ORGANIKO LIFE+

Ecosystem Function Restoration Study

Cost-Effectiveness and Ecosystem Services associated with an Organic Diet Treatment Intervention in Primary School Children of Cyprus

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May 2019

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Executive summary

Purpose: The possible implications of using a large scale organic dietary intervention to promote healthy living at the setting of primary school and at the same time to promote climate mitigation are enormous. However, the economic parameters associated with such interventions are the limiting factor for such intervention measures by the health authorities. We provide the means of executing calculations that simulate possible costs and benefits associated with the organic dietary intervention using Cyprus data. We also highlight various ecosystem services associated with the implementation of a sustainable agricultural organic system.

Outcomes: Two separate analyses were performed to determine the cost-effectiveness of an organic treatment intervention in primary school children of Cyprus against the no action scenario. The first analysis was performed to determine the cost of preventing one case of adult obesity and compare that to the lifetime societal and public health cost of obesity per person. The second analysis performed was to determine the cost to avert the loss of one type 2 diabetes-associated disability-adjusted life year (DALY) using this intervention.

Results: Based on the first analysis (obesity outcome), if the organic diet was administered for the 12 years of school, the cost would be €23,112/child over the 12-year period. This would eliminate the 9.3:1 return on investment value (ROI) based on the calculated 4.38 children fed to prevent one case of adult obesity as the cost of feeding 4.38 children for 12 years equals €101,230 (€78,288 saved for one case of obesity prevented). However, if we use the mean total lifetime cost of a child or adolescent with obesity of €149,206, the ROI is much lower (1.47:1), but still remains. Based on the second analysis (type II diabetes DALYs), the proposed organic diet treatment intervention for primary school children was proven to be a highly cost-effective intervention based on the criteria set by the WHO-CHANGE program. The ecosystem services potential of organic farming is substantial. It is evident that organic farming is an important agricultural system that is able to promote and sustain ecosystem functionality. The implementation of alternative nutrient management practices could reduce the emissions of greenhouse gases in arid and semi-arid areas. Indeed, organic farming through the reduction of external resources (i.e. nutrients and pesticides) could significantly alter soil functioning thereby increasing the biological activity, biodiversity and health of soils.

Conclusions: Our findings through the ORGANIKO LIFE+ project denote that the increase of agricultural land under organic farming scheme has the potential to improve soil fertility in the long term and substantially reduce GHG emissions for barley and apples. Similarly, the cost-effectiveness of the organic diet treatment intervention for primary school children was demonstrated and it can be a useful policy tool for the Cypriot government as it continues to tackle the childhood obesity pandemic in the island.

Σύνοψη

Σκοπός: Οι πιθανές επιπτώσεις μιας μεγάλης κλίμακας διατροφικής παρέμβασης με βιολογικά τρόφιμα για την προώθηση της υγιεινής διατροφής στο περιβάλλον του δημοτικού σχολείου είναι τεράστιες. Ωστόσο, οι οικονομικές παράμετροι που συνδέονται με αυτές τις παρεμβάσεις είναι συχνά ο κύριος περιοριστικός παράγοντας για τέτοιου είδους παρεμβάσεις από τις αρμόδιες αρχές. Παρέχουμε τα μέσα εκτέλεσης υπολογισμών που προσομοιώνουν το πιθανό κόστος και τα οφέλη που σχετίζονται με τη βιολογική διατροφική παρέμβαση χρησιμοποιώντας στοιχεία και δεδομένα του έργου και του πληθυσμού των παιδιών της Κύπρου.

Αντίκτυπος: Διενεργήθηκαν δύο ξεχωριστές αναλύσεις για να προσδιοριστεί η σχέση κόστους-αποτελεσματικότητας μιας βιολογικής διατροφικής παρέμβασης σε παιδιά πρωτοβάθμιας εκπαίδευσης της Κύπρου κατά του σεναρίου χωρίς δράση. Η πρώτη ανάλυση πραγματοποιήθηκε για να προσδιοριστεί το κόστος πρόληψης μιας περίπτωσης παχυσαρκίας σε ενήλικα και να συγκριθεί με το κόστος της κοινωνικής και δημόσιας υγείας καθ' όλη τη διάρκεια της ζωής ενός παχύσαρκου ατόμου. Η δεύτερη ανάλυση που πραγματοποιήθηκε ήταν για να προσδιοριστεί το κόστος για να αποτραπεί η απώλεια ενός προσαρμοσμένου στην ανικανότητα έτους ζωής (DALY), σχετιζόμενο με διαβήτη τύπου 2, με τη χρήση αυτής της παρέμβασης.

