SUSTAINABLE BROWNFIELDS REDEVELOPMENT AND TOOLS OF COMPUTER AIDED DESIGN

An inductive inquest on the case of Amman, Jordan.

DEYALA HAMMAD ALTARAWNEH
School of Geography, Earth and Environmental Sciences,
University of Birmingham, UK
deyalatarawneh@gmail.com

Abstract. The task of geography is to establish a critical system which embraces the phenomenology of space in order to grasp all of its meaning in the varied terrestrial scene (Sauer 1925). Brownfields are a global geographic concern that have been considerably researched within the universal discourse. Computer Aided Design (CAD) and its tools have been widely used to enhance and optimize urban plans during both design and implementation phases. Nonetheless, the connection between the two is often broken. While greenfield development enjoys the employment and implementation of a wide array of CAD tools, brownfield redevelopment projects are still struggling with traditional planning and management methods. Looking at the association between sustainable brownfield redevelopment and the optimization of CAD tools and software in the city of Amman, Jordan, the paper attempts to shed light on the unfulfilled potentials of advancement the spatial tools have to offer to the ongoing quest for sustainable urban development on the local scale and the global debate around the urban paradox on the wider scheme. Using empirical data collected and processed in response to the problem posed, the results indicate a CAD-based model could streamline sustainable brownfield development and save substantial time and resources which would otherwise be required using traditional methods. The paper therefore argues that the need for a comprehensive computer aided intervention for the development and management of marginal and overlooked geographies of brownfields in the city of Amman is long overdue.

1. Introduction

The term ‘brownfield’ has lent itself to the urban planning and the IT industry interchangeably. While understood as any previously developed land or premises currently not in full use, which may be partially occupied, vacant, derelict or contaminated and not necessarily available for immediate use without intervention in the first discipline (Alker *et al*., 2000), the term is commonly used to describe problem areas in new software systems in need of development in the presence of existing software applications and systems in the second (Hopkins and Jenkins, 2008). The two definitions collide in the sense that brownfield software development occurs within an already complex IT environment of existing applications and systems. On one hand, this suggests any new software architecture must take into consideration and coexist with software currently available on one hand (Baley the Belcham, 2010), while on the other, in the context of contemporary urbanism, brownfield redevelopment stands to introduce change according to the already existing urban fabric (CLARINET, 2002).

Computer Aided Design (CAD), understood as the use of computer systems to aid in the creation, modification, analysis or optimization of a design (Sarcar *et al.*, 2008), is another area where the two disciplines converge. It has been argued that a variety of CAD software has been, and still is, used to increase the productivity and improve the quality of the urban design (Ajene & Sylvester, 2014; Chakrabarty, 2001). However, discussions indicate a considerable lack of their use when it comes to the redevelopment of brownfield sites (Stevens *et al.*, 2007; Carsjens & Ligtenberg, 2007). Brownfield development adds a number of improvements to the conventional urban growth, with the help of CAD throughout design and implementation, brownfield redevelopment can extend its application by insisting the context needs are catered for through recreating spaces and integrating them into the development exercise.

The vast majority of the global construction activity is now focused upon the redevelopment of brownfield sites (David Adams, 2010; Wernstedt *et al.*, 2004; Environment and Economy, 2003; Owusu and Oteng-Ababio, 2015). Such development requires new design to be sympathetic towards existing structures. Unfortunately, the majority of existing brownfield sites pre-date the development of CAD systems and even where such systems have been used, few land databases have been maintained and updated (Turner *et al.*, 2000). This severely restricts the potential application of CAD in the management of the facility and the cost of the provision which is a significant factor during early design stages of any subsequent development.

