

Abstract

There is an increasing debate on the role and potential benefits of Free/Open-Source Software (FOSS), particularly in supporting developing countries in their attempts to increase the use of information and communication technology (ICT).

This research investigates the level of FOSS development and application in Sudan by analyzing the ecosystems that foster the development of FOSS: the Public sector, the Private sector, Universities and Communities of Developers. FOSS leads to the economic and social development. Data has been collected by surveying the four elements that are mentioned above through questionnaires and interviews to obtain qualitative and quantitative values. The SWOT Analysis report provides an inventory of the area's strengths, weaknesses, opportunities, and threats (SWOT) and assesses the degree to which each sector supports future growth. The overall goal of this thesis is to have a clear understanding of ecosystem strengths and areas of potential that can be built upon and better marketed and areas of weaknesses so as to be remedied. Findings of this thesis will lead to some recommendations to improve the situation.

In conclusion, a thorough overview of current situation regarding FOSS development and application is presented, creating a starting point for the identification of new business opportunities for Sudanese companies, and new fields of research and studies for developers to continue promoting the use and development of FOSS in Sudan.

ملخص الدراسة

هناك نقاش متزايد حول دور و احتمالات الفائدة المرجوة من البرمجيات الحرة والمفتوحة المصدر خصوصاً في دعم وتطوير الدول النامية لمحاولتها لزيادة استخدام تكنولوجيا الاتصالات و تقانة المعلومات. بحثت هذه الدراسة عن مستوى تطور وتطبيق البرمجيات الحرة والمفتوحة المصدر في السودان من خلال تحليل كل القطاعات التي تدعم تطوير وإستخدام البرمجيات الحرة والمفتوحة المصدر وهي : القطاع العام ، القطاع الخاص ، قطاع الجامعات و مجتمعات المطورين. يقود استخدام البرمجيات الحرة والمفتوحة المصدر إلي التطور الاقتصادي و الاجتماعي. لقد تم جمع المعلومات في هذه الدراسة عن طريق إجراء مسح عام لكل القطاعات الأنفة الذكر وذلك باستخدام الإستبانات للحصول على معلومات كمية وكيفية بلاضافة إلي إثراء المعلومة المتحصل عليها وتوسيعها من خلال الأسئلة المباشرة والمداخلات أثناء ملء الإستبانات بواسطة كل الشرائح المعنية. لقد وضح التحليل الذي أجري كل أماكن الضعف والقوة والفرص والمهددات وتم تقييم درجة نمو كل قطاع وقد كان الهدف العام من نتائج التحليل المتحصل عليها هو الفهم الواضح لكل نقاط القوة في القطاعات المعنية و احتمالات التطور التي يمكن القيام بها و بناؤها و تحديد مواضع الضعف حتى يمكن معالجتها. ستقود النتائج التي توصل إليها البحث إلي تقديم مقترح توصيات لتطوير الوضع الحالي.

وختاماً فقد تم عرض نظرة عامة على الوضع الحالي فيما يتعلق بتطوير و تطبيق البرمجيات الحرة والمفتوحة المصدر كبدائية لفتح وخلق فرص عمل للشركات السودانية وفتح مجالات جديدة للدراسات والبحوث للمطورين للاستمرار في ترويج استخدام وتطوير البرمجيات الحرة والمفتوحة المصدر في السودان .

Acknowledgement

I would like to thank Alla for being there for me and help me to finish this work.

My thanks to D. Mohamed Ali Hamad Abbas my supervisor for the help and guidance he has given me.

I would like to acknowledge D. Nimat Karamalla for her support.

I am grateful for my family and my friends for the support I received from them.