Αποτελέσματα: Με βάση την πρώτη ανάλυση, εάν η βιολογική διατροφή χορηγηθεί για τα 12 έτη του σχολείου, το κόστος θα είναι 23,112 € / παιδί κατά τη διάρκεια της δωδεκάχρονης περιόδου. Αυτό θα εξαλείψει την απόδοση της επένδυσης 9.3:1 με βάση τα υπολογισθέντα 4.38 παιδιά που τρέφονται για να αποφευχθεί μια περίπτωση παχυσαρκίας ενηλίκων, καθώς το κόστος της σίτισης 4,38 παιδιών για 12 έτη ισούται με 101,230 ευρώ (78,288 ευρώ που εξοικονομήθηκαν για μία περίπτωση παχυσαρκίας που αποτράπηκε). Ωστόσο, εάν χρησιμοποιήσουμε το μέσο συνολικό κόστος ζωής ενός παιδιού ή εφήβου με παχυσαρκία (149,206 ευρώ), η απόδοση της επένδυσης είναι χαμηλότερη (1.47:1), αλλά παραμένει. Βάσει της δεύτερης ανάλυσης, η προτεινόμενη

βιολογική διατροφική παρέμβαση για τα παιδιά πρωτοβάθμιας εκπαίδευσης αποδείχθηκε ότι είναι μια πολύ αποδοτική παρέμβαση με βάση τα κριτήρια που ορίζει το πρόγραμμα WHO-CHANGE. Το δυναμικό της βιολογικής γεωργίας για τις υπηρεσίες οικοσυστήματος είναι σημαντικό. Είναι προφανές ότι η βιολογική γεωργία είναι ένα σημαντικό γεωργικό σύστημα ικανό να προάγει και να διατηρεί τη λειτουργικότητα του οικοσυστήματος. Η εφαρμογή εναλλακτικών πρακτικών διαχείρισης των θρεπτικών ουσιών θα μπορούσε να μειώσει τις εκπομπές αερίων θερμοκηπίου σε ξηρές και ημι-άνυδρες περιοχές. Πράγματι, η βιολογική γεωργία μέσω της μείωσης των εξωτερικών πόρων (δηλαδή θρεπτικών συστατικών και φυτοφαρμάκων) θα μπορούσε να μεταβάλει σημαντικά τη λειτουργία του εδάφους αυξάνοντας έτσι τη βιολογική δραστηριότητα και την υγεία των εδαφών.

Συμπεράσματα: Τα ευρήματά μας μέσω του έργου ORGANIKO LIFE + υποδηλώνουν ότι η αύξηση της γης που χρησιμοποιείται για βιολογική γεωργία έχει τη δυνατότητα να βελτιώσει μακροπρόθεσμα τη γονιμότητα του εδάφους και να μειώσει σημαντικά τις εκπομπές αερίων του θερμοκηπίου για το κριθάρι και τα μήλα. Παρομοίως, αναδείχθηκε η σχέση κόστους-αποτελεσματικότητας της βιολογικής διατροφικής παρέμβασης για τα παιδιά πρωτοβάθμιας εκπαίδευσης και μπορεί να αποτελέσει χρήσιμο εργαλείο πολιτικής για την κυπριακή κυβέρνηση καθώς το νησί αντιμετωπίζει πανδημία παιδικής παχυσαρκίας.

Introduction

The goal of developing sustainable food systems is considered a high importance by several intergovernmental organizations. Agroecology and organic agriculture are strong thematic concepts of the global movement that values sustainable food production and consumption as vital for the health of the people, communities and environment. Healthy dietary habits during childhood and adolescence are of utmost importance for supporting the proper physical growth and cognitive development (Jacka et al. 2011). Obesity has been one of the most well-known public health challenges, worldwide. In Cyprus, a marked increase in the prevalence of obesity during a decade of collected data was reported for children and adolescents 6-17 years (Savva et al. 2014). In this context, the consumption of organic foods within a framework of a healthy and balanced diet scheme might contribute to the management of weight gain and therefore obesity.

As compared to a number of observational studies, the long-term interventional studies aiming to identify potential associations between organic food consumption and health are limited. Certain biomarkers have been examined in an effort to quantitatively conclude on the effect of organic diet on human health. Most of the experimental studies used specific organic products as the main intervention, such as wine (Akcay et al. 2004), apples (Stracke et al. 2010; Briviba et al. 2007), carrots (Stracke et al. 2009), grape juice (Gonçalves et al. 2011), honey (Alleva et al. 2015), and some other studies used a specific controlled intervention organic diet (Grinder-Pedersen et al. 2003; Di Daniele et al. 2014; De Lorenzo et al. 2010; Di Renzo et al. 2007).

