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The Sustainability of Riyadh City: A Backcasting Study Using Household Consumption Patterns

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Abstract. Sustainability is a major challenge for Riyadh City. Nearly all indicators tend to reveal a bleak future for the city if the current trends of resource consumption are allowed to go on. Forecasting methods that have been extensively used in urban planning research have shown little success to come up with sound policies to tackle sustainability issues. The problem with such technique lies in the fact that these forecasts are being built upon the current trends. Current trends and actions are part of the problem. Projecting them into the future would simply mean amplifying the problem and rendering it even worse and more complex. The backcasting approach is, therefore, required to deal with the issue of planning for sustainability. This approach consists of having an informed vision about the city's desired future in order to strategically deal with potential trade-off from different decisions. It shifts away from current trends and their associated problems to proceed towards a transitional state where a change in behaviors and lifestyles is needed to move society in the direction of sustainability.

The results show excessive use of energy and land for residential use and car movement which may exert a huge burden on the city environment. When household categories were compared, those with higher socioeconomic status tend to be more spendthrift than their counterparts of lower SES. Income was found to account for much of the variance in energy requirements and also for food, water and washing expenditures. To tackle the issue of Riyadh sustainability, a visionary image for the city in the year 2020 must be set up. The target is to achieve a Factor 30 in environmental efficiency for the city to curtail the overgrowing environmental stress.

To achieve this target, policies must be geared towards changing households consumption behaviors and lifestyles. Automobile trips must be kept to a minimum. For that, the physical plan layout of the remaining areas of the city must follow design principles that encourage pedestrian movements, promote means of public transport and reduce incentives to use the private car.

1. Introduction

Riyadh society faces the challenge of realizing sustainable development for its own sake and for the sake of its future generations. It is, thus, incumbent on this society to deal with the underlying persistent and complex problems of sustainability. In the coming decades the city will have to reduce its environmental burden enormously, especially when taking into account that its population is increasing at a staggering rate (5.4% per annum (CDSI, 2010)) and its household wealth is also growing considerably. These two factors combined will lead to even more increasing rates of household consumption patterns which is even more detrimental to the city's sustainability. To live up to this challenge, Riyadh will have to improve its environmental efficiency in a way that the city can raise its current wealth, while curtailing the environmental burden.

As mentioned above, the issue of sustainability is not only a matter of city officials and planners, but the whole society must get fully involved in the process of environmental stewardship through the reduction of household consumption and the frugal use of non-renewable resources and energy. It is precisely this issue of household consumption patterns and its impact on city sustainability in the context of Riyadh that constitutes the focus of the present paper.

2. Household Consumption and the Issue of Sustainability

During the past decades, although the issue of sustainable city development has received increasing attention from the scientist community and

environmental organizations, much of their work has been focusing on the collateral environmental damage caused by car emissions, industrial plants and lack of greenness. Little attention, however, has been paid to the impact of household consumption patterns on the sustainability of cities. Households tend to consume a substantial amount of energy, water and land and at the same time, dispose of huge quantities of waste into the city environment. Much of the environmental pollution is, therefore, caused by household consumption, either directly through energy use, and water consumption, waste production, or indirectly through consumers buying goods and services that pollute the environment over their life cycle. In various studies, it was demonstrated that 60-70% of the total energy consumption is directly or indirectly consumed by households (Wilting, 1996). Household consumption behavior is, therefore, key to the society's impact on the environment. The actions that people take and choices they make, to consume certain products and services or to live in certain ways rather than others, all have direct and indirect impacts on the environment. This is why the topic of 'sustainable consumption' has become a central focus for any city's sustainable policy.

The Riyadh society consists of a large and rapidly increasing numbers of households characterized by different lifestyles. By the year 2020, the number of households is projected to increase three times (ADA, 2005), whereas the household purchasing power, as measured by income, is expected to rise twofold and half. Not only the society is undergoing changes towards more nucleated families, but its members tend to adopt more and more individualistic lifestyles. All this would mean even greater amounts of waste disposal and consumption rates per capita. The combined effects of household growth and wealth increase will foster an unprecedented increase in consumption behavior and waste production which would lead to overburdening the city ecocapacity.

To borrow from Brundland report (1987), a city's sustainability would be the ability of the current city population to meet their own needs without compromising the ability of the city's future generations to meet their proper needs. Based on such definition, the challenge for Riyadh city would be that it has to fulfill the needs of its future households while at the same time enabling sustainable development. For such sustainability to occur, the environmental efficiency will have to be increased substantially. But since household consumption constitutes an enormous contribution to the environmental load, not only a substantial reduction of current consumption patterns and waste generation is required, but also a radical change in lifestyles and habits. In other terms, a manifold reduction of materials flow per unit of service is required over the next years, while at the same time it is necessary to meet household needs even many more times more efficiently in environmental terms.

The ArRiyadh Development Authority (ADA) has fixed the year 2020 as a target for the city's strategic plan. Until then, Riyadh will have to fulfill its household social needs at least *two* times more environmentally efficiently. Bearing in mind that the number of its households will be tripled and their income will have increased twofold and half by then, policies will have to be geared towards boosting the city's environmental efficiency by *Factor 30*. Factor 30 by 2020 is based on a tripling of the city's households combined with a 250% increase of wealth per household while cutting to a fourth the total global environmental burden (3 x 2.5 x 4 = 30). Both direct energy and indirect energy consumption have to be cut substantially and car travel distances have to be reduced to cut on motor fuel consumption and CO_2 emissions to an acceptable level by half by the year 2020. Backcasts should be made to achieve this target.

Needless to say that such environmental efficiency cannot be achieved by innovations in technology alone. Solutions will have to be found in a profound change in lifestyle, reducing resource-intensive modes of consumption. The objective of the paper is thus to develop and evaluate strategies for transitions to sustainable household consumption, focusing on what and how households through their modes of consumption can contribute to achieve a Factor 30 environmental gain. What is then the appropriate analysis technique that would allow setting up policies to reach this Factor 30 target? This is precisely what the next paragraphs will be dealing with.

