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Assessment of Selected Erosion- Related Parameters in Owerri West Local Government Area, Imo State.

Nwauzor C.U, Okeke P.N

Department of Environmental Management, Federal University of Technology, Owerri Nigeria,
Amangabara G.T Geomorphology & Hydrology Research Group)
Dept of Environmental Management School of Environmental Sciences,
Federal University of Technology.PMB 1526 Owerri, Achor, P.C (Development Economics) Dept of Economics.
Niger Delta University

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ABSTRACT
ErosionisamajorecologicalproblemintheSouthEast.Inthestudyareaalonethereareseveralgullyerosionsites(e.g. Nekedeerosionsites,Ihiagwa-FUTOerosionsites,AkwakumaMarketerosionsitesetc.) Thesegulliescontributesignificantsedimentstonwaorieandotamiririversystem.Thisresearchwascarriedouttoassessandestablisherodibilityfactorsunderlyingtheformationofgullyerosioninthestudyarea.Themethodologyadoptedincludedtheselectionoftwogullyerosionsites,measurementoftheircrosssectionalareastodeterminetheirmorphometricattributesfortwoyears(2018and2019).Collectionofsoilsamplesineachgullyformation,thesampleswereresealedincellophanebagsandtransportedtotheSoillaboratoryoftheInstituteofErosionStudies(IES)FUTOforgeotechnicalanalysis(soilconsistencytesttodeterminetheatterberglimits(Plasticlimits,LiquidLimitandPlasticityIndex),Shearstrength,drydensity,bulkdensity,and soiltexture/sieveanalysis).Theresultsofthemorphometricmeasurementshowedthatthegulliesinthestudyareaare U-shape,runningatrightangletotheOtamiriRiver.Elevationis65m,Slopeisbetween2and6%.ThelengthofFUTOgullywas145.2min2018and140min2019;averagewidthis 2.37min2018,5.24min2019;averagedepthis1.70min2018and1.20min2019.Thisindicatethatwhilegullywidthincreasedby10.28%between2018and2019,thedepthandlengthdecreased,anindicationoflateralsidefailureandsedimentationatthegullytoe.Theresultofsoillaboratoryanalysisshowed FUTOgullyhasplasticlimit(PL)47.7%,LiquidLimit(LL)63%andPlasticityIndex(PI)of12.3%whileatNekedegullyerosiontheLLwas19.1%,PL19.1%andPI10.4%thisresultisindicativeoflowcohesion.Theshearingresistanceofthesoilislowandpronetodeformationoncethresholdof30˚-35˚isreachedbyrunoff.Theconclusiondrawnfromthisstudyisthatgullyerosioninthestudyareaareformedbytheprocessesoflateralerosionandundercuttingwhenthegrass coverareremoved.Thesoilconditionbeinglesscohesive, weakshearstrengthetc.arethemajorerodibilityfactorsthatinfluencethegullyformations.Itisrecommendedthatremedialmeasuresforgullyerosionshouldbesitespecificasnotwogulliesarethesame.Inconstructionofroadsidedrains,returnperiodofcertainrainfalleventbedetermined.Clearingofriparianvegetationandin-streamminingatsensitiveareasshouldbediscouraged.

KEYWORDS: GULLY, EROSION, SHEAR STRENGTH, ATTERBERG LIMITS, MORPHOMETRIC, SLOPE, GRADATION, TEXTURE.

I. INTRODUCTION

SoilerosionandconservationinNigeria(especiallyintheSouthEastofNigeria)havebeenthesubjectofextensivestudiesformanyyears(e.gAmangabara&Otumchere,2016;Amangabara,2014,Amangabaraetal.,2014, NwiloandEbinne,2013,Nwiloetal.,2011,Mayowa&Ademola2009,Egboka,2004,IjiomaandNwachukwu,1990,Onwueme&Asiabaka,1992,Grove1949,Egbokaand Okpoko1984).Manyofthesestudiesshowthatmostofthistropicalregionisverysusceptibletorainfallerosion.Theeasternregionof Nigeriahasoneunfortunateclaimtofamewhichmightbetterbeleftunpublicized,exceptthatitrelatestoaproblemofmonumentalproportionsandoneofgreatinterestandconcerntoenvironmentalists,geographers, pedologists,agriculturists,conservationists,governmen

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t,administratorsaswellasotherscientiststheworldover-DramaticgullyerosionismostevidentintheplateauandescarpmentzoneparticularlyalongthescarpoftheAwka-OrluuplandsandtheNsukka-OkigweescarpmentintheEast(Iwujietal,2017a;Amangabara&Otumchere,2016,Ogbonna,2012).Lesspronounced,thoughequallyinsidious,sheetandrillerosioniswidespreadacrosstheregionhowever,extendingfromtheplateausintheNorthwestasfarsouthasthecoastalplains.