Thus far, non-pharmacological health intervention trials are limited and generally based on small population size (6 to 130 adults) and short intervention duration (from 2 – 30 days), consequently limiting the statistical power of the conclusions and the possibility of identifying long-term effects. Our ORGANIKO LIFE+ intervention trial in Cyprus has collected data for about 150 children participating in a cross-over trial in schools studying the effect of organic diet on key biomarkers of exposure (metabolites of pyrethroids and neonicotinoids) and effect (inflammation/oxidative stress). The possible implications of using a large scale organic dietary intervention to promote healthy living at the setting of primary school are enormous. However, the economic parameters associated with such interventions are the limiting factor for such intervention measures by the health authorities. We provide the means of executing calculations that simulate possible costs and benefits associated with the organic dietary intervention using Cyprus data.

Methodology

Outcome Analysis #1: childhood obesity

Data from the children's trial by Makris et al. (2019) as executed in Cyprus being part of the ORGANIKO LIFE+ project was used to determine the absolute and percent change in body mass index (BMI) for the participants by the end of the organic phase of the study (about 40 days) when compared to their baseline BMI status. Age-, and sex-standardized BMI z-scores using the WHO 2007 growth reference standard for primary school children were calculated based on the standardized measurements of weight and height taken at the baseline and at the end of the organic period (two time points). Statistically significant ($q < 0.05$) BMI z-scores reduction was found by the end of the organic treatment intervention that lasted for about 40 days (Makris et al., 2019).

Using data from the ORGANIKO LIFE+ trial, a ratio, need to be fed: case of adult obesity prevented (NF:OP) was calculated, representing the number of children that would need to be fed with the organic diet for a specific period of time to prevent one case of adult obesity. This NF:OP ratio was determined by the percentage of children that lost weight during the organic phase who were overweight/obese at baseline and would benefit from the intervention (4.38:1 or 149/34), the sex-standardized BMI median rate and the time required to reach a normal sex and age-standardized BMI that is neither over-, or under-weight.

The cost of feeding all Cypriot children during their 12 primary and secondary school years (until 17 years of age) was then determined. The number of primary school children in Cyprus was approximated to the number of children aged 5-19 years as determined by the European Statistical System (ESS) official country tables.

The selected cost of feeding one organic meal to each child (5.35 euros) was based on two data sources: i) actual cost estimates of organic meals part of the ORGANIKO LIFE+ children's trial in Cyprus, and ii) actual cost of providing organic, locally-sourced meals to children in Italy under a program dubbed "Gaining Health", which stemmed from the 2006 agreement between the European Union and the World Health Organization (Paolucci, 2010). This daily cost was used to determine total organic treatment intervention cost per case of obesity prevented cost estimates.

Using the NF:OP ratio, the organic intervention cost per child was used to calculate the cost of preventing one case of adult obesity, which was then compared against the lifetime societal and public health cost of one case of obesity, using data from the study conducted by the Center for

Social Dynamics and Policy, in partnership with the World Food Center of the University of California-Davis; the study considered and added up all direct medical costs and lost-productivity costs from absenteeism at work due to adulthood obesity, as well as short-term disability payments and foregone tax revenue (Finkelstien et al., 2010; Kasman, et al., 2015)

Outcome Analysis #2: type II diabetes

The second analysis determined the organic treatment intervention cost per type 2 diabetes (T2D)-associated disability-adjusted life year (DALY) in Cyprus so that it could be compared against the "do nothing" scenario in order to determine the cost-effectiveness of the proposed intervention scheme.

<u>Cost/DALY = Total Cost of Intervention/Total DALY's lost in the country due to the illness</u>

The numerator represents the total cost of the intervention per child in the trial using data by Makris et al. (2019). In cost/DALY calculations, "total cost" may be calculated either from the perspective of the "health system" administering the intervention or from the perspective of the patient receiving the health intervention (Gold et al., 1996). In this case, the total cost was calculated based on a school system initiative, providing organic meals 2 times per day, 5 days per week, for 9 months per school year, considering the whole duration of primary and secondary school (12 years).

Total DALYs lost in the country of Cyprus due to illness represent a single metric that combines mortality (Years of Life Lost or YLL) and morbidity (Years of Life Lived with a Disability or YLD). In order to determine —the total DALYs lost in the region due to the illness, the T2D-associated YLL and YLD had to be calculated.

DALYs is defined by the following equation: *DALYs = YLL + YLD*

Years of Life Lost (YLL) is a region-specific mortality measurement which is quantified by the number of years that a person is missing by dying prematurely. The annual age-standardized YLL in Cyprus due to diabetes was taken from estimated provided by the Institute for Health Metrics and Evaluation (IHME) (285.4/100,000; IHME, 2018).

Years of Life Lived with Disability (YLD) is a morbidity measurement that quantifies the effect of living with a disability by multiplying the number of incident cases (I) for the cause of morbidity in a particular time period (in this case, one year) by a disability weight (DW) and by the average duration of the case until remission or death.

$$YLD = I \times DW \times L$$

To determine the YLD for T2D in Cyprus, the national comparative, age-adjusted T2D prevalence was used, since the incidence of T2D was not available. This method has been used in the calculation of DALYs due to T2D in other studies (Darba et al., 2015).