3. The Backcasting Approach

Since the paper's objective is to attain a more sustainable future for Riyadh, a future modeling technique is required as a methodology of the study. Banister and Stead (2004) distinguish three types of futures, each of which is associated with an appropriate approach of analysis. The probable future, which is the most likely to happen, is a predictable future, and therefore the forecasting approach would be most useful. The possible future that is what might happen requires a descriptive scenario for its analysis. The third type is the preferable future which consists of what one would favor or desire to happen. For this type, predictive models are not appropriate. What is required instead is to construct a desirable future vision

or image to be reached. For such a case, the backcasting approach would be most useful.

The backcasting approach consists of designing a preferred future state then building up scenarios and strategies for reaching it. These scenarios should describe the sequential chain of events between the city's current situation and the sought-after desired future state. This is precisely what makes the backcasting approach quite different from forecasting. Forecasting is all about making projections on how the future would most likely be. Such projective scenarios are based on past and present data and the observed current trends. The starting point of forecasting scenarios is, therefore, the current situation. Backcasting, however, is not concerned with predicting any likely future, but instead it aims at shaping a desired future. For that reason, it sets up some visionary images of a preferred future and then develops the required strategies and course of events and processes to attain such future. Rather than following events that are merely a continuum of current situations being projected into the future, Backcasts take the reverse option in a way that is completely freed from the strains of the present state. Unlike forecasting, the starting point for backcasting is not the current situation but the desired future situation. Robinson (1990) mentioned that backcasting is not necessarily only about how desirable futures can be attained, but also possibly about analyzing the degree to which undesirable futures can be avoided or responded to. In a similar vein of reasoning, Vergragt and Van der Wel (1998) asserted that "Future visions alone are not enough: Backcasting implies an operational plan for the present that is designed to move toward anticipated future states. Backcasting, then, is not based on the extrapolation of the present into the future—rather, it involves the extrapolation of desired or inevitable futures back into the present. Such a plan should be built around processes characterized as interactive and iterative" (Vergragt and Van der Wel, 1998: p. 173). Similarly, many criticisms have been leveled at future predictions based on a forecasting approach for sharing a conservative bias, as they seek the future within the boundaries of existing institutions. To be able to think outside this box of conservative reasoning, scholars like Holmberg (2000) argued that backcasting should deliberately seek for possibilities to breaking with dominant trends. In a similar vein, Höjer (1998) insisted that backcasting is "a scenario technique, which focuses on presenting solutions to problems that do not seem to be solved, according to conventional scenarios, trends and forecasts" (1998: p. 446; also Holmberg, 2000). Figure 1 summarizes the backcasting approach in comparison with the forecast approach in a sustainability framework.

Since sustainability is a normative concept that looks at the future of the community and the city environment, the backcasting approach as a normative problem-solving process would, therefore, be most appropriate as a tool of analysis. Following this line of thought, the World Health Organization (WHO) defines backcasting as a "Moving step-wise back in time from a future scenario to the present in order to identify the decisions and actions that must be taken at critical points if the scenario is to be achieved". It stands out as a plausible alternative to traditional forecasting. The predictive models of forecasting analysis can only be suitable for smoothly growing cities without any severe constraints being impinged upon. On the other hand, the normative models of backcasting are most useful for situations facing severe constraints such as environmental problems and natural resources. In recent years, backcasting analyses are gaining grounds over forecasting techniques, because city constraints, like sustainability issues, become severer.

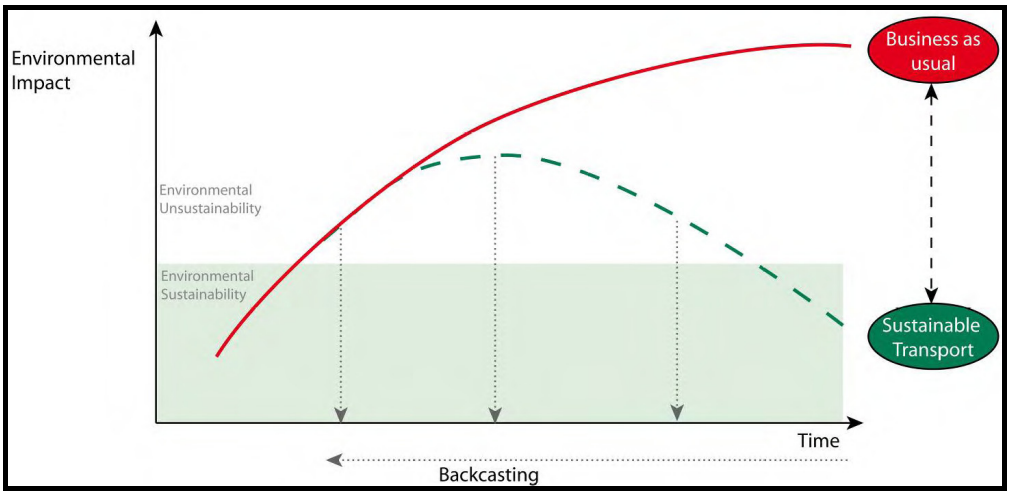

Fig. 1. The backcasting and forecasting approaches in a sustainability framework (Banister, 2006).

4. Backcasting Analysis and Riyadh Household Consumption

The paper concentrates on the household as a unit of analysis for two reasons. First, household consumption tends to have the largest share in environmental pollution, especially because of the increase in household cumulative energy use. Second, with the development of ICT technologies and the influence of globalizing forces, society is undergoing some profound changes to a point that its institutions are dwindling in their influence on people. In this respect, Ling (2002) argued that the traditional social institutions are less powerful in affecting change through simple and straightforward policy response. Instead, there is a growing and elevated autonomy of individual actors (Ling, 2002). Since the issue in this study is about fostering a radical change in lifestyles and consumption patterns, it would be wise to adopt a bottom-up approach where the focus is on individual households rather than on larger social institutions.

