



# Veterinary medicine and food animal practice in the era of footprints and “One-Health”: a descriptive approach

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## ABSTRACT

Our continually changing world has created new demands in society and has profoundly affected ecosystems, cultures, and professions. Ignoring the requirements and consequences of this ever-changing milieu could have devastating effects on all aspects of veterinary medicine. With the increasing global interconnections, several concepts have been created that should be addressed by the veterinary profession; otherwise, some instabilities will affect both the job and the society. In this article, these concepts will be critically analyzed and synthesized to portray an integrated perspective to address the necessities for the economic success of food animal practice, as well as describing the complicated role of veterinary medicine in the future. The first concept is the “evolving veterinary education”, introduced by OIE in 2009, to address the new requirements of competent veterinarians who are able to respond and adapt to modern trading and business requirements. The second concept is “One-Health”, which was introduced to address an integrated and all-inclusive perspective to health issues. All the specifications of this new concept are reflected in each letter of the word HEALTH (Humans, Ecosystems, Animals, Living Together, Harmoniously). The third concept is related to the “virtual water” theory, the total water consumed in the process of every activity, namely, the water footprint. It has been estimated that about 1000 and 15,500 liters of water are consumed in the process of production of a liter of milk and a kilogram of meat, respectively. Finally, the carbon footprint concept has been introduced to measure the total greenhouse gases emissions that enter into the atmosphere as carbon dioxide equivalent through individuals, events, organizations, services, places, products, and industries. The veterinary profession has a critical role and responsibility in the integration of the four abovementioned concepts.

## Keywords

waterfootprint, carbonfootprint, One-health, Foodanimal practice, sustainability of the environment

## Abbreviations

CO<sub>2</sub>-eq: CO<sub>2</sub>-equivalent  
CP: Crude Protein  
FAO: Food and Agriculture Organization of the United Nations

GHG: Greenhouse gases  
GDP: Gross domestic product  
GMP: Good manufacturing practices

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This article is dedicated to the memory of Larry Paul Thornburg, (1946-2019), a veterinary pathologist at the University of Missouri College of Veterinary Medicine, USA. I enjoyed a thoughtful journey by reading his nice insightful article, Four essential components of Veterinary education for the 21st century, in *Journal of the American Veterinary Medical Association*, 1992 Oct 15;201(8):1180-3, and translating it into Persian (*Veterinarian Quarterly*, 1998, 2:1, 29-34.).

## Introduction

Animal husbandry has been started in the pre-historic era of human life, creating a paradigm shift in the lifestyle as well as the disease patterns of mankind. About 10,000 to 15,000 years ago when cattle were domesticated, the rinderpest virus, entered the human lives as the probable causal archevirus agent of several important diseases including, measles virus in human populations, and peste-des-petits ruminants virus in sheep flocks [1,2].

The first recorded documents pointing out to the veterinary practice backs to Babylonia's Laws of Hammurabi in around 2100 B.C. that include fees for treatment of a cow or an ass and penalty for malpractice. [3]. There is a considerable amount of literature and documents on the historical veterinary practice in ancient Iran that could probably be extended to all the Middle East [4].

The modern institutes of college-based veterinary practice were established in 1762, following the repeated attacks of rinderpest in Europe, after a decree by the council of State in France, led by Claude Bourgelat. The modern era for western veterinary medicine has been kick started in the Lyon Faculty of Veterinary Medicine, Lyon, France.

Between 1919 and 1935, several devastating attacks of rinderpest caused a huge cattle mortality in Iran, which eventually ruined agriculture as well, especially in the northern provinces. This repeated epidemics of the disease forced Iranians to establish modern western-based institutions such as the Faculty of Veterinary Medicine in Tehran University, the Iranian Veterinary Organization (IVO), and Razi Institute [4], in order to combat the consequences of rinderpest, at a period that lots of scientific endeavors should be devoted to have the Plowright tissue culture rinderpest virus developed in 1960 [5]. The famous pandemic of Influenza had caused heavy mortality around the world during 1918-1919 at that time. It has

been reported that around 30,000 people succumbed to the so-called Spanish influenza just in Tehran, Iran [6]. The planet had to wait until 2005 to have the entire genome of 1918 H1N1 pandemic influenza been sequenced [7]

## The role of veterinary medicine in Society

In the modern days, veterinary medicine is assumed to take responsibility for addressing health issues of all kinds of animals, however, at the beginning of modern veterinary medicine, the practice was mainly focused on diagnosing and treatment of live-stock diseases. The owners of cattle herds and sheep/goats flocks, as well as native poultries, enjoyed largely from the innovations in the biological, pharmaceuticals, therapeutics, and surgical procedures in veterinary medicine. Sheep and goats production has been the cornerstone of the traditional subsistence livelihood, both in terms of nomadic and rural lifestyles, which is still current in developing and underdeveloped countries.

During the entire 20th century, fundamental progressions can be observed in the quality of lives of rural and nomadic people, after the development of the diagnostic preventive and therapeutic measures of control of devastating viral, bacterial and parasitic diseases, e.g. anthrax, foot-and-mouth disease (FMD), rinderpest, glanders, enterotoxemia, various animal poxes, agalactia, different types of pneumonia, Newcastle disease, parasitic diseases, etc.

