An Attempt to Modeling Fundamental Needs(First Draft)

Farzad Didehvar, Shabnam Rahimi, Sepideh Ahmadian

Amirkabir University of Technology, Tehran, Iran

February 2020

Abstract

In this study we represent a model which gives an evaluation for the relation between available supply of a fundamental need such as water, to an individual in a particular moment, and the body's physiological need for water. Then we continue by discussing the model on a given population based on the involved factors.

Introduction

Satisfaction is a complex concept which has a key role in each individual's everyday life and impacts their behavior. Abraham Maslow (1943) suggested a framework [1] to study *human motivation*, which was a starting point towards developing the *quality of life(QOL) theory.* On that article, he described a hierarchy of human needs, that is generally consist of fundamental needs which are required for human survival, and environment dependent ones, like society, safety and etc. In this study, we are trying to represent a tangible mathematical model for assessing the *sense of need for water* in terms of the available source of water. On this very subject, M. Joseph Sirgy [2] states that "From a human developmental perspective, QOL goals can be defined as satisfaction of human developmental needs in a community or society". Accordingly, in the first section we propose a model for the water needs of an individual. In the second section, we continue the discussion by checking the behavior of the model on a given population, and each time by assuming that we have two out of three involved factors, we try to suggest an estimation for the other one.

I. Modeling of Individual's Basic Needs

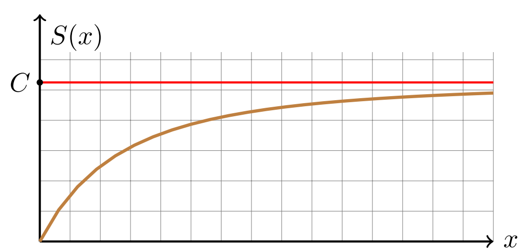
We are studying the needs based on changes in amount of available water. Let T be the threshold value of internal water supply(meaning the body supply) of a living person. For simplicity we are assuming that having less than T

amount of water at the moment t_0, results the death of an individual. Let $w(t)$ be a function showing the amount of available water, $w(t) = w_e(t) + w_i(t)$, meaning the sum of both the external and internal water supply in a particular moment, where:

$$w_e(t) : \text{available environmental source of water}$$
$$w_i(t) : (\text{water supply of the body}) - T$$

Based on this definition of $w(t)$, a person dies if and only if $w(t) = 0$ for a while, but for the rest of this article we assume that death happens instantly when $w(t) = 0$. Also $w(t)$ as described above is definitely a function since in each particular moment like t_0 we have got a definite available amount of water for each individual.

The objective of this section is to introduce a function which gives us a tangible estimation of how satisfied is the need water in an individual's body. We define $S(x)$ to be such a function. Accordingly for water supply of $w(t)$, $S(w(t))$ shows the sense of satisfaction associated to that amount of water. And assume that C shows the amount of available water in the state at which the person is the most content about the need for water. So $S(w(t))$ would fall to 0 when the person's need of water has the most value it can take:



If the function $S(w(t))$ falls to zero when the person dies of thirst, that is when $w(t) = 0$ in this case the $S(w(t))$ is in its minimal state, and by increasing the value of $w(t)$ the $S(w(t))$ would also increase but it will never get higher than C (since our bodies have a specific desire for water and more than that will not change anything). The function $S(w(t))$ has the value 0 if $w(t) = 0$ then and also its asymptote line is $y = C$ (this holds for time in general not just on the specific moment of t), here we propose the following function:

$$S(w(t)) = C(1 - e^{\frac{1}{w(t)+1} - 1})$$

In this study, we cannot deterministically specify the mathematical behavior of $w(t)$ function(but we know that $w_e(t)$ depends entirely on environmental factors, and $w_i(t)$ depends on biological factors), so the calculations are done regardless of what that might be. Therefore in each case by observing one's situation the value of $w(t)$ can be estimated, and hence we can specify the behavior $S(w(t))$ of the amount of water available to each individual and the value of $C(1 - e^{\frac{1}{w(t)+1} - 1})$ which is the objective of this paper, can be estimated.

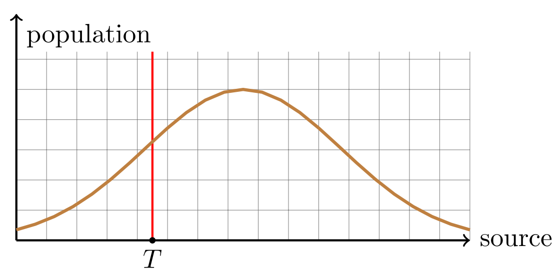
For the purpose of generalization and obtaining more flexibility, we may describe the function by new parameters α, β, γ.

$$S(w(t)) = e^{\frac{\alpha}{\beta}-\gamma} - (e^{\frac{\alpha}{w(t)+\beta}-\gamma})$$

It is notable that this function is a positive one, ascending with the value of zero when $w(t) = 0$ and asymptotic line, we can check easily that our candidate functions satisfy all these constraints.