Soilerosionintermsoftheprogressivelossoflandiswell-nighuniversal,duelargelytooverfarmingandprimitive,destructivemethodsofcultivation,poorengineeringpracticesetc.Theeffecteitherlossofwaterresourcesordeteriorationofsoilmaywellbethemostseriousandleastreversibleformoflanddegradationintropicalenvironments.InImo State,erosionofdifferenttypesandformisaseriousproblem.Gullyerosionforexamplehavedisplacedmanycommunitiescoupledwithhugelossoffarmlandthroughtheexcessiveremovalofthetopsoil(Njokuetal,2017;Amangabaraetal.,2015,ChukwuochaACetal,2014).Newmap(2014)studyreportedthatroads,telecommunicationandelectricpolesarecontinuouslydamagedandwashedawaygullyerosion.AccordingtothesurveyandEngineeringdesignreportbyNewmap(2013),UruallaIdeatoNorthgullyremainsthelongestgullyerosionintheSouthEasternRegion, measuringabove2kmandcuttingacrossmanycommunities“Umuomeji,Umuturu,EzemazuUmuezenwanagu(Umuezewudo),ElueamaandOzuakoli”toUrashiRiverfromEkeObodo-UkwuObiohiajunctionwiththreefingers.Similarly,Iyuzogullyerosioncutacrossfourcommunities“Iyuzo,Ihioma,OgberuruandObibiochasi”withoverfivefingers(Newmap,2014).

STUDY AREA

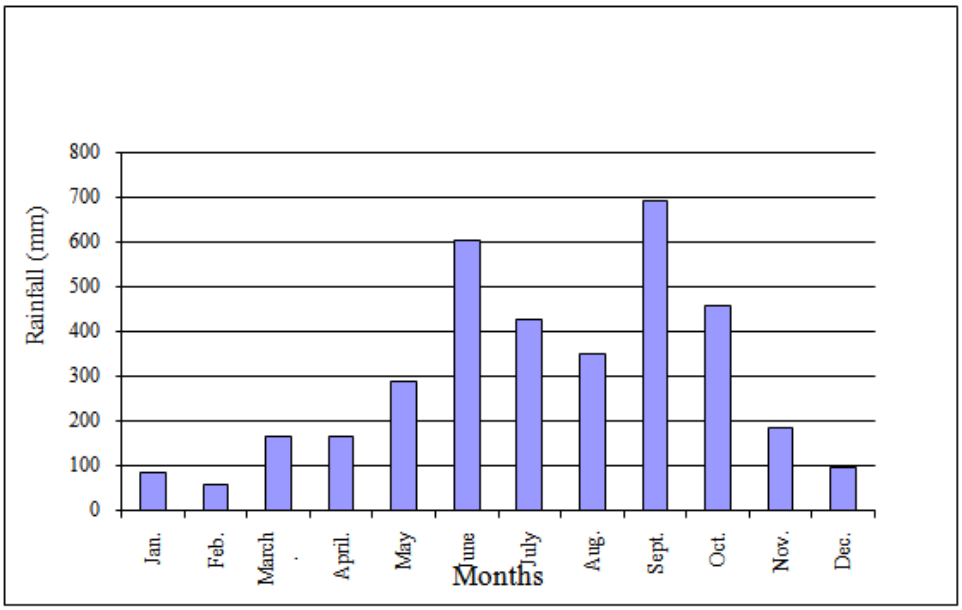

Fig 1.1 Map of the Study Area (Source: Author’s generated GIS Map)

- Climate and Vegetation
- Temperature/Rainfall/Relative Humidity/Vegetation
- Population and Activities
- Gullies

SAMPLE COLLECTION

Fig 1.2 Gully at FUTO roundabout/Otamiri River Bridge

MATERIALS AND EQUIPMENT INVOLVED

- Sandpouringcylinderofabout3litercapacity,mountedaboveapouringconeandseparatedbyashuttercoverplateandashutter.
- Cylindercalibratingcontent(10cm)internaldiameterand(15cm)internaldepthfittedwithflougeapproximately5cmwideabout5mmthick.
- Glassplateabout(45cm)squareand(1cm)thick.