2. Literature Review

In the current high demand for sustainable urbanism, many argue that critical decisions should be made during the design and preconstruction stages (Haas, 2012). CAD enables in-depth sustainability analysis of brownfield typologies, occupancy status, physical conditions, chemical contamination levels, special regulations or required treatment, value/cost and context, amongst others. It allows for multi-disciplinary information to be superimposed within one model, creating an opportunity to conduct these analyses accurately and efficiently when compared to the traditional methods (John, 2013). Recent studies indicate that the demand for sustainable urban development with minimal environmental impact is today higher than ever before (Azhar *et al.*, 2011; Carsjens and Ligtenberg, 2007; Fistola, 2011). Rising energy costs and environmental concerns are the catalyst of such high demand. The environmental and human benefits of sustainable development have been widely recognized. A slight increase in upfront costs can result in a life cycle saving (ibid).

The early design and preconstruction phases of urban development are the most critical to make decisions on sustainability features. Traditional tools lack the capability to perform sustainable analysis in the early stages of design development. Performance analysis is typically measured after the design and construction have already begun. This failure to analyze sustainability continually during the design process results in an insufficient process of retroactive modifications to the design to achieve better performance criteria (Turner *et al.*, 2000; Azhar *et al.*, 2011). However, since CAD allows for multi-disciplinary information to be superimposed within one model, it creates an opportunity for sustainability measures to be incorporated throughout the design process.

A considerable amount of information can be obtained easily and directly from the CAD database to determine many development variables. For example, various design options for sustainability can be studied or tracked using CAD software, and, when choosing redevelopment sites, it allows architects and urban planners to input spatial and geographical data which in return imports information related to climate, resources, eco-system and such. The availability of this information helps designers make better decisions that can reduce environmental impact and determine the most efficient solutions for development in general, brownfield redevelopment included (Stevens *et al.*, 2007; Thomas, 2002).

3. Problem and Methodology

Worldwide, individuals and organizations have responded to the increased demand on sustainable urbanism – included but not limited to, the United Kingdom, United States, and many European countries such as Germany, France and Switzerland – the majority of these ventures are similar in that they utilize CAD tools to provide decision-makers with a concise framework for identifying and implementing practical and measurable construction, operation and maintenance solutions. The examined examples have tracked an overall improvement in brownfield redevelopment projects over the years; however, even today, many projects still fail more often than they succeed. Urban management in such environments has many construction concerns; brownfield sites are often full of hazards, unexpected complexities and tend to be risky and expensive to redevelop. Moreover, the accumulated lack of CAD-based management and development has also made them 'brownfield' sites. Current brownfield and redevelopment projects in Amman, if existing in the first place, use informal tools and traditional methods that often ignore such complexities. Often witnessed in construction, they result in delays, expensive rework and even failed development. A brownfield-oriented approach embraces existing complexities and is used to reliably accelerate the overall development process wherever possible.

The dilemma of brownfields in Amman extends both before and beyond the case set forth in this paper, from the lack of systematic definition of the variety of brownfield typologies materialized, to their conspicuous absence in the national agendas and future urban development action plans in addition to inconsistency, ambiguity, and parochialism which are the bane of brownfield redevelopment. Nonetheless, the sole purpose of this study is to demonstrate ways stakeholders may and wish to use CAD tools and software for various sustainability analyses in pursuit of brownfield redevelopment best practice. The scope of research is limited to brownfield site redevelopment only. Due to the limited time and availability of data, only the case of Amman has been discussed in this research. The final result of the study will be published in the near future.

The paper identifies, as a qualitative case-study, research which allows the exploration of individuals and organizations through interventions, relationships, communities and programs (Yin 2013). For the purpose of the study, a mixed-method approach to acquiring information was adopted. Tools of ethnography, informal chats, semi-structured interviews, in-depth interviews, focus groups and workshops in addition to visual methods were employed to collect data (Atkinson *et al.*, 2007; Banks & Zeitlyn, 2015; Calhoun *et al.*, 2005; de Vaus, 2001). The variety of tools employed allowed

for the exploration of the topic of interest from a variety of angles encompassing its versatile aspects.

The paper leans on a larger set of empirical data dedicated for the wider scope of the PhD research. However, by showcasing relevant segments of the data collected, the paper attempts to further investigate the specificities of the problem the paper is addressing.