For this regard, attention is paid to the use of energy, shopping behavior, waste disposal, means of movement and transport and housing, as critical measurement variables for investigation in promoting sustainable consumption at the household level. Prior research tends to suggest that the crucial areas for achieving sustainable consumption are food, housing, and transportation because of their use of resources and environmental impact (Spangenburg and Lorek, 2002). Some kinds of lifestyle change and innovations are also indispensable for such transition to sustainable living to take place.

For analysis purposes, the environmental consequences of household consumption are calculated in energy terms. A distinction is made between direct energy and indirect energy use. Direct energy is all about the energy used for fuel consumption, natural gas and electric power for different appliances like cooling, heating refrigerating, lighting, etc., whereas indirect energy is the energy spent on producing, transporting, storing products and using services households buy or rent. The total energy budgets are then computed. Different household consumption categories in Riyadh are determined. The calculations are based on the household expenditures in Saudi Arabian Riyals (SAR) (1 USD = 3.75 SAR).

Household consumption patterns are measured using various sets of indicators (energy use indicators, water waste indicators, housing indicators, solid waste indicators, etc.). Several household types with different characteristics like income, household composition, and household size are studied in the various neighborhoods of the city. A questionnaire survey covering household consumption patterns was used to collect the required data for analysis.

The paper argues that measuring household consumption patterns enhances the understanding of how to direct them towards environmentally sustainable goals. Insight on the total energy use of households offers insight in how to direct the present day consumption patterns into more environmentally sound directions in the future, in both the short term and the longer term.

The method adopted was based on households' consumption survey to assess their consumption patterns. The data used in this study is based on 512 responses on a questionnaire survey of household consumption in Riyadh. The respondents were asked to provide information about their consumption patterns regarding eating, cooking, lighting and housing.

5. Data Analysis and Interpretation

The city of Riyadh has just over 5,254,560 inhabitants living in about 744,000 households with an average size of 6.2 members. Household formation grows at a rate of 2.74% per year (ADA, 2010). The rate of car possession is 1.88 per household. Nearly 95% of households have cars and about 21.54% of them have three or more cars. All expectations indicate that these figures will rise quite sharply by the turn of the year 2020 (ADA, 2005). Families in the city of Riyadh show a preference to live in detached dwelling units (villas). The city counts around 704,745 housing units with 58% of them are detached house type (ADA, 2005). The average household income is about SAR 100,000 per year. It was around SAR 56,000 twenty three years ago. In 1987, the average household budget expenditures in Riyadh was 73% (SAR 40,933.29) of its income, but now it is about 89% (SAR 89,000) of the household income. This means that the share of income consumed by the average household in Riyadh has increased by 117%, whereas the income itself has only increased by about 78% during the same period. This indicates that households in Riyadh tend to adopt a more consumer-oriented behavior and sometimes even more extravagant lifestyle.

5.1. Household socioeconomic status and expenditures on direct energy

5.1.1. SES and expenditures on motor fuel

The socioeconomic status variable was measured by income, educational attainment and employment. The data reveal a positive association

between socioeconomic status and vehicle kilometers travelled. Thus, the higher the economic status the higher the motor fuel consumption expenditures either at the individual or family level. The data reveal that respondents enjoying a higher SES tend to spend more time on the road travelling about 116 km per day as compared to their counterparts with low SES who only travel 97 km a day. This could be explained by the fact that higher SES residents tend to have numerous connections all over the city which may require frequent and longer travel distances. On the other hand, lower status people may be more inclined to shorten their travel distances unless it is really necessary to keep their transportation budget to a minimum. Since the travel distances are highly correlated with motor fuel consumption, the results confirm this fact indicating that lower status families tend to consume far less fuel than those with higher status.

Respondents were asked about their own consumption on motor fuel and that of their families. One should bear in mind that many households in Riyadh do have more than one car. Here again, the results tend to corroborate the above conclusion that higher status respondents tend to travel more, and therefore spending more on motor fuel for their own use as well as for their families. However, higher status households in the sample survey tend to have lesser cars per family than their counterparts of the remaining two status categories. The higher SES group has declared to own only 2.4 cars per household, whereas the medium SES category possesses just a little less than three cars per family (2.9), and the lower group tends to own less about 2.5 cars per household as shown in Table 1. This unexpected discrepancy between different socioeconomic status categories can be explained by the household size factor. The size of the household for higher status families turned to be the smallest of all categories (5.8). Whereas, the medium status families have the largest size with 8.5 members and the lower SES group has only 7.4 members per household. In fact, it must be born in mind that it is highly unlikely for a family in Riyadh to live without a car regardless of its income or status. Table 1 shows a higher association between household size and the number of cars per households.

Households in Riyadh tend to rely heavily on the use of the private car for their movements in the city. In 2005, they have generated about 5.5 million trips per day, that is 60 million kilometers and 1 million hours drive daily. By 2010, these figures are projected to reach 8 million trips and 5 million hours drive daily with 100 million kilometers a day in average (ADA, 2005). That is an increase of about two thirds of the distances traveled.

5.1.2. SES and expenditures on electricity and gas

Here again, the data collected seem to indicate a positive relationship between household electric power consumption and family socioeconomic status. The results presented in Table 2 indicate that the higher the SES the higher the consumption for electricity. Higher status families tend to spend about SAR 388 per month on electric power for all its household activities whereas their counterparts of lower status pay only SAR 239 per month. However, this pattern does not hold when examining gas consumption. Here the relationship was inversed in the sense that the higher the socioeconomic status the lower the gas consumption. Families at the lower end of the SES ladder tend to spend more on gas energy (56 SAR/month), whereas higher status families spend a lot less (37.7 SAR/month). This pattern can be explained by the fact that higher status families tend to rely more on electric power than on gas as in cooking activities for instance. That is why they have shown much higher expenses on electric bills.

5.2. Water consumption

When examining the sample survey data, no relationship was revealed between water consumption and family status. It turned out that all categories tend to spend more or less the same amount per month on water (SAR 120) (Table 3). This could be explained by the fact that this scarce resource is highly subsidized by the state which leads to its use without paying much attention to its quantities.