The Control and monitoring foodborne diseases is another aspect of community expectations that should be addressed by veterinarians. It will start from the early time of decision making on the multifaceted therapeutic approach to diseased animals, in terms of the prediction of the outcome of diseases and withdrawal times of drugs, to slaughterhouse and carriage of the raw materials to the processing industries or house and restaurant kitchens. The contribution of veterinarians in tracing back the origin of the German outbreak of *Escherichia coli* O104:H4 associated with sprouts is an example of the fascinating contribution of veterinarians in ensuring food safety [8].

The need to keep companion and recreational animals has soared up since the 1960s in the US, a translocation of dogs and cats from farms to houses. Moreover, the transformation of lifestyles around the

## Abbreviations-Cont'd

IOFC: Income Over Feed Cost  
 MDGs: Millennium Development Goals  
 N: Nitrogen  
 NPN: Non-Protein Nitrogen  
 OIE: World Organization for Animal Health (Office International des Epizooties)  
 PLF: Precision Livestock Farming  
 WHO: World Health Organization of the United Nations

world have made veterinarians an inseparable part of families' health, well-being, and happiness [3].

The inherent broad-based educational climate of veterinary medicine makes veterinarians, potentially eligible persons in many areas of research projects, including basic sciences, vaccinology, biotechnology, epidemiology, cancer research, and many other innumerable scientific domains. Such a broad contribution to the generation of biological and medical knowledge and science has an immeasurable impact on the sustainability of global society.

### A changing world continually challenges veterinary medicine

An avalanche of social, technological, economic, and political trends continually challenges veterinary medicine. Lagging behind the critical events and ignorance of the upcoming changes might have serious consequences. From fifty veterinary colleges that had been established in the US during 1852-1924, thirty-nine schools ceased their operations when the internal combustion engines gradually replaced horses in the transport business. At that time, the veterinary profession had focused almost entirely on horses, paid very little attention to other livestock species. The introduction of coccidiostats shortly after World War II, when fed continuously at low levels, enabled the poultry industry to bypass veterinarians who bounded to the traditional concept of treating sick individual animals [3]. These historical experiences show that the veterinary profession should always be watchful of the impacts of social and global changes on the very existence of the profession.

Despite some miserable points in the history of the profession, veterinary medicine has had a spectacular cooperation and leadership in the development of modern food animal production from rural barns to huge industrial farms. Milk production per cow has steadily risen from less than a yearly average of 2 tonnes per cow to more than 8 tonnes in 2000 in the US [9]. In Denmark as an example of Western Europe, the milk production on an energy corrected milk basis (ECM) has increased from 1800 to 9000 kilograms in 2010 [10]. Field observations in the Iranian dairy cattle industry, which has largely set foot on the path of the US dairy cattle production model, show that primiparous heifers and multiparous cows with annual milk production of 11 and 13 tonnes, respectively, are not uncommon.

The same scenario has occurred in the poultry industry. The 100-days period for a broiler chicken to get a weight of 2 kg was decreased to 40 days in 2005. The feed efficiency (kg of feed to live weight ratio) was improved from 3 in 1960 to 1.7 in 2005. Annual eggs

laid by a layer chicken in 1960 grew from 230 to 300 in 2005, while laying 5000 and 9000 eggs per tonnes of feed, respectively [11].

The problem of achieving concurrent high milk yield and reproductive performance in dairy herds can be viewed as a historical challenge that has been responded successfully. Milk yield in dairy cattle is highly correlated to reproductive indices. As previously stated, considerable progress in milk yield has been achieved from 1900 so far. The peak in the lactation curve is an important factor in determining the total milk productivity of typical dairy cattle. Based on the regression analysis of the Wisconsin milk yield data, Nordlund and Cook (2004) reported that every pound (or kg) increase in milk production at peak means an extra 290-380 lbs (or kg) increase in rolling herd average milk yield [12]. Milk production of individual cows depend on the potential of the udder to produce milk, the supply of nutrients to the mammary glands, and farm management quality, as well [9].

It is widely accepted that with an incremental increase in milk yield, dairy cows may experience a state of negative energy balance (NEB) during the early lactation period, leading to losing some degrees of body condition score. It has been reported that some problems would raise, e.g. a severe body condition loss may increase the risk of pregnancy failure following the first artificial insemination [13]. Moreover, there is a negative correlation between the increase in serum non-esterified fatty acids (NEFA) and 3-hydroxybutyrate (BHB) with pregnancy rate [14]. The decline in serum glucose levels is associated with a decrease in the rate of embryos that could develop to the blastocyst stage [15].

The reproductive indices profile seemed frustrating. In reviewing the trends in reproductive indices from 1970 to 2000, an increase in mean calving interval has been reported from 13.3 to 14.7 months, respectively. At the same period, the conception rate increased from 1.8 to 3, while the annual milk yield of dairy cows reached from 6400 to approximately 9000 kg [13]. There were claims that a negative relationship between milk production and reproductive performance does exist [17,18]. Some people advocated a longer calving interval of about 18 months to be appropriate for modern dairy cows [9], through genetic enhancement of persistent lactations and increasing animal welfare by managerial innovations [19].

