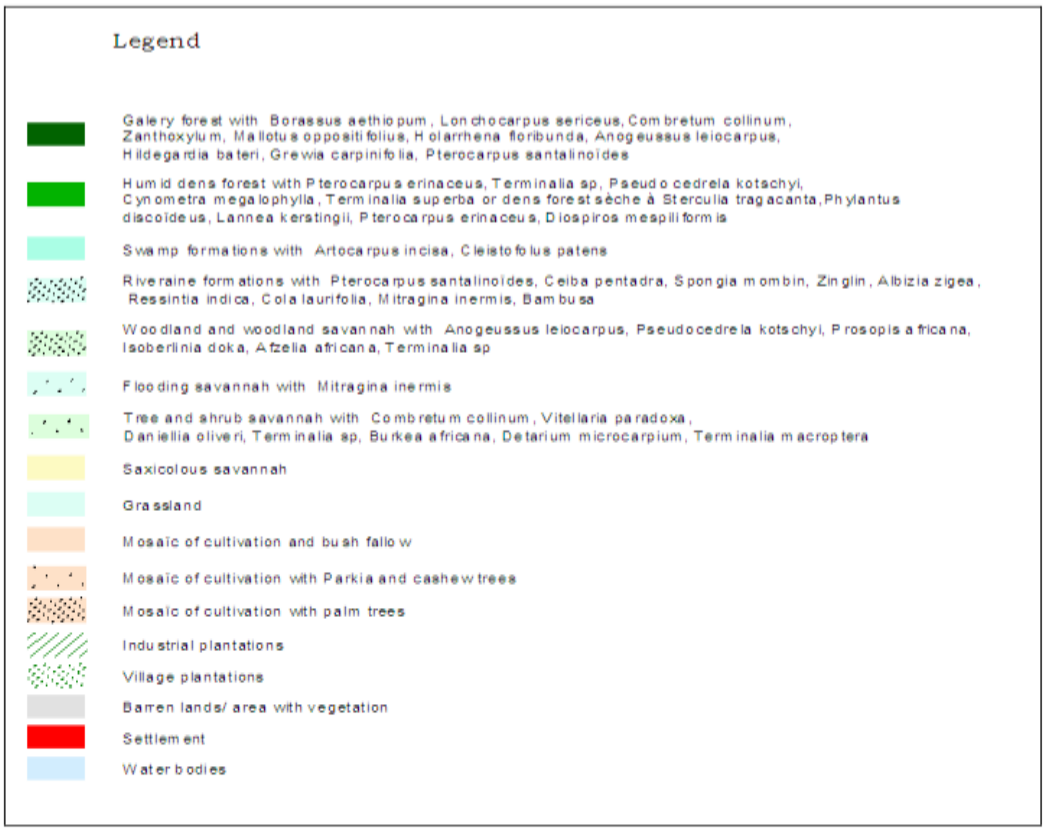

Table 2. Land use/cover categories their area and % of total area

Land use category	Area (km^2)	% of Total Area
Galery forest	1758.68	3,88
Humid and dry dense forest	1219.55	2,76
Swamp formations	16.92	0,04
Riverain formations	106.79	0,24
Woodland and woodland savannah	6715.78	17,10
Flooding savannah	221.86	0,30
Tree and shrub savannah	17230.86	38,07
Saxicolous savannah	313.43	0,61
Grassland	13.70	0,03
Mosaïc of cultivation and bush fallow	13713.08	31,03
Mosaïc of cultivation with Parkia and Cashew trees	32.41	0,07
Mosaïc of cultivation with palm trees	1189.45	2,49
Industrial plantations	127.11	0,29
Village plantations	1209.01	2,54
Barren lands/area without vegetation	4.59	0,01
Urban and built-up	276.83	0,43
Water bodies	46.79	0,11
TOTAL	44196.84	100,00

Photo 1. Tree and shrub savannah (Sa)

The flora composition of tree and shrub savannah (Sa), which occupied 38 % of the land use/cover map was: Parkia biglobosa, Terminalia macroptera, Terminalia avicennioides, Terminalia glaucescens, Detarium microcarpum, Daniellia oliveri, Combretum molle, Combretum nigricans, Burkea africana, Vitellaria paradoxa (Photo 1)

In the northern part of the study area, the mosaic of cropland and fallow (MC, about 31 % of the area) was characterised by the species *Vitellaria paradoxa, Parkia biglobosa, Anacardium occidentale, Terminalia avicennioides and Daniellia oliveri* (Photo 2). On the southern plateaus of the basin, the only characteristic species in the cropland/fallow mosaic was *Elaeis guineensis*. This land cover type covered 2.69 % (Photo 3). In addition, the mosaic of cropland and fallow with *Parkia biglobosa and Anacardium occidentale* occupied about 0.07% of the study area.

