

Gis-Based Mapping of Drainage Channels and Flood Pathways Within the Extension Area of Imo State University, Owerri, Nigeria

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Abstract

Urban flooding has become a persistent environmental challenge in many Nigerian cities due to poor drainage infrastructure, rapid urbanization, indiscriminate waste disposal, and increasing rainfall intensity associated with climate variability. This study presents a Geographic Information System (GIS) and Remote Sensing-based assessment of drainage channels and flood pathways within the extension area of Imo State University (IMSU), Owerri, Nigeria. The objectives of the study were to map the drainage network, identify flood-prone zones and flood pathways, evaluate the effectiveness of existing drainage systems, and develop a geospatial database for flood management and sustainable urban planning. Primary data were acquired through field surveys using Kolida KTS-442UT Total Station and Garmin Etrex 10 GPS receiver for the collection of X, Y, and Z coordinates of drainage channels, spot heights, and control points. Secondary data included existing maps and Google Earth imagery of the study area. ArcGIS 10.8, QGIS 3.4, and Surfer 20 software were utilized for spatial analysis and generation of Digital Elevation Models (DEM), contour maps, drainage network maps, flood pathway maps, flow direction maps, and spot height maps. The results revealed that the study area exhibits a dendritic drainage pattern with significant variations in terrain elevation controlling runoff movement. Low-lying areas characterized by inadequate drainage facilities and blocked channels were identified as highly vulnerable to flooding. Flow direction analysis indicated that stormwater runoff generally moves from elevated terrains toward depressions where water accumulates during heavy rainfall events. The study established that several drainage channels within the IMSU extension area are structurally deficient, poorly maintained, and undersized, thereby exacerbating flooding conditions. The research demonstrates the effectiveness of GIS and Remote Sensing techniques in urban flood vulnerability assessment and drainage management. The study recommends periodic drainage maintenance, integration of geospatial technologies into campus planning, improved waste management practices, and construction of additional drainage structures to mitigate flooding within the study area.

Keywords: Flood Mapping, Drainage Channels, GIS, Remote Sensing, DEM, Urban Flooding, Spatial Analysis, Flood Pathways, Imo State University.

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I. INTRODUCTION

Flooding is one of the most destructive environmental hazards affecting urban and semi-urban environments globally. It causes significant socioeconomic losses through destruction of infrastructure, disruption of transportation networks, environmental degradation, and threats to human health and safety. In developing countries such as Nigeria, urban flooding has intensified due to rapid urbanization, inadequate drainage infrastructure, poor land-use planning, and climate-induced increases in rainfall intensity.

Drainage systems are essential components of urban infrastructure designed to convey stormwater runoff from built-up environments to receiving water bodies. Efficient drainage networks help minimize water accumulation, reduce erosion, and maintain environmental sustainability. However, poor drainage maintenance and indiscriminate disposal of solid waste frequently obstruct drainage channels, thereby reducing their discharge capacity and increasing flood risks.

The extension area of Imo State University (IMSU), Owerri, experiences recurrent flooding during the rainy season. Waterlogging and drainage overflow often disrupt academic activities, damage infrastructure, and create unhealthy environmental conditions. These flood incidents are primarily associated with inadequate drainage facilities, blockage of existing channels, poor environmental sanitation, and increasing impervious surfaces resulting from urban expansion.

Advances in Geographic Information System (GIS) and Remote Sensing technologies have significantly improved flood risk assessment and urban drainage management. GIS enables the collection,

storage, analysis, and visualization of spatial information, while Remote Sensing provides valuable topographic and land-use data through satellite imagery and aerial observations. The integration of GIS and Remote Sensing techniques facilitates Digital Elevation Model (DEM) generation, hydrological analysis, floodplain mapping, and runoff simulation.

Several studies have applied GIS and Remote Sensing techniques in flood mapping and drainage analysis within Nigerian urban environments. However, limited studies have focused specifically on institutional environments such as university campuses where flooding significantly affects educational activities and infrastructure. This study therefore aims to bridge this gap by mapping drainage channels and flood pathways within the extension area of Imo State University, Owerri using geospatial techniques.