Some researchers questioned the existence of a causal relationship between high milk yields and the decline in reproductive performance [20]. With a concurrent high performance in both milk production and reproductive indices, the share of the early period to the whole area under the curve of the lactation chart, compared with mid-and late- lactation

periods will increase, leading to a greater net income. With such a high performance in milk yield and reproduction, the maneuverability of dairy farms would increase, for example, in terms of financial resilience during economic crises. Moreover, with higher net incomes, the dairy industry would be able to invest in new technologies, e.g., earlier reliable pregnancy diagnosis [21], as well as new high-tech vaccines. According to computerized simulations, the economic value of every pregnancy was 278 \$ compared with 555\$ for a case of abortion, based on 2006 costs [22], indicating that a strategy of keeping both milk yield and reproductive measures at high levels is rational. Determining appropriate selection goals other than milk yield and reproductive indices, e.g. calf survival rate, metabolic diseases, and male fertility [23] should be considered as part of the concept of GMP, a criterion for ensuring that products are consistently produced and controlled according to quality standards within a system.

Multifaceted and multidisciplinary scientific cooperation among veterinary science and other scientific disciplines, e.g. basic sciences, animal sciences, agricultural economy, and agribusiness have resulted not only in the concurrent high-performance achievements in both milk yield and reproduction but also in other aspects of the dairy industry. Dozens of scientific trends can be traced in all aspects of food animal industries, for example, neonatal dairy calves, heifer rearing, genetics and breed improvements, hatcheries and pullet rearing that all are examples of an incremental intertwining process in all aspects of biology with animal welfare. The scientific trends just in colostrum studies [24, 25] are small grits in a sand hill.

Some lessons can be concluded from the aforementioned experiences: 1) Job opportunities for veterinarians that limit their practice to diagnosing diseases and treatment of single animals, at least in the food animal sector are incrementally fading. In the present highly dynamic situations, the art of diagnosis of diseases in a single animal remains crucial as an important part of the monitoring process of the behavior of diseases in the whole herd/flock; a trend of feeling the jungle not only through seeing the trees but by examining weeds. 2) Veterinarians should consider the economic and financial aspects during making decisions on a herd/flock basis. As an analogy, the role of veterinarians in food animal practice is increasingly getting more similarities to the industrial engineers in industrial plants, when production, management, and economics are highly integrated. 3) The old and emerging problems in the modern industries should be addressed through a multidisciplinary approach and a broad-based vision.

## Sustainability of the food animal industry: the impact of diminishing return law

The progressive decline of rural livestock production in favor of increased urbanization caused an advantage towards the establishment of large food animal production facilities. A continual increase in average herd size with a concurrent decrease in the number of farms has been reported in the dairy industry in all developed countries [26]. It appears that the same scenario will be seen in developing and even underdeveloped countries, inevitably. It has been estimated that 15 percent of the total energy and 25 percent of dietary of the world, as well as essential micronutrients that are not easily obtained from plant-based foods, are supplied by livestock production [27]. Increasing the production to the maximum levels seems the best way to increase the monetary income as well as resilience during the economical/financial crises for typical farms. It has been shown, however, that optimum vs. maximum productions are not necessarily interchangeable concepts [9].

First described by economists, the diminishing return law is generally depicted by a curve that expresses the response to every unit of input on the horizontal axis, into efficiency output on the vertical axis. The omnipresence of this law can be seen not only in economics but also in many aspects of nature, e.g. bacterial growth rate curve, clinical medicine [28], pharmacology [29], as well as the increase in milk yield in response to increasing the proportion of concentrates to forages in dairy cattle ration. The latter could even probably be used to describe the situations leading to subacute ruminal acidosis (SARA) in dairy cattle. Based on this law, additional inputs produce smaller and smaller outputs to a system from a certain point, and the efficiency curve trend goes to get flattened. Thus, using diets maximizing milk production may not be the most profitable policy [9]. For a long time, the board of senior consultants of dairy farms was comprised of at least a nutrition advisor (either a nutritionist or a veterinarian), a theriogenologist or an expert veterinarian for reproductive issues, a veterinarian (may also be a specialist to manage herd health issues) and a geneticist to improve the genetic merit of the herd/flock. In the current situations, an agricultural economist is highly needed as well, to find the best points of inputs for optimum production efficiency and ensuring sustainability of the herds/flocks and economical resilience of the industry.

## The need to dynamically updating veterinary curricula and educational climate

Thornurg (1992) published an article with the fascinating title "Four essential components of vet-

erinary medicine for the 21st century” [30]. He critically reviewed the points of weakness of veterinary education and proposed the four components that should be included in veterinary curricula as follows: a broad-based education, nurturing critical thinking abilities in the students, induction of the diagnostic competency in graduates, and institutionalizing the enthusiasm of lifelong self-education in veterinarians. At that time, he was very concerned about how the students and veterinarians can cope with the so-called information explosion that has sky-rocketed these days. According to him, the veterinary curriculum in the US has been extensively and critically reviewed by the American Veterinary Medical association in 1931, which preceded the report of the Pew National Veterinary program by Pritchard in 1989 [3]. From that time, a considerable amount of articles and valuable innovations and modifications have been introduced in veterinary curricula, mostly in Western countries.

