

# GOOGLE SKETCHUP: 3D ENVIRONMENTAL MODELING TOOL FOR SUSTAINABLE LANDSCAPE DESIGNING

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## ABSTRACT

Globally, landscaping is a popular hobby and a profession. The landscape industry has a critical and leading role to play in design, construction, management and maintenance of environment in a sustainable manner. This global trend has created a demand for new and exciting 3D modeling systems. Architects and Landscape designers in Sri Lanka are mostly adapted to traditional modeling software such as AutoCAD. Google SketchUp is a modern 3D modeling system equipped with tools help planners to work with green engineering and sustainable concepts. This paper aims at discussing Google SketchUp as a sustainable virtual environmental modeling tool. SketchUp is capable of creating collaborative virtual environments consist of flora, fauna and built infrastructures which are useful as visual communication tools for environmental decision-making. Arranging suitable plants in most suitable locations is one key principle in sustainable landscape designing. SketchUp users can time-test the effects of tree shadows on buildings, which is a vital consideration in reducing energy consumption of buildings. Geographical visualization of landscapes supports policy-makers, designers and other experts to make better land management decisions.

**Keywords:** Google SketchUp, Computer Aided Designing, Environmental Decision making, 3D modeling, Landscaping

## 1. INTROCUCTION

Landscape can be defined as the appearance of land, which includes its shapes, textures and colors. During landscaping, human beings alter the landscape to add aesthetics and to obtain some functional benefits.

Plants with its dynamic relational functions together with other biotic and abiotic entities in the environment play a major role in landscapes. Plants used as soft landscape materials. In designs not only enhance aesthetics of the design, but also perform some architectural and environmental functions in addition to health, social and economic benefits. A good landscape design based on proper time-tested design ideology and plant placement is an essential part of landscape project planning. Biomass reduction due to various constructions can be restored by well planned interior and exterior plant-scaping practices, and it is the modern way of reducing the carbon foot print of built infrastructure. Landscaped areas give a variety of environmental benefits which includes control of soil erosion, stabilization of banks, prevention of air pollution, noise abatement, glare reduction, heat dissipation, wind break, cooling and shading. All these functions may vary as plants constantly change with time. Certain changes are permanent such as increase in height of a plant while certain changes are seasonal such as flowering and fruiting. Thus plants follow

permanent and cyclic changes. Therefore, it is important to visualize these changes before implementation of the design so that the customer can perceive the intended outcome.

Computer aided designing (CAD) software have made it possible for designers to test the future appearance and the intended outcome of the designs, thus useful in adjusting the designs prior to making the final decision before construction. Traditional CAD software helps to test different types of options such as building materials, textures and colors. However, using traditional CAD systems are inadequate for today's challenges in construction industry, as designers have to deal with issues such as climate change and disasters. Designers need to be familiarized with design systems that support sustainable procedures and methodologies to overcome future challenges in the landscape industry. However, the introduction of virtual modeling systems such as SketchUp has given planners and designers the opportunity in testing models beyond engineering and architectural aspects. SketchUp have capabilities such as shadow management, daylight simulation, terrain modeling, building information modeling and energy analysis. Most importantly, it is an easy learning, user friendly rapid modeling tool [9].

## 2. OBJECTIVES

This paper aims at discussing ways of using Google SketchUp and its plug-ins in sustainable landscape designing. However, authors do not intent to discuss methods of using SketchUp in sustainable designing. Paper aims to discuss “What can be done using SketchUp?” rather than discussing “How it can be done?”.

Under the topic of “Tree shadow simulation analysis”, describes the results of a simple tree shadow experiment performed using Google SketchUp’s shadow tools. Results of this experiment may help local landscape designers to arrange trees in effective ways in certain landscaping situations and also it provides basic guide for local researchers to conduct more detailed tree shadow simulation experiments in Sri Lanka.

## 3. DISCUSSION

**Google SketchUp;** SketchUp 3D modeling program was originally developed by @Last Software Inc., a small software company in Colorado, USA in 1999. SketchUp rapidly became popular after @Last Software Inc. was purchased by Google Inc. in 2006. From its debut release SketchUp had a simple, playful user interface (Figure 1) than other traditional 3D modeling software. SketchUp 8 is the latest release with support to both Windows and Mac operating systems. Part of its popularity comes from Google making a standard version available for free.