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- Metaltraywithacentralcircularholeofdiameterequaltothediameterofthepouringcare
- Toolforexcavatinghole.
- Balanceaccurateto1g
- Containerforwatercontentdetermination.

SAMPLE PREPARATION

Themorphometryofthevariousgullyerosionprofilessampledinthisprojectaswellastheelevation,slope andothermorphometricattributesofthegullyarepresentedastable4.1below.(Nwauzor, 2021)Itshowsthelength,depthandthecrosssectionalareaofeachgullymeasured.Gulliesarefoundtobeshortinlength,theyareU-Shapeinform.TheyatrightangletotheOtamiristreamelevationisabout65mwhileslopeisbetween2%and6%.
Table4.1AGullyMorphologicalAttributes:NekedeGullyErosion.

MORPHOLOGICAL ATTRIBUTE OF GULY AT IHIAGWA AND NEKEDE.
NEKEDE

Gully	LGA	Length	Seg 1			Seg2			Seg3			Seg 4		
			D	W	C	D	W	C	D	W	C	D	W	C
Nekede (Omukoto)	Owerri West	188	18	12	216	22	13	286	25	16	400	25	19	475

D=Depth W=Width, C=CrossSectionalArea

Table 1.1BFUTOGullyErosion

Year	2018				2019			
Segments	A	B	C	D	A	B	C	D
Length(m)	36.3	36.3	36.3	36.3	35	35	35	35
Width(m)	2.59	1.80	2.31	2.79	6.07	3.07	4.97	6.85
Depth(m)	1.28	1.63	1.86	2.03	2.90	1.77	0.90	0.30

ForCalculationoftotallengthofthegullyforbothyears,
Totallength=SumoflengthsofeachSegment(AtoD)
Totallengthfor2018=36.3+36.3+36.3+36.3=145.2m
Totallengthfor2019=35+35+35+35=140m
ForCalculationofaveragewidthofthegullyforbothyears
Averagewidth=
Averagewidthfor2018==2.37m
Averagewidthfor2019==5.24m
Forcalculationofaveragedepthofthegullyforbothyears;
Averagedepth=
Averagedepthfor2018==1.70m
Averagedepthfor2019==1.20m

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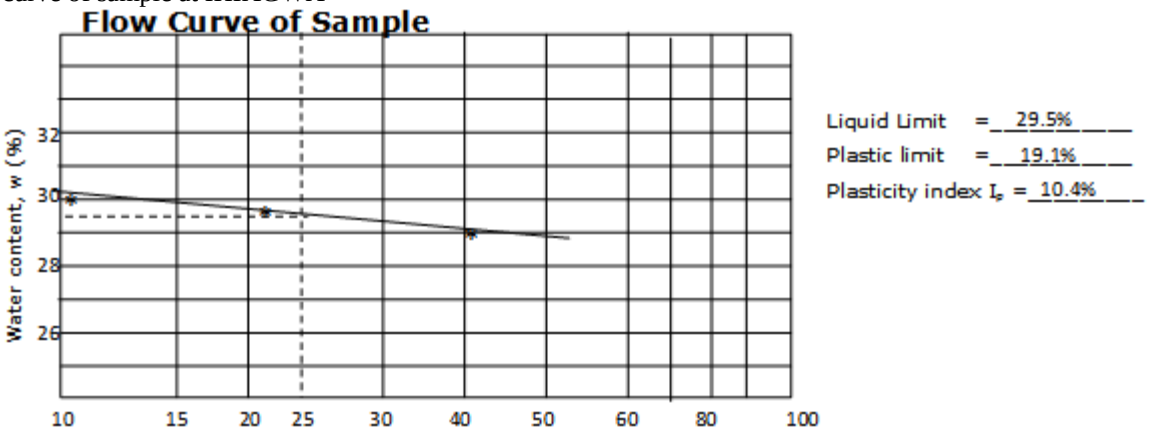
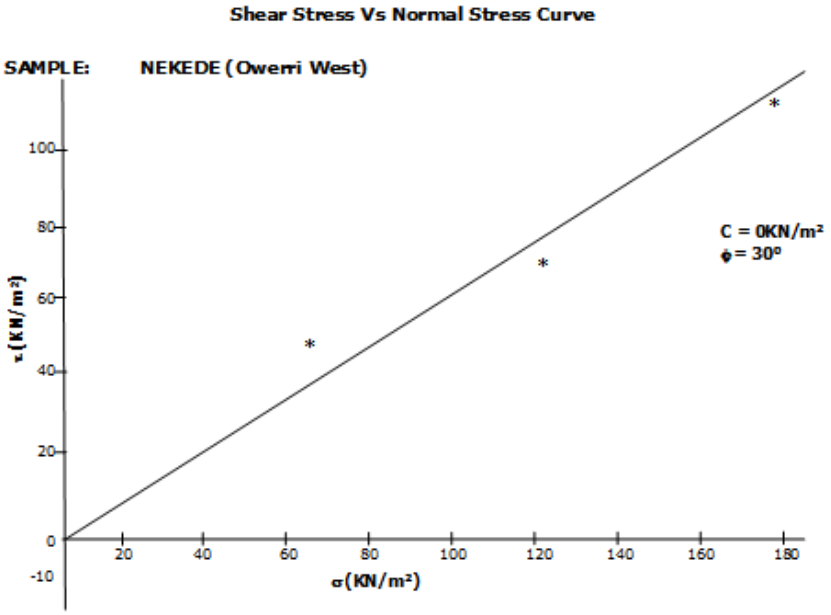
ATTERBERY LIMITS
Flow curve of sample at IHIAGWA