A comprehensive special issue entitled “Veterinary education for global animal and public health” has been published by *Revue Scientifique et Technique*, the journal of OIE (number, 2, volume 28, 2009). The collaborations of deans and associate deans of veterinary medicine Faculties in this issue were considerable. In 2009, OIE held a conference under the title of “evolving veterinary education” to address the specifications of the veterinarians to deal with the new expectations of a highly dynamic world as well as the requirements of globalization, keeping pace with the basic requirements in terms of the capacity of the public and private components of veterinary services in the field of animal disease surveillance and control in a globally broad-based perspective [31].

The current situations and expectations of the world societies are highly dynamic. During a tripartite meeting in 2010, WHO, FAO, and OIE committed to coordinate their efforts to solve the overlapping issues of the three organizations. The last session was held in 2017, determining three major subjects to deal with simultaneously, including rabies, zoonotic influenza, and resistance to antimicrobials. A dozen of other subsidiary issues were also discussed [32]. At that time, nobody had any idea about the pandemic of COVID-19 in the near future.

There are numerous compelling evidences in favor of the critical role of veterinary medicine in a changing world. Global warming facilitates the spread of infectious agents to previously clean countries. The spread of bluetongue virus [33] and Lumpy skin disease [34] from Africa to Europe and then, the Eastern Mediterranean basin, respectively, causing major economic losses can be taken into account for emphasizing as an urgent necessity that the surveillance and control of animal health issues should be reviewed in

order to be compatible with the requirements of a new era of interplay between infectious diseases and the planet.

The poisoning by melamine is another historical experience showing the crucial role of veterinarians in the discovery of health hazards to society. Melamine (1,3,5-triazine-2,4,6-triamine.  $C_3H_6N_6$ , molecular weight=126) an industrially synthetic chemical, contains a high level of N (66.6%). The deliberate addition of small amounts of melamine will mistakenly lead to a considerable rise in CP contents of feedstuffs and food products. As part of the series of Proximate analysis that was designed to indirectly estimate, not precisely measure, the nutrients and chemical composition of feed/food samples through relatively and economically justifiable prices, the N content (%) of a typical sample are estimated by the Kjeldahl method at first step. There are specific coefficients for a wide variety of feedstuffs, however, 6.25 is generally accepted as the mean of coefficients and used as something like a wildcard. The multiplication of the N content of melamine (66.6%) by 6.25 leads to 416.67% of the CP content of melamine. In other words, the addition of 100 grams of melamine to a product, will increase the CP content of the final mix by about 416.67 grams. Borrowed from computer literature, it is a bug or a security hole in the Kjeldahl method, which is unable to differentiate between NPN and true protein sources, as the suppliers of N in the feed/food samples.

A causal relationship was made between some specific pet foods to nephrotoxic cases in 2004 and 2007 that finally the phenomenon was known as melamine-induced nephrotoxicity [35]. These kinds of food adulteration gave rise to public health concerns [36], which has been traced back to imported and domestic products in Iran, as well [37]. These reports show that even those sectors of veterinary medicine that are not professionally related to food animal practice and food supplying sectors should have astute, vigilance, and preparedness in addressing the health status and expectations of the society originated from edible products of food producing animals.

Thornburg (1992) expressed his worries about the shortcomings of workaholic nonflexible veterinary curricula that were suffocated by an avalanche of discipline-based courses in educating competent veterinarians to deal with emerging and re-emerging problems in the society. Revision of the veterinary education is the starting point and has a pivotal role for the whole profession to play a highly efficient role in society; however, this task has received minor attention at least in the developing countries, those that urgently need a renewal of their veterinary curricula.

## One health and the leading role of veterinary medicine in the community

It is known from ancient times that the health status of human beings, animals, plants, and environment are highly interrelated. There are reports suggesting that the ancient Egyptian disasters might be triggered by ecological issues [38]. Robert Matthews (1999) through a striking subtitle in his nice article has pointed out the fine interrelationships among the aforementioned constituents of the concept of "One Health" as follows:

Through an arrogant or ignorant disregard for ecological complexities, ceaseless human encroachment on nature can unleash a terrible new threat of killer diseases carried by microbes that have long lain undisturbed [39].

Veterinarians were tirelessly warning the outcomes of the neglects to a unified perspective to human and animal health from the start of the modern veterinary medicine and science in Iran, but frequently received feedbacks were implicating that the word health was just limited to humans. As a result, a frustrating numbness was displayed by disciplines that were inherently responsible to participate in a comprehensive approach to health hazards. Just due to the

recent devastating emerging and re-emerging diseases, however, obliged the community to reconsider the health-related concepts critically.

Part of the problem in the delay to realize the importance of "one health" may be due to this fact that there are different perspectives toward health issues. The letters in the HEALTH acronym denote the inherent integrated health components: Humans, Ecosystems, Animals, Living, Together, Harmoniously [40]. This fundamental perspective leading to a harmonious comprehensive approach to health concept in a globally accepted interpretation should be supported by scaffolds are to be constructed by an integrated education and interdisciplinary cooperations [41,42].