II. MATERIALS AND METHODS

2.1 Study Area

The study area is the extension area of Imo State University (IMSU), located in Owerri Municipal, Imo State, southeastern Nigeria. The area lies approximately between latitudes 5°27'N and 5°30'N and longitudes 7°02'E and 7°05'E. The region falls within the tropical rainforest climatic zone characterized by distinct wet and dry seasons. Annual rainfall ranges between 2,000 mm and 2,500 mm, with peak precipitation occurring between June and September. Temperatures generally range from 23°C to 34°C throughout the year.

The vegetation of the area consists mainly of secondary rainforest vegetation interspersed with built-up environments and open spaces. Rapid urban development within the university extension area has significantly altered the natural drainage pathways and terrain characteristics.

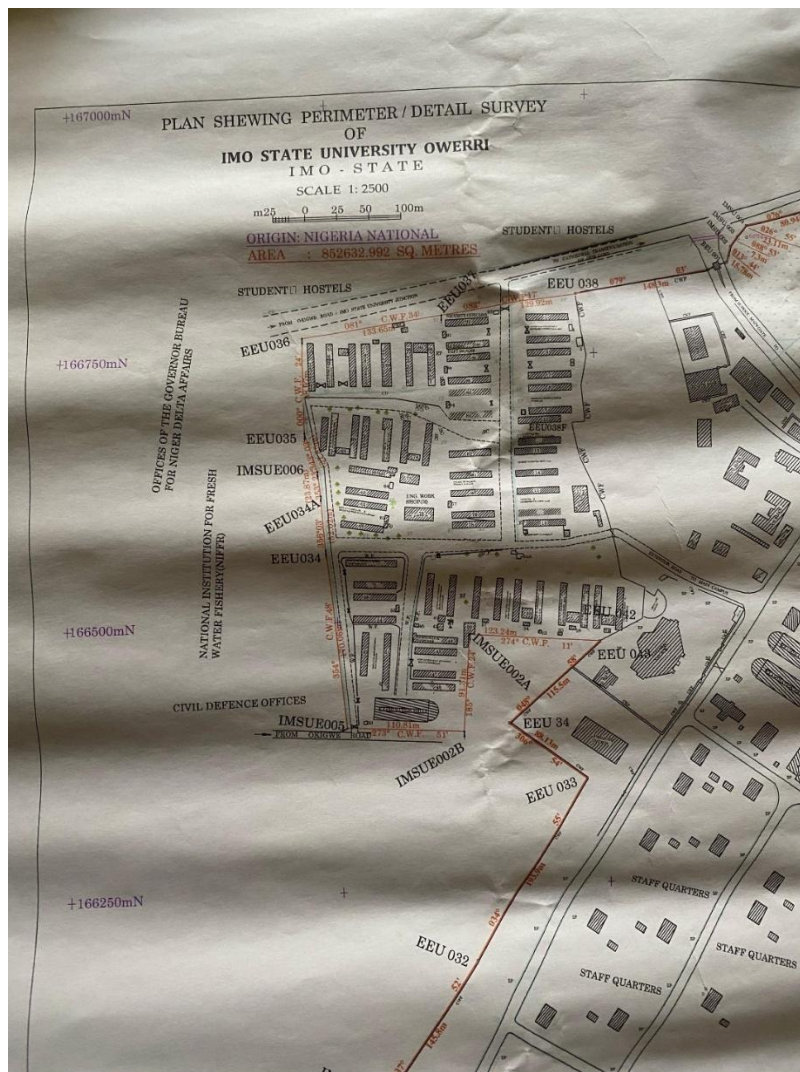


Fig 1: The perimeter map of Imo state university showing extension area of Imo state University
Source: Department of Surveying and Geo-informatics Year: 2014

2.2 Data Sources

2.2.1 Primary Data

Primary data utilized in this study included:

- X, Y, and Z coordinates of drainage channels;
- Spot height data;
- Perimeter coordinates of the study area;
- Ground control points.

These data were acquired through field surveys using:

- Kolida KTS-442UT Total Station;
- Garmin Etrex 10 GPS receiver.

2.2.2 Secondary Data

Secondary data included:

- Existing maps obtained from the Department of Surveying and Geoinformatics, Imo State University;
- Google Earth imagery;
- Relevant journals, textbooks, and published literature.