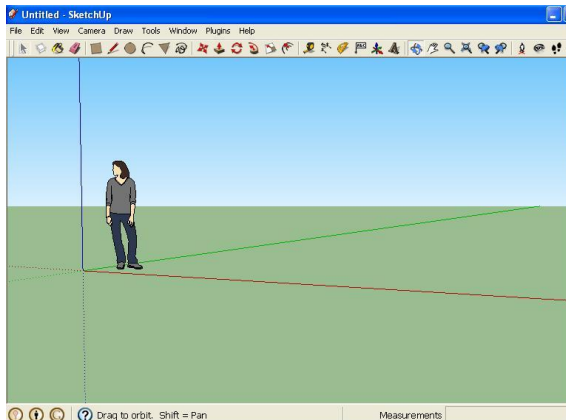


Figure 1: General appearances of SketchUp’s Graphical User Interface

### Google 3D Warehouse

3D Warehouse is a database and a search engine for free 3D models [6]. It enables SketchUp users to share their models with other users and acquire free geometrical elements for their designs.

SketchUp users usually share their smaller models as well as complete site designs in 3D Warehouse, and

that has made it the largest database of 3D models (Figure 2). It contains 3D models of plants, building materials and almost all kinds of template models needed for architects, engineers, students and 3D enthusiasts of all ages [3] Using models from 3D Warehouse, allows SketchUp users to create large and detailed models with ease [7].

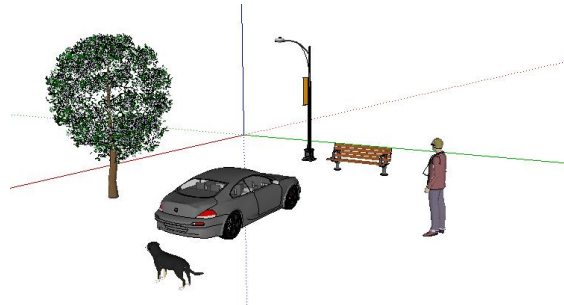


Figure 2: Imported 3D objects of flora, fauna, avatar and infrastructure from 3D Warehouse

Designers can search plants in their common names as well as in scientific names. Figure 3 shows search query results for *Cycas revolute* species. This way, designers can search plants by Genus, Species or Variety names. Designers have the freedom to download as many plants as needed, helping provide clarity to exterior and interior model designs.



Figure 3: Searching plants in 3D Warehouse

### Google Earth

Google Earth is a Web GIS platform made of thick client approach, originally invented by geospatial Software Company called Keyhole Inc. and now owned by Google Inc. It supplies 3D satellite views of the earth surface as well as valuable geo-environmental and spatial datasets for land management practices [4].

Google Earth’s aerials and terrain can be uploaded to SketchUp to get real earth surface experience for site designers [12]. Once imported into SketchUp, the aerials and terrain can be used to model site plans and buildings onto the surfaces. SketchUp models can be exported and viewed in context within the Google Earth interface. As important, the SketchUp models in Google Earth can be saved as Google Earth file format (.kmz).

Information layers of weather, global awareness and disaster warnings in Google Earth helps SketchUp planners to adjust buildings and landscapes appropriately. Latest additions such as space-time feature and other real-time data services are useful in early planning stages for precise decision making.

### SketchUp Advantages

Because of the shorter learning curve, there is a trend of using SketchUp as a learning tool in engineering, mechanical and sustainable design courses [5]. Many school teachers are using it in mathematics, geography, social studies, history, art and many other design classes.

Traditional architectural designing systems gives flat surfaces for environmental designing [8]. This limitation leads to problems when it comes to implementation. Because every bit of land have some sort of elevation. By importing terrain from Google Earth, SketchUp users can design on real earth surface environments (Figure 5). Models of contour lines (Figure 4) are also valuable in various land management and irrigation engineering practices. Seeing the whole model placed in real terrain environment will allow designers to make better presentations for clients, experts and other project stakeholders.