Reminding the issues discussed on the difference between optimal and maximal production levels, it is noteworthy that targeting the maximum economic income might have adverse environmental impacts. On a national approach in dairy cattle industry in the US, It has been estimated that choosing the IOFC criterion versus maximum efficiency of N means increasing the CP contents of a typical dairy cow producing 35 kg milk /day from 14.9% to 18%, respectively. The inevitable outcome of such an increase in the CP content of the rations other than an increase in net monetary in-

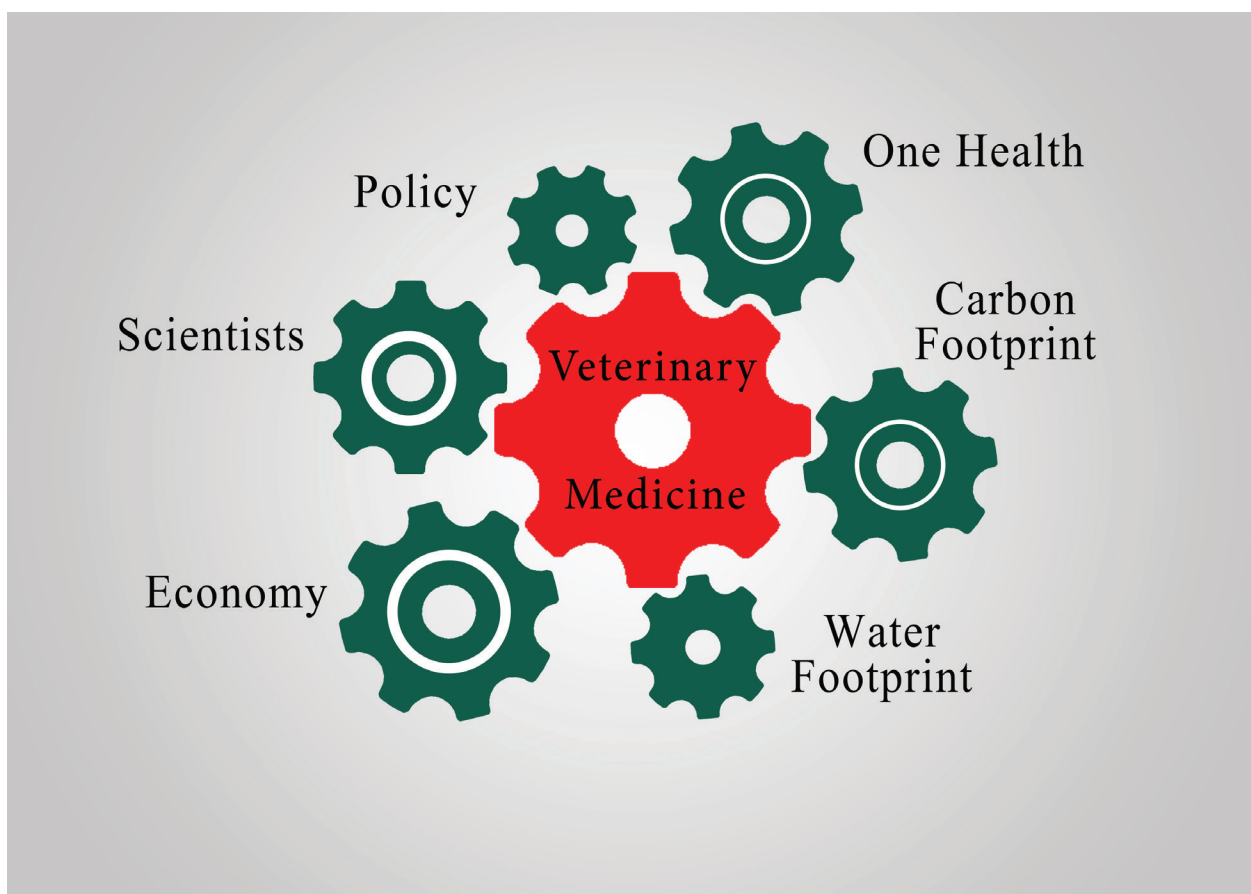


Figure 1.

The integration of different subjects to be addressed by veterinarians. Adapted from King, 2009 (45).

come is the excretion of an extra 150,000 metric tons of N into the environment [9,43]. If some regulatory laws are to be assigned for industries to oblige them to compensate for the adverse environmental impacts of their activities, this may submit an impulse to encourage the industry to pursue more environment-friendly strategies rather than focusing merely on maximum monetary income.

The same scenario, in terms of energy, might be true for the counterpart of IOFC in the poultry industry, the feed conversion ratio. The interaction of genetic changes and the trends seen in both the energy use efficiency and the heat production rate has been critically reviewed [44]. These examples clearly show that food animal industries should consider both the economic and environmental aspects of production, simultaneously; being economically profitable and environmentally justifiable. The interrelated areas of One-health that should be kept working together harmonically and systematically by veterinarians as one of their major responsibilities have been depicted in Figure 1.

### Water footprint-virtual water-embedded water concept in food animal practice

The water footprint of a product is the volume of freshwater used to produce the product, measured over the full supply chain. It consists of the blue water footprint resources (surface and groundwater), green water footprint (rainwater insofar as it does not become run-off), and the grey water footprint (the volume of freshwater that is required to absorb the load of pollutants given natural background concentrations and existing ambient quality standards. It may be frustrating for the food-producing animal industries to realize that for the production of each kg of beef meat, milk, cheese, and chicken meat about 15,500, 1000, 5000, and 3900 liters of water are consumed throughout the full production line, respectively [46]. With the introduction of the concept of virtual water, the sustainability of food animal industries, in terms of economic and environmental issues will be highly complicated, especially in areas suffering from chronic drought or lack of sufficient renewable water resources.