2.3 Data Processing and Spatial Analysis

The acquired field coordinates were processed using Microsoft Excel and converted into CSV format before importation into ArcGIS 10.8 software. Spatial datasets were georeferenced in the Nigeria Transverse Mercator (NTM) coordinate system based on Minna Datum.

The methodology involved:

1. Ground truthing and field validation;
2. Creation of shapefiles for drainage and topographic data;
3. Generation of Digital Elevation Model (DEM);
4. Terrain analysis;
5. Hydrological analysis;
6. Production of thematic maps.

Spatial analyses conducted included:

- Contour analysis;
- Drainage network extraction;
- Flow direction analysis;
- Flood pathway mapping;
- Spot height analysis.

QGIS 3.4 and Surfer 20 software were additionally used for terrain visualization and thematic map production.

III. RESULTS AND DISCUSSION

3.1 Digital Elevation Model (DEM)

The DEM generated from spot height data revealed considerable variations in terrain elevation within the study area. Areas characterized by low elevations were observed to correspond with flood-prone locations where stormwater accumulates during rainfall events.

The DEM further demonstrated that runoff movement is controlled primarily by terrain gradient and slope direction. Surface runoff generally flows from elevated regions toward depressions and low-lying areas.

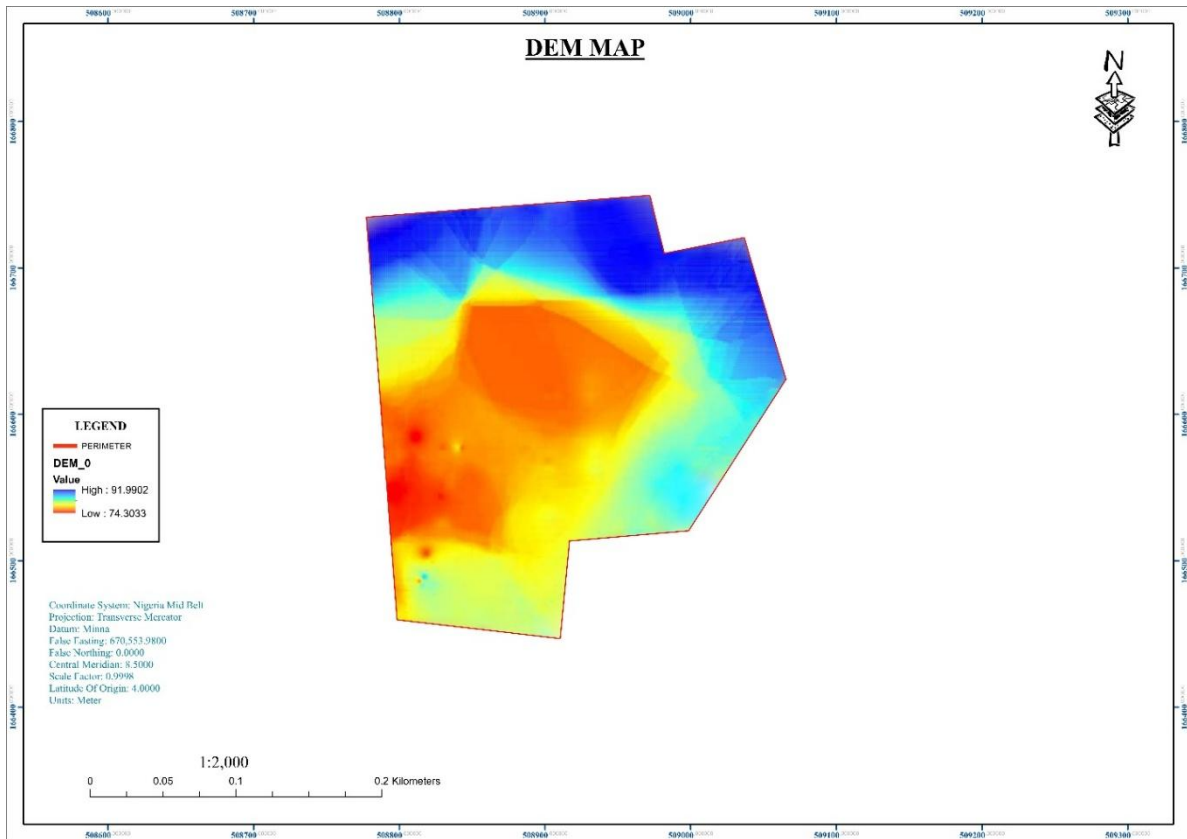


Fig 2: DEM of the extension area of Imo State University Owerri

3.2 Contour Analysis

The contour map illustrated the topographic characteristics of the IMSU extension area. Closely spaced contour lines indicated regions of steep terrain, while widely spaced contours represented relatively flat surfaces.