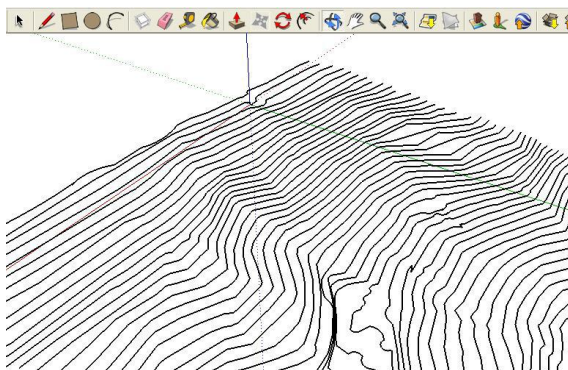


Figure 4: Contour Lines of a real earth surface

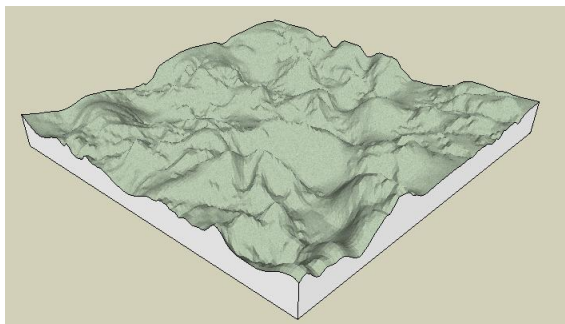


Figure 5: 3D model of a real earth surface

The SketchUp Sandbox tools allow users to create and adjust terrain. Using these tools, modelers can create terrain, generate and sculpt their own landforms or integrate site design models into

imported terrain like those from Google Earth. Additionally, there are extra tools, most of which are free, for SketchUp that greatly enhance the ability to work with terrain.

Match Photo tool is handy in converting 2D photos into 3D geometrical models faster. Designers can take photos of a building from different angles and those photos can be used for developing a complete 3D model using Match Photo tool. These practices are valuable when reconstructing buildings and analyzing performance of existing buildings and infrastructure.

SketchUp's greater compatibilities with many CAD systems help designers to easily work with large scale multi-disciplinary projects. Files from AutoCAD (.dwg, .dxf), 3D's max (.3ds), 2D graphics applications (.jpg, .png, .tif, .tga, .bmp), Geographic Information Systems (.shp) and Digital elevation models (.dem, .ddf) can be imported into SketchUp for various purposes. Imported 2D AutoCAD ground plans can be transform to 3D on SketchUp, and that's the synergetic process most professionals are following now [11].

Google SketchUp is equipped with a suite of plug-ins that can aid in sustainable designing, and compatible with other green architectural systems such as Green Building Studio and Ecotech. The Ruby plug-ins vastly increase SketchUp's potential of becoming the focal point of environmental designing software [1].

### Smart Plant Selection and Placement

Many recent landscaping projects in Sri Lanka have created problems because of unsuitable plant selection and placement. The effects have lead to reduction of natural beauty, spreading of invasive species, physical damage to commercial properties, spread of epidemic plant diseases and disturbance to transportation systems. These have lead to economic consequences as additional money must be invested to repair damage or to remove and replant areas. Improper plant selection and placement will lead to long lasting maintenance problems like repeated labour cost, greater irrigation expenditure, additional fertilizer and pesticides which may also lead to greater pollution and loss of aesthetic qualities.

Following some guides and principles in early design stages could have prevented these incidences. Smart plant selection and placement are long term investment on environment with many economic and social benefits. Proper plant testing under SketchUp environment is useful in avoiding early decision making errors.

Selecting right plant for right location will facilitate vigorous growth and allow for increased hardiness and survival against factors such as drought, pests, invasive species and diseases. Lastly, a healthy and diverse landscape provides social and aesthetic benefits.

When selecting plants, it is best to use 3D models of landscapes to collaborate with horticulturists and other plant experts who possess a good knowledge on plant characteristics, interaction with the surrounding environment, response to climatic factors and its social impact. Different plant combinations should be tested before making final decision.

It is clear that selecting the right plant for the right place is a complex task because of the variety of factors involved and need proper testing. Aid of a SketchUp combined with Google Earth and 3D Warehouse is vital for smart plant selection, placement and testing before realization. Vast collection of plants in 3D Warehouse gives the freedom of selecting many plants, and to try different combinations.

Imported terrain from Google Earth helps to decide best locations for planting. Imported surface elevations helps to identify places which are prone to water logging, soil erosion, so that susceptible plants can be avoided and suitable resistant plants can be placed on those locations.