The disability weight (DW) is a weighting factor that reflects the severity of the disease under consideration on a scale from 0 (perfect health) to 1 (equivalent to death). The WHO releases a Global Burden of Diseases Report (WHO, 2004) every ten years to institutionalize the disability weights used for each disease. A study that calculated DALYs lost due to diabetes in several European countries used the DW of 0.033 for treated diabetics and 0.012 for untreated. For this study, the treated diabetics DW estimate was used (Darba et al., 2015).

The L in this formula refers to the average duration of the disability before remission or death, the number of years that an affected person lives with the disability over his or her lifetime. For this calculation, L= 13.6 years was used as taken from Leal et al. (2009) who relied upon a set of tables reporting life-expectancy stratified by age–sex groups for combinations of modifiable risk; these tables were constructed based on predictions from the United Kingdom's Prospective Diabetes Study outcomes model (Darba et al., 2015). The number 13.6 years represents the median duration of disability for a 65 years old individual, who is non-smoking (man or woman) with a systolic blood pressure of 150 mmHg and an HbA1c of 8.0% (Leal et al., 2009).

In order to compare total DALYs at stake with the total cost on an individual basis, the number of DALYs at stake for each individual was determined by dividing the total DALYs by the number of adults in Cyprus who would develop T2D without the intervention. From the literature, it is well known that obese adults between the ages of 25 and 64 are at least four times more likely to have been diagnosed with T2D than those who have normal weight and that by their mid-to-late 30s, 9.3% of adults who are obese will have been diagnosed with diabetes, compared with 1.8% among those who are normal weight (Witters and Liu, 2017). Using data from the Witters and Liu (2017) study, and the obesity percentage of adults in Cyprus, the number of individuals who would become obese and develop T2D without the study intervention in the primary/secondary school years was calculated.

Two diabetes prevention studies conducted in Australia (Bertram, 2010; Coligiuri, 2008) reported cost per DALY averted from the health system perspective and used the Australian 2013 per capita gross domestic product of $67,468 as the cost-effectiveness threshold estimate (World Bank). Both studies found the prevention programs being cost-effective at $21,195 and $50,707 per DALY, respectively. The Cypriot Gross National Income (GNI) in Purchasing Power Parity (PPP) (current international dollars $) was $33,609 in 2017 (Trading Economics, 2018) or equivalent to €28,741.

Results

Analysis #1 (intervention outcome: adulthood obesity prevention)

Data from the trial by Makris et al. (final dataset of n=149) showed that 56% of children lost weight from the start of the study to the end of the organic phase (about 40 days of duration); 33 (67%) of overweight children lost weight; 4 (8%) had no change in weight and 2 children (4%) gained weight; no data was available for 9 overweight children. Of those that lost weight, the average BMI loss was equivalent to a 3.67% (range -0.017%- -11.04%) reduction of their BMI (0.092% daily); of those that gained weight, the average weight gain was equivalent to a 2.97% increase in their BMI (range 0.33% - 6.82%).

Of the 84 children that lost weight, 34 (40.5%) were overweight at baseline and 8 of those moved from overweight to normal weight category and one of them moved from obese to overweight. Of the 12 children that did not lose weight, 5 (42%) of them were overweight at baseline. Of the 36 children who gained weight, 2 were overweight at baseline and 1 child moved from normal to the overweight category. For 17 children there were no data.

Overweight males who lost weight, lost a median of 0.0113 BMI units / day and in order to reach a normal BMI of 20, it would take a median of 113.9 (114) days. Overweight females who lost weight, lost a median of 0.0216 BMI units/day and in order to reach a normal BMI of 21, it would take a median of 64.2 days.

Males with initial BMI > 20

There were 31 children with initial BMI > 20, 5 of which had incomplete data and were removed. Since the days to get to BMI 20 is not well behaved for changes in BMI that were 0 or increased, we calculated the median instead of the average.

Females with initial BMI > 21

There were 18 children with initial BMI > 21, 4 of which had incomplete data and were removed. Since the estimate of days to get to BMI 21 is not well behaved for changes in BMI that were 0 or increased, we calculated the median instead of the average.

Because 34 overweight children out of the 149 study participants lost weight during the organic phase of the intervention, the ratio of 4.38 children would need to be fed the organic diet for at least a period of 114 days for males and 65 days for females to prevent one case of adult obesity (NF:OP ratio).

The cost of feeding one organic meal to each child was €5.35. The mean lifetime societal and public health cost of adult obesity as determined by the World Food Center of the University of California-Davis was estimated at €78,288, or a mean lifetime cost of €149,206 for an obese child or adolescent using data by Hamilton et al. (2018).