Dedication

**I would like to dedicate this work to all persons
who guided and supported me**

Table of contents

Title	Pag.No
Abstract	I
المستخلص	II
Acknowledgement	III
Dedication	IV
Table of Contents	V
List of tables	IX
List of Figures	XIV
Glossary	XVII
Abbreviations	XIX
Chapter 1: Introduction	1
1.1 Problem Definition	1
1.2 Research Objective	1
1.3 Importance of the Research	2
1.4 Scope of Research	2
1.5 Target Audients	2
1.6 Research Methodology	2
1.7 Thesis layout	3
Chapter 2: Theoretical Background and literature Review	4
2.1 Theoretical background	5
2.1.1 Definition	6
2.1.1.1 The Free Software Foundation(FSF) definition	6
2.1.1.2 The Open Source Initiative (OSI) definition	7
2.1.1.3 IOSN definition	7
2.1.2 The benefits from using FOSS for developing countries	8
2.1.2.1 Strategic benefits	8

2.1.2.1.1 Developing Local Capacity/Industry	8
2.1.2.1.2 Reducing Imports/Conserving Foreign Exchange.	8
2.1.2.1.3 Enhancing National Security	9
2.1.2.1.4 Reducing Copyright Infringements	9
2.1.2.1.5 Enabling Localization	9
2.1.2.2 Economic Benefits	10
2.1.2.2 .1 Increasing Competition	10
2.1.2.2 .2 Reducing Total Cost of Ownership	10
2.1.2.2 .3 Achieving Vendor Independence	10
2.1.2.3 Social Benefits:	11
2.1.2.3. 1 Increasing Access to Information	11
2.1.3 The Shortcomings of FOSS	11
2.1.3.1 Lack of business applications	11
2.1.3.2 Interoperability with proprietary systems	12
2.1.3.3 Documentation and “polish”	12
2.1.4 Software Regulation:	12
2.1.4 .1 Different between FOSS and Proprietary Software	13
2.1.4 .2 FOSS licenses	14
2.1.4 .2 .1 GNU General Public License (GPL)	14
2.1.4 .2 .2 GNU Lesser General Public License	16
2.1.4 .2 .3 BSD Style Licenses	17
2.1.4 .2 .4 Multiple Licensing	17
2.2 literature Review	19
Chapter 3: FOSS Ecosystem model & Methodology	22
3.1 Research Questions	23
3.2 Ecosystem Model	23
3.3.1 Communities of Developers	24
3.3.2 Universities	24

3.2.3 The Public Sector	24
3.2.4 The Private Sector	25
3.3 Motivations and Needs Assessment.	25
3.3.1 Existing ICT infrastructure	26
3.3.2 Existing human ICT capacity	26
3.3.3 Education infrastructure	27
3.3.4 Policy and Legal Environment	27
3.3.5 Regional context	27
3.3.6 Intellectual property (IP) law framework and enforcement	28
3.3.7 Low cost, widely available Internet access	28
3.4 Research design and methods	29
3.4.1 Study Population	29
3.4.2 Sampling	29
3.4.3 Instruments to collect the necessary data for the study	30
3.4.3.1 Interview	31
3.4.3.1 Questionnaire	31
3.4.4 The methods of data processing and analysis	32
3.4.5 SWOT analysis	33
Chapter 4 : Results	34
4.1 Introduction.	34
4.2 The obtained result from questionnaire	34
4.2 .1 Developers	35
4.2.2 Universities	52
4.2.3 Public Sector	63
4.2.4 Private sector	78
4.3 The summary of the Interview.	91
4. 4 Community of developers SWOT Analysis	94
4.5 Universities SWOT Analysis	95

4.6 Public Sector SWOT Analysis	96
4.7 Private sector SWOT Analysis	97
Chapter 5 : Discussion	98
5.1 Introduction	99
5.2 Key SWOT Findings of Community of Developers	99
5.3 Key SWOT Findings of Universities	102
5.4 Key SWOT Findings of Public Sector	103
5.6 Key SWOT Findings of Private sector	105
Chapter 6 : Conclusion and Recommendations	103
6.1 Conclusion	108
6.2 Recommendations for Developers	109
6.3 Recommendations for universities	110
6.4 Recommendation for Public Sector	111
6.5 Recommendations for private sector	112
6.6 Limitations of Study	113
6.7 Recommendations for further work (research)	113
References	116
Appendix	118