Plastic Limit Determination
Liquid Limit =____63.2%
Plastic limit =_47.7%
Plasticity index Ip =__15.5%

Flow curve of sample at NEKEDE



PlasticLimitDetermination
LiquidLimit =____29.5%
Plasticlimit =_19.1%
PlasticityindexIp=__10.4%
SHEAR STRESS

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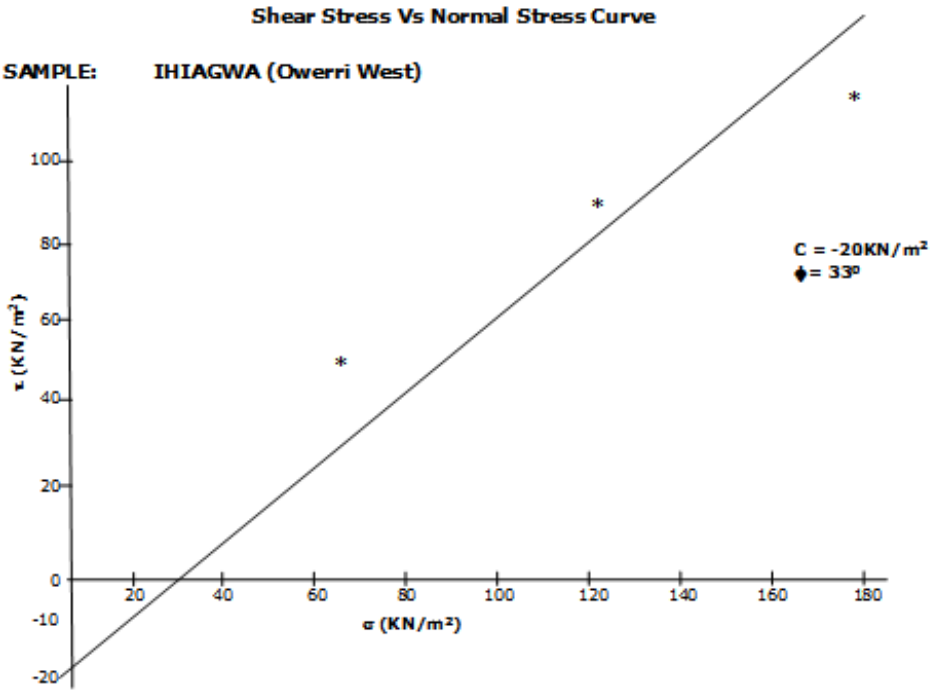

TABLE 1.5GRAINSIZEDISTRIBUTIONS(GRADATIONOFSOIL)ATGULLYEROSIONSITES

				$D_{10}D_{30}D_{50}D_{60}D_{80}$								
1	Nwaorie	Ow. North	Akwakwuma	0.09	0.22	0.32	0.42	0.95	4.66	0.225	Sandy	Poor
2	Otamiri	Ow.West	Ihiagwa	0.18	0.38	0.55	0.75		4.16	0.601	Sandy	Poor
3	Otamiri	Ow.West	Nekede	0.15	0.30	0.45	0.58		3.86	0.348	Sandy	Poor
			MEAN	0.177	0.312	0.455	0.589	0.813	3.458	0.316		
			MEDIAN	0.15	0.3	0.425	0.56	0.8	3.23	0.3		
			STANDARDDEVIATION	0.055	0.071	0.117	0.111	0.216	0.774	0.148		

