VOL. 12, NO. 17, SEPTEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

GREEN PUBLIC PROCUREMENT CRITERIA FOR ROAD INFRASTRUCTURES: STATE OF THE ART ANDPROPOSAL OF A WEIGHTED SUM MULTI-CRITERIA ANALYSIS TO ASSESSENVIRONMENTAL IMPACTS

L.Moretti, P. Di Mascio and A. D'Andrea
Department of Civil, Constructional and Environmental Engineering, Sapienza, Università di Roma, Rome, Italy
E-Mail: laura.moretti@uniroma1.it

ABSTRACT

In the last years, the attention to environmental issue is growing, demonstrating the interest to protect the nature and to better use the non-renewable resources. At international level, and especially in the European Community, for different trades, a wide production of voluntary documents and institutional acts proves the interest and the need for a green economy. An innovative approach may lead to the experience of Green Public Procurements (GPP), to protect the environment as a public interest and to promote technological developments. So far, the experiences of GPP are limited, not entirely positive and in the field of road infrastructures almost entirely absent. Construction and maintenance of road infrastructures is objectively more complex than purchasing goods or services. The paper proposes the integration of the weighted sum multi-criteria analysis into existing procedures. The methodology needs for environmental labels related to materials, machines and works which contribute to the final product "road". The labels are recognized at international level and consistent with procedures, conditions and criteria currently published in road tenders, therefore the approach can be followed to pursue the environmental sustainability of road infrastructures without compromising the economic attention.

Keyword: green public procurement, environment, multi criteria analysis, roads, sustainable development.

INTRODUCTION

Performance of road infrastructures during their service life affects consumers, supply chain and manufactures. Technical, structural and functional characteristics determine direct and indirect costs (Cantisani*et al*., 2016). A correct and desirable road infrastructure design should consider construction, maintenance and repair works during all service life, balancing economic considerations, environmental performance and market availability (Ecoplan & Infras, 2010). Environmental, technical, and social data have to be considered to avoid improper decisions and to guarantee the overall infrastructure sustainability (Cantisani *et al*., 2012; Miccoli *et al*, 2015; Bernardini *et al*., 2017; Loprencipe *et al*., 2017).

Sustainability is an approach which involves business practices around the world: some indices pursue an integrated approach to assessing sustainability performance. Not only public agencies, but also private companies focus on sustainability issues to enhance long-term potential. Companies consider opportunities and risks deriving from economic, environmental and social developments to plan their investments. Environmental issues are also in financial contexts, as recommended by the Dow Jones Sustainability World Index launched in 1999. It is the first global sustainability benchmark, the most important stock market index of evaluation of corporate social responsibility.

In 2000, the United Nations promoted the United Nations Global Compact initiative to encourage sustainable and socially responsible policies in businesses worldwide. The initiative lists Ten Principles in business strategy and operations around the world to embrace universal principles. They concern the human rights, the labours standards, the environment and the anticorruption behaviour. For the environmental issues, "business should support a precautionary approach to environmental challenges, undertake initiatives to promote environmental responsibility and encourage the development and diffusion of environmentally friendly technologies". Enlightened global business may not give up the implementation of comparative Life Cycle Assessment (LCA) in the development of innovations and the use of Employing Environmental Technology Assessments (EnTA) (International Labour Organization, 1998; United Nations, 1948; United Nations, 1992; United Nations, 2003).

These positions stimulate both industrial competition looking for technologies ensuring environmentally friendly solutions and political initiatives to promote effective and real results.

In 1987, the report "Our Common Future", known as the Brundtland Report, defined the sustainable development as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). Moreover, the World Bank Group, in 1996, stated "the external effects of transport [should] be taken into account fully when public or private decisions are made" (World Bank, 1996). In recent years, the international community showed a growing interest about these issues, demonstrating efforts to optimize the management of available resources in many areas (Miccoli *et al*, 2014a; Bonin *et al.*, 2017). Many assessment tools for urban design are used (Miccoli *et al,* 2014b), as for transit planning with many case studies funded by the European Commission (Musso and Corazza 2006). These are similar on environmental dimensions, but they differ widely in economic, social and cultural approaches (Ameen *et al*., 2015). Recently, the

Ecological Impact Assessment methodology has been proposed to evaluate ecological effects of road construction (Igondova *et al*., 2016), but it does not consider economic criteria.