The problem of water resources not only can be evaluated as a hot topic but as a dangerous situation for water security. It has been stated that about 74 cubic kilometers of groundwater in Iran has been withdrawn during 2002-2015 [47], meaning a state of water bankruptcy. The continuous overexploitation of water resources in Iran has reached hazardous levels, in terms of water security as well as the danger of increased water salinity. The cumulative withdrawal of nonrenewable groundwater in Iran from 1965 soared

to  $1.33 \times 10^{11} \text{ m}^3$  in 2019 [48].

The industrial and rural dairy cattle and small ruminant production have been under the pressure of chronic drought situations in terms of supplying economically justifiable forages. The minimum recommended levels of forages should be met to ensure the rumen health status and efficient use of the concentrate ingredients of the ration in ruminant animals. The prices of concentrate and forage in the UK are reported to be about 160£ and 60£, respectively on a dry matter basis with a ratio of 2.67 in 2010 [49]. The price of different forages have chronically been equal to or higher than concentrates in Iran. The relatively higher prices of forages compared to concentrates can be accounted as a major constrain to the sustainability of the ruminant sector of food animal production industry. On the other hand, hidden subsidies paid to fuel and electricity consumption in oil-rich countries, if not managed on virtual water concept, would exacerbate the environmental unsustainability, by preventing the real value of water being taken into account. To match the personal, social, and environmental interests as much as possible through the action of the so-called Adam Smith's invisible hand, high levels of transparency are needed.

With the current drought conditions in Iran which are unprecedented in the last 50 years, the import of forages like alfalfa hay or alfalfa meal, is an urgent tactical intervention, to save the herd/flock owners from financial bankruptcy as well as ameliorating the pressure on the rangelands. It has been reported that the water footprint of alfalfa hay in Argentina ranged from about 728 to 881  $\text{m}^3 \text{ t}^{-1}$  as virtual or embedded water [50]. In these critical periods, the temptation to irrigate vegetables for human consumption and/or forages for ruminant feeding by unrefined wastewater should be considered as a serious criminal health threat to humans, animals, agriculture and the environment and planet, altogether. Strict regulatory laws and penalties should be enacted to restrain such a terrible villainy. Facilitation of the international trade of virtual water, e.g. as international import and export of vegetables and forages can be considered as a strategy in order to dissuade using wastewater for irrigation. Virtual water trade potentially is helpful to mitigate the global water crisis, in addition to virtual water flow for agricultural products [51].

### Carbon footprint and food animal production

While not as locally sensible as virtual water, the carbon footprint is considered an important issue from a global perspective. Greenhouse gases, including methane, nitrous oxide, and carbon dioxide are emitted into the atmosphere by dairy production. The global dairy sector contributes 4.0 percent to the total

global anthropogenic GHG emissions [52].

It should be noted that deforestation might be accounted as part of the prerequisites for the initial phase of the establishment process of dairy farms in many locations in the world; a major contribution to the GHG emissions phenomenon. The share of pig and chicken in the annual GHG emissions are 669 million tonnes and 606 million tonnes CO<sub>2</sub>-eq, respectively [53].

The paradox of increasing demand for food from animal sources, and the urgent need to decrease GHG emissions at the same time, should be addressed by the interrelated disciplines involved in food animal practice. As much as possible, deforestation should be considered as a major obstacle in establishing new food animal facilities, monitored by regulatory laws.

### The importance of politics

A mutual interrelationships among scientists and politicians are needed. It should be taken into consideration that many decisions may have environmental side effects that should be scrutinized by both parties. The strategies like self-sufficiency on high water demanding products, e.g. wheat (1300 liter/kg) or milk (1000 liter/kg) [46] in countries with scarce water resources could have devastating outcomes. Moreover, the apparently water-conserving activities, such as building dams in arid and semi-arid countries may have a backfire outcome. The drying out of the majority of the internal lakes in Iran should be critically evaluated because dried-out lands would had direct negative effects on the food animal practice and potential job-creativity of animal husbandry. The dams at the upstreams of Tigris and Euphrates in Turkey may result in the drying out of the downstreams at the south Iraq, leading to terrible sand storms in the region. The southeastern Sistan and Baluchestan province of Iran as the downstream, is suffering from the dam(s) at the upstream of Hirmand (Helmand) river in Afghanistan, to the point that Hamoon lake has been dried out for many years, ruining fishing, fisheries and animal husbandry activities in the region as well as the livelihoods, causing considerable immigration of the native people. It is advisable to review the dam construction policy or craziness, at least in the Middle East, where a proinflammatory status is present for further conflicts on water. At the present time a dam removal debate is current in scientific communities in the US [54].

The approval of laws and major decisions on country/regional/global scales should always be done under the umbrella of sustainability of the environment. An international common sense is needed to exempt health and environmental sustainability issues

from domestic and/or international political conflicts, for example, sanctions.

