# FOSS for Geoinformatics (FOSS4G)

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Geoinformatics constitute a vital component of information science for addressing the problems of geography, geosciences and related branches of engineering. This domain combines geospatial analysis and modeling, development of geospatial databases, information systems design, human-computer interaction and both wired and wireless networking technologies. Geoinformatics uses geocomputation for analysing geoinformation. One of the major applications of geoinformatics in recent times is the study of variation in landscapes over multiple spatial and temporal scales encompassing a variety of domains – land use and land cover change, climate change, water resources, urban development, natural disaster mitigation, etc. Geoinformatics include geographic information systems, spatial decision support systems, global positioning systems (GPS), and remote sensing.

Geographic Information Systems (GIS) are increasingly being used as the principal tool for digital exploration of variation in landscapes, as they provide the necessary functions for spatial data collection, management, analysis and representation (Turner et al., 2001; Longley et al., 2005; Steiniger and Weibel, 2009; Ramachandra et al., 2004). These tools

provide new and critical ways of understanding our earth and its biogeochemical cycle. GIS software used for this kind of studies fulfill several GIS functionality including:

i.) Ensure world wide development, advancement and application of solutions.
ii.) Allow studying of data, methods and algorithm implementation.
iii.) Furthermore, developed models and algorithms need not be reimplemented by others in order to continue research or validate previous results.

Apart from these, researchers should have access to libraries of the original models for analysis, validation, development and implementation (Steiniger and Hay, 2009; Jolma et al., 2008b) for further improvement and customisation depending on the local requirement.

Over the last years the paradigm of Free and Open Source Software (FOSS) development has taken root in the GIS community, resulting in the creation of several sophisticated GIS software projects whose aim is to develop free software for numerous purposes. GIS software fulfilling the specific requirements have been distributed with licenses that grant more freedoms of use and that support openness, such as licenses used by FOSS GIS projects (for example: http://grass.itc.it/; http://wgbis.ces.iisc.ernet.in/grass).

FOSS have proved to be promising tools that allow us to see and change the *software codes* written in any programming language. FOSS is generally synonymous with *free software* and *open source software*, and describes similar development models, but with differing cultures and philosophies. Because of the way it is licensed, it has the potential to be legally given away for free or for very little cost and copied and shared with others.

FOSS, F/OSS or FLOSS (for *Free/Libre/Open Source Software*) is liberally licensed to grant the right of users to study, change, and improve its design through the availability of its source code. It has more scope for being available in multiple languages and for being adapted or tweaked to particular needs. This can be very useful for students, researchers, teachers, scientists wanting to use legal software that is appropriate to their needs and fits within their modest budgets. This approach has gained both momentum and acceptance as the potential benefits have been increasingly recognised by many (Steiniger and Hay, 2009). This is proving to be the boon to researchers from economically disadvantaged countries.

The open source definition is used by the Open Source Initiative to determine whether or not a software license can be considered open source. Under the open source definition, licenses must meet the following ten conditions in order to be considered open source licenses:

- Free redistribution: the software can be freely given away or sold. (This was intended to expand sharing and use of the software on a legal basis.)
- Source code: the source code must either be included or freely obtainable. (Without source code, making changes or modifications can be impossible.)

- Derived works: redistribution of modifications must be allowed. (To allow legal sharing and to permit new features or repairs.)
- Integrity of the author's source code: licenses may require that modifications are redistributed only as patches.
- No discrimination against persons or groups: no one can be locked out.
- No discrimination against fields of endeavor: commercial users cannot be excluded.
- Distribution of license: the rights attached to the program must apply to all to whom the program is redistributed without the need for execution of an additional license by those parties.
- License must not be specific to a product: the program cannot be licensed only as part of a larger distribution.
- License must not restrict other software: the license cannot insist that any other software it is distributed with must also be open source.
- License must be technology neutral: no click-wrap licenses or other medium-specific ways of accepting the license must be required.

There is a distinction between open source software and free software. Open source software are those, for which the human-readable source code is made available under a copyright license (or arrangement such as the public domain) that meets the Open Source Definition. This permits users to use, change and improve the software, and to redistribute it in modified or unmodified form. It is often developed in a collaborative manner in a public domain. Public domain comprises the body of knowledge and innovation (especially creative works such as writing and inventions) in relation to which no person or other legal entity can establish or maintain proprietary interests within a particular legal jurisdiction. This body of information and creativity is considered to be part of a common cultural and intellectual heritage, which, in general, anyone may use or exploit, whether for commercial or non-commercial purposes. Public domain software is not protected by copyright and may be copied and used without payment (http://www.fsf.org/; wikipedia).