The introduction of environmental criteria in decision (economic) processes about collective interests needs a new approach to evaluate the proposed solution: the Green Public Procurement (GPP), to be applied in road infrastructures call for tenders. Such new approach is most needed also in light of the recurring underestimation of the environmental issue by many transport stakeholders (Musso and Corazza 2015, Corazza *et al*., 2016a).

The best environmental option should consider the functional infrastructure performances (Loprencipe and Cantisani, 2013; Bonin *et al*., 2007; Cantisani *et al*., 2013), the use of waste materials (Fiore *et al*., 2014; 2017), the structural characteristics of materials (Moretti *et al*., 2017a; Tozzo *et al*., 2016). In addition, it should take into account the available budget (Di Mascio *et al*., 2014). In literature, some studies about product overall costs are available. The most frequent documents are: for economic issues, "Life Cycle Cost" (LCC), and, for environmental issues, "Life Cycle Impact Assessment" (LCIA), but often the evaluations lack of synthesis.

Several software permit to calculate environmental impacts (Thinkstep, 2016; PRé Sustainability, 2016; Green Delta, 2014), some also costs (Ifu Hamburg, 2016), using life cycle databases (Ecoinvent, 2016; European Commission's Joint Research Centre, 2014).

In the past, criteria to sustain the road manager in the decision phases have been dealt with roads (Di Mascio *et al*., 2012; Moretti, 2014), railways (Botniabanan ab, 2010), airports (Shahin, 2005; Moretti *et al*., 2017b) and sidewalks (Corazza *et al*., 2016b; Zoccali *et al*., 2017), construction and maintenance infrastructures activities (CIMbéton, 2011; Moretti *et al*., 2016; Moretti *et al*., 2017c).

In many fields of industrial products, the Multi Criteria Analysis (MCA) (Balasubramaniam and Voulvoulis, 2005) with the weighted sum method as decision-making tool (Bond and Morrison-Saunders, 2011; Moretti *et al*., 2017d) has been proposed. In the last few years, this approach has been considered also in the construction of the road infrastructure. Each chemical, physical or practical factor contributing to the final product "road" involves the ecological harm of chain production (Acciona Infraestructuras, 2013).

Considering this new approach, this paper presents a new methodology that uses the ecoinvent databases related to each data involved in the examined infrastructure. The environmental data may be published by producers or suppliers and certified by third party, or provided by independent databases. Each dataset considers the production, extraction, manufacturing, transportation and laying of one declared unit considering emissions in air and in water, material and energy consumption. The available datasets and the bill of quantities of the examined project should be composed to assess the environmental impact.

The proposed method goes for all levels of decision-making encouraging the environmental protection, minimizing costs and protecting public interests. The method is framed in the current European laws dealing with the environmental issue.

ENVIRONMENTAL ISSUES IN EUROPE: APPROACHES TO GREEN PUBLICPROCUREMENT

Several measures adopted by European Commission mark the environment protection as a component of the Community policy.

In 1996, the Communication "Public Procurement in the European Union: Exploring the Way Forward. Green Paper" allows adopting "green" approach in PP (European Commission, 1996). PP policy may "generate sustainable, long term growth" and contribute to a reach public aims. For the European authority, the environment protection is a relevant Community policy and it should be pursued by technical rules.

In 2001, the Community legislature has continued the line proposed in 1996 (European Commission, 1996) adopting the Communication "Development Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development". It emphasizes that Member States should support the use of material goods and practices eco-friendly through the procurement legislation (European Commission, 2001a).

The "Interpretative Communication on the Community Law Applicable to Public Procurement (PP) and the Possibilities for Integrating Environmental Considerations into Public Procurement" (European Commission, 2001b) and the Communication "Sixth Environmental Action Programme: Environment 2010: Our future, our choice" (European Commission, 2001c) address this issue. The former recognizes the "possibilities of … integration of environmental considerations into public procurement". The latter focuses the need of a whole range of instruments and measures to influence the decision-makers.

In 2004, two European Directives demonstrate the Community interest to enhance sustainable growth through public procurement. The "Directive 2004/17/EC coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors" (European Parliament and Council, 2004a) and the "Directive 2004/18/EC on the coordination of procedures for the award of public works contracts" (European Parliament and Council, 2004b) are the European framework for the public-sector contracts. The tendering process can integrate both environmental criteria and economic interests in public purchasing.

Green Public Procurement has been defined by the Communication "Public procurement for a better environment" (European Commission, 2008) as "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured".