Table 1. Cross-tabulation of socioeconomic status and distance travelled, individual and family fuel consumption expenditures

SES	Distance Travelled (Km)	Indiv Fuel (SAR/Week)	Fuel/Family (SAR/Week)	Cars/Hhld	Hhld Size
Low	97	62.2	137.9	2.5	7.4
Medium	114	85.8	213.05	2.9	8.5
High	116	100.9	219.2	2.4	5.8

Table 2. monthly energy consumption and socioeconomic status

SES	Electricity (SAR/month)	Gas(SAR/month)
Low	239	56
Medium	251	52.5
High	388	37.7

Table 3. Water consumption and waste disposal by socioeconomic status

SES	Water (SAR/month)	Waste (kgs)
Low	120.5	4
Medium	128	3.9
High	120.3	4.1

With regard to water consumption, Riyadh households seem to use large quantities of this scarce resource. According to the data of the Riyadh Water Company, the average water consumption in 2001 was about 2,091 liter/household/day. In 1999, it was 1,835 liter/household/day. That is an increase of 7% per year (Riyadh Water Company, 2005). The water costs are heavily subsidized by the state.

Households pay roughly SAR 300 per year which is only 2.5% of the real costs. What remains is being taken care of by the state. As long as Riyadh households continue to rely heavily on desalinated water, this scarce resource will constitute a serious challenge for the city long-term sustainability. Every effort must, therefore, be made to considerably cut on any intensive use of this resource. Subsidizing it may no longer remain a sound policy option.

5.3. Solid waste disposal

As far as solid waste disposal is concerned, the surveyed households tend to generate about 4 kilograms per day (Table 2). Here again no sound relationship was discovered between waste disposal and socioeconomic status. This lack of association can be interpreted by the fact that even though Riyadh society is becoming more and more consumer-oriented, households are not charged a penny for waste collection. The state alone covers all the expenses related to household waste. The collection of waste costs the municipality about SAR 22.5 per household per month (SAR 15 million/month).

These results are very modest when compared with the official data provided by Riyadh Municipality for waste collected during Eid festivities. The figures for the 2010 Eid Al-Adha show that Riyadh waste collection services have amassed about 23,476 tons for the three Eid days. This makes a total of 35.80 kilograms of waste per household for the three days of Eid (interview with the Director of Sanitary Services at Riyadh Municipality, Al Jazirah Newspaper). That is 11.93 kilograms per day, which is a lot higher than the average 4 kilograms of the sample survey during the ordinary days. According to municipality estimates, the amount of household waste collected for the year 2005 was around 2 million tons, that is a little over 3 kilograms per household per day (Riyadh Municipality, 2005).

5.4. Socioeconomic status and household expenditures

Energy requirements can be expressed in two ways, either directly or indirectly. Directly through energy expenditures on motor fuel, electric power and natural gas, and indirectly through expenses on other activities like washing, eating, and buying goods and services. All these require energy for their production, storage, use and disposal. For that matter, the paper examined the relationship between socioeconomic status and indirect energy expenditures through the analysis of living expenses and costs incurred by some routine activities like washing and eating services.

The results presented in Table 4 below reveals a positive relationship between socioeconomic status on one side, and living expenditures, washing and food expenses on the other. It is quite striking to find out that even lower status families tend to rely quite extensively on the service of washing clothes as much as their counterparts of other status categories. Their frequent use of this service amounts up to 2.23 visits to the laundry shop per week, which is quite similar to those of middle and high status (2.28 and 2.32 visits respectively). This could be very promising in developing policies that favors reliance on service use rather than performing activities at home. That is, household energy requirements would be cut to a large extent if households make use of the washing service rather than performing themselves the washing activity at home. Similarly, sizeable energy cuts at the household level could be made if other services like meals home delivery and the like are promoted and developed.

Table 4. Monthly expenditures and weekly spending on washing and food by socioeconomic status

SES	Expenditures (SAR/month)	Washing (SAR/week)	Food (SAR/week)
Low	2138.2	18.2	225.6
Medium	4094.4	18.7	382.3
High	4819.1	33.8	455.6

Household socioeconomic status is an important explanatory factor to household consumption patterns. Higher socioeconomic status households tend to use more of all three forms of direct energy (fuel, electricity and natural gas). Lower socioeconomic status households consume the greater part of their direct energy requirement in the form of electricity and do not spend very much on transportation fuel. Medium and higher status households tend to consume relatively higher amounts of energy on transportation. They can spend up to 15% of their income on motor fuel. Lower status families cannot afford to spend a substantial proportion of their income on transportation energy.

The analysis of the collected data has revealed large variations in monthly energy requirements among households of different socioeconomic status. Since the income is an important component of SES measurement, much of the observed variations associated with SES can, therefore, be largely explained by the intertwined effects of income. Households with higher incomes tend to spend their money, and their energy, in a different way compared to their counterparts of lower income levels. The energy requirements of transport and motor fuels tend to increase with income, while the energy requirements of natural gas and electricity decrease. Based on these findings, one can safely conclude that the differences between the various socioeconomic statuses and income groups provide good options for change, scenarios development and policy recommendations. The effects of the income variable are further examined in the following paragraphs.

5.5. The effect of income

By the way households choose to spend their incomes, they strongly affect the activities that take place at the production side of the economy and the environmental load associated with. This insight may lead to the conclusion that household income and lifestyle are important parameters to take into account when searching routes to the reduction of the long-term environmental impacts of consumption and production.

As shown by the collected data, the net income was found to have a very important relationship with the total energy requirement. But the net income cannot explain all the variance in the total energy requirement, not even in combination with other socio-economic variables such as employment status and educational level. For an efficient consumer energy policy, it is essential to know why some households require more energy than others. The differences in the total household energy requirement can be described as differences in consumer behavior. The important relationship between income and total energy requirement suggests that, with further increases in income levels, the average household energy requirement rises as well.

