

# Functions and Effects of Green Facades in the Developing Countries: Case Study of Tehran

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**Abstract**—Many people lost their life caused by environmental pollution every year. The negative effects of environmental crises appear to be much higher in Asian countries. The most important environmental issue in the developing countries and especially in Tehran, to our best knowledge, is air pollution that has affected many aspects of life in society. Environmental topics related to technology's development have been salient issues among the main concerns of designers. Green facades are the most considerable solutions which designers and architectures are focused on, all over the world. But there are lots of behavioral and psychological problems about this point. In this line, this excavation has tried to reveal the cultural and psychological influences of green façade in developing countries like Tehran. Green façades in developing countries are so useless, although they are so expensive. As a matter of fact, users consider green facade as a decorative item. This research is an attempt to recognize the reasons which show green façades as worthless element. Also, some solutions are presented to promote green façades in the developing countries as an intrinsic solution. There are so many environmental threats, especially about air pollution, for a city as Tehran, which might be solved by green facades.

**Keywords**—Air pollution, developing countries, effects, green facades.

## I. INTRODUCTION

WORLD population is growing astronomically during recent years. The whole population of the world's cities increased from less than 30 million to about 4 billion during the past two centuries of global economic expansion [1]. A growing focus of individuals and economic function and also increasing use of cars have led to air pollution severely in metropolises of developing countries, such as Bangkok, Beijing, Mexico City, Jakarta and Calcutta [2]. The environmental performance and economic development in Asia have not progressed harmoniously. In fact, one of the most remarkable challenges for the region is pollution. Asian environment quality has become worse and environmental exiting circumstances are grave in numerous countries. Asian cities have the dirtiest air in the world. Generally in these cities, the level of smoke, bits and dust and ambient particles are about twice the world average and five times as high as industrial countries [3]. Iran is one of the developing countries. The urban growth rate in this country, between 1950 and 2002, has grown from 27% to 60% [4]. The United National has estimated that by 2030, 80% of the population

will be residents of the city. Most of the internal migrants have resided in the surrounding sections of Isfahan, Qom, Ahvaz and Tehran [5].

## II. TEHRAN CITY

Tehran, the Capital of Iran, is faced with many socioeconomic and environmental problems. Approximately 12.5 million people live in the city [6]. The air pollution is the most effective environmental problem in this city [7]. Tehran atmosphere consisting of high levels of pollutants affected the life and health of people negatively, that in recent years, the residents have experienced occasional school cessations and traffic restriction, because of the air pollution. Many people were forced to stay home and wear face mask outdoors, and many others have been influenced by the poor health caused by the air pollution [8]. According to these problems there are some rules which would be helpful to mitigate such environmental problems. Sustainable development goals are provided to manage environmental problems.

## III. SUSTAINABLE DEVELOPMENT

Sustainable development is defined briefly as “the ability to make development sustainable- to guarantee that it meets the needs of the present without exposing the capacity of future generations to meet their own needs”, which is definitely a standard definition, especially when the criteria are its widespread use and high rate of frequency [9].

There is a world-wide need for a sustainable development [10]. There are basic explanations of what sustainable development is and how it is reached [11]. Various countries have cultivated their specific vision of how to incorporate sustainable development particularly to the built environment. As the local climate needs the modified solutions, establishing an envelope design must be concentrated particularly. Sustainable urban development includes a foundation and preservation of urban greenery. Decreasing the effects of human activities such as global warming, ameliorating well-being and also conserving the wild-life are just a few influences of natural environment and vegetation. Park, green space and planting trees in the street are some ways to green the cities [12]. Green facades and roof gardens are used in order to make the urban spaces and buildings green, efficiently.

## IV. GREEN FACADES

Increasing the vegetation of building envelop is a chance to reestablish the environmental quality of crowded city sections through uniting nature and built areas [13]. Among the

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elements of the urban environment, the appearance of buildings and apartments can be mentioned which could be built creating in favor of sustainable [14] or biophilic [15] development. Combining traditional architecture and modern materials and technology has led to form present green facades and also to improve sustainable building functions [16]. Today, many different expressions are used to debating vegetated vertical building surfaces. For instance, free standing walls which called wall vegetation are used in Germany and made of brick and stone constrictions, are appropriate places for plant colonies to live in cracks, see Fig. 1 [17].