Since 2008, the EU Commission has published more than 20 common GPP criteria. The involved sectors have been selected through a multi-criteria analysis considering environmental improvement; public expenditure; impact on suppliers; political interest; criteria availability; effectiveness. The European Union published in 2013 the last GPP criteria, other criteria have been updated or are currently under revision: it shows the interest that EU Commission and European local authorities have to improving the environmental and economic performance of products. As referred, until now, the environmental considerations into public procurement do not concern the construction of road infrastructures. Some SME launched successfully the green tenders, but some difficulties appeared.

Recent studies have identified the reasons that hinder the spread of GPP (Bouwer *et al.*, 2006; Arrowsmith and Kunzlik, 2009). They could be classified in two categories: lacks and difficulties. Lacks refer to political, cultural, legal and practical experience; Difficulties refer to the cultural resistance to change and to the difficulty in managing the new procedures.

In 2008, the Report on methodologies "Collection of statistical information on Green Public Procurement in the EU" (Price Water house Coopers, Significant and Ecofys, 2009) developed suitable criteria for measuring the quantitative levels of GPP, its CO_2 emissions and financial impact. The study founded the seven EU Member States best performing in terms of GPP. The indexes defined to evaluate the GPP diffusion were the percentage GPP of total PP in terms of monetary value and in terms of number of contracts.

The introduction of environmental criteria is subject to communication and information policies by the government agencies to promoting a critical and global green approach. Indeed, sometimes it has spread incorrect evaluations of environmental impact.

For example, recycled aggregates for road pavement layers are uncritically preferred to natural aggregates. The Italian Ministry of the Environment and Protection of Land and Sea of Italy sets the employment of at least the 30% of recycled materials in new constructions (Ministerodell'ambiente e dellatutela del territorio, 2003; Ministerodell'ambiente e dellatutela del territorio, 2005). Aggregates with equivalent performance requirements can be extracted from a close quarry or caught from a faraway recycling plant. Recycling process or recycled materials may cause environmental burdens of secondary raw materials higher than primary raw materials: their consequences should be investigated (D'Andrea *et al.*, 2004). Life Cycle Analysis (LCA) is the tool to measure the global environmental performance of materials and to select the most advantageous solution.

The Report about traffic signs (European Commission, 2010) states that cold asphalt concrete technology can save energy and cost compared to traditional hot asphalt mixing. However, cold asphalt mix probably requires more frequently replacement, leading to higher maintenance costs (D'Andrea and Fiore, 2003).

At present, the environmental strategies of the international community (ISO, 2004, ISO, 2004; United Nations Environment Management Group, 2007) did not influence the design, construction, maintenance, rehabilitation of roads.

The Report about traffic signs is the only document adopted by European Commission about road infrastructures. (European Commission, 2010). Hungary, Netherlands, Japan and Korea have published a number of standards for road constructions. Some Ecolabels are available: they are schemes about environmental sustainability of flexible or rigid pavements; concrete products as barriers, concrete paving blocks and concrete tiles; concrete materials, including cement (Buzzi, 2014; Holcim, 2013; Cementerie Aldo Barbetti, 2014), aggregates (Union Européenne des Producteurs de Granulats, 2012), secondary raw materials (Officinadell'Ambiente S.p.A., 2015), steel reinforcement (Industrie Riunite Odolesi, 2013) and additives. They consider construction, use, maintenance, management, disposal and recycling of products used during service life because they influence the final sustainability of project. In some other types of services, as for instance urban public transport, the need to have programs very similar to Ecolabels (to promote more eco-friendly and accessible transit supply) has been recurrently highlighted (Corazza et. al 2016a, Corazza et al. 2017).

Public administrations could contribute to the green purchasing policy only by means of GPP. In Italian infrastructure area, various examples of innovative design can be provided (Cantisani *et al.*, 2012).In 2010 Italferr, the Italian State Railways Group engineering firm, operating on the Italian and international markets of railway transport engineering, has assessed the CO_2 emissions of some projects: for example, the definitive project of upgrading of the existing Rho-Arona line (Italferr, 2010) and the definitive project of doubling of the track Fiumetorto-Cefalù-Castelbuono (Italferr, 2011). More lately, Italferr and IRIDE (Institute for Ecosustainability Research and Engineering) have defined a method to assess sustainability of a project (Del Principe *et al.*, 2015). This methodology considers 10 social, economic and environmental macro-objectives gathered from the main international papers: improve collective decisions, mobility, welfare and environment; preserve and promote quality of context; reduce traffic, use of resources, waste production and pollution. The tools measure the environmental sustainability of railway infrastructures, considering only a few laid down indicators.

