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DIGITAL URBAN SURVEY AND DATA MANAGEMENT AN INTERNATIONAL COOPERATION PROJECT FOR THE DEVELOPMENT OF BETHLEHEM CITY CENTER

Middle Eastern territory manifests complex phenomena of stratification and development of urban architectural realities, as historical result and contemporary scenario of uncontrolled interventions on architecture and landscape. The presented research illustrates an experimental analysis conducted on the historic center of Bethlehem. Investigating the complexity of the urban fabric with on-site documentation actions, the project is configured as an experience of international cooperation whose scientific responsibility is entrusted to the Experimental Laboratory DAAd LAB of University of Pavia. The research, co-financed by AICS, started in 2018 in synergy with administrations and local authorities and represents a comparison between academic partners and Italian-Palestinian territorial bodies as a starting dialogue for the realization of a concrete program of rehabilitation, prevention and planning of architecture, territory and services in the city of Bethlehem.

Keywords: digital urban databases, urban modelling, international cooperation, Bethlehem.

Analysis and strategies for improvement of the knowledge for Bethlehem historic city. The built fabric of Bethlehem highlights an historic succession of architectural events and transformations that, analyzed through the evidence of masonries, stratigraphies and construction techniques, has characterized the architectural evolution of the city in its various historical-political phases¹. Archi-

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¹ The complex building system of the city, developed by the Constantinian rural settlement (400 AD) through the Ottoman empire to the British mandate (1918–1948), defines one of the most critical urban management issues, in particular in relation to the complexity of volumetric articulation of the built units with respect to public streets and urban voids. For a complete description of building coexistences in the historic city, see: Picchio Francesca, De Marco Raffaella (2019). Landscape Analysis and Urban Description of Bethlehem Historical Center: A Methodological Approach for Digital Documentation. HERITAGE, 2018, vol. 2 (1), p. 507–518.

tectural heritage, defined by the presence both of Arabic and European influences, highlights an overlap of systems and constructive units, also found in the use of materials and reuse of components, in which to identify the transformations of buildings and more generally the history of settlements, characterized by a conformation both residential and productive².

Bethlehem concretizes the planimetric irregularity of the Arab city, with a tortuous plan of open spaces and dense volumes, articulated in labyrinths of streets and courts, both public and private, which refer to the labyrinthine paths of Islamic medina's typology³.

Previous researches on the documentation of the urban space of Bethlehem⁴ suggest an update of representation practices for the analysis of the historical city with the application of digital survey protocols as a key support in clarifying the complexities of built relations, transferring the correspondence between units and volumes in the digital space, necessary for the understanding of the urban nucleus. This scientific analysis, based on established principles of the academic discipline of drawing, becomes aware, in the case of the stratified city, of the indispensable need for interaction and dialogue with the territorial administration, for the development of languages and tools directed to programs and collaborative management of data⁵.

These products, both scientific and managerial at the same time, are required to experience an urban identity defined by 8 distinct areas of different historical-cultural profile, where 30 thousand residents live, and that welcome an international touristic influx of about 1 million of people every year. This system is characterized by incidences and critical issues concerning the use of services, urban spaces, activities and monuments. No-controlled construction policies, that

² Parrinello S., Picchio F., De Marco R. Il paesaggio ed il colore del Medio Oriente: sistemi di rappresentazione ed analisi tra passato, presente e futuro, in *Colore e Colorimetria Contributi Multidisciplinari*, vol. XII A, V. Marchiafava, Eds. Milano: Gruppo del Coloreore, 2016, p. 49–60.

³ The comparison between the city of Bethlehem and the historical settlement context of Arab cities, conformed in the *medinas*, is recalled by the similarity of typological characters, with labyrinthine alleys, built blocks, internal courtyards, road close-sections inaccessible to traffic. For many details, see. Dabdoub, 2005.