Fig. 1 Free Standing Green Wall

In an urban area, green walls and roof help develop city greenery without involving the street spaces [18]. Indeed, developing urban biodiversity [19], managing storm water [20], increasing air quality [21], reducing temperature [22] and mitigating the heat island effect [23] and some positive influences of putting vegetation over the surface of buildings. In covering building facades with vegetation, climbers either woody or herbaceous planted in the ground or in planter box can be used. Sometimes to maintain these plants support systems are essential and planter boxes generally need green roofs and supplemental watering [24]. In addition to environmental effects, covering the buildings with vegetation have economic and social aspects. Some benefits of greening systems consist of fostering the realization of urban sections [25], have a therapeutic effect by inducing a psychological well-being through the presence of vegetation, improve cities' image [26], increase property value [27] and function as a complementary thermal and acoustic protection [28].

#### A. Culture of Green Facades in Traditional Architecture

About 2000 years ago, the vines were applied in order to cover the narrow back yards of places in the Mediterranean region, as the primary form of the vertical gardens. These gardens had many benefits such as providing shade for the facades, circulating fresh air and growing the fruits [33].

Tehran, Shiraz and Isfahan, in the past were garden cities and nature was an integral part of them. A good definition of a garden can be "the purest of human pleasures and the greatest refreshment to the spirits of man" [29]. As stated by Hunt, gardens are "concentrated or perfected forms of place-making" [30]. In addition, garden is supposed to be a symbolic

place representing Eden on the earth [31]. Ancient Persian gardens all transferred a mystical feeling for flavors and a great passion of garden. Supreme values and ideas are perfectly made evident and meaning, see Fig. 2 [32].



Fig. 2 Shazde Mahan Garden, Kerman, Iran

This matter manifests the great attention and respect of ancient Iranians for greening their lives. The exterior appearance of buildings in Iran was covered by climbers such as Ivy (*Hedera Helix*) and Grape ivy (*Ampelopsis*) form the old days. As Fig. 3 shows, seemingly they used the plants in that way just for decorating their buildings and not for their ecological or environmental effects [13].



Fig. 3 Residential building with Ivy, Tehran

#### B. Green Facades in Developed Countries

Many studies have shown the significant role of vegetation against air pollution which impacts urban air pollution, which impact, urban air negatively; only 10-15% of the total dust bits exist in an urban street in comparison with a similar street without trees [34]. According to Minke and Witter, a street without trees in Frankfurt has an air pollution of 10.000 – 20.000 dirty particles per liter, while in a street in the same neighborhood the air pollution is about 3000 dirty particles [35].

Stomata on plants and leaves are responsible for dissolving or sequestering gaseous pollutants [36]. Tan and Sia [37] in Singapore by applying light sensors, particle counters and

volume aerosol samplers, tested roof temperatures and other air quality parameters both before and after the installation of green roof; they concluded that after the installation of this kind of roofs, acid gaseous pollutants, carbon mass levels and ambient green roof surface temperature decreased greatly. According to Yang and his colleagues, 52% of O<sub>2</sub>, 27% of NO<sub>2</sub>, 14% of PM<sub>10</sub> and 7% of SO<sub>2</sub> were absorbed by green roofs in Chicago [38].

Another aspect of greening systems can be improved biodiversity; they play a vital role in crowded urban areas that the ground lacks sufficient vegetation [32]. Kohler revealed that sparrows, green finches and blackbirds chiefly existed between the climbers of green facades in Berlin, Germany, green roofs and facades by consisting insects serve as a food source and also as a nesting or breeding place [24].

Green facades contribute to ameliorate the whole environmental quality and function herby as a way to grow the connection between the human and nature. Application of greening systems includes several benefits as for the building and its residents (privet levels) and also for the urban area and the society (public level) [39]. The advantages of green facades are classified in to groups: environmental, economic and aesthetic, see Table I [40], [41].

TABLE I  
 ADVANTAGES OF GREEN FACADES [40]