METHOD

The objective of this paper is to consider not only economic but also environmental issues in the design and decision phases. The authors propose an innovative and modular methodology useful for calculating the environmental impact of a road construction. The method is based on type III Environmental Declarations defined by ISO 14025 to evaluate the LCA t of any manufacturing process. All environmental and quantitative data used to

calculate an "Environmental Bill of Quantities" are closely associated with the most known "Bill of Quantities". Indeed, they involve all required machines, works or materials needed for the project. The "Environmental Bill of Quantities" consists of chapters on environmental harm related to the final product "road". For example, the Environmental Bill of Quantities could consider the global warming potential, the ozone layer depletion, the dust production, the net fresh water consumption, the abiotic elements and fuels depletion, the use of secondary raw materials, the production of waste and the energy consumption.

These environmental pollution categories should appear, if available, in each product bulletin provided by manufacturers like an EPD®. EPD is a standardized report of data collected in the LCA. It must follow the rules and guidelines defined product category rules (PCR) to provide comparable documents; a third party green audit proves that the collected data meet all ISO requirements, including the concerning PCR. For example, it is possible to consult the standard "Sustainability of construction works, Environmental product declarations, Core rules for the product category of construction products" (UNI EN 15804, 2014). The results listed in an EPD are interesting, but they lack synthesis (Moretti and Caro, 2017).

The authors have identified the MCA as a tool to compare products. The MCA method may be applied in the GPP procedures, according to the environmental priority established by the Public Administration. Depending on the specific problem, the weighting factors vary: each solution is therefore dropped in the context to which it refers.

Methodology explanation

Each of *m* design alternatives could be represented by the vector *d*(*1*n*), where *n* is the number of considered environmental categories. Each damage vector *d* represents the environmental impact related to each alternative. The aligned vectors *d* compose a matrix (*m*n*), defined as matrix of options *O*.

$$O = \begin{matrix} o_{1,1} & \dots & o_{1,n} \\ o_{i,1} & o_{i,j} & o_{i,n} \\ o_{m,1} & \dots & o_{m,n} \end{matrix} \quad (1)$$

Each column of matrix *O* allows a comparison among the options, one for each environmental category. The matrix *O* still not allows comparing the mixtures, but offers a schematic prospectus useful to stakeholders. Obviously, each column of matrix *O* has a physical dimension, so a procedure to have an equivalent, but dimensionless, matrix needs. To do this, a methodology of standardization should be adopted using standardization functions, which vary according the examined project.

Table-1 lists examples of standardization functions.

Table-1. Standardization functions.

Methodology of standardization	Function
Column maximum	x/x_{max}
Ideal value	(x-xmin ideal)/(x-xmax ideal)
Average value	x/xmean
Interval standardization	(x-xmin column)/(x-xmax column)
Additive constrain	x/∑xcolumn
Vector normalization	x/√x2
Range value	x/xmax-xmin
Linear value	x- xmin/xmax-xmin

The selected standardization function *f(x)* transforms the o_{ij} scores according to their relative values as in Equation (2).

$$I = f(O) \quad (2)$$

In the analysis, the impact matrix *I* substitutes the option matrix *O*, as in Equation (3).

$$I = \begin{matrix} i_{1,1} & \dots & i_{1,n} \\ i_{i,1} & i_{i,j} & i_{i,n} \\ i_{m,1} & \dots & i_{m,n} \end{matrix} \quad (3)$$

The multiplication between the impact matrix (*I*) and the weight vector (*w*) gives the impact vector (*i*) as in Equation (4)

$$I \times w = i \quad (4)$$

w_j elements are real nonnegative numbers, such that (Equation 5):

$$\sum_j w_j = 1 \quad (5)$$

where w_j represent the relative importance of examined *j* variables.

The proposed methodology demonstrates that it is possible to use an unbiased tool to calculate and examine the environmental performance of a road project. Furthermore, the results from LCA conducted for road materials, machines, and works provide reliable information to identify potential actions that could contribute to reduce the environmental impact and optimize the available resources. Current practices in road infrastructure projects demonstrate that there is a need for a rigorous methodology that combines unbiased and comparable environmental criteria. This methodology permits to have a proper environmental approach and it avoids choosing a low-cost material with higher environmental burden, balancing often-conflicting objectives

Every possible weight vector stands for different sensibilities of stakeholders, experts, public authorities (Stillwell, 2001) to address the problem. Consequently, for the same configuration of damage matrix *I*, different weight configuration gives back different best option.
The impact vector represents a quantitative and objective declaration of the environmental impact of the selected design alternative.