⁴ The research on analysis and representation systems for the understanding of the urban complexities of the historic center of Bethlehem and the proposal for cognitive frameworks on the project of the city is already set in the disciplinary sectors of Drawing and Restoration. It is mentioned the research project of University of Rome "La Sapienza": *Conservation Master Plan for the town of Bethlehem*, in the cooperation program ICOMOS-CIVVIH and ISPROM (1998), Scientific coordinator: prof. T. Kirova, with the elaboration of *Master Plan – General Town Plan of the city of Bethlehem* (2002–2005), Coordinator of the Design team: prof. M. Docci.

⁵ The survey of urban spaces increasingly recalls the action of representation to an ideal of critical expression of the historical signs of the anthropic place, defining analytical graphical frameworks able to guide an action of conservation of the heritage and to stimulate the experimentation of instruments of promotion of culture and historical memory. For an extended discussion, cfr. Balzani, Maietti, 2018.

constantly alter the image of the city center, are interposed by protection policies provided by UNESCO regulations, applied in the area adjacent to the Nativity Church. The presence of this constraint constitutes an opportunity to develop a reflection, not only theoretical, on the value of the signs and permanences that characterize the historical nucleus, advantaging conservation and enhancement mechanisms of heritage in a cooperative action of international awareness.

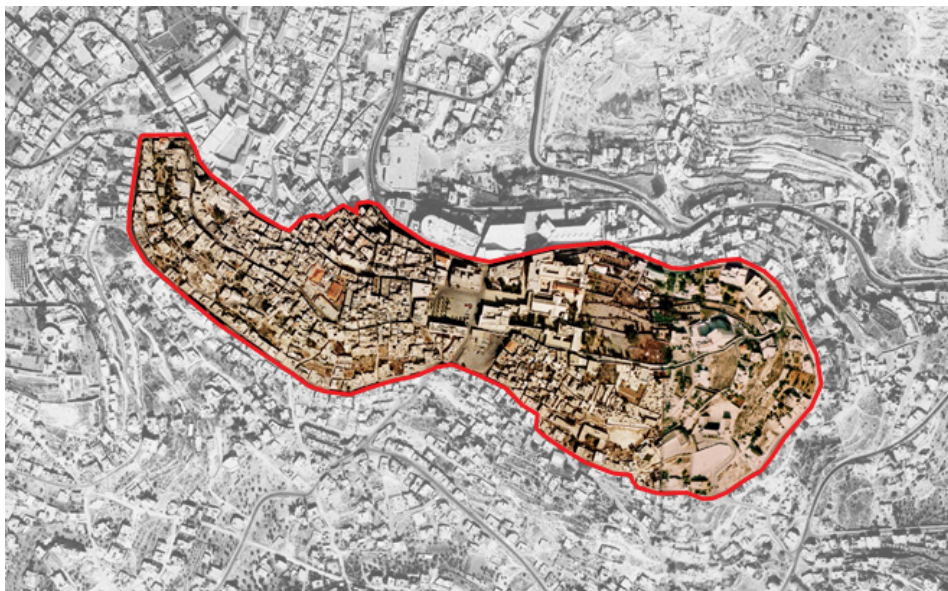


Fig. 1. Orthophoto of the territory of the urban centre of Bethlehem with in evidence the area of investigation of the project

Рис. 1. Ортофотоплан территории городского центра Вифлеема с указанием территории исследования

A cooperation project for digital documentation and the production of interactive database. The research project prospected for the city of Bethlehem is characterized by objectives of urban renewal, and it is subjected to implement a technological process of analysis of urban configuration for the definition of tools useful to provide the future of the city. Aim of the project is to create a methodological protocol that, through the “drawing of the city”, is able to plan its development and transformation policies: through the digital documentation of the historical center, virtually elaborated in the form of a highly reliable 3D model with informative contents, the drawing of a “smart city” is realized, creating the appropriate context for design actions, urban development and quality of services⁶.