On the other hand, free software is software that can be used, studied, and modified without restriction, and which can be copied and redistributed in modified or unmodified form either without restriction, or with restrictions only to ensure that further recipients can also do these things. To make these acts possible, the human readable form of the program (called the source code) must be made available. The source code can be placed in the public domain, accompanied by a software license saying that the copyright holder permits these acts (a free software licence), etc. (http://www.fsf.org/).

The first formal definition of free software states that software is free software if people who receive a copy of the software have the following four freedoms:

1.) Freedom 0: The freedom to run the program for any purpose.
2.) Freedom 1: The freedom to study and modify the program.
3.) Freedom 2: The freedom to copy the program so you can help your neighbor.

4.) Freedom 3: The freedom to improve the program, and release your improvements to the public, so that the whole community benefits.

Freedoms 1 and 3 require source code to be available because studying and modifying software without its source code is highly impractical (http://www.fsf.org/).

Proprietary software has restrictions on copying and modifying as enforced by the proprietor. Restrictions on modification and copying are sought by either legal or technical means or sometimes both. Technical means include releasing machine-readable binaries to users and withholding the human-readable source code. Legal means can involve software licensing, copyright, and patent law.

Copyleft is a form of licensing and may be used to modify copyrights for works such as computer software, documents, etc. In general, copyright law allows an author to prohibit others from reproducing, adapting, or distributing copies of the author's work. In contrast, an author may, through a copyleft licensing scheme, give every person who receives a copy of a work permission to reproduce, adapt or distribute the work as long as any resulting copies or adaptations are also bound by the same copyleft licensing scheme. A widely used and originating copyleft license is the GNU General Public License.

The GNU General Public License (GNU GPL or simply GPL) is a widely used free software license, originally written by Richard Stallman for the GNU project. It is the license used by the Linux kernel. The GPL is the most popular and well-known example of the type of strong copyleft license that requires derived works to be available under the same copyleft. Under this philosophy, the GPL is said to grant the recipients of a computer program the rights of the free software definition and uses copyleft to ensure the freedoms are preserved, even when the work is changed or added to. This is in distinction to permissive free software licences, of which the BSD (Berkeley Software Distribution) licenses are the standard examples. The GNU Lesser General Public License (LGPL) is a modified, more permissive, version of the GPL, intended for some software libraries.

FOSS has become an essential component in geoinformatics research. Many free and open source software are available that facilitate customisation, provide good support via forums and email lists and have up-to-date documentation. Among the many GIS tools that are frequently used are Desktop GIS, Mobile GIS, Remote Sensing and Image Processing software, GIS extensions and libraries, Spatial Database Management Systems, Map Server and Geostatistical tools (Steiniger and Hay, 2009).

Next, we present a non-comprehensive list of the FOSS commonly used in GIS applications along with their web address for further references.

| | Application | Software | References |
|---|---|---|---|
| 1 | GIS | Sav GIS | http://www.savgis.org |
| 2 | | Forestry GIS | http://www.forestpal.com/fgis.html |
| 3 | Image Processing / Raster, Vector Analysis | GRASS | http://wgbis.ces..isc.ernet.in/grass |
| 4 | | QGIS | http://qgis.org |
| 5 | | ILWIS | http://ilwis.org |
| 6 | | uDIG | http://udig.refractions.net |
| 7 | | SAGA | http://saga-gis.org |
| 8 | | OpenJUMP | http://openjump.org |
| 9 | | MapWindow | http://mapwindow.org |
| 10 | | gvGIS | http://gvsig.gva.es |
| 11 | | InterImage | http://www.lvc.ele.puc-rio.br/projects/ |
| 12 | | Landserf | http://www.landserf.org |
| 13 | | OSSIM | http://www.ossim.org |
| 14 | Landscape Analysis | r.li (GRASS) | http://grass.itc.it/grass70/manuals/html70_user/r.li.html |
| 15 | | Fragstats | http://www.umass.edu/landeco/research/fragstats/fragstats.html |
| 16 | Spatial DBMS | MySQL | http://www.mysql.org |
| 17 | | PostGIS for Postgre SQL | http://postgis.refractions.net |
| 18 | Web MapServer | GeoServer | http:// www.geoserver.org |
| 19 | | MapServer | http:// www.mapserver.org |
| 20 | Statistical software | R | http://www.r-project.org/ |
| 21 | | Gstat | http://www.gstat.org |
| 22 | | Past | http://folk.uio.no/ohammer/past/ |
| 23 | Exploratory Data Analysis | GeoDa | http://geodacenter.asu.edu/software |
| 24 | | GeoVista | http://www.geovistastudio.psu.edu |
| 25 | | STARS | http://regionalanalysislab.org/index.php/Main/STARS |
| 26 | Libraries | GDAL/OGR | http://gdal.osgeo.org |
| 27 | | Generic Mapping Tool | http://gmt.soest.hawaii.edu/ |
| 28 | | JAMA/GNU | http://math.nist.gov/javanumerics/jama/ |
| 29 | | JTS Topology Suite | http://tsusiatsoftware.net/jts/main.html |
| 30 | | LUPOLib | http://www.ufz.de/index.php?en=4302 |
| 31 | | OpenBugs | http://mathstat.helsinki.fi/openbugs/ |
| 32 | | Sextane | http://forge.osor.eu/projects/sextante/ |
| 33 | | TerraLib | http://www.terralib.org/ |
| 34 | Multi Agent | MASON | http://cs.gmu.edu/~eclab/projects/mason/ |
| 35 | | Rapast Simphony | http://repast.sourceforge.net/ |
| 36 | | SWARM | http:// www.swarm.org |
| 37 | | Netlogo | http://ccl.northwestern.edu/netlogo/ |