The contour analysis revealed that slope variation significantly influences the movement and accumulation of runoff within the study area. Areas with gentle slopes and depressions exhibited higher susceptibility to flooding.

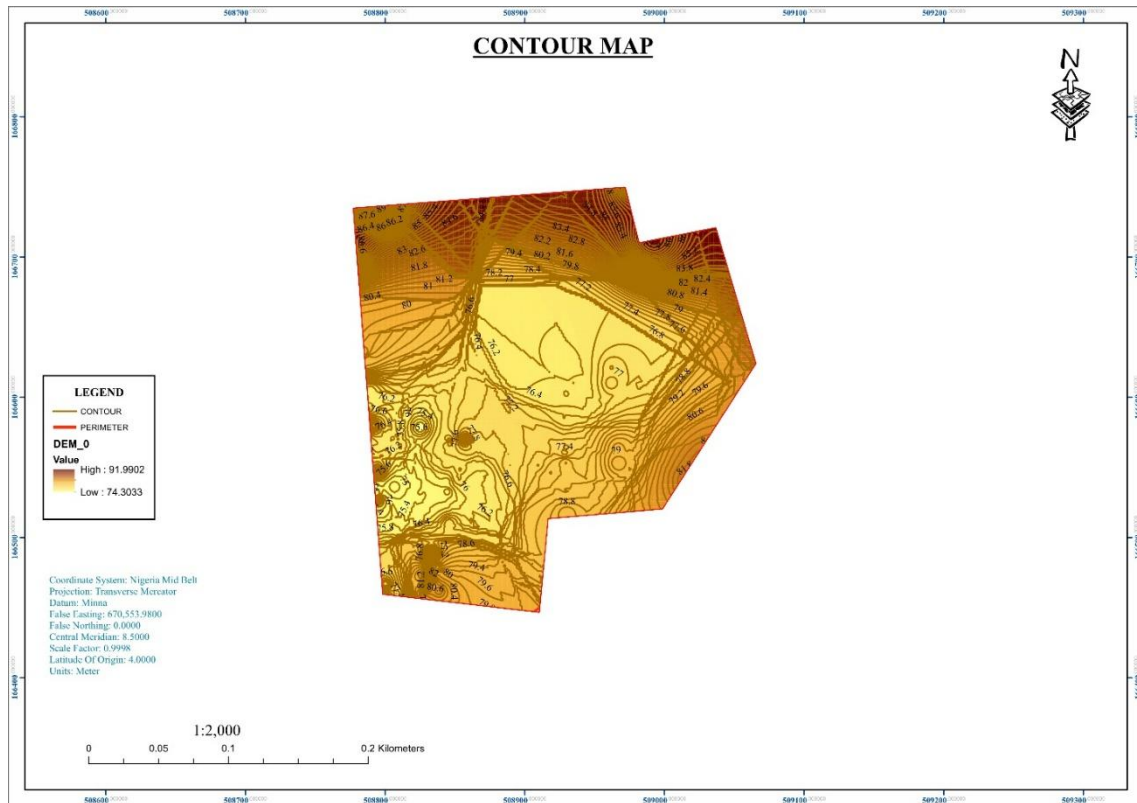


Fig 3: Contour map of extension area of Imo state University Owerri

3.3 Drainage Network Analysis

The drainage network analysis indicated that the study area exhibits a dendritic drainage pattern. This drainage pattern is commonly associated with relatively homogeneous geological formations and natural branching runoff systems.

The drainage channels within the study area were observed to vary in size, structural condition, and discharge capacity. Several drainage channels were found to be partially blocked by sediments and refuse materials.