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GrainSizeDistributionCurveChartsforIhaigwa(PrinttheAttachedGraph)Sheet**Sample:Ihiagwa(OwerriWest)**
Initialweightofsample=60.6g

SieveSize(mm)	Massretained(g)	MassPassing(g)	%Passing
2.00	6.7	53.9	88.9
1.18	6.9	47.0	77.6
0.85	6.8	40.0	66.3
0.600	9.2	31.0	51.2
0.425	8.3	22.7	37.5
0.300	10.2	12.5	20.6
0.150	8.8	3.7	6.1
0.075	2.0	1.7	2.8
Pan	1.2	0.5	

GrainSizeDistributionCurveChartsforNekede
Sample:Nekede(OwerriWest)
Initialweightofsample=58.1.g

SieveSize(mm)	MassRetaining(g)	MassPassing (g)	%Passing
2.00	0.4	577	99.3
1.18	4.5	53.2	91.6
0.85	6.6	46.6	80.2
0.600	9.8	36.8	63.3
0.425	9.0	27.8	47.9
0.300	10.7	17.1	29.4
0.150	11.5	5.6	9.6
0.075	3.2	2.4	4.1
Pan	1.7	0.7	4.1

Note:
SieveNo.4=4.75mm
SieveNo.10=2.0mm
SieveNo.40=0.425mm
SieveNo.100= 0.150mm
SieveNo.200=0.075mm
Butthesesoilsareeitherinexcessofcoarsegrainordeficiencyofcertainsizesandthisisthecaseforallthesampledwatershedsoilwithover99%ofthemhavingsoilwithover90%coarse(sand)compositionfigs above .

II. DISCUSSION OF RESULTS

GullyCharacteristics

ThegulliesinOtamiriwatershedsareshortinlengthcomparedtothoseinOrashiwatershedbutarebynomeanssmallinsize.TheyareU-shapeinform,theyrunatrightangletotheOtamiriRiver,theyarefoundonanelevationof65mabovesealevel.Slopeisbetween2%and6%,theycanbestbedescribedasbankgullies.

FACTORS OF GULLY DEVELOPMENT AND GROWTH

SoilErodibilityFactors

Ourfindingsonthesoilphysicalpropertiesgavecredencetotheassumptionthatthenatureofthesoilasaresultoftheunderlyinggeologyistheprincipalfactorresponsibleforthemassivegullyerosioninourstudyarea.Theprincipalvariableofsoilerodibilityfactoristhesoilstructurewhichisreflectedintheconsistency(Moisturecontent/Atterberglimits),shearstrength,andbulkdensity.Forexample,soilconsistency(moisturecontent/Atterberglimits)showsmostofthegullyerosionarenoneplastic,meaningtheyhavenobindingmaterialsinthesoilandassuchtheyarelesscohesive.WhiletheaverageLiquidlimitsoftheremainingninegullychannelsis33.9%.PlasticLimitis22.5wecanrecallthatPLof35%isindicativeoflowplasticity.Thisfindingsasexpectedreflectedinthe PlasticityIndex(P.I)withanaverageof11.1%.PlasticityIndexvalueof1–5%isslight;5–10%islowwhilevaluesgreaterthan20%arehigh.TheP.Ivaluesarelowindicatingthatcohesion(bindingofgrainparticles)islow.Poorbindingorpoorcohesioninsoiltendtodi

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saggregatewhenincontactwithmovingwaterunderthefo rceofgravity.