4. The Investigation

The association between CAD and brownfield site redevelopment was measured on three levels: educational, professional and operational. On the educational level, a total of 62 architecture and urban planning students were surveyed, 28 of whom were later interviewed and 16 of whom that volunteered for a brownfield mapping exercise. A total of eight architecture and urban planning academic staff were also interviewed: four teacher assistants, two assistant professors and two associate professors.

On the professional level, a total of eight architecture and urban planning practitioners were interviewed, while on the operational level, the head of the Geographic Information Systems (GIS) department at the Greater Amman Municipality (GAM) was interviewed in addition to the head of the planning department and head of the development and studies department.

On the three levels, consensus on the significant role CAD plays in brownfield development was established. Students, professionals and officials unanimously highlighted the notable absence of the employment of these tools and the considerable effects it has on urban development in general, and brownfield redevelopment specifically.

Following are selected statement from the three disciplines:

> "… GIS enjoys many spatial analysis tools. We can do selection by attribute, calculate operations… Spatial analysis is basically the connection between data and attributes and their locations on the maps and the patterns that might result from that. Unfortunately, we use none of this."
>
> (Y. Q, Head of the GAM GIS department)

> "… See, I can do a selection by attribute, so for example here I'm doing it on use [clicks on his screen], I click the secondary, unique, now see what it can do? Let's say am looking for residential A land use, it will select the residential A code in all of Amman. Now if I want ownership with this operation and this operation, it would calculate it and give you the areas you are looking for specifically. Tell me you can do this manually."
>
> (A. A, Employee the GAM GIS department)

"… I mean the manual map of Amman just like everywhere else I believe has a human factor error since the person that is doing the data entry might [make] an unintentional mistake. And that happens. This is an obstacle we can overcome I guess if the mapping used technology and was able to detect the error"

(A. A, Employee the GAM planning department)

"… There will be a problem however in transferring the data into GIS because the students do the drawings manually or in the best cases they use AutoCAD, in the least professional way that is, and are not really familiar with the GIS as a software… I mean they use AutoCAD yes, but they don't use any of the analysis tools it offers, also AutoCAD doesn't have attributes… True. AutoCAD is a drawing tool, it can do simple calculations but it's not equipped to do any spatial analysis like GIS. This is why GIS would be better for you, the way I see it"

(N. A, Teacher assistant)

"…There should be collaboration ventures between the different stakeholders, at least between the government and the universities, perhaps GIS employees could teach and train our students and our students can help in the mapping of brownfields in return, we have an army of students and this exercise can teach them a lot about the city… in my opinion, it's a win-win situation, a bit farfetched though, you know how things take forever to get done here."

(A.R, Assistant professor)

"… It is time to upgrade our education system, the student should learn about the history and development of traditional techniques… otherwise, they should be learning new ones to employ in the market… it all starts here, those students are tomorrow's architects and urban planners, they should be equipped with the right tools."

(S.M, Associate professor)

"… It takes less than ten minutes to run the complete analysis, CAD proved to be a quick and easy way for a design team to develop an accurate estimate of a proposed development design. It may be used during a project's pre-design as well as design phases."

(S.N, Practising architect)

5. Results and Analysis

Based on the survey analysis, three commonly used CAD-based software were found to be fundamentally utilized in the management, design and implementation of the urban planning and development practice between the educational, professional and operational disciplines in Amman, Autodesk's AutoCAD, BIM's Revit and ESRI's ArcGIS. And while the first and second are most routinely used by students and practitioners, the third is more

popular for the spatial mapping and master planning of the city by governmental officials. According to the survey, AutoCAD is most preferred between students for its time-saving drawing tools, Revit is most preferred between practitioners for its building performance such as energy consumption and other analysis tools and ArcGIS is most preferred between officials for its spatial analysis tools.