The data shown in Table 5 reveals a strong positive association between income categories and direct energy expenditures, that is motor fuel, electric power and natural gas. Among all types of energy, expenditures on motor fuel hold the highest share of income. Families of the lowest income category spend about SAR 414.52 per month on fuel. This amount goes crescendo as income increases to reach up to SAR 1,341 for the highest income category. In terms of proportions, lowest income categories spend as much as 14% of their meager revenues on fuel. This proportion shrinks to about 11% for the highest income category. Electric power comes second in terms of expenditures. Natural gas has the lowest share in energy expenditures. Expenditures on direct energy tend to grab a sizable share (23.8%) of the lowest income categories. Those with the highest income category (above SAR 12,000) spend a much smaller proportion (15.5%). However, when examining the percent change between income categories, the results were surprising. The percent change between the two income categories at the bottom of the ladder is the smallest (8% only). This proportion increases sharply for categories at the top of the scale where the percent change between the two highest income categories is 74%. It may, therefore, be concluded that as income increases so does the excessive use of energy. To tackle such consumption behavior, it would be wise to impose an increase factor on those exceeding a certain threshold of energy consumption defined as necessary for some required household activities.

Table 5. Income and direct energy expenditures

Income Level (SAR)	Fuel/Individual	Fuel/Family	Electricity	Gas	Total	% Change
< 3,000	208	414.52	244.9	56.41	715.83	
3,000-4,999	274	474	251.5	47.22	772.72	**8%**
5,000-7,999	232.28	624.6	244.33	30	898.93	**16%**
8,000-12,000	429.32	717.32	313.33	42.66	1,073.3	**19%**
> 12,000	484.2	1341	477.77	52.36	1,871.2	**74%**

The heaviest consumers of direct energy are usually households with considerably more money to spend. They, therefore, buy more powerful bigger cars and electrical household appliances. The relatively high number of persons per household, and the high rate of car ownership probably lead to higher use of motor fuel and electricity. Higher incomes and living in higher status neighborhoods of the city both lead to more transport, and hence more fuel consumption.

As far as the electric energy is concerned, the research was much concerned with the indoor conditions of the house, that is, room temperature (including heating/cooling), and lighting. Due to the Riyadh's harsh climate, households put a high value on comfortable indoor temperature. The data indicate, for instance, the electricity bill during summer can be up to 10 times higher than the winter bill.

It is clear that much of all the energy consumed by private households is used for cooling the house. From the quantitative point of view, lighting is far less important than cooling. The data show, for example, that it takes only a tiny proportion (3%) of the energy consumed in private households. This rate, however, could be far lower if energy for lighting is used very efficiently.

When analyzing the monthly direct energy budget expenditure of different types of households, it is revealed that owner-occupier households and households living in detached houses have much more money at their disposal than tenant households and those living in flats. The biggest difference is to be found between owner-occupier households living in larger detached houses and flat tenants.

The data also show the direct energy expenditure of households of varying sizes in the city of Riyadh. As might be expected, the larger households spend more money. However, expenditure per person is the lowest. Larger households with more male members spend relatively larger sums on motor fuel. This is due to the fact that only males are allowed to drive in Saudi Arabia. Hiring drivers for women is very common.

When looking closely at the expenditure on transport by household types, the data show that different household types spend their transport budgets in quite different ways. Lower-income households spend more than half (65%) of their transport budget on journeys to work and shop. Other income categories (medium and higher-income households), on the other hand, spend 78% of their transport budget on driving cars moving around the city for recreation purposes. They spend only 22% on transport to work, shop and schools. This probably explains the rapid expansion of drive-thru businesses like cafes, fast food restaurants and the like all over the city of Riyadh.

With respect to the effect of income on indirect energy expenditures, the data presented in Table 6 below indicate that their association is not straightforward. There appears to be no striking differences between some income categories and household waste disposal or water expenditures. However, a positive relationship is revealed between income variations and differences in total expenditures, washing and food expenses. A closer examination of the results points toward some important findings in which the lower income group tends to spend a sizable proportion of their revenues. The data seem to indicate the higher the income the lesser the proportion of total expenditures. The expenditures of income categories (below SAR 12,000) seem to be curtailed because the majority of respondents declared that they have installments to pay back for their creditors. In fact, many Riyadh households rely on bank credits to buy cars, houses, home furniture and appliances. After installment payments, theses households are left with not much money to spend on cost of living. The highest income category tends to be the most spendthrift group as they squander nearly twice as much as their counterparts of the category just next to them (SAR 7,168.4 vs. SAR 3,826.6 and SAR 994.7 vs. SAR 453.3) (Table 6).

Table 6. Income level and household waste disposal, washing, water, food and expenditures

Income Level (SAR)	Waste kg/Day	Washing	Water	Food	Expenditures
< 3,000	2.8	12.4	96.8	277.7	2010
3,000-4,999	2.8	15.8	106.5	361.1	2375
5,000-7,999	3.1	19.8	106.9	382.1	2430
8,000-12,000	3.2	28.2	126.5	453.3	3826.6
> 12,000	3.6	34.3	173.3	994.7	7168.4

It is clear that households with higher income put a higher burden on the environmental through their extravagant lifestyle. They tend to own more home appliances and spend prodigally to fulfill their needs which require the use of higher amounts of energy from all sources.

It's not easy to impose on a household to cut on their expenses; however, it could be a plausible option to look for alternative ways to cater for their needs and even for their lavish lifestyle. Service home delivery could be one such option. Delivery services of meals and washing clothes and many other things could save a lot of resources and energy, and by the same token promote environmental stewardship.

5.6. The effect of household size

When examining expenditures and energy requirements of Riyadh households with different sizes, the relationship indicates that energy spending increases with household size. However, when this relationship is further scrutinized for the total energy requirements per person, it is quite remarkable that the energy expenditure per capita decreases with rising household size, especially for those with eight and more family members.