Bulkdensityofsoilintheareashowthattheavera gebulkdensityoftheareais1.7g/cm^{3}andthisfindingisina greementwiththeworksofObasiandIjeoma(1991);Hud ecetal.,(2006)andOnu,2011thathavefoundsimilarresul tforthearea.Thestandardmeasurementforbulkdensityis 1.6g/m^{3}whensoilbulkdensityisabovethislimititendsto hardenedupthesoil.Therearetwopossiblescenariosthatc anresultfromthis:first,thecompactionwillleadtocracks onthesoilsurfaceduringtheDryseasonandduringtherain ingseason,thesecrackswillformthechannelsforwatertof lowandsincemostoftheunderlyinggeologyisgravelyan dpoorlysorted,erosionwillbegintooccurbytheformatio nofrills,incipientgulliesandgulliesaprocessknownasdr yandcrackingSecondly,whentheunderlyingformationi sshale,asaresultoftheleachingofsilicainthesandalongsi desodium,potassiumandcalciumbypercolatingwater;ir on,aluminumoxidesandhydroxidesstaybehind,theclay mineralwillswell,increaseinvolume,becomeplasticand covertheporespacespreventingpercolationandinfiltrati onresultinginexcessivesurfaceoverlandflowandatathre sholdvelocityof3.0–
3.5cm/scausethesoiltoslidebecauseitissaturatedandwe akened.

Itisreportedintheliteraturethatoverlandflowincreasesra pidlyonceashearvelocityof3.0–
3.5cm/sisexceeded.Workingonafieldplotwithsoillesst han5kpaandaslopeangleof2–5%(1.15˚-
3.40˚),ObasiandIjeoma(1991)recordedanoverlandflo wof10–15cm^3/scorrespondingtoshearof3-
3.5cm/swhichistheminimumerosivepowerofoverlandf low,sowhenbulkdensityisincreasedandresultsinincreas edoverlandflow,rillformationishighlyexpected.

AnotherSoilParameterthatshowsthevulnerabi lityofthesoiltoerosionisPermeabilityofthesoil.Usually non-
plasticsoilsaregoodtransmitterofwater.Soilsaremostly sandyandareusuallyassociatedwiththereductioninthea ggregatestabilityofthesoilleadingtoincreaseinsoildegr adation.TheworksofAmangabara(2014)showedsimila rfindings.

BulkDensity,AtterberglimitsandPermeability arecharactersthatinfluencetheShearStrengthofanysoils .Thewayandmannergrainsarepackedisimportantasitgo vernstheangleofreposeorinternalfrictionofthesoil.Thes hearingresistanceshowthattheaveragecohesionofthest udyareaislow.Theinternalfrictionofthesoilalsofallsbet ween27˚and34˚.Thesefiguresarelowindicatingthatthef ormationissandyorsandy-
loamandlowincohesion.Ourfindingsaresimilartoworks donebyOnunkwoetal.,(2011)andOnu,2011forOwerria ndhavebeencategorizedasmajorfactorsthatcauseserosi oninAkwaIbomStatewhichisalsoonthesamegeologicF ormations(BeninFormation)asreportedbyEtukudo,(19 880andUdosen,(2009).

SoilTextureisanotherveryimportantvariablet hatinfluenceerosionintheArea.Fromtheprecedingdiscu ssion,thedominantsoiltypeissandysoilwhichispoorlyso rtedandinsomecasesgravely.Table4.8showsthesoiltext ureofallthesampledgullyerosion.Themeaneffectivesiz eis0.177,coefficientofuniformity3.458andcoefficiento fcurvature0.316.Thisisindicativeofcoarsegrain(mediu m–
fine).Coarsegrainsoilshavelittletonobindingmaterialsa ndassuchallowquickpassageofwaterwhichultimatelye nhancessedimenttransportation(Hjustromcurve).

Topography(Elevation/Altitude&Slope)

InthestudyconductedbyOfomata(1987)relief accountedforabout26%ofvariationinthecauseoferosio ninthewholeofsoutheast.InourpresentstudyTopograph y(slopeandterrainaltitude)wasfingerprintedasanimport antfactorofgullyerosion.Correlatinggullysizewithslop eandgullyelevation,wefoundoutthatatP<0.05(r=0.400) slopeandgullyelevationshowsignificantrelationshipacr ossasectionoftowns(gullylocations)inImoState.

TRIGGERS OF GULLY EROSION IN OUR STUDY AREA.

Thusfarwehavebeenabletoclearlyshowtheth eprincipalfactorsofsoil(gully)erosioninOwerriWestist henatureandconditionofsoilpredicatedupontheunderly inggeologicformation.Wehavediscussedsomewhereth aterosionisnatural(geologicalprocess)andaccelerated(humanintervention),Rainfallintensityandamountaswel lastherelief(elevation/terrainaltitude,lengthandtypeofs lope)doplaysignificantroleoncethesoiliserodible.Insim pleterm,whatwemeanhereisthatamajorfactorgovernin gtheoccurrenceofgulliesinOweriWestisthepresenceof erodiblematerialinthoselandscapepositionswhereconc entratedsurfaceorsubsurfacerunoffcanoccur;i.e.confin edalluvialdeposits,unconsolidatedsedimentsanddeepl yweatheredrocksandsediments.