Feeding one child 2 meals per day, 5 days per week for the 9 months of the school year would result in an annual cost of €1,926 per child. If 4.38 children were fed the organic diet for one year, 1 case of adult obesity would be prevented. This would equate to €8,436 (4.38*€1,926) spent to save €78,288 (expenses for one case of obesity), which equals to a return on investment value (ROI) of 9.3:1 (€9.30 saved for every €1 spent). When considering the mean total lifetime cost of a child or adolescent with obesity, the ROI increases to 12.2:1 (€149,206/€8,436). However we can assume that if the children were to fully resume the conventional diet after one year of organic dietary intervention, the weight would likely return, eliminating the ROI of the intervention.

If instead, the diet was administered for the 12 years of school, the cost would be **€**23,112/child over the 12-year period. This would eliminate the 9.3:1 ROI based on the calculated 4.38 children fed to prevent one case of adult obesity as the cost of feeding 4.38 children for 12 years equals **€**101,230 (€78,288 saved for one case of obesity prevented). However, if we use the mean total lifetime cost of a child or adolescent with obesity of €149,206, the ROI is much lower (1.47:1), but it remains.

The annual cost of feeding 142,600 Cypriot children was estimated at €275 million. However, when one considers that the direct and indirect economic impact of obesity have been estimated roughly at €43.7 million/100,000 residents, obesity costs Cyprus a total of €370 million annually (Nat League Cit, 2018).

In addition to the direct and indirect health cost savings of providing organic meals to school children, there are additional economic benefits to the region. The economic impact of organic agriculture on local economies, despite often being small in scale is argued to be beneficial. It is theorized that because of generally higher levels of labor required in organic agriculture as compared to conventional agriculture, this results in more earnings and more money staying within the local economy. Value-added organic products with shorter supply chains may also be contributing factors to enhanced economic gains with organic agriculture (Marasteanu and Jaenicke, 2018). The study by Marasteanu and Jaenicke (2018) found that U.S. counties classified as organic hotspots lowered the county's poverty rate by as much as 1.6% and increased annual median household income by over US$1600 (€1382); in the study, organic hotspots definition was based on multiple criteria that included numbers of production operations, as well as handling operations. They found that in counties with 10 or more organic operations, significant positive impact on lowering poverty rates was demonstrated, while an increase in median household income was observed for counties with > 20 organic operations (Marasteanu and Jaenicke, 2018).

Counties determined to be organic hotspots by numbers of production operations only had county-level, median household incomes that were nearly US$820 (€709) higher. Hotspots based on all organic operations (production and handling) realized an increased income by nearly US$1615 (€1395); and organic hotspots based on handling only saw increased income by over US$2373 (€2050). Conversely, general (conventional) agriculture hotspots did not realize a statistically significant increase in the county-level median household income (Marasteanu and Jaenicke, 2018).

Organic agriculture sector in Cyprus represents a slowly emerging market. Upon its independence in 1960, Cyprus was small-scale and subsistence agriculture dominated the economy. In the early 1970s, Cypriot farms supplied approximately 70 percent of commodity exports and employed about 95,000 people, or one-third of the island's economically active population. (Solsten, 1991) Agriculture's share of GDP had declined to 18 percent in the first half of the 1970's as the importance of manufacturing and service sectors increased. By 1978 the number of persons working in agriculture had declined to 47,000, or 23 percent of the working population, declining further to 20.7 percent in 1979 and 15.8 percent in 1987 (Solsten 1991). Agriculture's share of GDP also declined from 17.3 percent 1976 to 10.7 percent in 1979 and 7.7 percent in 1988 (Solsten 1991).

In addition to macroeconomic considerations, small-scale organic agriculture provides rural employment, maintaining village life and population levels in rural regions, and relieving urban crowding (Solsten 1991). As such, a return to small-scale organic agriculture from which organic meals for children could be sourced would have far reaching, positive economic impacts as well in addition to the environmental services and benefits outlined later in this report.

Analysis #2 (intervention outcome: adulthood type II diabetes prevention)

According to the Institute for Health Metrics and Evaluation (IHME), the annual age-standardized YLL in Cyprus due to diabetes was estimated to be 464.2/100,000 people. Based on a population of 854,800 (CENSUS data), this equates to 3968 YLL from T2D annually in Cyprus (IHME, 2018).

The T2D national prevalence in Cyprus was estimated to be 9.2% for those 18 years old and over in a representative Cypriot population sample of about 1000 adults (Andreou et al., 2017). The number of individuals 20 and over was 665,100 (Census data, ESS).

Incidence, I = (# of individuals over 18 yrs. old) x (prevalence rate of T2D)

I = (665,100) x (0.092) = 61,189

$YLD = I \times DW \times L$

$YLD = 61{,}189 \times 0.033 \times 13.6$

$YLD = 27{,}461$

That is, 27,461 life years are lived with disability in Cyprus due to treated T2D.