When looking at Table 7, it is quite clear the positive association between electric power expenditures and family size, in the sense that the larger the size the higher the monthly bill. However, when further examining these expenditures per capita for electric energy, the results were astonishing in that the larger the family the lower the cost per capita for electricity. Table 7 shows that households with more than seven members tend to pay lower bills for electricity per capita than those of smaller household size (SAR 35.17 against 52.96 per month per capita respectively). Similarly, the same pattern is revealed when looking at expenditures for natural gas (SAR 5.36 vs. SAR 6.21 per month per capita for larger and smaller family sizes respectively).

The interpretation of such a pattern could lie in the fact that larger households often live in larger houses, which require more energy for cooling, heating and lighting. However, members of larger households enjoy the advantage of space sharing which may explain to a large extent why the energy requirements per space and per person are relatively lower for larger households.

Larger households use significantly more of all three forms of direct energy (natural gas, electricity, and motor fuel) than average. However, the differences with respect to motor fuel consumption are much greater than those with respect to electric power and natural gas, which can be explained by the much higher rate of car ownership among the household types mentioned. The results unequivocally reveal that the lower the household size the higher the per capita motor fuel expenses and vice versa (SAR 23.82 vs. SAR 9.96 per week per capita for lowest and largest sizes respectively). About 240% of economies are achieved for fuel consumption per week per capita for households with more than seven members over their counterparts of up to four members. It is quite interesting to mention that the car share per family member is relatively higher for smaller households with 0.41 cars/capita against only 0.36 for larger households (more than seven members), which substantiates the previous findings relative to motor fuel consumption per capita. This also indicates that huge economies for motor fuel expenditures can be made if vehicle sharing policies or public transportation means are encouraged.

This pattern remains consistent when focusing upon indirect energy requirements as measured by washing, home meal delivery and waste refusal per capita. Here again the smaller the household the more the environmental load per capita. When looking at food expenses per capita, the data in Table 7 indicate smaller households tend to spend SAR 108.22 per week per capita, whereas their counterparts with eight members and over spend only SAR 71.21 per week per capita. The waste disposal seems to follow an identical pattern to food and washing elements. Larger households tend to throw away lesser amounts of garbage per capita than their counterparts of smaller households (0.49 kilograms/capita vs. 0.83 kilograms/capita respectively).

Table 7. Household size and energy requirements expenditures

Household Size	Electricity	Gas	Fuel	Cars	Washing	Food	Waste
Up to 4	179	21	80.5	1.4	20	365.8	2.8
Per capita	52.96	6.21	23.82	0.41	5.92	108.22	0.83
5 to 7	360.4	54.2	97	2.5	35.5	505.8	4
Per capita	59.37	8.93	15.98	0.41	5.85	83.33	0.66
8+	376.3	57.4	106.6	3.6	22.1	761.9	5.2
Per capita	35.17	5.36	9.96	0.34	2.07	71.21	0.49

Once again, these findings pinpoint to an important conclusion in which sharing activities, services and spaces could be a sound policy option to be taken into account if environmental stress caused by households is to be reduced substantially. Policies and scenario development along this path are, therefore, worth examining quite closely.

5.7. Energy expenditures by neighborhood type

The economic situations of the participating neighborhoods differ strongly. The northern sector can be characterized as the richest one in the city. Household income and spending levels are high. Spending per person is somewhat higher than in other sectors of the city.

The data provided in Table 8 show that the sector of Riyadh in which a household lives has an impact on its direct energy requirements and hence expenditures. Those who live in the northern part of Riyadh are expected to spend more on electric power and natural gas more than any other part of the city. However, when compared with those living in the eastern and southern sectors of Riyadh they tend to spend much less on motor fuel either at the individual level or even at the family level. This may be explained by the fact that the northern sector is well serviced in the sense that all important malls and institutions tend to locate in the north. Residents of this area, therefore, would not be required to travel longer distances to get to these services which may lead to important economies in motor fuel for the individual as well for the family.

As far as the central sector is concerned, it turned to house families with relatively weaker economic situation and lower SES. There, motor fuel expenditures are by far the lowest in the city. The physical layout is more compact with quite higher residential densities. Most of the daily services are within walking distance. Hardly can one require the use of the car to get what is needed from the corner shop. The central city neighborhoods do not also provide much space for car parking which may deter many car owners to drive in this part of the city. Households living in the eastern and southern parts of Riyadh tend to spend more on motor fuel because they need to travel to the north for many of the services and institutions where they are concentrated.

5.8. Land consumption by residential neighborhood sector

The city of Riyadh is subdivided into six residential sectors, each of which contains residential neighborhoods with some specific socioeconomic characteristics. These sectors are the central city as Sector 1, the northern sector with as Sector 2, the eastern one as Sector 3, the southern as Sector 4, the western as Sector 5, and finally the Diriyah area as Sector 6. Figure 2 shows these sectors on Riyadh map.

The data for residential land use consumption by Riyadh households were collected from the Ar-Riyadh Development Authority survey on housing and population conducted during the course of the year 2005. GIS analysis tools provided by ArcMap 9.3 packages were used to analyze the Riyadh digital map. The data presented in Table 9 reveals some striking differences between Riyadh sectors. The smallest average residential area turned to be in the western sector (Sector 5) with a residential parcel of about 553.02 m^2, followed by the central sector with an average area of 602.2 m^2. The northern sector, however, is by far the most profligate in residential land consumption with an average area of 1402.75 m^2, which is nearly three times the average of the western sector (Table 9). When computing land consumption per capita, the northern sector again was singled out as the most excessive in consuming this land resource with 337.20 m^2, which is about four times the land consumption per capita in the western sector.

Household density is another measure for more sustainable use of residential land. That is, the higher the household density the more frugal the use of land and hence the more sustainable the settlement. The data in Table 9 show that the central city sector to be more compact and thrifty in consuming land resources as indicated by a higher density of 11.86 households per hectare. The lowest density is again at the northern part of the Riyadh (Sector 2) with a density of only 0.48 household per hectare. In fact, the central city contains the traditional neighborhoods constituting the older city of Riyadh. These neighborhoods were designed along the precepts of sustainable development. They are compact in design, the roads are skinny and the residential parcels relatively are small in area. However, the northern sector is housed by the most affluent social classes of the city who not only can afford to build large residential areas, but require larger houses and wider roads as a way of expressing their actualization and self esteem needs.