List of Tables

Title	Pag.No
Table (2.1): FSF definition	7
Table (3.1): sample size allocation	30
Table (4.1): Arithmetic mean equation.	35
Table (4. 2A): The level of awareness of FOSS between Sudanese developers.	35
Table (4. 2B): Average Mean	35
Table (4. 3): factors prevent Sudanese developers from using FOSS	36
Table (4. 4): factors promote FOSS adoption in Sudan.	37
Table (4. 5): Categories of motivations.	38
Table (4.6A): level of FOSS communities' development	39
Table (4.6B): Average Mean.	39
Table(4.7A): level of support received by FOSS communities.	40
Table (4.7B): Average Mean.	40
Table (4.8): Type of support received by FOSS communities.	41
Table (4.9): the main organizations/bodies that provide support to FOSS Communities.	41
Table (4.10): sources of income	42
Table (4.11): key resources allocated to Sudanese developers.	43
Table (4.12A): level of Sudanese developer access to the internet.	43
Table (4.12B): Average Mean.	44
Table (4.14A): level of protection mechanism of intellectual property rights in Sudan.	44
Table (4.14B): Average Mean.	45
Table (4.15): Cooperation between universities and FOSS Communities.	46
Table (4.16): Cooperation between public sector and FOSS Communities.	47
Table(4.17): Cooperation between private companies and FOSS Communities.	47
Table (4.18): Main FOSS project achieved in Sudan	48

Table (4.19): Trends regarding the projects carried out by FOSS Communities.	50
Table (4.20): countries from which developers make contributions to the developer in Sudan.	51
Table (4.21 A): The level of awareness of FOSS in Sudanese universities	51
Table (4.21B): Average Mean	52
Table (4.22): aims from using FOSS in Sudanese universities.	52
Table (4.23A): The level of Education infrastructure in Sudanese universities.	53
Table (4.23B): Average Mean.	53
Table (4.24): Training received in the field of FOSS by universities staff members.	54
Table (4.25): Number of courses received in FOSS by universities staff members.	54
Table (4.26): Universities role of FOSS training.	55
Table (4.27A): The level of support for FOSS project in Sudanese universities.	55
Table (4.27B): Average Mean.	56
Table (4.28): Type of support for FOSS project in Sudanese universities.	56
Table (4.29A): The level of Internet access in Sudanese universities.	57
Table (4.29BA): Average Mean	57
Table (4.30A): The level of protection mechanism of intellectual property for software in Sudan.	58
Table (4.30B): Average Mean.	58
Table (4.31): main barriers that prevent universities from adopting FOSS.	59
Table (4.32): Sudanese universities needs to be able implementing FOSS.	60
Table (4.33): main resources in Sudanese universities that encourage the use of FOSS.	60
Table (4.34): The matching of the learning outcome obtained by universities and the needs of the labor market.	61
Table (4.35): Projects achieved in Universities.	62
Table (4.36 A): The level of awareness of FOSS in the public sector.	63
Table (4.36B): Average Mean.	63

Table (4.37A): the level of availability of infrastructure regarding the adoption of FOSS in public sector institutions	64
Table (4.37B): Average Mean.	64
Table (4.38): Training in the field of FOSS IT managers in public sector were received.	65
Table (4.39): Number of courses IT managers in public sector received in FOSS.	65
Table (4.40A): The level of support for FOSS projects in public sector.	66
Table (4.40B): Average Mean.	66
Table (4.41): Type of support for FOSS project in the public sector.	67
Table (4.42A): The level of Internet access in public sector institutions.	68
Table (4.42B): Average Mean.	68
Table (4.43A): The level of protection mechanism of intellectual property for software in Sudan.	69
Table (4.43B): Average Mean.	69
Table (4.44): main benefits as a result of adopting FOSS in public institution.	70
Table (4.45): main barriers that prevent public organization from adopting FOSS.	71
Table (4.46): needs improve in public organization to be able to implement FOSS projects.	72
Table (4.47): main resources in public organization that encourages the use of FOSS.	73
Table (4.48): The learning outcome obtained by universities and its match to the needs of the labor market.	73
Table (4.49): Opportunities offers for graduates in the development of FOSS project.	74
Table (4.50): The role that public sector institutions are doing to motivate staff in the field of ICT, specifically in FOSS development.	75
Table (4.51): The role in training workers in the field of ICT specifically in the field of FOSS.	75
Table (4.52): Existing of Open Standard for Software in Sudan.	76
Table (4.53): Projects achieved in public sector.	77