Typically,geologicerosionmaynotbecatastro phicintheimmediateterm,however,whentheerosionise nhancedoracceleratedtheproductisusuallycatastrophic. Acceleratederosionisactivatedbybothnatureandhuman activities.Thehumancomponentsinsoilerosionareconn ectedwithpoorengineeringandagriculturalpracticesand otherlanduseactivities.Onlythemostsevererainfallandl

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argehailstormeventswillleadtooverlandflowinaforest,ifthetreesareremovedbylogging,infiltrationratesbecomehighanderosionlowtothedegreetheforestfloorremainsintact.Inthecaseofconstructionorroadbuilding,whenthelitterlayerisremovedorcompacted,thesusceptibilityofthesoiltoerosionisgreatlyincreased.

OneoftheseriouscausesofacceleratederosioninowerriWestLGAfromfieldobservationislanduseactivities.e.g.theremovalofripariancoverandgrasscoveratFUTOledtotheformationofFUTOgullywhileallthegulliesatOmuokotoMechanicShedatNekedemayhavebeeninfluencedbytheon-goinginstreamminingatOtamiririverbecausemanygulliesrepresentreadjustmentofalandscapetoanewequilibriumaftersomesortofthresholdofresistancetoerosionhasfinallybeenexceeded,theymaygrowastonishinglyquicklyoncetheyhavebeeninitiated.Forthesamereason,theyarenoteasilystoppeduntiltheyhaveextendedtotheupslopelimitofconcentratedorrapidflow,orhavere-gradedtothenewbaselevel,orboth.Asaresult,gulliesareeasiertopreventthantocure,atleastuntiltheimpetusforgrowthhasbeenexhausted,atwhichtimethegullywillbegintostabilizeandtohealitself.(Verylonggulliesmaybehealingatthedownstreamendwhiletheheadendisstillexpanding).

Thus,preventingorcuringagullyrequiresunderstandingofitsstageofgrowthanditsspecificproximatecausesandgrowthprocesses.Forexample,ifthegullyisgrowingbyheadwardretreatofawaterfall,thenupslopemanagementofrun-offisrequired,suchasdiversionditchesandre-gradingthechannelfloorwithloosebrokenstone(rip-rap).Ifun-channeledslopewashistheproblem,thenthebestsolutionswouldbetopromoteinfiltrationrelativetorun-offbycontour-ploughingofthewatershed,divertingflowintoblindtrenches,andplantingtreesandothervegetation.Thisistheapproachbeingadoptedat FUTOgullysitewhereadiversionditchhasbeencreatedtopreventgullyingwhilerepairworksstartatthegully.

III. SUMMARY AND FINDINGS

TheaimoftheresearchundertakeninthisdissertationhasbeentodeterminefactorsthatwillinduceorinfluencetheformationofgullyerosioninOwerriWestLGAofImoState.Thisaimwasguidedbyfourbasicobjectives.First,toidentifythreegullyerosionsitesandtheircrosssectionalareasinthestudyarea.Thesecondwastoidentifyordetermineth eircharacteristics.

Thethirdobjectivesthatguidedthisresearchincludetheexaminingrelief,slopeamdcovertype,thespatialcharacteristicsofthegulliesacrossOwerriWestandbasedonthisspatialcharacteristicsclassifythegulliesbymorphologicalprocess,size,andlocationonthelandscape.Thefourthandthefinalobjectiveweretocomparethegulliesandaccountfortheirdevelopment.

Thecurrentworkwasbasedonthegeomorphicthresholdtheory.Geomorphicthresholdscanbeoftwotypes,intrinsicandextrinsic.Itcanbedefinedasathresholdoflandformstabilitythatisexceededeitherbyintrinsicchangeofthelandformitself,orbyaprogressivechangeofanexternalvariable.Thethresholdconcepthaspracticalsignificance.Ifthethresholdconditionscanberecognized,notonlywilldifferentexplanationsforsomelandformsemergebutalsotheabilitytoidentifyincipientlyunstablelandformsandtopredicttheirchangewillbeofvaluetolandmanagersandengineers.