The methodology of weighted summation ensures synthetic, measurable and precise results for performing environmental impact assessments of roadwork. Moreover, it clarifies the strengths and weaknesses of the alternative policies to support stakeholder interests.

CONCLUSIONS

Although the interest in environmental-related construction issues has grown fast in recent years, there is still a need for a comprehensive approach that could be universally applied to different civil works. Often, the environmental analysis is conducted using a qualitative rather than quantitative approach, providing weak and far from reliable effects.

International concern over climate change and urban pollution is growing. Often call for tenders of road construction applied just economic criteria, due to difficult estimation of eco-responsible targets. By means of Green Public Procurement, the international framework is taking an interest about environmental issues in Public Administration. So far, however, the GPP approach has not been implemented to roads construction. The present study deals with an innovative method developed to estimate environmental harms of road construction and to choose the most environmentally-friend solution. The proposed research has identified the weighted sum multi-criteria analysis as the tool to assess the sustainability of a road project, to consider equivalent options and to choose the one that meets public requests. The method is objective, user-friendly and comprehensive method: it applies the Multi Criteria Analysis as a tool for assessing the environmental impact of a road project. By means of weighting factors, it allows comparisons among alternative projects, so it is advisable in tendering rules.

Therefore, when decision makers should evaluate more solutions, the comparative Multi Criteria Analysis could ensure the “greenest” solution. This approach reduces risk of considering “greenest” a good more pollutant and dangerous than others. The numeric and not dimensional value of environmental effects takes into account the local context and the stakeholders’ objectives. It could be a valid support-decision maker for politicians and technicians. The methodology allows applying GPP in road works: it is an appropriate tool to stimulate the market and encourage technological innovation by the development of products with high environmental performance throughout the life cycle.

The importance of this study is that it provides a literature review about European green public procurement related to road infrastructures, which is growing its importance in call for bids. The current conditions highlight the need for a methodology synthetic, objective and simple to solve the observed lacks. The explained methodology provides a tool for management bodies and/or authorities to implement strategies, procedures of policies to guarantee environmental protection.

REFERENCES

AccionaInfraestructuras. 2013. Environmental Product Declaration “N-340” road.

Ameen R.F.M., Mourshed M., Li H. 2015. A critical review of environmental assessment tools for sustainable urban design. Environmental Impact Assessment Review; 55, 110-125. 10.1016/j.eiar.2015.07.006.

Arrowsmith S., Kunzlik P. 2009. Social and Environmental Policies in EC Procurement Law: New Directives and New Directions. Cambridge University Press.

Balasubramaniam A., Voulvoulis N. 2005. The appropriateness of Multicriteria Analysis in environmental decision-making problems. Environmental technology, Sep 26(9):951-62. DOI: 10.1080/09593332608618484.

Bernardini L., Leone M.,D’Andrea A., Loprencipe G., Malavasi G. 2017. Building Information Modeling (BIM): prospects for the development of Railway Infrastructure industry. TIS 2017 International Congress on Transport Infrastructure and Systems, Rome, Italy.

Bond A. J., Morrison Saundes A. 2011. Re-evaluating Sustainability Assessment: Aligning the vision and the practice. Environmental Impact Assessment Review; 31, 1-7. doi:10.1016/j.eiar.2010.01.007.

Bonin G., Cantisani G., Loprencipe G., Ranzo A. (2007). Dynamic effects in concrete airport pavement joints. IndustriaItaliana del Cemento. 77(834), 590-607.

Bonin G., Folino N., Loprencipe G., Oliverio Rossi G.,Polizzotti S. and Teltayev B. 2017. Development of a Road Asset Management System in Kazakhstan. TIS 2017

International Congress on Transport Infrastructure and Systems, Rome, Italy.

Botniabanan ab, 2010. Environmental Product Declaration for railway track foundations on the Bothnia Line. http://gryphon.environdec.com/data/files/6/7221/epd198.pdf.

Bouwer M., Jonk M., Berman T., Bersani R., Lusser H., Nappa V. *et al*. 2006. Green Public Procurement in Europe - Conclusions and recommendations. Virage Milieu & Management bv, Korte Spaarne 31, AJ Haarlem, the Netherlands. http://europa.eu.int/comm/environment/gpp.

Buzzi Unicem. 2014. Dichiarazione ambientale Cemento.