II. Water Distribution Effects on a Given Population

In a given population, suppose that $P(t)$ shows the size of the population in the time t, $ws(t)$ stands for the total amount of available water to the population based on litter at the moment t and let $f_t(w)$ be a distribution function of population on the water supply at the moment t. Accordingly, we may introduce the notion $F_t(w)$ as $F_t(w) = f_t(w).P(t)$ that means the number of people having w litter of water at the moment t. Note that p_i indicates ith person (assuming that we assign numbers 1 ... $P(t)$ to people).



Assuming that T is a value such that for anyone having water less than that at any arbitrary moment t_0, that person dies. It does not seem so realistic to consider a specific number of T for everybody, but it sort of makes sense if there is no outlying value, human bodies behaves the same in these situations. For simplicity we may assume that T is a constant and death of an individual happens when

$$ws(p_0, t) < T$$

Number of Deaths

First, assuming that the distribution function f, of population on the amount of water, and the constant T are known thereafter, we are going to calculate number of deaths. The available water for each person in t is:

$$\text{Available water for } ws(p_j, t) = ws_e(p_j, t) + w_i(p_j, t)$$

Having a probability distribution function $f_{t_0}(w)$ on a given amount of water supply $ws(t_0)$ as in the diagram above, and assuming that T is computed empirically(it's a biological factor), the equation below is held:

$$\int_0^{w(t_0)} f_{t_0}(w)dw = 1$$

Considering the definition of $F_{t_0}(w)$, at t_0, this many $\int_0^T F_{t_0}(w)dw$ people have died as a result of thirst. The number of people is a positive integer but for the purposes of calculation we are discussing on the real numbers, besides that, it does not make that much of a difference if the population is great enough.
The objective of this section is to calculate number of deaths $(P(t) - P(t_0))$. Note that here for simplicity we have assumed that deaths happen only because of thirst.
For example at the moment t_0, the number of deaths caused by thirst would be $\int_0^T f_{t_0}(w)P(t_0)dw$. Therefore we can write:

$$P(t) - P(t_0) = \int_{t_0}^{t+\delta} \int_0^T f_t(w)P(t)dwdt + ... + \int_{t-\delta}^{t} \int_0^T f_t(w)P(t)dwdt$$
$$= \int_{t_0}^{t} \int_0^T f_t(w)P(t)dwdt$$
$$P(t) - P(t_0) = \int_{t_0}^{t} \int_0^T f_t(w)P(t)dwdt$$
$$P'(t) = \int_0^T f_t(w)P(t)dw$$
$$\frac{P'(t)}{P(t)} = \int_0^T f_t(w)dw = s(t)$$
$$\int_{t_0}^{t} \frac{P'(t)}{P(t)}dt = \int_{t_0}^{t} s(t)dt$$
$$ln(P(t)) - ln(P(t_0)) = \int_{t_0}^{t} s(t)dt$$
$$P(t) = e^{\int_{t_0}^{t} s(t)dt} = e^{\int_{t_0}^{t} \int_0^T f_t(w)dwdt}$$

Calculating T

Secondly, we will try to estimate the value of T, supposing that the death rate in t_0 and the distribution function are given. How could we calculate T? Assuming that D people die in t_0, for calculating the T we need to solve an integral equation:

$$D = \int_0^T f_t(w)P(t)dw$$
$$\int_{w_1}^{w_2} f_t(w)P(t)dw = \hat{F}(t, w_2) - \hat{F}(t, w_1)$$

in which $\hat{F}(t, w)$ indicates number of deaths at moment t with water supply less than or equal to w

$$\int_0^t (\hat{F}(t, T) - \hat{F}(t, 0))dt = g(t) - g(0)$$
$$\hat{F}(t, T) - \hat{F}(t, 0) = g'(t)$$
$$\hat{F}(t, T) = g'(t) + \hat{F}(t, 0)$$
$$(t, T) = \hat{F}^{-1}(g'(t) + \hat{F}(t, 0))$$
$$T = \pi_2(\hat{F}^{-1}(g'(t) + \hat{F}(t, 0)))$$

and thus T is calculated in terms of known factors.

Conclusion

In the first part of the article we proposed a model in order to give a sensible explanation about the association between available water supply to an individual and physiological attributes related to sense of thirst. We continued by studying both the physiological and environmental factors of this fundamental need on a given population, and there the issue of death in this population appeared. It is notable that this model is also applicable to some other fundamental needs such as the need for air and food.

References

[1] Abraham Harold Maslow. A theory of human motivation. *Psychological review*, 50(4):370, 1943.

[2] M Joseph Sirgy. A quality-of-life theory derived from maslow's developmental perspective: 'quality'is related to progressive satisfaction of a hierarchy of needs, lower order and higher. *American Journal of Economics and Sociology*, 45(3):329–342, 1986.