In the woodland and woodland savannah (FC, about 17% of the area) the medium height of the trees was 10 m. The trees occupied 50 to 75 % (Photo 4) of the ground. It was one of the most important vegetation formations in the Ouémé basin. The characteristic species were: *Anogeissus leiocarpus, Pseudocedrela kotschyi, Prosopis africana, Isoberlinia doka, Isoberlinia tomentosa, Afzelia africana, Terminalia glaucescens Terminalia macroptera, Detarium microcarpum, Daniellia oliveri, Bombax custatum and Burkea africana.*

The gallery forests (Fg) covered about 3.88% of the study area (Photo 4). Characteristic species were: *Borassus aethiopum, Lonchocarpus sericeus, Combretum collinum, Zanthoxylum zanthoxiloides, Mallotus oppositifolius, Holarrhena floribunda, Anogessusleiocarpus, Hildegardia bateri, Grewia mollis, Pterocarpus santalinoides, Vitex doniana and Daniellia oliveri*

The humid and dry dense forests represent about 2.76 % of Ouémé basin area (Photo 5). The characteristic species in the humid dense forest were: *Terminalia spp, Pseudocedrela kotschyi, Cynometra megalophylla, Terminalia superba, Vitex doniana.* However the dry forest was characterised by other species: *Sterculia tragacantha, Phyllanthus discoïdeus, Lannea kerstingii, Pterocarpus erinaceus, Diospyros mespiliformis and Anogeissus leiocarpus.*

3.2 Accuracy of the land use/cover map

The subsequent quality check showed that the overall precision of interpretation was high (87 %).

Table 4 shows the interpretation errors by land cover category as well as the balance between the ratio of map coverage and the ratio of interpretation error. These two ratios are also illustrated by figure 4. Figure 4 shows that the land use unit "mosaic of cropland and fallow" (MC) had been interpreted with the highest accuracy.

The land use units "tree and shrub savannah" (Sa) and "gallery forest" (Fg) had the same error percentages compared to the map coverage. Thus, these three land use units were very well interpreted. Classification of the other two units (Fc and Fd), particularly the unit "humid and dry dense forest" (Fd) had lower accuracy. These two units covered about 21% of the study area (Table 2).

4. DISCUSSION

In order to obtain land use/cover information, Landsat ETM Plus imagery was analysed. The overall precision of classification was estimated at 87 %. Mama (2005) indicated that, various methods could be used to evaluate accuracy of the land

Table 3. Synthesis of the Land use/cover map evaluation

Axes	**Description of axes**									
					Incorrect Informations					
	Length (km)	***Nb CP***	***Correct Inf.***	***Précision*** (%)	*MC*	*Sa*	*Fc*	*Fd*	*Fg*	*Total*
Kilibo-Okpara	19	15	11	73		2		2		4
Toui-Ayétoro-Toui	49	28	26	93	1	1				2
Papané-Kassouala	37	20	16	80	1	1	2			4
Papané-Kpatako-Owodé	16	10	6	**60**		2	2			4
Boko-Sakarou	21	16	15	94					1	1
Tamarou-Pèrèrè	38	21	18	86		2	1			3
Pèrèrè-Biro	12	7	6	86	1					1
N'dali-Kori	27.4	16	15	94		1	0			1
Kori-Bori	24.8	16	14	88			2			2
Bori-Djougou	86	46	41	89		3	2			5
Pélébina-Banigri	15.7	10	10	100						0
Banigri-Bayakou-Wélam	19.5	12	11	92		1				1
Wélam-Sarmanga-Bassila	37.7	23	19	83	1	2		1		4
Savè-Djègbé	35	20	19	95	1	0				1
Djègbé-Tchallagoï	27.7	16	14	88	1	1				2
Savè-Igbodja-Efèoutè	48.7	33	30.5	92	1	2				3
Togon-Fita-Hounkpogon	27.6	18	17.5	97			0		1	1
Banamè-Samiodji	23.8	15	7.5	**50**			3	4		7
Kétou-Nord	15	6	5	83	1					1
Odomèta-Massè-Aïzè	16.4	11	11	100						0
					8	18	12	7	2	**47**
TotaL	**597**	**359**	**313**	**87**						

Nb.CP: Number of checked point; Correct inf: Correct Information; MC: Mosaic of cropland and fallow; Sa: Tree savannah;
Fc: Woodland and woodland savannah; Fd: Dense forest; Fg: Gallery forest

Photo 2. Mosaic of cropland and fallow (MC) (left) and mosaic of cultivation with *Elaeis guineensis* (right)


Photo 3. Mosaic of cropland and fallow with *Parkia biglobosa, Vitellaria paradoxa* (left) and mosaic of cropland and fallow with *Anacardium occidentale* (right)


Photo 4. The woodland and woodland savannah (FC) (left) and gallery forest (Fg) (right)