Cantisani G., Loprencipe G., Primieri F. 2012. The integrated design of urban road intersections: A case study. ICSDC 2011: Integrating Sustainability Practices in the Construction Industry - Proceedings of the International Conference on Sustainable Design and Construction 722-728. doi: 10.1061/41204(426)88

Cantisani G., Fascinelli G., Loprencipe G. 2013. Urban road noise: The contribution of pavement discontinuities. ICSDEC 2012: Developing the Frontier of Sustainable Design, Engineering, and Construction - Proceedings of the 2012 International Conference on Sustainable Design and Construction. 327-334. ISBN: 978-078441268-8 doi: 10.1061/9780784412688.039

Cantisani G., D'Andrea A., Di Mascio P., Loprencipe G. 2016. Reliance of pavementtexturecharacteristics on mix-design and compactionprocess. 8thRILEM International Symposium on Testing and Characterization of Sustainable and Innovative BituminousMaterials. Springer Netherlands.pp. 271-281.

Cementerie Aldo Barbetti. 2014. Dichiarazione ambientale Cementi.

CIMbéton. 2011. Analyse du cycle de vie de structures routières- T89. Collection Technique CIMbéton, Paris, France. http://www.infociments.fr/publications/route/collection-technique-cimbeton/ct-t89.

Corazza M. V., Guida U., Musso A., Tozzi M. 2016a. A new generation of buses to support more sustainable urban transport policies: A path towards "greener" awareness among bus stakeholders in Europe. Research in Transportation Economics. 55, 20-29. Doi: 10.1016/j.retrec.2016.04.007

Corazza M. V., Di Mascio P., Moretti L. 2016b. Managing sidewalk pavement maintenance: A case study to increase pedestrian safety. Journal of Traffic and Transportation Engineering. 3: 203-214. doi:10.1016/j.jtte.2016.04.001.

Corazza M. V., Musso A., Karlsson M. A. 2017. More accessible bus stops: Results from the 3iBS researchproject, in Dell'Acqua, G., Wegman, F. (ed), TransportInfrastructure and Systems, Proceedings of the Aiit International Congress on TransportInfrastructure and Systems (Tis 2017) CRC Press, Taylor & Francis Group, London. pp. 641–650

D'Andrea A., Fiore N. 2003. Fatigue life of asphalt concrete with rubber grains. Paper presented at the Advances in Damage Mechanics; 65-74. doi: 10.2495/FDM030071.

D'Andrea A., Bonora V., Drago D. 2004. Asphalt concrete with bottom ash: Environmental aspects. Proceedings of the International Conference on Restoration, Recycling and Rejuvenation Technology for Engineering and Architecture Application. pp. 56-63

Del Principe M., Di Prete M., Martino A. 2015. La sostenibilità ambientale nei progetti di infrastrutture ferroviarie.

Di Mascio P., Moretti L., Panunzi F. 2012. Economic Sustainability of Concrete Pavements. Procedia - Social and Behavioral Sciences; 53: 125-133, Proceedings, V International SIIV Congress Sustainability of Road Infrastructures, Rome, Italy, 29th-31st October 2012. doi: 10.1016/j.sbspro.2012.09.866.

Di Mascio P., Loprencipe G., Moretti L. 2014. Competition in rail transport: methodology to evaluate economic impact of new trains on track. ICTI2014 - Sustainability, Eco-efficiency and Conservation in Transportation Infrastructure Asset Management; 669-675, Losa & Papagiannakis (Eds)-Taylor & Francis Group.

Ecoinvent. 2016. Ecoinvent 3.2. available at http://www.ecoinvent.org/database/database.html

Ecoplan&Infras. 2010. External Effects of Transport 2010 - Monetising Environmental, Accident and Health-Related Effects.

EN 15804:2014. Sustainability of construction works, Environmental product declarations, Core rules for the product category of construction products.

European Commission. 1996. Public Procurement in the European Union: Exploring the Way Forward. Green Paper. Communication COM (96)583.

European Commission. 2001a. Development Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development. COM (2001)264.

European Commission. 2001b. Interpretative Communication on the Community Law Applicable to Public Procurement and the Possibilities for Integrating Environmental Considerations into Public Procurement.

Commission Interpretative Communication COM (2001)274.

European Commission. 2001c. Sixth Environmental Action Programme: Environment 2010: Our future, Our Choice. Communication from the Commission to the Council COM (2001)31.

European Commission, 2008. Public procurement for a better environment. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions COM (2008)400.

European Commission, 2010. Road Construction and Traffic Signs Technical Background Report. AEA, Harwell.