⁶ Huffman K.L., Giordano A., Bruzelius C. Visualizing Venice. Mapping and modeling time and change in a city. Abingdon: Taylor & Francis Ltd, 2017.

The building and urban analysis conducted and their application in digital 3D management systems are thus designed as joint cognitive results, supported by a renewed formative awareness of operators and products on tools and knowledge operations for urban planning. In this way, the strengthening of administrative *governance* involves a transfer and exchange of both cognitive experiences and methodological practices between the academic and institutional sphere, suitable for the management and control of urban growth for heritage development.

The institutional and technical dialogue established with the technical office, G.I.S. section, of the Municipality of Bethlehem, responsible for the urban planning tools, consolidates the management of the project in all its phases, setting an action of comparison and confidence with the city, preliminary to the plan of survey, building analysis and modelling of a 3D urban database as implementation structure for the information system.

The survey campaigns, conducted in June 2018, December 2018 and February 2019, have been implemented with different digital acquisition tools, designed to adapt to the various expansions and contractions of the urban landscape, from the narrow streets to the urban staircases of the historical areas, from the modern mansions of the external perimeter to the internal courts of the ahwash historical quarters.

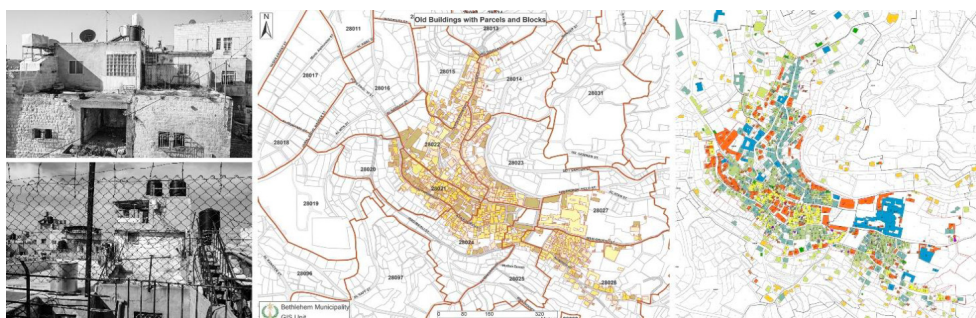


Fig. 2. Cartographic analysis of the historic center of Bethlehem adopted by the GIS. Office archive. The critical bi-dimensional reading, according to parameters of historical relevance, does not allow the analysis of the modification and addition components of individual building units

Рис. 2. Картографический анализ исторического центра Вифлеема по Офисным архивам ГИС. Критическое двумерное чтение данных в соответствии с параметрами, имеющими историческое значение, не позволяет анализировать модификации и дополнительные компоненты отдельных строительных блоков

The proposal of query descriptors, predisposed for the semantic planning of management and maintenance interventions on the city, structures the dialogue with the technical sections of the Municipality of Bethlehem: building,

infrastructural and territorial requirements explained by the scientific-administrative comparison are thus converted into structural parameters of the revised archive, directing the action of operators with respect to the design practices. The set of a process of agreement and operational integration, planned over the three-year action, guides the choice of forms and values to be attributed to units, building facades and public space structures, allowing the municipality to improve reflections and programs on the intervention in the built context, both public and private. To support the validation of experimental outputs, dissemination and communication activities at universities and cultural institutes are included, to pursue a common awareness, not only scientific but cultural and social, of the urban development process.

The result of the expected survey project is a technical awareness that identifies in the Drawing and its traditional and contemporary tools the ability to represent and study these complexities, developing through 3D databases the cataloguing and management of architectural heritage for the development of Middle Eastern territories⁷.

Digital survey and representation practices for the joint analysis process.