The analysis indicated the proposal to optimize a CAD-based model in brownfield redevelopment is not only welcomed but encouraged. However, most of the surveyed sample agreed that the problem would be in the implementation due to a number of reasons: the outdated curricula, the traditional methods employed in the organizational level, the needless bureaucracy, and the time, effort and resources the whole transformation process is estimated to consume, to name a few. Furthermore, the examined sample suggested collaboration between the different stakeholders is needed to fast-forward the procedure.

The results of these analyses were also compared to hand-prepared documents. Though most results produced by software were in close agreement, some notable differences were also recorded due to many factors, for example, the digital map of Amman was not updated and was lacking key changes; also, some proposed design features could not be accurately modelled in all CAD software. Therefore, the participants were advised not to rely blindly on software results and always apply manual checks for verification.

The analysis indicates optimizing the use of CAD tools and software can help designers visualize the design at the very early stages prior to construction. Results could not be considered very accurate, but they may be taken as indicators. The indicators eliminate the need to design a space and wait for completion to evaluate it. Using a CAD tool or software, a design team can closely predict outcomes, it allows designers to bypass the onerous and demanding set of calculations required to support sustainable design than when using the traditional tools.

6. Discussion

One of the reasons brownfield development projects often go wrong – not probably as often as discussions claim, but commonplace nonetheless – is because, due to the use of conventional methods in their development and mapping, manually produced maps tends to become brittle when they have been edited by many hands, badly handled or stored, produced with deliberate shortcuts on quality to save time, or been patchily documented, and thus they get harder and harder to change (Turner *et al.*, 2000). Moreover, although most drawings and information sheets can be developed

manually and using traditional and conventional techniques, CAD software produces the same information more efficiently as part of their building information model and have the added advantage of parametric change technology which coordinates changes and maintains consistency at all times (John, 2013). Digital map development has also been stubbornly resistant to automation attempts. Thus, small tasks remain expensive and labor intensive and it is seldom cost-effective to convert all the information contained in the manual database into a CAD-based model.

7. Conclusions

In this preliminary research, the paper bid to expand the narration on sustainable brownfield redevelopment and the use of CAD tools and software by looking at case study of Amman. The paper looked at how sustainable brownfield redevelopment can utilize CAD tools and software, and addressed key differences between them and traditional methods in the context of Amman. It looked, crucially, at the current practice and its demand for an upgraded urban management model with an emphasis on the optimization of CAD's role in the process. It finally concludes with advice to urban planners and other stakeholders: to juxtapose CAD with sustainable brownfield redevelopment as reliably reengineering existing environments into the current competitive, integrated commercial city is non-trivial.

The complexity of brownfield redevelopment and CAD has been accumulating almost unchecked for decades, making change now more difficult. As a result, an increasing proportion of the effort involved in developing brownfield sites is spent on the aftercare and maintenance of projects rather than design and preconstruction analysis. The brownfield redevelopment industry as a whole has a poor success rate in delivering noteworthy change to begin with, add that to employing traditional, old-fashioned tools and the prospects further decline.

References

AJENE, A.A. & SYLVESTER, I.T., 2014. Computer Aided Design and 3D Visualization Technology : an Urban Design Imperative. , 2(4), pp.1–8.

ALKER, S., JOY, V., ROBERTS, P. & SMITH, N.., 2000. The Definition of Brownfield. *Journal of Environmental Planning and Management*, 43, pp.49–69.

ATKINSON, P., COFFEY, A., DELAMONT, S., LOFLAND, J. & LOFLAND, L., 2007. *Handbook of Ethnography*, SAGE Publications. Available at: https://books.google.jo/books?id=KtEx1-A9SvMC.

AZHAR, S., CARLTON, W.A., OLSEN, D. & AHMED, I.., 2011. Building information modeling for sustainable design and LEED ® rating analysis. *Automation in Construction*, 20(2), pp.217–224. Available at: http://dx.doi.org/10.1016/j.autcon.2010.09.019.

BALEY, K. & BELCHAM, D., 2010. *Brownfield Application Development in .NET*, Manning. Available at: https://books.google.co.uk/books?id=rOspAQAAMAAJ.