European Commission's Joint Research Centre, 2014. European reference Life Cycle Database (ELCD) 3.2. available at http://eplca.jrc.ec.europa.eu/ELCD3/processList.xhtml

European Parliament and Council, 2004a. Directive 2004/17/EC of 31 March 2004 coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors.

European Parliament and Council, 2004b. Directive 2004/18/EC on the coordination of procedures for the award of public works contracts.

Fiore N.,D'Andrea A.,Tozzo C.,Zagaroli M. 2014. Gasification bottom ash in road pavements. Sustainability, Eco-Efficiency and Conservation in Transportation Infrastructure Asset Management - Proceedings of the 3rd International Conference on Transportation Infrastructure. ISBN 9781138001473.

Fiore N., Caro S.,D'Andrea A.,Scarsella M. 2017. Evaluation of bitumen modification with crumb rubber obtained through a high pressure water jet (HPWJ) process. Construction and Building Materials. 151, 682-691. doi: 10.1016/j.conbuildmat.2017.06.100

Green Delta. 2014. openLCA 1.4 overview and first steps. Available at http://www.openlca.org/documents/14826/0/openLCA_1+4_overview_and_first_steps_v1.pdf.

Holcim, 2013. Environmental Product Declaration of Portland Cement.

Ifu Hamburg, 2016. Umberto NXT Universal. Available at http://www.umberto.de/en/versions/umberto-nxt-universal/.

Igondova E., Pavlickova K., Majzlan. 2016, O. The ecological impact assessment of a proposed road development (the Slovak approach). Environmental Impact AssessmentReview. 59, 43-54.

Industrie Riunite Odolesi. 2013. Dichiarazione ambientale di prodotto per tondo in acciaio in barre per calcestruzzo armato di Industrie Riunite Odolesi I.R.O. S.p.A.
International Labour Organization, 1998. Declaration on Fundamental Principles and Rights at Work.

ISO 14001: 2004. Environmental management systems -- Requirements with guidance for use.

ISO 14004: 2004. Environmental management systems -- General guidelines on principles, systems and support techniques.

Italferr. 2010. Rapporto di sintesi sulla emissione (rimozione) della CO_2- Progetto definitivo "Potenziamento linea Rho-Arona tratta Rho-Gallarate.

Italferr. 2011. Rapporto di sintesi sulla emissione (rimozione) della CO_2 – Progetto definitivo "Raddoppio linea Fiumetorto-Ceflù-Castelbuono Tratta Ogliastrillo-Castelbuono.

Loprencipe G., Cantisani G. 2013. Unified Analysis of Road Pavement Profiles for Evaluation of Surface Characteristics. Modern Applied Science. 7(8): 1-14. http://dx.doi.org/10.5539/mas.v7n8p1.

Loprencipe G., Pantuso A., Di Mascio P. 2017. Sustainable Pavement Management System in Urban Areas Considering the Vehicle Operating Costs. Sustainability (Switzerland). 9(3), 453. doi:10.3390/su9030453

Miccoli S., Finucci F., Murro R. 2014a. Criteria and Procedures for Regional Environmental Regeneration: A European Strategic Project. Applied Mechanics and Materials. 675-677. 10.4028/www.scientific.net/AMM.675-677.401.

Miccoli S., Finucci F., Murro R. 2014b. A Monetary Measure of Inclusive Goods: The Concept of Deliberative Appraisal in the Context of Urban Agriculture. Sustainability. 6(12): 9007-9026. Doi:10.3390/su6129007.

Miccoli S., Finucci F., Murro R. 2015. Measuring Shared Social Appreciation of Community Goods: An Experiment for the East Elevated Expressway of Rome. Sustainability; 7(11), 15194-15218. doi:10.3390/su71115194.

Ministero dell'ambiente e della tutela del territorio. 2003. Norme affinché gli uffici pubblici e le società a prevalente capital pubblico coprano il fabbisogno annuale di manufatti e beni con una quota di prodotti ottenuti da materiale riciclato nella misura non inferiore al 30% del fabbisogno medesimo. Decreto n.203/2003.

Ministero dell'ambiente e della tutela del territorio. 2005. Green Public Procurement - Indicazioni per l'operatività

nel settore edile, stradale e ambientale, ai sensi del decreto ministeriale 8 maggio 2003, n. 203. Circolare n. 5205/2005.

Moretti L. 2014. Technical and economic sustainability of concrete pavements. ModernApplied Science; 8(3): 1-9. DOI: 10.5539/mas.v8n3p1.