Table (4.54A): The level of awareness of FOSS in private sector.	78
Table (4.54B): Average Mean.	78
Table (4.55A): the level of availability of infrastructure regarding the adoption of FOSS in private sector institutions.	79
Table (4.55B): Average Mean.	79
Table (4.56A): Training received by IT manager in the field of FOSS in private sector.	80
Table (4.57B): courses received by IT manager in the field of FOSS in private sector	80
Table (4.58A): the level of support for FOSS projects in private sector institutions.	81
Table (4.58B): Average Mean.	81
Table (4.59): Type of support for FOSS projects in private sector institutions.	82
Table (4.60A): The level of Internet access in private sector institutions.	82
Table (4.60B): Average Mean.	82
Table (4.61A): The level of protection mechanism of intellectual property for FOSS in Sudan.	83
Table (4.61B): average Mean	83
Table (4.62): Main benefits as a result of adopting FOSS in private organization.	84
Table (4.63): main barriers prevent private organization from adopting FOSS.	85
Table (4.64): needs improve in private organization to implement FOSS projects.	85
Table (4.65): main recourses in private sector organizations encouraging use of FOSS.	86
Table (4.66) The learning outcome obtained by universities and its match to the needs of the labor market.	86
Table (4.67): Opportunities offers for graduates in the development of FOSS project.	87
Table (4.68): The role that private sector institutions are doing to motivate staff in the field of ICT, specifically in FOSS development	88
Table (4.69): The role in training workers in the field of ICT specifically in	88

the field of FOSS.	
Table (4.70): Open standards regarding the use of software in general in Sudan	89
Table (4.71): Projects achieved by private sector.	90
Table (4.72): Community of Developers SWOT analysis.	94
Table (4.73): Universities SWOT analysis.	95
Table (4.74): Public Sector SWOT Analysis.	96
Table (4.75): Private Sector SWOT Analysis.	97

List of Figures

Title	Pag.No
Figure (3.1) Ecosystem	24
Figure (3.2) Factors affect FOSS development	26
Figure 4.1: Percentage level of awareness of FOSS between Sudanese developers	35
Figure 4.2: Percentage level of FOSS communities' development	39
Figure 4.3: Percentage level of support received by FOSS communities	40
Figure 4.4: Percentage of FOSS communities according to source of income	42
Figure 4.5: Percentage level of Sudanese developer access to the internet	44
Figure 4.6: Percentage level of protection of intellectual property rights in Sudan	45
Figure 4.7: Percentage level of awareness of FOSS in Sudanese universities	52
Figure 4.8: Percentage level of Education infrastructure in Sudanese universities	53
Figure 4.9: Percentage of university staff members who received training in FOSS	54
Figure 4.10: Percentage level of support for FOSS projects in Sudanese universities	56
Figure 4.11: Percentage level of Internet access in Sudanese universities	57
Figure 4.12: Percentage level of protection of intellectual property for software in Sudan	58
Figure 4.13: Percentage level of the match of the learning outcomes obtained at universities to the needs of the labor market	61
Figure 4.14: Percentage level of awareness of FOSS in the public sector	63
Figure 4.15: Percentage level of availability of infrastructure regarding the adoption of FOSS in public sector institutions	64
Figure 4.16: Percentage of IT managers in public sector who received	65

training in the field of FOSS	
Figure 4.17: Percentage level of support for FOSS projects in public sector	66
Figure 4.18: Percentage level of Internet access in public sector institutions	68
Figure 4.19: Percentage level of protection of intellectual property for software in Sudan	69
Figure 4.20: Percentage level of match of the learning outcomes obtained at universities to the needs of the labor market	74
Figure 4.21: Percentage of institutions who offer to graduates opportunities in the development of FOSS project	74
Figure 4.21: Percentage level of the role that public sector institutions are doing to motivate staff in the field of ICT, specifically in FOSS development	75
Figure 4.22: Percentage of organizations that have a role in training workers in the field of ICT specifically in the field of FOSS	76
Figure 4.23: Percentage of those who think that open standard for software exist in Sudan	76
Figure 4.24: Percentage level of awareness of FOSS in private sector	78
Figure 4.25: Percentage level of availability of infrastructure regarding the adoption of FOSS in private sector institutions	79
Figure 4.26: Percentage of private sector IT managers who received training in the field of FOSS	80
Figure 4.27: Percentage level of support for FOSS projects in private sector institutions	81
Figure 4.28: Percentage level of Internet access in private sector institutions	83
Figure 4.30: Percentage level of match of the learning outcomes obtained at universities to the needs of the labor market	87