Category	Benefits
Aesthetic	<ul style="list-style-type: none"> <li>The variety of plants and the change of seasons replace the monotony of a naked facade by a change of colors and appearance.</li> <li>The facade of building, partly or fully covered with plants, will be truly exclusive.</li> <li>Improve the microclimate both in winter and summer.                             <ul style="list-style-type: none"> <li>The surface of the leaves binds fine dust particles.</li> <li>The plants' photosynthesis reduces CO<sub>2</sub> emissions.                                     <ul style="list-style-type: none"> <li>The plants' evaporation increases air humidity.</li> <li>Therapeutic effects of plants and landscape.</li> </ul> </li> <li>There is greater biodiversity, as plants and blossoms attract insects and birds.</li> </ul> </li> </ul>
Environment	<ul style="list-style-type: none"> <li>Functioning as a complementary insulation layer, and in summer.                             <ul style="list-style-type: none"> <li>Absorbs large amounts of solar radiation.                                     <ul style="list-style-type: none"> <li>Control heat gains and losses.</li> </ul> </li> <li>Improve indoor thermal comfort and reduce energy demands for heating or cooling.</li> <li>Sound insulating: the sphagnum absorbs up to 18 d BA of the street noise.                                     <ul style="list-style-type: none"> <li>Insulating effect of the vegetation [44]:  The evaporation makes the façades cool (by -7°C to -15°C).  Applying as a sun-screen.  The trapped air behind the panels cools the surfaces.  Mitigating of wind speed by leaves.  Providing shade.  Evaporative cooling effect.</li> </ul> </li> </ul> </li> </ul>
Economic	<ul style="list-style-type: none"> <li>The facade is protected against the influence of the acidic rain.                             <ul style="list-style-type: none"> <li>A green facade discourages graffiti sprayers.                                     <ul style="list-style-type: none"> <li>Used as a passive design solution.</li> </ul> </li> </ul> </li> </ul>

#### V. HUMAN PERCEPTION

To perceive the benefits of green facades, people need to perceive their environment at first. Motivating the human senses and as a result, more appeal of the nature in people's

view can be conducted by evaluation of the function of all these senses in relation to the environmental scenery [42]. Many possible opportunities and information exist in the surrounding environment of human in real level, that people immediately identify some of these realities in form of actual and real information (objectively). After that some judgments are formed based on people's perceptions to make subjectively form the environment using those judgments. Basic elements of human behavior are subjectivities [43]. Psychological perceive of green façade consider to accomplished interviews, accounted with some problems which will describe in the following.

#### VI. METHOD

In this paper inquired individuals who, applied green façades for their building. Among 122 accomplished projects in Tehran, which known as residential, institutional or commercial, considering to Morgan chart interviewed 92 individuals as owners, designers, spectators and building managers. At first asked them to write cause of their choices, without interviewer intervention. Afterwards, asked some people as viewers of green façade (neighbors) randomly.

Besides, they interviewed about goals and the main reason in terms of green façades application, see Figs. 4 and 5. To select individuals (samples) impose a few limitations about age, education and exposedness level as mentioned below:

- Age: 20-50
- Education: graduate – post graduate
- Exposure: once at least



Fig. 4 Health paradise, Tehran



Fig. 5 Residential building, Tehran

## VII. FINDINGS

Then their reasons clustered in five groups, generally. As Fig. 3 shows the number of the persons who concerned about price factors is more than the others. Indeed, 67.3% of peoples are considered about. In fact, they express that green façades

increase building value in terms of price. 61% of them think about aesthetic aspects. The individuals who care about freshness is 45.6%. 18% vote to modernization features and the nostalgia factor is the most underrated item in this chart by 15%, see Fig. 6.

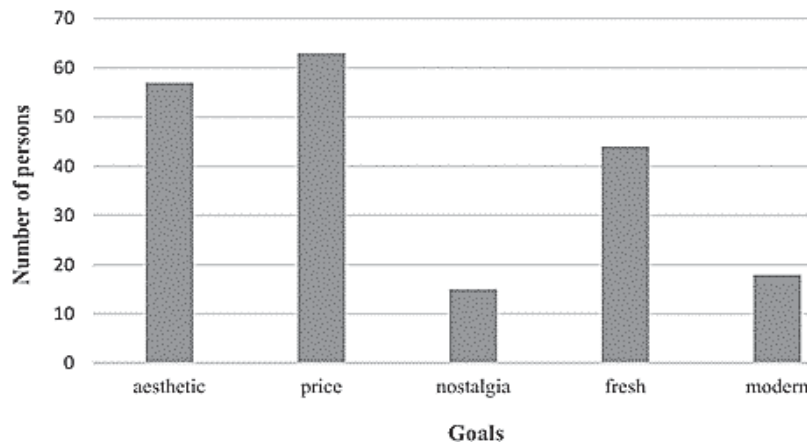


Fig. 6 Significant Features in Spectators Point of View

In the next step, they were questioned about objective features and benefits of green facades that are the main goals of green façade application in developed countries.