The first year of project has included an on-site program aimed at experimenting different methods of surveying and cataloguing of built heritage, in a joint application and training action for the preliminary revision of the information structure. The adoption of terrestrial laser scanner (TLS) survey strategies, static and mobile mapping system⁸, and photogrammetry, terrestrial and UAV, has updated the technical approach to the knowledge of the Middle Eastern city through representation, acquiring spatial information for the identification and analysis of building systems in the historic city. The possibility of managing the high complexity of architectural volumes of the city thus receives the administrative needs in the extension and coordination of the investigation.

The typological subdivision of the historical fabric in areas, aggregate units, building units and open spaces, relates urban forms by scale of analysis, providing different typological classes of information, from technological details to structural

⁷ Parrinello S. A Development Project for the United Nations. The Digital Survey for the Planning of East Jerusalem // Putting Tradition into Practice: Heritage, Place and Design, G. Amoroso, Eds. Cham: Springer, 2017, p. 551–559.

⁸ The possibility of generating point clouds from mobile mapping systems, systems of “mobile survey” that combine survey (laser scanner) and navigation (GPS) instruments, introduces the concept of “acquisition trajectory”. The experimentation of a Stencil unit, compared to a static campaign with FARO laser scanner, highlighted the possibility of automation in acquisition and registration, with a range of 100 meters of about 15' for urban block with a total of 30 million points. The particularity of a vertical visual field of acquisition limited to 30°, in the presence of extended blocks with contained road sections and high façades, has however oriented the metric reliability towards databases obtained by a terrestrial static laser, defining a discrete system on which to operate integrations of data from Stencil dataset and UAV photogrammetry.

conformation. The preliminary cataloguing approach, alphanumerically coded, delivers a comparison with the digital maps adopted by administration, reinterpreted in the building classification to allow the urban units to be managed separately in relation to operative intervention provisions by Municipality.

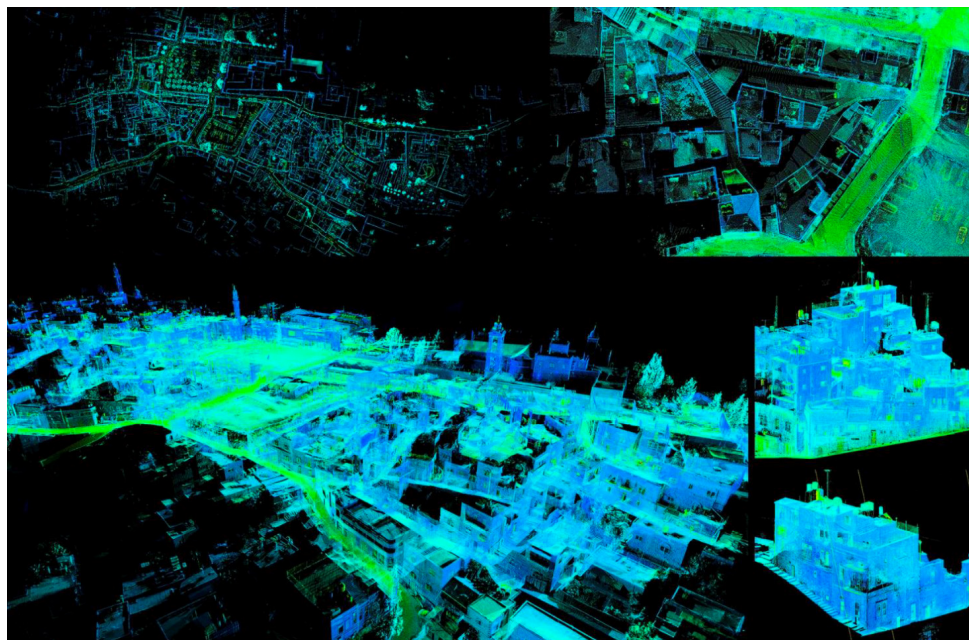


Fig. 3. Survey output with Terrestrial Laser Scanner, developed through strategies for acquiring and recording spatial data for reliable and detailed management of urban surfaces

Рис. 3. Результаты исследования с помощью лазерного сканера и с использованием технологии сбора и регистрации пространственных данных