$DALYs = YLL + YLD$

$DALYs = 3{,}968 + 27{,}461$

DALYs at stake annually in Cyprus due to T2D = 31,429

Number of obese adults in Cyprus = 665,100 adults (age 20 and over) X 25.5% (obesity rate) = 169,600 (WHO 2013)

$$\text{Adults who would develop T2D without the intervention} = \text{Number of obese adults} \times \text{\% of obese that would develop T2D}$$

$$\text{Adults who would develop T2D without the intervention} = 169{,}600 \times 9.3\% \text{ (Witters and Liu, 2017)}$$

$$\text{Adults who would develop T2D without the intervention} = 15{,}773$$

$$\text{DALY per adult who developed T2D without the intervention} = \frac{\text{Total DALY}}{\text{Adults who would develop T2D without the intervention}}$$

$$\text{DALY per adult who developed T2D without the intervention} = \frac{31{,}429}{15{,}773} = 1.99$$

The DALY per obese adults who would develop T2D without the intervention was 1.99 disability-adjusted life years. The total cost of providing the intervention (2 meals per day, 5 days per week, 9 months) for 12 years was calculated to be €23,112/child. The total cost of the organic treatment intervention per DALY averted per child participating in the intervention was calculated to be 23,112/1.99 = 11,614 euros.

Based on these calculations, therefore, it costs approximately €11,614 to avert the loss of one disability-adjusted life year using this intervention.

The Commission on Macroeconomics & Health and the World Health Organization 's intervention programme called WHO-CHANGE have proposed a standard of 3 times Gross National Income (GNI) per head per DALY averted as being cost-effective. The GNI in PPP dollars was $33,609 in 2017 or €28,741 for Cyprus; thus, 3 X GNI = 3 X €28,741 = €86,223. Thus, the proposed organic treatment intervention for primary school children is a highly cost-effective intervention based on the criteria by the WHO-CHANGE program.

Discussion

Data from the largest global children's trial intervention on organic diet treatment (ORGANIKO LIFE+, Makris et al., 2019) revealed significant reductions in z-scores of sex and age standardized BMI. However, because of the nature of typical non-pharmacological intervention, it is often not clear which specific biological components of the intervention may be charged with the observed effect outcomes. Thus, it was unclear why the organic diet treatment resulted in significant weight loss among the participants. Energy intake during the conventional period was reported to be higher (2200 calories/day) than the recommended reference levels (2000 calories/day) which could partially explain the weight loss during the organic phase. In addition to the weight loss explanation, children in the study had significantly lower urinary metabolite levels of exposure to both pyrethroid and neonicotinoid pesticides. Evidence accumulated in the literature regarding the effects of exposures to neonicotinoids (e.g., imidacloprid) on potentiating lipid accumulation in adipocytes and significantly increasing expression of a key regulator of adipocyte differentiation and key regulators of lipogenesis; such evidence hints towards the involvement of imidacloprid in altered adipogenesis, resulting in increased fat accumulation. (Park, et al. 2013) Likewise, data suggest that oral exposure to permethrin (a ubiquitous pyrethroid pesticide) may be associated with obesogenesis, linked to altered lipid metabolism and voluntary activities in mice. (Xiao, et al. 2015)

The literature points to an increase of 0.25 percentage points in obesity prevalence for each percentage point increase in the household availability of ultra-processed foods, defined as industrial formulations which, besides salt, sugar, oils and fats, include substances not used in culinary preparations, in particular additives used to imitate sensorial qualities of minimally processed foods and their culinary preparations (Monteiro, et al. 2018).

In Cyprus, about 20.1% of all household food purchases are considered to be ultra-processed (Monteiro et al., 2018). While this percentage seemed to be lower than that of Ireland, the UK, Belgium, Germany, Austria, Poland, Lithuania, Latvia, Finland and Malta, the rate is on par with Slovakia, Hungary and Spain rates, while Greece, Italy, France, Portugal and Croatia have lower rates. (Monteiro, et al. 2018) Interestingly, Cyprus, Greece, Italy, Malta, San Marino and Spain, have higher childhood obesity rates (approximately 1 in 5 boys, ranging from 18% to 21%),while Denmark, France, Ireland, Latvia and Norway are among the EU countries with the lowest rates, ranging from 5% to 9% in either sex (COSI 2018). This only perplexes the issue of childhood obesity further, however, regardless of the reason for the weight loss in the intervention trial by Makris et al. (2019), the benefit was clear. Additional economic and environmental benefits from locally-sourced, organic meals also exist which will be discussed later in this report.