BANKS, M. & ZEITLYN, D., 2015. *Visual Methods in Social Research*, SAGE Publications. Available at: https://books.google.jo/books?id=kvsaCAAAQBAJ.

CALHOUN, C., ROJEK, C. & TURNER, B.S., 2005. *The SAGE Handbook of Sociology*, SAGE Publications. Available at: https://books.google.jo/books?id=WkSAGwABNjIC.

CARSJENS, G.J. & LIGTENBERG, A., 2007. A GIS-based support tool for sustainable spatial planning in metropolitan areas. *Landscape and Urban Planning*, 80(1-2), pp.72–83.

CHAKRABARTY, B.K., 2001. Urban Management: Concepts, Principles, Techniques and Education. *Cities*, 18(5), pp.331–345. Available at: http://www.sciencedirect.com/science/article/pii/S0264275101000269.

CLARINET, 2002. *Brownfields and Redevelopment of Urban Areas*,

DAVID ADAMS, C.D.S. & S.T., 2010. Brownfield Development: A Comparison of North American and British Approaches. *Urban Studies*, 47, pp.75–104.

N.R.T. ON THE ENVIRONMENT & THE ECONOMY, 2003. *Cleaning Up the Past, Building the Future: A National Brownfield Redevelopment Strategy for Canada*, National Round Table on the Environment and the Economy. Available at: https://books.google.co.uk/books?id=eRmebW6zlnEC.

FISTOLA, R., 2011. The unsustainable city. Urban entropy and social capital: The needing of a new urban planning. *Procedia Engineering*, 21, pp.976–984. Available at: http://dx.doi.org/10.1016/j.proeng.2011.11.2102.

HAAS, T., 2012. *Sustainable urbanism and beyond : rethinking cities for the future*, New York, NY ; London: Rizzoli.

HOPKINS, R. & JENKINS, K., 2008. *Eating the IT Elephant: Moving from Greenfield Development to Brownfield*, Pearson Education. Available at: https://books.google.co.uk/books?id=GYvP0u2k2uMC.

JOHN, E., 2013. *CAD Fundamentals for Architecture*, Laurence King Publishing. Available at: https://books.google.co.uk/books?id=2TMimQEACAAJ.

OWUSU, G. & OTENG-ABABIO, M., 2015. Moving Unruly Contemporary Urbanism Toward Sustainable Urban Development in Ghana by 2030. *American Behavioral Scientist*, 59(3, SI), pp.311–327.

SARCAR, M.M.M., RAO, K.M. & NARAYAN, K.L., 2008. *Computer Aided Design and Manufacturing*, PHI Learning. Available at: https://books.google.co.uk/books?id=zXdivq93WIUC.

SAUER, C.O., 1925. *The Morphology of Landscape*, University of California Press. Available at: https://books.google.jo/books?id=Tf2KQgAACAAJ.

STEVENS, D., DRAGICEVIC, S. & ROTHLEY, K., 2007. iCity: A GIS-CA modelling tool for urban planning and decision making. *Environmental Modelling and Software*, 22(6), pp.761–773.

THOMAS, M.R., 2002. A GIS-based decision support system for brownfield redevelopment. *Landscape and Urban Planning*, 58(1), pp.7–23.

TURNER, A., CHAPMAN, D. & PENN, A., 2000. Sketching space. *Computers and Graphics (Pergamon)*, 24(6), pp.869–879.

DE VAUS, D., 2001. *Research Design in Social Research*, SAGE Publications. Available at: http://books.google.co.uk/books?id=9yurQt7T65oC.

WERNSTEDT, K., HEBERLE, L., ALBERINI, A. & MEYER, P., 2004. The brownfields phenomenon: Much ado about something or the timing of the shrewd. , p.30. Available at: http://www.rff.org/documents/RFF-DP-04-46.pdf.

YIN, R.K., 2013. *Case Study Research: Design and Methods*, SAGE Publications. Available at: https://books.google.jo/books?id=OgyqBAAAQBAJ.