Photo 5. Humid and dry dense forests

Table 4. Distribution of error by land cover category

	Observation							**Balance**	
Map	MC	Sa	FC	FD	Fg	Pl	**Total**	%C	%E
MC		3	3	0	0	2	8	31	17
Sa	7		7	4	0	0	18	39	38
FC	6	4		1	0	1	12	15	26
Fd	1	2	3		0	1	7	3	15
Fg	0	0	1	1		0	2	4	4
Total	14	9	14	6	0	4	**47**	**92**	**100**

%C (% Map): Ratio or proportion of the map represented by map Unit;
%E (% Error): Ratio or proportion of error noted on Superposed map on land use map

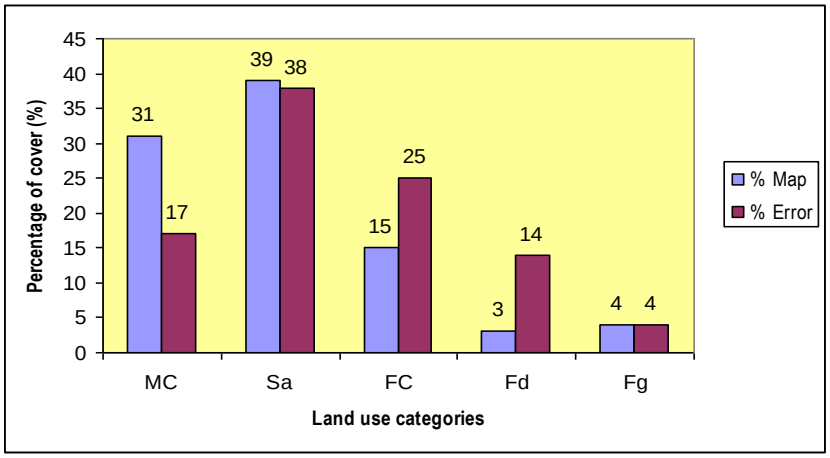

Fig.4. Error percentage compared to map coverage by land use/cover type (LUC)

cover classification. In a related study (commune of Save, Ouesse and Tchaourou which are located within the Ouémé basin) an accuracy of 71.1 % was determined and this concluded that a high precision of interpretation was achieved, with an accuracy of between 50 and 75 %. Mama (2005) showed that the result changed when using the kappa index (Pontius, 2000).

If the overall classification accuracy is high, this does not exclude any difficulties arising from analysis of the satellite imagery. Many errors were recorded during imagery analysis. These errors resulted from the use of multisource and multitemporal satellite data that may have differed in spectral quality (Bolstad and Lillesand, 1991). The possibility of discriminating against land use classes largely depends on the quality of the satellite images and to a great extent depends on the skill of the image interpreter.

5. CONCLUSION

Evaluation of the land use/cover map of the Ouémé basin derived from satellite images of the year 2003 showed that the map was of good quality. The degree of precision was unequal depending on the different axes and land use categories. The land use unit "mosaic of cropland and fallow" was the most accurate interpretation, whereas classification of the unit "humid and dry dense forest" was the least accurate.

6. ACKNOWLEDGEMENTS

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REFERENCES

Anderson JR, Hardy EE, Roack JT, Witmer RE (1976) A land use and land cover classification system for use with remote sensor data. Professional Paper 964. USGS 964, Washington DC. 73p.

Bolstad P, Lillesand TM (1991) Automated GIS integration in land cover classification. Technical papers. 1991 *QCSM-ASPRS* Annual Convention. Remonte Sensing 3: 23-32

CENATEL (2005) Notice explicative de la carte d'occupation et d'utilisation du sol du bassin de l'Ouémé. 24p.

Houndagba CJ, Igué AM, Mensah GA (2006) Rapport de validation de la carte d'occupation du sol du bassin versant de l'Ouémé à 1/200.000 ; 8p. + Annexes 18p.

IGN (1954) Cartes topographiques du Dahomey à 1/50.000. Cotonou, Bénin.

IGN (1969) Cartes topographiques du Dahomey à 1/200.000. Cotonou, Bénin.

Igué AM, Houndagba CJ, Gaiser T, Stahr K (2006) Land Use/Cover Map and its Accuracy in the Oueme Basin of Benin (West Africa). Conference on International Agricultural Research for Development. Tropentag 2006, University of Bonn, October 11-13, 2006, www.tropentag.de.

Igué AM (2005) Soil information system for the Oueme basin. http://www.rivertwin.de/assets/publications/D15_ SLISYS_Oueme basin2.pdf.

Mama, V.J., 2005. Accuracy assessment in improvement land use/cover classification in Benin. Bulletin de la Recherche Agronomique du Bénin. Numéro 47: 38-45

Pontius JrRG (2000) Quantification error versus location in comparison of categorical maps. Photogrammetric and Remote Sensing 66: 1011-1016