Inpursuanceofourobjectivesinaddressingtheproblemsofgullyerosion.Soilsampleswerecollectedinthefieldandsubjectedtolaboratoryanalyses,resultsofwhichwereusedaserodibilityinputdataforcarefulevaluation.

Themethodsusedtoanswertheresearchquestionswerealiteraturereview,fieldobservation,measurementofgullycharacteristicssuchasdepthwidthandlengthofthegulliesincludingtheirgeographicallocation(GPS)anddelevationabovemeanselevelaswellasthecollectionofsoilsamplesforlaboratoryanalyses,theresultofwhichwereusedasinputdataforcarefulevaluation.OwerriWestLGAcannotbesaidasoneofthoseLGAsinImoStatethathasaheavyoccurrenceofgullyeorisonbutafewexistmainlyatslightlyelevatedterrainwithintheOtamiriRiveratIhiagwa/FUTOandattheMechanicWorkshopareaofNekede.

Major Findings

Therearethreemajorfindingsthatcanbedrawnfromthisresearch.Thefirstmajorfindingisthatthedevelopmentofgulliesinourstudyareausuallydoesnotfollowstrictlythegeneralizedstagesofprogressionoferosionfromsplasherosiontosheeterosiontorillerosionandthentogullyerosion.Furthermore,whiletherearefourdominantprocessescontrollingtheinitiationanddevelopmentofgullyerosioninImoState,theprocessesthatoccurinOwerriWestislateralbankfailureandundercutting.Thisprocessisassociatedwithin-streammining.ThegulliesinNwaorieandOtamiriwatershedsareformedbythisprocess.

Thesecondmajorfindingthatarisesfromthisresearchisthatcontrarytothecommonlyheldviewthatallerosion–proneareasofthesoutheasternpartofNigeriaecologicalzonearehomogenousandporous,thisstudyshowsthatthevariousunderlyinglithologicformationsareheterogeneous(heterolithic)andvariablyporousandpermeable.Even withinthesamegeologicformation

Thethirdmajorfindingthatcanbedrawnfromthisresearchisthatearlyresearchersunderpinrainfallcharacteristicsasthedominantagentofsoilerosion.

IV. CONCLUSION

Theconsensusamongsttheseresearchersisthathighintensityrainfallintheareaproduceshighvolumeoverlandflowwhichcausesthescourandwearoftheearthsurface.Asaresultofthisconclusion,remedialmeasurehavebeenbasedontechniquescapableofreducingtheerosivecapacityofthesurfacerunoff,Andthishaslargelybeenresponsibleforthecontinuedoccurrenceofgullyerosioninthearea.Fromfieldandlaboratoryworkwefoundoutthatsoilcharacteristicsarethedominantagentofsoilerosioninourstudyarea.Thisisbecausethelithologicandstratigraphicsequenceoftheunderlyingmaterialsislargelythickcohesionlesssandstrataoverlainbyaredclayeysandstratumandsurfaceearthofeithersandy-loamorsilty-loam.Manyofthesoilarenon-plastic.Soilthatareplastic,haveverylowplasticityindex.Bulkdensityishighinsoilunderlainbyshaleandlowinsoilunderlainby BeninFormation,leadingtocompactioninthefermerinstancewhichresultsincrackingofthesurfacethatformschannelforconcentratedflows.Shearingresistance(internalfriction)isbetween27˚about34˚andthisisverylow.Gradationtestshowmeaneffectivesizeof0.177,Cu3.458,Cc0.316indicativeofcoarsegrain(mediumtofine)withlittlebindingmaterials.

V. RECOMMENDATIONS

Fourmajorrecommendationsaremadebasedonthefindingsofthisresearch.

1. Thefirstmajorrecommendationisthatremedialmeasuresforanygullyerosionsiteshouldbesitespecific. Giventhatsoilconditionistheprincipalfactorofgullyerosioninimo State,
2. Theconstructionofroadsandroadsidegutters,considerationshouldbegiventoone,thedeterminationofreturnperiodofcertainrainfallevents.
3. Thematerialstobeusedshouldbeofadequatequalitytoforestallcracksandcollapseofthegutter.
4. Theguttersshouldbearmoredtoreducethevelocityofwaterdischargedfromthedrains.Therecommendationisbasedontheoccurrenceofthegullybyfutobridge.
   TheThirdmajorrecommendationisthatriparianclearanceandin-streamminingshouldberegulated.

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