Testing plant combinations are useful for managing shade for different plants according to their light requirements. Some plants gain shade from other plants in different intensities, while some prefer full sunlight throughout the year. Many physiological functions such as flowering, fruiting and flushing are sensitive to light duration and intensity, and managing shade is important in getting optimum beauty from plants. In Xeriscaping practices plants with similar irrigation requirements can be grouped and positioned in appropriate site locations so that irrigation intensity and frequency can be managed easily. Time-testing of all these factors helps to reduce plant death rates, cost of replanting and maintenance.



Figure 5: Urban roadside landscape design



Figure 6: 3D models of various plants

### Tree Shadow Analysis

According to US EPA [13] Smart tree placement can reduce energy bills by 25%. Creating well spread canopy cover by placing of taller trees can avoid the excess solar heating of buildings, and believed to be an effective way of reducing cost of Air conditioning [10]. SketchUp's shadow engine can help to test tree shading arrangements that can give proper shade for buildings throughout the year.

SketchUp's shadow engine is handy in time testing of trees and other infrastructure. Figure 8,9,10 and Table 1 demonstrates results of tree shadow experiments performed using SketchUp shadow tools.

Virtual tree shadow experiment was carried out using SketchUp shadow tools to assess the effect of solstice on tree shadows changes. Photos of ten trees with similar canopy shapes (approximately round) and with stem height between 4m to 4.5m were selected. Trees in the photos (2D) were extracted and converted into 3D models using Match Photo tool. Then 3D trees were placed in SketchUp virtual landscape. Geo-location of SketchUp was set to Makandura, Kurunegala, North Western Province, Sri Lanka (Latitude 7.323553N, Longitude 79.989638E).

Canopy shadow area ( $m^2$ ) and clockwise shadow angle ( $^\circ$ ) from north were measured at 2.00PM in 1<sup>st</sup> day of every month of year 2011. Direction of tree stem was used to measure the shadow angle. Angle from North (green axis) to the stem direction was measured using protractor tool. Area covered by canopy shade was measured by drawing an unopened shape similar to the shadow using free hand tool and taking the area ( $m^2$ ) of it. Relative shadow angle change (RSA) and Relative canopy shade (RCS) was calculated using following formulae.

$$RSA_m = SA_m - SA_1$$
$$RCSA_m = CSA_m \div CSA_1$$



Where;  $RSA_m$  = Relative shadow angle  $m^{th}$  month ( $^{\circ}$ ),  $SA_m$  = Shadow angle on 2.00PM in  $1^{st}$  of  $m^{th}$  month ( $^{\circ}$ ),  $SA_1$  = Shadow angle on 2.00PM in  $1^{st}$  of January ( $^{\circ}$ ),  $RCSA_m$  = Relative canopy shadow area of  $m^{th}$  month,  $CSA_m$  = Canopy shadow area on 2.00PM in  $1^{st}$  of  $m^{th}$  month ( $m^2$ ),  $CSA_1$  = Canopy shadow area on 2.00PM in  $1^{st}$  of January ( $m^2$ )  $m$  = Month of the year (any number between 1 to 12)

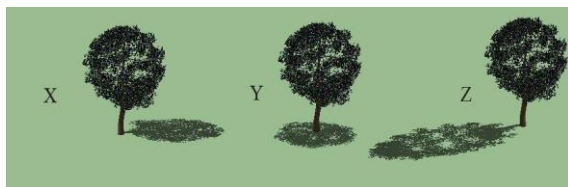
**Table 1: Seasonal Tree Shadow Analysis**

Date (M/D)	RSA	RCSA
1 <sup>st</sup> of January	0.0 <sup>o</sup>	1.00
1 <sup>st</sup> of February	3.8 <sup>o</sup>	0.99
1 <sup>st</sup> of March	19.0 <sup>o</sup>	0.92
1 <sup>st</sup> of April	47.6 <sup>o</sup>	0.91
1 <sup>st</sup> of May	72.1 <sup>o</sup>	0.93
1 <sup>st</sup> of June	86.3 <sup>o</sup>	0.94
1 <sup>st</sup> of July	89.4 <sup>o</sup>	0.94
1 <sup>st</sup> of August	79.8 <sup>o</sup>	0.89
1 <sup>st</sup> of September	56.2 <sup>o</sup>	0.86
1 <sup>st</sup> of October	32.6 <sup>o</sup>	0.90
1 <sup>st</sup> of November	15.6 <sup>o</sup>	0.95
1 <sup>st</sup> of December	5.1 <sup>o</sup>	1.01

*RSA= Relative shadow angle, RCSA= Relative canopy shadow area*

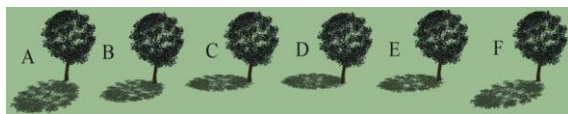
According to the results in Table 1, shadow angle (RSA) and in shadow area (RCSA) were significantly varied throughout the year.