Table 8. Direct energy expenditures and neighborhood area

Neighborhood area	Electricity	Gas	Fuel/Individual	Fuel/Family
Central	279.5	30.6	74.3	130.2
Eastern & Southern	315.3	45.2	97.2	296.2
Northern	531	92.5	90.3	184.7

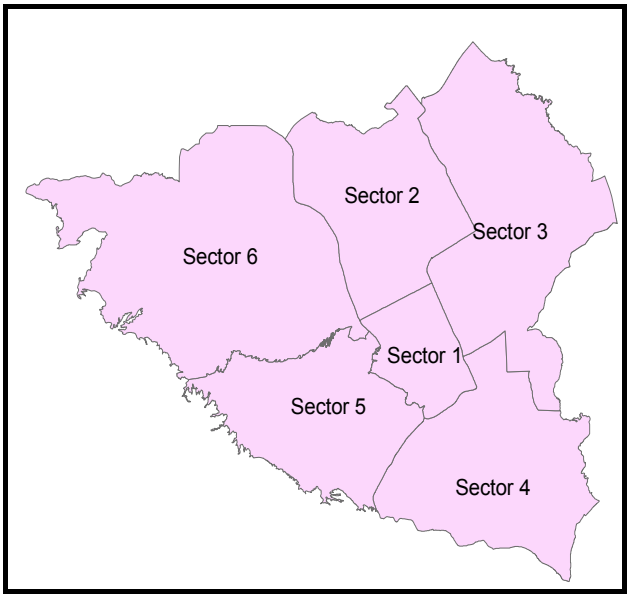

Fig. 2. Riyadh map showing its six residential sectors (source: Riyadh digital map; ADA, 2005).

Table 9. Residential area land consumption by sectors in Riyadh

Riyadh Sector	Average Area	Residential Parcel Count	Average Hhld Size	Area Per Capita	Total Road Area	Total Residential Area	Road/ Resid	Hhld Density
Sector 1: Central City	602.2	104452	5.43	110.90	76075598	67371010	1.13	11.86
Sector 2: North	1402.75	5055	4.16	337.20	69266557	9193106	7.53	0.48
Sector 3: East	852.39	52962	6.13	139.05	90393505	42692914	2.12	3.75
Sector 4: South	704.81	27364	6.2	113.68	9629824	22582351	0.43	1.76
Sector 5: West	553.02	47575	6.63	83.41	106097005	27883869	3.80	2.5
Sector 6: Diriyah	811.41	3182	3	270.47	3529314	671502	5.26	3.24
Whole Riyadh	821.09	240590	5.25	156.40	354991803	170394752	2.08	3.93

The unsustainable way of using land is not only expressed through the larger areas of housing units, but also through the reservation of land for road traffic and car movement. For this, the proportion of the total area used for roads to the total area occupied by residential dwelling is computed for each sector. The results show that again the northern sector is the most squandering is consuming land for roads. The proportion of land for motor cars to that for human residence is 7.53, whereas the lowest proportion turns out to be for Sector 4 which is the southern part of the city.

All in all, the whole city of Riyadh is using this non-renewable resource in a very extravagant, wasteful and unsustainable way. The average residential parcel for the whole city is about 821.09 m^2 for an average household size. That is a residential land per capita consumption of 156.40 m^2. This average exceeds by far the area of a residential flat in many parts of world cities. The car is king in the sense that it has been allocated twice as much in terms of land use compared to human residential space. City planning authorities should make a brake to such unsustainable consumption patterns of land.

6. Conclusions

The paper sets out to analyze potentials to fulfill the target of reduced household consumption in Riyadh by the year 2020. The primary objective of the study is, therefore, not to deal the estimated growth in consumption patterns, but to halt its momentum so as not to exceed a targeted ceiling by 2020. For that matter, a backcasting approach is used instead of the conventional consumption forecasting. The reason lies in the fact that the former approach focuses more on identifying a desirable targeted future and deriving appropriate policy goals to reach it. The latter approach, however, is mainly based on trend extrapolation and making projections of rapidly increasing consumption. Such forecasting approach is argued unable to deal with the complexity of planning for sustainability since current trends, actions and planning are part of problem. With forecasting, these current problems will be projected into the future and there are as a result substantial risks that 'fixing the problems' will retain the principle mechanisms from which these current problems arose.

The paper argues that the sustainability targets set for Riyadh will not be reached unless considerable changes to entirely break up with current consumption behavior patterns are made. It then moves on to sketch out an alternative future image in which the established targets are to be attained. This process of "working backwards from a particular future end-point to the present to determine what policy measures would be required to reach that future" is the essence of this study's recommendation. That is, the adoption of backcasting in dealing with the issue of Riyadh sustainability.

The study has identified a desirable future target that would be a necessary credible challenge scenario for Riyadh sustainability by the year 2020. This target scenario consists of a Factor 30 increase in environmental efficiency. In more precise terms for example, households need to reduce their daily distances traveled by cars by almost half the projected value for the year 2020. That is 100 million km/day instead of the projected forecasts of 200 million km/day. The cumulative household energy consumption would be cut by a quarter the foreseen amount. From these set up future targets, an ensemble of coordinated policies must dwell much on the process of working backwards from that future scenario rather than identifying the possibilities for, and consequences of, any transformations needed.

It is clear from the backcasting study that the potential for achieving the Factor 30/2020 target already exists. The primary focus must, therefore, be on how to reduce societal obstacles and bring about necessary changes in social and institutional structures. Other policies pertaining to reducing pollution and car use should also be developed such as: Increased prices on energy and CO_2 emissions, local road pricing, policies to make Riyadh more attractive and liveable by diminishing the dependence on car travel, increased accessibility by IT, more space and higher priority for walking, cycling and public transport combined with decreased space for cars and parking, substituting highly energy intensive modes with less energy intensive modes and other forms of communication, support to the use of Teleconference facilities, and promoting dematerialization of the economy through reduction of the necessity for transport and giving at the same time, incentives for rental and sharing of goods and services.