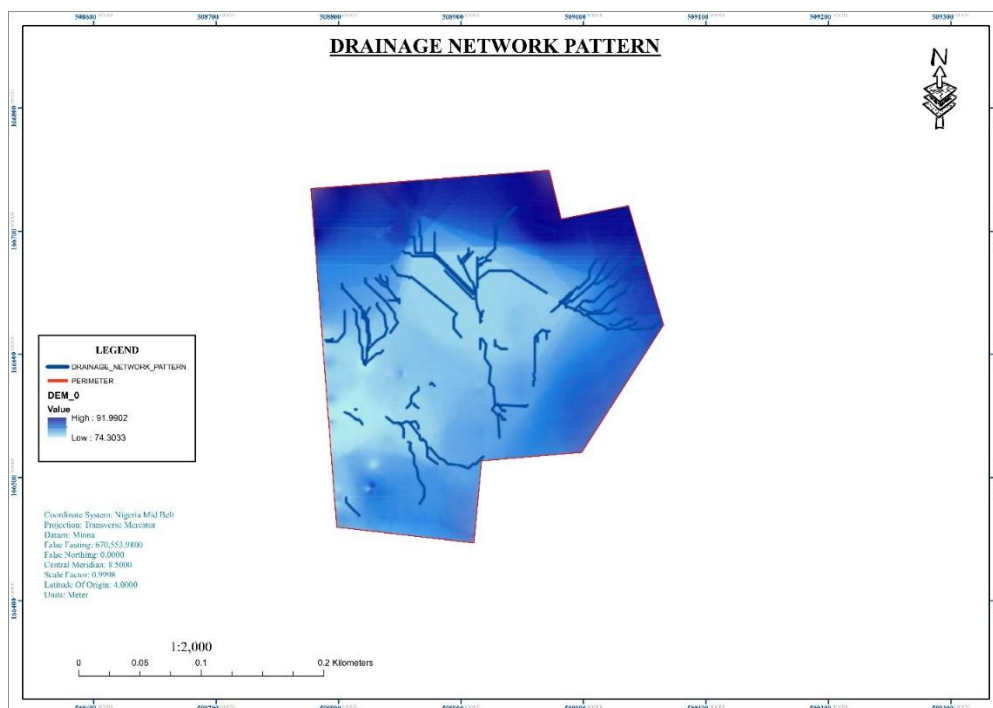


Fig 4: Drainage network pattern of the extension area of Imo state university

3.4 Flood Pathway and Flow Direction Analysis

Flow direction analysis showed that runoff movement follows natural terrain gradients from higher elevations toward lower terrains. Flood pathway mapping identified major runoff routes and water accumulation zones within the campus extension area.

Areas lacking proper drainage connectivity experienced severe runoff accumulation during rainfall events. These flood-prone zones were concentrated mainly within low-elevation depressions and poorly drained sections of the campus.