Because of the significant shadow variations, designers have to consider about both daily and annual shadow variations to identify best planting locations.



**Figure 8: Tree shadows in different times of the day**

Figure 8 shows real shadow positions of a tree located in Makandura, Kurunegala, North Western Province of Sri Lanka (Latitude=7.323553N, Longitude=79.989638E) in three times (X= 9.00AM, Y= 12.00AM, Z= 3.00PM) of a particular day (in 26-09-2011).



**Figure 9: Tree shadows of a particular time of the day of different months of the year**

Figure 9 shows seasonal shadow position changing due to solstice in same geographic location as Figure 10 at different intervals of the year 2011 (A= 1<sup>st</sup> of January, B= 1<sup>st</sup> of March, C= 1<sup>st</sup> of May, D= 1<sup>st</sup> of July, E= 1<sup>st</sup> of September, F= 1<sup>st</sup> of November) in exact time of the day (2.00PM).

Figure 10 illustrates shade effects of trees associated with buildings in morning and evening (1= 9.00AM, 2= 3.00PM) positioned at the same geo-location as in Figure 8.

Because of changes in shadow angles and sizes, positioning of trees requires adequate time testing. However, in real world situations managing trees won't be easy as arranging them in digital 3D models, due to complexity in tree structures, their functionality and various environmental factors. But, this kind of a tree shadow analysis is useful in understanding different sizes and angles of shadows occur in different times of the day and in different days of the year, and it would help designers to arrange trees in suitable positions that would offer long term direct and indirect benefits to both project stakeholders as well as to environment.



**Figure 10: Incorporating tree shadows with buildings**

**Water Management**

Imported terrain from Google Earth helps to identify different shapes and forms of land. Terrain models (Figure 5) and contour lines (Figure 4) are useful in designing flood prevention strategies for cities, crop irrigation systems for farms, and other water resource engineering practices. In addition to ground surface data, Google Earth also consists of Sea surface height (SSH), ground water levels and various other data sets useful in water resource management.

### Solar Panel Placement

Installing a photovoltaic system in the most suitable location to harvest maximum sunlight is not an easy task due to number of common environmental factors and specific obstacles involved in each site. Shadows of barriers such as trees and other built infrastructure are preventing optimal sunlight harvesting. Problem becomes severe because of seasonal shadow position changing due to solstice. Shadow and solar analysis using SketchUp can be used to detect the most suitable ground or roof location for photovoltaic system installation to generate maximum kilowatt-hours of electricity annually.

### Energy Analysis

**Table 2: Useful SketchUp plug-ins**

Tool	Functions
IES-VE	CO <sub>2</sub> emissions, occupant comfort, daylight levels, solar levels , airflow analysis
EnergyPlus	Heating, Cooling, Lighting, and Ventilation Analysis
1001Shadows	Generates a cycle of shadow outlines for user defined intervals
Su2ds	Daylight analysis
4D Virtual Builder	Building information modeling
Envision	Cloud service for construction project management

Complete set of assessment tools are available for environmental building performance assessments (Table 2) such as carbon emission, daylight levels, solar heating and airflows [2]. Analysis tools greatly help site designers, architects, consultants, environmentalists, engineers and policymakers to make decisions right from the early design stages. Plug-ins for Building information modeling (BIM) and construction project management were also introduced by various companies and developers recently [1].

Orientation of the buildings, surface materials of walls and roofs, positions of the windows can be adjusted according to reports of Energy analysis tools. This way, designers can plan buildings with minimal solar heat gain and maximum energy efficiency.

### 4. FUTURE DIRECTIONS

At present, Google SketchUp is well equipped with far better features and tools for Engineering design

rather than landscape designing. There are lot of additional features and plug-ins needed to be developed for sustainable site designing.

Further, tools and plug-ins that can be used to generate analysis reports on site irrigation requirement, rainwater catchment ability, and various pollution outputs are useful in sustainable designing.

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