Another set of policies to introduce a variety of measures to encourage greener practices and influencing household behavior must be adopted by local public authorities. The aim of such policies would be to influence households' responses towards environmental policies in five key areas: residential energy and water use, transport choices, organic food consumption, and waste generation and recycling.

Designing policies to influence household behavior is a challenge for policy makers. The objective of such policies is to improve the understanding of the determinants of households' responses to environmental policies in five areas: residential energy use, water consumption, transport choices, organic food consumption, and waste generation and recycling. A wide range of policy measures to influence households' decision making in the five areas of study may include the imposition of taxes and charges (e.g. for fuel); subsidies (e.g. grants for insulation); direct regulation (e.g. appliance standards); information-based measures (e.g. eco-labels); and provision of infrastructure (e.g. walking and public transport).

As far as residential water use is concerned, measures of volumetric charging for water increases the likelihood that households will undertake several water saving behaviors and investments. With regard to residential energy use, a significant role can be played by incentive-based policy instruments to reduce energy demand from households. Electricity metering (and charging) encourages energy-saving behavior together with support for insulation and renewable energy sources. Policies to develop public transport service quality are likely to decrease car use and increase public transport use. In addition, a better walking and cycling infrastructure is also likely to lead to similar results. For waste disposal, the policy

recommendations should insist on a charge per unit of waste generated in volume terms (weight-based charging) for its significant impact on reducing waste generation. Such regulatory framework is a key element in reducing waste generation and improving waste management. Other integral policies that aim to influence consumer behavior towards more environmentally-friendly consumption patterns and reduction of waste generation through prevention, reuse and recycling of products are also of paramount importance to reach Riyadh sustainability goals.

At the end, it must be mentioned that conventional policy recommendations have mainly focused on the supply side and little has been done on the demand side to tackle the growing demand for future sustainability. This paper has attempted to shed some light on the consumer behavior as the end user of energy and resources using a new approach. That is backcasting.

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مدينة الرياض وقضية الاستدامة:
دراسة لتأثيرات أنماط استهلاك الأسر باستخدام مقاربة التنبؤات بالتراجع

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ملخص البحث. تشكل قضية الاستدامة أحد أهم التحديات التي تواجه مدينة الرياض. وتكاد تشير كل المؤشرات إلى مستقبل مخيف يتربص بالمدينة إذا ما استمرت أنماط الاستهلاك الحالية على ما هي عليه. ما من شك أن طرق الدراسات التنبؤية التقليدية التي استُخدمت بكثرة في الدراسات العمرانية قد أثبتت محدوديتها في قدرتها على اقتراح سياسات تخطيطية ذات جدوى في مواجهة مثل هذه الإشكالية. يكمن المشكل في مثل هذه التقنيات التنبؤية في انطلاقها من معطيات الوضع الراهن واعتمادها على الاتجاهات السائدة في الحاضر لتحديد معالم المستقبل والتنبؤ له. إلا أن هذه الاتجاهات الحالية ووقائع الوضع الراهن هي في حد ذاتها جزء من المشكل، وبالتالي فإن إسقاطها على المستقبل سيعني بالضرورة تضخيم المشاكل التي تحملها في طياتها وزيادتها مع تضخم وتزايد باقي التقديرات الخاصة بغيرها من المتغيرات، وهو ما من شأنه أن يجعل الوضع المستقبلي أشد تعقيداً وأكثر إشكالية. من هنا تبدو الحاجة ملحة لاستخدام منهج مغاير يعتمد على التنبؤ بالتراجع والذي يقضي بتحديد طبيعة المستقبل الذي نرغب في بلوغه ونسعى إليه ونهدف لتحقيقه. مثل هذه المقاربة تحررنا من إشكالات الوضع الراهن وما يحمله من مخاطر لينصب الاهتمام على كيفية تحقيق الانتقال إلى وضع مستقبلي يستدعي بالضرورة إحداث تغيير جذري في أنماط السلوك وأساليب العيش ليتبنى المجتمع وجهة تكون الاستدامة هدفاً أساسياً لها.

تبين نتائج الدراسة أن الاستغلال المفرط للطاقة وللأراضي، سواء لأغراض السكن أو لأغراض حركة السيارات، سيشكل ضغطاً كبيراً على البيئة في مدينة الرياض. وبمقارنة فئات الأسر وُجد أن الطبقة الميسورة من العائلات تبدي ميولاً واستعداداً جامحاً نحو الاستهلاك بنسب تفوق بكثير نظيرتها من الطبقات المحدودة الدخل، وبتحليل العوامل المؤثرة في الاستهلاك وُجد أن عامل الدخل هو المؤثر الحاسم في مثل هذه الفوارق، حيث إنه يفسر معظم التغيرات والتباين في مختلف سبل الإنفاق كاستهلاك الطاقة أو اقتناء المأكولات واستهلاك المياه سواء للاستعمال المنزلي أو للغسيل. من هنا فإن مواجهة إشكالية الاستدامة لمدينة كالرياض يتطلب تحديد وضع مرغوب فيه للمدينة بحلول سنة الهدف ٢٠٢٠م. وليتحقق هذا الهدف المنشود فإنه يتعين عندئذ رفع مستوى الكفاءة البيئية للرياض لدرجة تعادل معامل ٣٠ مرة ما هي عليه الآن حتى يتسنى تخفيف وتقليص الضغط البيئي المتزايد على مدينة الرياض. وعليه تخلص الدراسة إلى ضرورة وضع سياسات تخطيطية تركز أساساً على تغيير سلوكيات الأسر وأساليب معاشها، مثل تقليص الرحلات اليومية بالسيارة الخاصة إلى حدودها الدنيا. ويستدعي هذا الأمر تبني أساليب تخطيطية لتشكيل بيئات عمرانية صديقة للمشاة بحيث تشجع وتحفز حركة المشي والنقل العام بدل اللجوء لاستخدام السيارة الخاصة باستمرار.