### Conclusion

Setting foot on the path of development is not a straightforward process. Lots of information, disciplines, and specialties should come together, to increase the precision of decisions and accuracy of actions. Agribusiness, defined as the food sector of economy, should be considered as an important part of the domestic as well as international political stability. Every wrong step may not only result into environmental adverse effects, but social and economic crises could potentially spin out of control (55). Veterinary medicine has a pivotal role in integrating health issues, economy and environmental sustainability, decreasing poverty, ensuring security, and increasing the welfare of humans, animals, and the planet in the era of footprints and "One-Health". It should be taken into consideration that the starting point to address all these highly complicated tasks is providing high quality, broad-based education by all disciplines, and in this case by veterinary medical schools and faculties. The critical role of veterinary science and veterinary medicine in the substantiation of "global vision and local action" has been depicted in Figure 2.

Veterinarians are among the first responders in the frontline of the battle against threatening global issues that are always ready to escalate to worrying dimensions, including population growth, economic stagnation, environmental stress, increased prices of food animals and products that are now flowing in international markets, emerging and re-emerging infectious and exotic diseases, bioterrorism, public health hazards, etc. [56]. The engagement of scientists and veterinarians in strengthening biosecurity systems is of paramount importance to ensure resilience and sustainability [57].

Veterinary medicine should play its leadership role as one of the most talented disciplines in global and environmental issues [56]. One of the key interconnecting rings in the armor that the modern world should wear against the threatening crises is veterinary medicine, which is designed to achieve economic promotion as well as stability, sustainability and salvage of the environment and planet.

A major part of the successful achievements and promotion in food animal industries is due to the artistic integration of animal welfare concepts and criteria, as an important factor both from production efficiency and disease prevention perspectives, into the whole practice of food animal production medicine. The concept of PLF, as a potential strategy to mitigate environmental risks of livestock farming [58] is an-



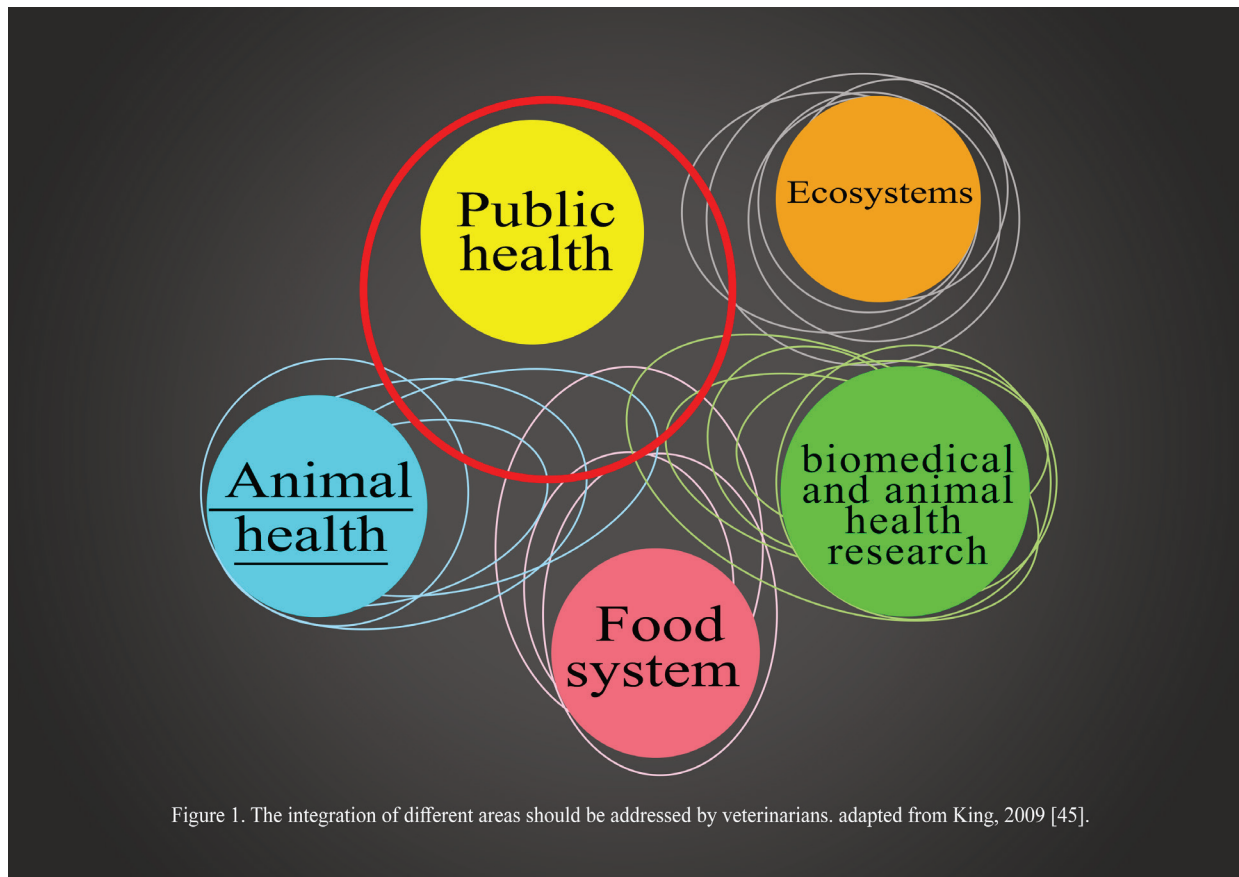


Figure 2.