The literature suggests an association between weight loss and disease reduction risk including a lower risk of T2D, hypertension and cardiovascular disease (Wing, et al. 2011). Analysis of prospective data from a questionnaire-based study of 43,457 overweight, never-smoking US white women aged 40–64 indicated that intentional weight loss among women with obesity-related conditions was associated with decreased premature mortality. Among these women (*n*=15069), intentional weight loss of any amount was associated with a 20% reduction in all-cause mortality, primarily due to a 40–50% reduction in mortality from obesity-related cancers; diabetes-associated mortality was also reduced by 30–40% in those who intentionally lost weight. However, among women with no pre-existing illness (*n*=28388), the association was somewhat more equivocal.

Additionally, it was difficult to estimate how significant the impact would be when dietary patterns of an entire generation of children is shifted. As an example, in 1960 the prevalence of childhood overweight and obesity ranged from 4-9% in developed nations (Hruby, Hu 2015) and adherence to the 'Mediterranean diet' in the region in the 1950's and 60's was near universal. The traditional Mediterranean diet as theoretically considered in Cyprus is based mainly on plant sources such as vegetables, fruits, whole grains, legumes and seeds. Fish and poultry are consumed weekly and dairy products daily, in low to moderate amounts, with an emphasis on fish. The primary source of fat intake is from olive oil and meals are accompanied by moderate amounts of wine (Kyriacou, et al., 2015).

The shift away from this Med diet and other traditional diets over the last 50 years has led to the current 30% global average for child overweight in developed nations (Hruby and Hu 2015).

Therefore, feeding children a locally (Mediterranean) produced, organic diet for the duration of their primary school years would presumably shift the childhood overweight rate back towards the background rate of <10% in the 1990s; however, this statement may be unstable with a large uncertainty associated with it. Likewise, because childhood overweight and obesity is a significant risk factor for adult obesity, a shift in the childhood overweight prevalence will impact adult obesity prevalence (Ward et al., 2017).

One study found that 30% of overweight youth who receive treatment are no longer obese in late adolescence or early adulthood. (Epstein et al., 1994) Using this assumption, if there are 142,600 Cypriot children aged 5-19 years, then 42,780 are expected to be overweight (30% prevalence), based on the global average value of childhood overweight percentage estimate in developed countries, Hruby and Hue, 2015).

142,600 x 0.30 = 42,780

If all children receive the organic treatment intervention, then 30% (Epstein et al., 1994) of those overweight children (12,834) would be expected to no longer be so by late adolescence or early adulthood.

42,780 x 0.30 = 12,834 (or a 9% reduction in the rate of adolescent/early adult obesity)

The cost for this rate reduction is 142,600 children x 2 meals/day x 5 days/week x 52 weeks/year x €5.35/meal = €275 million annually.

One of the determinations of cost-effectiveness is society's willingness to pay. Based on that measure, this intervention is deemed cost-effective as a survey found that New York State residents would be willing to pay US$690.6 million (€587.8 M) in additional taxes annually to reverse the epidemic of childhood obesity (Cawley, 2008).

Additionally, costs of feeding children could be offset by the family paying €2 per day (€6,240 over 12 years) for a cost of €27,144 per student to the government over a 12-year period. The Italian lunch program referenced earlier, offset the costs of the daily meal by having parents contribute €3.85 for each meal while the government contributed €1.50.

The second analysis of this report focused on the cost effectiveness of the proposed organic treatment intervention per DALYs of type 2 Diabetes averted. Adiposity and intra-myocellular lipid accumulation are the primary risk factors in the development of insulin resistance and type 2 diabetes. (Krssak et al., 1999) Therefore, preventing or reversing overweight and obesity, could substantially reduce the incidence and prevalence of T2D.

Diabetes is the source of a global pandemic with major public health and economic implications. The Global Burden of Disease 2010 (GBD) study series published in the Lancet covered all causes of morbidity and mortality in all age groups in 197 countries. The series revealed that T2D is the biggest endocrine driver for GBD and led to over 12 million deaths in 2010, a 92.7% rise over the 1990 figure of 6,65,000 for lost lives. This percentage rise is one of the steepest for any disease, with the notable exceptions of Human Immunodeficiency virus (HIV), Alzheimer's disease, Parkinson's disease, atrial arrhythmias, and peripheral vascular disease. While T2D does not account for all-cause NCD mortality, poorly controlled T2D is certainly a strong contributor to deaths from other causes such as ischemic heart disease, cerebrovascular disease and chronic kidney disease (CKD) (Jaikrit, Bhutani 2014).

Like obesity, pyrethroid pesticides have been associated with an increased risk of abnormal glucose regulation in factory workers exposed to such pesticides (Wang, et al. 2010) and also in mice exposed to neonicotinoids (Park, et al. 2013) Again, whether this organic treatment intervention reduces diabetes risk via obesity and overweight reversal or reduction, or via pesticide exposure reduction or some yet unknown symbiotic relationship, it was demonstrated that this was a cost-effective intervention based on the standard of 3 times Gross National Income (GNI) per head per DALY averted as being cost-effective.