Moretti L., Cantisani G., Di Mascio P. 2016. Management of road tunnels: Construction, maintenance and lighting costs. Tunnelling and Underground Space Technology. 51: 84-89. doi:10.1016/j.tust.2015.10.027.

Moretti L., Mandrone V., D'Andrea A., Caro S. 2017a. Comparative "from cradle to gate" life cycle assessments of Hot Mix Asphalt (HMA) materials. Sustainability (Switzerland).9(3), 400. doi:10.3390/su9030400.

Moretti L., Cantisani G., Caro S. 2017b. Airport veer-off risk assessment: An Italian case study. ARPN Journal of Engineering and Applied Sciences.Vol. 12/3, February.

Moretti L., Cantisani G., Di Mascio P., Caro S. 2017c. Technical and economic evaluation of lighting and pavement in Italian road tunnels. Tunnelling and Underground Space Technology. 65, 42-52. http://dx.doi.org/10.1016/j.tust.2017.02.007.

Moretti L., Di Mascio P., Bellagamba S. 2017d. Environmental, human health and socio-economic effects of cement powders: The multicriteria analysis as decisional methodology. International Journal of Environmental Research and Public Health.14/6), 645. doi:10.3390/ijerph14060645.

Moretti L., Caro S. 2017. Critical analysis of the Life Cycle Assessment of the Italian cement industry. Journal of Cleaner Production. 152, 198-210. doi: 10.1016/j.jclepro.2017.03.136

Musso A., Corazza M. V. 2006. Improving Urban Mobility Management: The Rome Case. TransportationResearch Record – Journal of the TransportationResearch Board. 1956, 52-59.

Musso A., Corazza M. V. 2015. Visioning the bus system of the future: stakeholders' perspective. TransportationResearch Record: Journal of the TransportationResearch Board. 2533, 109–117. doi: 10.3141/2533-12

Officinadell'Ambiente S.p.A. 2015. Dichiarazione Ambientale di Prodotto (EPD) delle materie prime seconde o aggregati di origine industriale -sandmatrix.

PriceWaterhouseCoopers, Significant and Ecofys, 2009. Collection of statistical information on Green Public Procurement in the EU-Reports on methodologies. http://ec.europa.eu/environment/gpp/pdf/statistical_information.pdf.

PRé Sustainability. 2016. SimaProTutorial. Available at http://www.presustainability.com/articles/download/simapro-tutorial/680/pdf

Shahin M. Y. 2005. Pavement Management for Airports, Roads and Parking Lots. Kluwer Academic Publishers, Dordrecht.

Thinkstep. 2016. GaBi Life Cycle Engineering Suite. Available at https://www.thinkstep.com/content/brochure-gabi-life-cycle-engineering-suite.

Tozzo C.,Fiore N.,D'Andrea A. 2016. Investigation of dilatancy effects on asphalt interface shear strength. Rilem Book series doi: 10.1007/978-94-017-7342-3

Union Européenne des Producteurs de Granulats. 2012. Environmental Impact Categories of cradle to gate aggregates.

United Nations. 1948. The Universal Declaration of Human Rights. Declaration adopted by the United Nations General Assembly on 10 December 1948 at the Palais de Chaillot.

United Nations. 1992. The Rio Declaration on Environment and Development. Report of the United Nations Conference on Environment and Development.

United Nations. 2003. United Nations Action against Corruption and Economic Crime.

United Nations Environment Management Group. 2007. Report of the Annual Meeting of the Environment Management Group. Annual meeting of the Environment Management Group hosted by the World Health Organization at its Headquarters Geneva. http://www.greeningtheblue.org/sites/default/files/UNClimateNeutralStrategy.pdf.

Weidema B. P., Bauer C., Hischier R., Mutel C., Nemecek T., Vadenbo C. O., Wernet G. 2011. Overview and methodology: Data quality guideline for the ecoinvent database version 3. http://www.ecoinvent.org/fileadmin/documents/en/ecoinvent_v3_elements/01_DataQualityGuideline_FinalDraft_rev1.pdf.

World Bank. 1996. Sustainable Transport: Priorities for Policy Reform. Washington, DC.

World Commission on Environment and Development. 1987. Our Common future.

Zoccali P., Loprencipe G., Galoni A. 2017. Sampietrini Stone Pavements: Distress Analysis using Pavement Condition Index Method. Applied Sciences (Switzerland). 7(7), 669. doi:10.3390/app7070669.