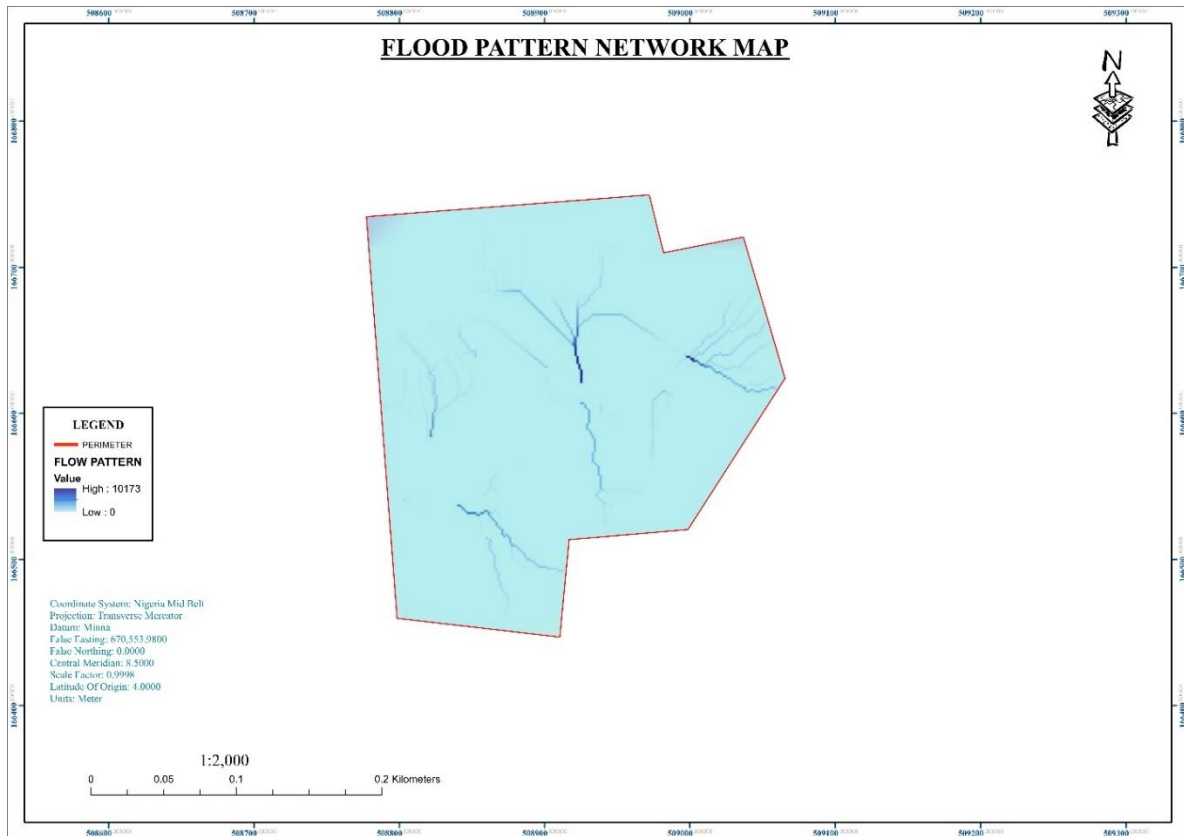


Fig 5: Flood pattern network map of the extension area of Imo State University Owerri

3.5 Discussion of Findings

The findings of this study are consistent with previous studies conducted by Okorafor et al. (2021), Ugwu et al. (2021), and Eteh and Okpobiri (2021), which established that terrain elevation, poor drainage infrastructure, and uncontrolled urbanization significantly contribute to flooding in urban environments.

The identified dendritic drainage pattern suggests that natural runoff movement within the study area is controlled largely by topographic characteristics. However, anthropogenic activities such as construction works, poor waste disposal practices, and inadequate drainage maintenance have disrupted natural drainage efficiency.

The study further revealed that many existing drainage structures are undersized and structurally deficient, thereby limiting their ability to effectively convey stormwater runoff during intense rainfall events. These conditions increase the vulnerability of the IMSU extension area to recurrent flooding.

The integration of GIS and Remote Sensing techniques proved highly effective in flood vulnerability assessment, hydrological analysis, and drainage mapping. The generated thematic maps provide important spatial information for flood mitigation planning and sustainable campus development.

IV. CONCLUSION

This study successfully employed GIS and Remote Sensing techniques to map drainage channels and flood pathways within the extension area of Imo State University, Owerri. The integration of field survey data, Digital Elevation Models, contour analysis, and hydrological modeling enabled the identification of flood-prone areas and runoff pathways within the study area.

The findings established that terrain elevation, inadequate drainage systems, blockage of channels, and poor environmental management practices significantly contribute to flooding within the IMSU extension area.

The generated maps demonstrated that low-lying areas with insufficient drainage infrastructure are highly susceptible to stormwater accumulation and flooding.

The study further demonstrated the effectiveness of GIS and Remote Sensing technologies in urban flood risk assessment and drainage management. The developed geospatial database and thematic maps provide valuable tools for flood mitigation planning, environmental management, and sustainable urban development within institutional environments.

V. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed:

1. Existing drainage channels within the study area should be regularly desilted and maintained to ensure free flow of stormwater.
2. Additional drainage structures and culverts should be constructed in identified flood-prone areas.
3. Proper waste management practices should be enforced to prevent blockage of drainage channels.
4. GIS and Remote Sensing technologies should be integrated into campus planning and environmental monitoring systems.
5. Flood vulnerability assessments should be conducted periodically to monitor environmental changes and drainage conditions.
6. Construction activities should be properly regulated to avoid obstruction of natural drainage pathways.
7. Environmental awareness campaigns should be organized to educate students and staff on flood prevention and sanitation practices.

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