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|---|---|---|---|
| 38 | | (Open-)Start Logo | http://education.mit.edu/openstarlogo/ |
| 39 | | OBEUS | http://www.tau.ac.il/~bennya/research1.html |
| 40 | CMS | Drupal | http://drupal.org/ |
| 41 | | Joomla | http://www.joomla.org/ |
| 42 | | Atutor | http://www.atutor.ca/ |
| 43 | Modelling | Open Modeller | http://openmodeller.sourceforge.net/ |
| 44 | | Desktop GARP | http://www.nhm.ku.edu/desktopgarp/index.html |
| 45 | | Maxent | http://www.cs.princeton.edu/~schapire/maxent/ |
| 46 | | Landisview | http://sourceforge.net/projects/landisview |
| 47 | Miscellaneous | PCRaster | http://pcraster.geo.uu.nl |
| 48 | | SANET | http://ua.t.u-tokyo.ac.jp/okabelab/atsu/ sanet/ |
| 49 | | S-Distance | http://www.prd.uth.gr/res_labs/spatial_analysis/software/SdHome_en.asp |
| 50 | | TAS | http://www.uoguelph.ca/~hydrogeo/TAS/ |
| 51 | | Harvest | http://www.nrs.fs.fed.us/tools/harvest/ |
| 52 | | Qrule | http://www.al.umces.edu/Qrule.htm |

Proprietary software licenses impose several restrictions on the use of software such as not allowing users to distribute the software or to install it on a second computer or to give it to others. The licenses also prohibit a reverse engineering of the software and modifying the software. If the source code is not available, then it is not possible to study how algorithms are implemented and it is not possible to improve the software. FOSS licenses, such as the GPL and the LGPL, explicitly allow users to study, modify and re-distribute software. Consequently the following three benefits of FOSS have been identified (Steiniger and Bocher, in press):

(i) FOSS avoids ‘reinventing the wheel’,
(ii) in terms of the source code, FOSS provides the best ‘documentation’ available, and
(iii) users can adapt the software to their own needs without restrictions.

All three points are essential for research, when considering that

- research should not be limited by the functionality that is provided by the software,
- research experiments need to be repeatable and reproducible, and
- research can progress faster when models can be analysed, validated, and improved directly, i.e. based on source code, without the problem of misinterpretation, as may be the case when knowledge is obtained/interpreted from articles (Steiniger and Hay, 2009).

In addition to these general research advantages, the use of FOSS licenses have enhanced education and knowledge transfer, particularly in developing countries that don't have the (financial) resources. Students and researchers can freely and legally download the software and study the algorithms. Finally it benefits society in general, as the use of free

software licenses can facilitate the application of new technologies and knowledge that enables a sustainable use of resources (Jolma et al., 2008b). If such unified software development and research efforts could be initiated then we see great potential to accelerate geoinformatics research world wide.

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**Useful links:**

- http://wgbis.ces.iisc.ernet.in/foss
- http://www.opensourcegis.org
- http://www.spatialserver.net/osgis
- http://www.spatialanalysisonline.com
- http://www.ai-geostats.org
- http://ces.iisc.ernet.in/grass Mirror site for GRASS in India
- http://ces.iisc.ernet.in/biodiversity Geoinformatics Applications
- http://ces.iisc.ernet.in/energy