An illustration depicting the central role of veterinary medicine in informative connection and leadership between policymakers, economists, and various scientific disciplines to address On-Health, water- and carbon-footprints in an ever-changing world.

other step in the evolution of livestock production industry. All these concepts makes the emergence from rural activities to industries feasible; from piggeries to Muyuand foods hog enterprise (Nanyang, China); from backyard poultry production to Egg city in California, from barns to Mudanjiang City Mega Farm (Heilongjiang, China). But it is not yet enough.

### Future directions

As previously described, virtual water is an important determinant in the sustainability of the environment and the development of the community. It is true that high virtual water is demanded in the process of the production of meat, milk, eggs and chicken meat, the interconnection between high and relatively low demanding virtual water industries, would potentially provide more efficient less destructive use of the ever-limited resources. Just as an example, the share of the tourism industry in GDPs of countries is getting more attention globally. It is reported that tourism accounts for more than 10% of Spain's GDP and the total water consumption of the residents and non-resident tourists equals 9.985 km<sup>3</sup>. The required blue and green water consumption to meet the demand of non-residents (foreign tourists) in Spain is 3.737 km<sup>3</sup> and

the requirements from Spanish resources just equals 1.570 km<sup>3</sup>, while consumption of Spanish blue water resources is 0.885 km<sup>3</sup>. The latter is politically controlled, which is the subject of public debate as well, in Spain [59].

It seems that it is rational for the food animal industries to follow new paths in order to be integrated into new markets as well as promote their roles from an agro-alimentary activity to agro-alimentos-industrial levels, such as tourism industry, which potentially provides higher payments for a defined amount of nutrients in terms of carbohydrates and proteins supplied by the native residents of a country, provided that the quality, esthetic and organoleptic measures of the final product on the plate in front of the enthusiastic tourists seeking new experiences are guaranteed. For the countries that have all the components of a tourism destination, "sea/sun/sand", a multisectoral relevance among different disciplines, e.g. policy, economics, agriculture, veterinary medicine, and tourism should be constructed. The final interplay should be reflected in the increased GDP. In the modern world, veterinary medicine should follow the approaches to highlight its share in GDP, by taking part in "one-health" and increasing efficiency, based on the issues raised by the era of footprints and "One-Health". Med-

ical tourism is another example of increasing the income that could potentially be reflected in the promotion of the economic and health status of the tourism destinations that are providing or potentially are able to supply medical-services as well.

Other similar collaborative remedies should be sought by veterinarians as well as other disciplines to decrease the current intolerable pressure on water resources, land and sustainability of environment and planet through the reincarnation of environment-friendly industrial soul into the bodies of agriculture, agribusiness, human and animal health. The extra income from these innovations could be invested in education, seeking innovations and new technologies, research and/or compensation of the harms insulted to the environment by the industry. Veterinarians should be appreciated as vigilant observers of a broad planet issues; ensuring sustainable production. Political decisions, on domestic or international scales, which may potentially affect environment should be critically monitored by a variety of scientists, including veterinarians. It is tempting to deforest a jungle to establish dairy or beef cattle rearing farms for both the investors and peoples that are threatened by a damping economy, which ruins the versatile job opportunities. The scandal in Brazil, "Bolsonaro's treatment of the amazon" is condemned by celebrities and world leaders [60], is a prominent example that should have received prompt and on time reactions by various scientists; especially veterinarians should always be ready to swim against the tide, be prepared to show rapid reaction, in addition to publishing scientific articles that will be inherently submitted with a considerable delay, when the public has forgotten the relevant crisis. Without a sustainable economy and society, as well as reliable job opportunities, resurgence of the instability conditions may have destructive effects on the sustainability of the environment. "Bolsonaro's treatment of the amazon" in Brazil has had roots in the past; chronic pathologic sociological states that had been described as land-hungry [61], which has been led by fanning the flames of greed [62] were present for decades before, as hidden fire under the ashes. The same scenario would be possible to be occurred everywhere, as well as Iran. It has been warned that shortcomings in relevant laws oriented toward jungle preservation, would invariably result into degradation of forests in Iran [63].

Several currencies should be managed rationally in order to address health and economics issues, from ATP in the intracellular biochemical processes to strong currencies in the global market. Veterinary Medicine and veterinarians are among those few disciplines that can have an influential vision on both sides; from the depth of the cells to the highlands

of health, environment, economy, technology, engineering and political issues, deserving their global leadership role, if environmental commons are to be managed sustainably, not selfishly base on self-interest beneficiaries, because many human societies might not reach the post-industrialization stage in the near future [64]. The veterinary education has a pivotal role in the keeping lots of concepts in a united perspective, e.g. water footprint, carbon foot, environment sustainability, GDP, PLF as well as providing efficient and meaningful interconnections among major institutions like OIE, WHO and FAO together, in addition to scientists, politicians and governments who are supposed to be highly committed to MDGs [65]. These goals were signed and declared in September, 2000, programmed to be achieved till 2015. At the present time, it is superseded by a more comprehensive renewed targets named Sustainable Development Goals [66]. The critical role of veterinarians in the accomplishment of the latter is undeniable.

### Authors' Contributions

The author has written, read and approved the first and final drafts of the manuscript.

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### Conflict of interest

The author has nothing to disclose, however, was highly worried about the arrogant and ignorant disregard taking place toward the ecology, destiny of the people and planet during the writing of this manuscript.

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