According to Table I, which introduce most benefits of this kind of façade, 14 principle features elicit and individuals just marked if they have thought about these, or not, see Fig. 7.

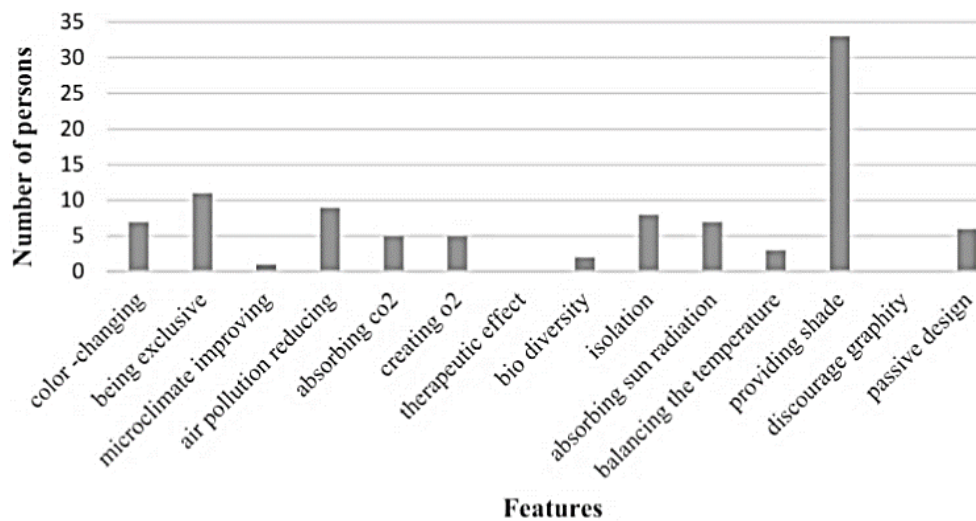


Fig. 7 14 Principle Features

Based on Fig. 7, 35.8% think that green façades can provide shade. Although 11.9% of samples mention it would be an exclusive façade. Air pollution awareness is 9.7% and 8.6% vote to isolation aspect. 7.6% vote Color-changing equally absorbing sun radiation. Also, 6.5% of individuals know about its passive function. 5.4% of people notice absorbing co2 and creating o2 process and 3.2% think that green façades can balance the building temperature. 2.1% identify improving microclimate as a positive features and Just 1% of individuals have some knowledge about biodiversity at last, Therapeutic factor and discourage graphite spray are the features that anyone have not thought before, at all.

## VIII. CONCLUSION

Regard to studies in this paper, profit-making is the first priority and virtual aspects are the second in green façades issue for peoples who live in Tehran. Cost of building which equipped with green façade will increase significantly and it is kind of profit for the owners except for government institutions. As mentioned a few of the samples pertinent to Non-Residential buildings that they applied green facades for aesthetic and freshness aspects. High percentage of people tend to aesthetic factor of green façades due to their culture and willing to know how they could apply to their buildings. Since these facades are located in affluent neighborhoods

seems that applying green façades is more feasible for prosperous people, so it is not affordable for the middle class of society. If the costs do not balance, it will gradually change to a luxury element for buildings. Thus, it is contrary to sustainable development goals and is likely to be particles of luxury culture. Notwithstanding that a few people choose these façades consciously, other people do not have any awareness about installations, benefits or its function. Lack of knowledge shows green facades as an ornamental object in architecture.

Reduction of air pollution by green façades would be practical while spread over a large area. To achieve these goals governments should invest in the cultural aspect. As noted, Iranian have valuable culture in terms of using vegetation. Studies in this paper indicate that people's mindset about green facades are not so realistic. Some of them, did not know anything about some particle of these questions and the other was excited about this feature due to their novelty and willing to know more about. They are eager to explicit from greenery ideas. They feel pleasure in vicinity of green facades. It means green façades calm psychological stresses of urban life. So, informing about drainage systems, proper plant, maintenance costs, advantage and disadvantage of green facades, assure people to use them. Enhance peoples' knowledge leads to better perception about their environment, it makes them more responsible about environment treatments. Mentioned benefits can be used to influence people, to persuade them to developing the technology. One the commonest challenges facing the architects, landscape architects and developers of vertical greenery technology is convincing the people of its benefits and also its capacity to be practical. In general, so much knowledge of advantages of greenery systems other than its aesthetic attraction is lost in the community. Eventually, it converts to positive social culture. Therefore, more research is needed on green facades development in developing countries.

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