Figure 4.31: Percentage of organizations who offer to graduates opportunities in the development of FOSS project	87
Figure 4.32: Percentage of the private sector organizations who have a role in training workers in the field of ICT specifically in the field of FOSS	89
Figure 4.33: Percentage of organizations who say there are open standards regarding the use of software in general in Sudan	89

Glossary :

Free/open source software (FOSS) :

Free and open source software is distributed with the underlying source code open for other programmers to look at and use. When everyone is allowed to read, modify, and redistribute the source code for a piece of software, then programmers can improve and adapt it, and fix bugs; and users can share the software with their neighbors, colleagues and friends [7].

Source Code:

Source code is written in special kinds of languages designed for programming. A program in its source code form might not be easy for lay people to understand, but it is comprehensible to trained programmers. When the source code is converted to machine readable form, even programmers will have difficulty understanding and modifying the program. Therefore, access to the source code is a prerequisite for the development of FOSS and a principle embraced in all FOSS licenses [3].

Proprietary software

Proprietary software is privately owned and controlled, usually by a company. The owners of proprietary software hold a copyright that awards them the exclusive rights to publish, copy, modify, and distribute the software and they usually keep the source code hidden. Most proprietary software companies sell an "end-user license" to people who use the software programme on their computers. The end-user license agreement limits the way the software can be used -- for example, only allowing non-commercial uses -- and it often restricts sharing [7].

Copy left:

Proposed by free software advocates, copy left is an alternative framework conceived within copyright law which usually confers exclusive rights to copyright holders and thus limits access to the work by all others. Authors may want to "copy left" their works to grant certain rights to people who are interested in distributing or modifying their works, provided these people will also "copy left" all the derivative works. Although copyright and copy left might represent very different ideas regarding the relationship between authors and their works, copy left is not against copyright law. On the contrary, without the rights granted by the copyright law, authors will not have the power to copy left their works [3].

GNU:

GNU is a recursive acronym for “GNU’s Not Unix” and the name of a project started in 1984 by Richard Stallman to develop a complete UNIX-like operating system that is available as Free Software. This is called the GNU operating system [1].

GNU GPL:

The GNU General Public License (GNU GPL) was originally used as the license for “Free Software” distributed by the Free Software Foundation (FSF). Under the GPL, users may run copy and modify the software, and distribute the modified software. However, users are not allowed to add their own restrictions and the modified software must be released under the same licensing terms. The GPL also requires that the source code be made available to anyone who possesses the program binary [1].

Multiple Licensing:

The copyright holder of a work can have various ways of making use of his/her work available to others. The terms and conditions she would want users to accept may differ from case to case. For example, the copyright holder of an editor software may be willing to issue an academic license that is cheaper and more affordable for students, while commercial licenses are adopted when the program is sold to commercial entities. A copyright holder can also decide to license a work under both FOSS licenses and proprietary licenses to achieve different purposes [3].

TCO:

Total Cost of Ownership (TOC) includes all the costs involved in a technology or business solution. In addition to the initial investment cost, TCO includes training, maintenance, support, replacement costs, and the like. In the case of software, the TCO should include the initial cost of the software; up gradation cost; and maintenance, support and training costs [1].

Ma3bar:

The Arab support center for Free and Open Source Software.

Abbreviations

ICT	Information and Communication Technologies
FOSS	Free/Open Source Software
FSF	Free Software Foundation
OSI	Open Source Initiative
IOSN	International Open Source Network
TCO	Total Cost of Ownership
GPL	General Public License
LGPL	Lesser General Public License
BSD	Berkeley Software Distribution
IP	Intellectual Property
SUDAFOSS	Sudanese Association of Free Open Source Software