The investigation action thus evolves in a renewed perspective of administrative-management priority of the urban planning, where the bi-dimensional cartographic information, weak in the description of the volumetric irregularities of the stratified city, is expanded into a digital constitutive three-dimensionality, aimed at investigating the peculiarities and characteristics of the urban environment. Actually, the main cause of invalidity of existing cartographic documentation and metric imprecision of measured data is linked to the reduced updating of monitoring of the historical center, with extended degraded and abandoned area of particular historical value, both in a social and constructive/structural view, as along the west side of Bethlehem center. The goal of the project is also to pursue an action of structural monitoring and census documentation structured on sectors of architectural, constructive, structural and urban survey with more than

50 levels of analysis recorded in a single digital format of registration and consultation, infinitely implementable, that guarantees cross-comparison.

Through a concrete possibility of integrated cooperation, drawing and *governance* deepen and reinterpret their relationship in a cognitive support on the city, mapped in its historical and contemporary layers.



Fig. 4. Output of photogrammetric survey Structure from Motion (SfM), terrestrial and aerial UAV, integrated to guarantee a global and complete coverage of urban environments and volumes

Рис. 4. Выходные данные фотограмметрического обследования структуры через движение (SfM) с помощью наземного и воздушного беспилотного летательного аппарата, интегрированные для обеспечения глобального и полного охвата городской среды и объемов

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**ЦИФРОВОЕ ГОРОДСКОЕ ИССЛЕДОВАНИЕ
И УПРАВЛЕНИЕ ДАННЫМИ: МЕЖДУНАРОДНЫЙ ПРОЕКТ
ПО РАЗВИТИЮ ЦЕНТРА ГОРОДА ВИФЛЕЕМА**

В результате исторического развития, а также вследствие неконтролируемых вмешательств в архитектуру и ландшафт на территории Ближнего Востока проявляются сложные явления расчленения и развития архитектурно-градостроительной среды. Сложившаяся в Вифлееме городская ткань подчеркивает историческую последовательность архитектурных событий и преобразований, которые на основе свидетельств кладки, стратиграфии и строительных технологий характеризуют архитектурную эволюцию города в его различных историко-политических фазах. Представленное исследование иллюстрирует экспериментальный анализ, проведенный в историческом центре Вифлеема. Проект, задачей которого является изучение сложности городской структуры с параллельным документированием архитектурно-градостроительной среды непосредственно на месте исследований, реализуется как международное сотрудничество, научное руководство которым возложено на Экспериментальную лабораторию DAda LAB Университета Павии. Исследование началось в 2018 году в сотрудничестве с административными органами и местными властями. Проект финансируется при поддержке Итальянского агентства для развития кооперации (AICS) и представляет собой сравнение между академическими партнерами и итальянско-палестинскими территориальными органами в качестве исходного диалога для реализации конкретной программы реабилитации, предотвращения и планирования архитектуры, территории и услуг в городе Вифлееме. Экспедиции по сбору данных проходили в июне, декабре 2018 года и в феврале 2019 года. При работе использовались различные цифровые инструменты сбора данных, которые применимы к различным масштабам и характеристикам городского ландшафта: от узких улиц до городских лестниц исторических районов, от современных особняков по внешнему периметру кварталов до внутренних дворов исторических кварталов. Целью проекта также являлось проведение структурного мониторинга и инвентаризации. Документация по инвентаризации была структурирована по блокам архитектурного, конструктивного, структурного и городского обследования, записанных в едином цифровом формате, в которых представлено более 50 уровней анализа. Благодаря возможности интегрированного международного сотрудничества произошло переосмысление управления данными, а также такое сотрудничество углубило исследование в части отображения реального соотношения данных в исторических и современных слоях городской среды.

Ключевые слова: цифровые городские базы данных, городское моделирование, международное сотрудничество, Вифлеем.

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