In this analysis, the total cost was calculated based on the school system providing organic meals 2 times per day, 5 days per week for the duration of primary school (12 years). While this may seem like an unrealistic intervention, the organic phase of the study was designed to feed children 5 organic meals per day for 40 days. As such, the Cost/DALY calculation had to be consistent with the study design for accuracy.

Ecosystem Services and Organic Agriculture Production and Sustainability

It is well recognized that climate change will adversely affect the quality of life of the people living in Mediterranean basin. The majority of the available studies, projects that the climatic conditions over the Mediterranean region will be increasingly drier and warmer (Mariotti et al., 2008). This phenomenon is expected to be more severe during summer in Eastern and Western Mediterranean regions (Giorgi et al., 2008; Gao et al., 2008). The increase of temperature and reduced precipitation increases the threats for agriculture while at the same time creates environmental challenges that have to be faced. The agricultural model implemented globally during the 20th century created risks and challenges that have to be tackled. Monocultures, deforestation, uncontrolled use of pesticides are common practices in the Mediterranean countries resulting in a substantial loss of ecosystem services. Most of these environmental consequences have been derived from arable land that comprises 12% of the global land cover (FAO Stat online database).

It is evident that the large-scale design and implementation of sustainable agricultural systems are unavoidably the approach for meeting the challenge of feeding a growing global population, while securing environmental performance and provided ecosystem services. For example, the implemented agroecology practices and methods should substantially increase crop yields and quality without increasing the negative environmental impacts of agricultural activities. Organic farming can meet these criteria since it is “a holistic production management (whose) primary goal is to optimize the health and productivity of interdependent communities of soil, life, plants, animals and people”. Anticipated ecosystems services benefits are those associated with sourcing food that is produced locally and organically, providing indirect and positive health impacts through climate change mitigation and improvement of environmental degradation. Human diets contribute to climate change and environmental degradation through food choice and its production (HCWH, 2017).

Ecosystems Services impacts from Food Type and Production Method

Conventional agriculture is characterized as intensified agriculture utilizing large synthetic inputs that include fossil gas-based nitrogen fertilizers and petrochemical-based pesticides and herbicides in large areas of monocultures. This type of agricultural intensification could jeopardize many of the ecosystem services provided within an agricultural ecosystem. (Matson *et al.* 1997). Simplification of landscape structure that results from land use change (conversion from natural land to agricultural land), leads to loss of field margin vegetation and elimination of natural habitat and, therefore, (Robinson & Sutherland 2002) higher levels of pest damage and lower populations of predatory insects that are natural enemies of these pests (Brewer *et al.* 2008; Gardiner *et al.* 2009; O'Rourke 2010). Agricultural intensification also threatens groundwater and surface water quality due to increased amount of leaching and surface runoff of nutrients, agrochemicals and dissolved nutrients (Dale & Polasky 2007).

(i) Biological Pest Control and Pollination

Pest control in agroecosystems can be supported by natural ecosystems as natural habitats provide the resources required for predatory insects and parasitoids, insectivorous birds and bats, and microbial pathogens that act as natural enemies to agricultural pests, reducing the need for pesticides (Tscharntke *et al.* 2005). Pollination is another ecosystem service to agriculture that is often provided by pollinators living in natural habitats and interacting with agricultural landscapes. Analysis of data from 200 countries indicated that 75 percent of crop species of global significance for food production rely on animal pollination, primarily by insects (Klein *et al.* 2007) and of the most important animal-pollinated crops, over 40 per cent depend on wild pollinators and domesticated honeybees. According to the United Nations Food and Agriculture Organization (FAO) the consequences of a complete loss of pollinators would be linked with a reduction in total global agricultural production of about 3–8%. (FAO 2003)

Pollinator numbers are in decline and neonicotinoids, a class of insecticides introduced to the agricultural market in the early 1990s, have become particularly suspect culprits. As suc, the European Commission recently banned 4 neonicotinoids in attempts to support pollinators. Debate remains over the extent to which these specific insecticides contribute to pollinator collapse, especially as other fungicides and insecticides have also been associated with poor colony health. (Traynor et al. 2013)

The critical question is whether the loss of pollination services could jeopardize world food supply. A study by Gallai *et al*. (2009) concluded that a setting of complete loss of pollinators, overall production would keep pace with consumption allowing for sufficient total caloric intake however, it would result in a global deficit of fruits, vegetables and stimulants (coffee, tea, cacao) leading to market disruptions and nutrient deficiencies.

(ii) Soil and Water

Soil sustainable management is a prerequisite to enhance agroecosystem productivity and food quality. Indeed, this is extremely important both in areas where productivity and food security issues are emerging and also in areas where environmental issues are concerned. The business as usual scenario could not be an option for soil resource management and novel toolbox and practices should be developed and implemented. The adoption of organic farming practices could be an alternative for a sustainable management of soil resources. Several studies demonstrated that the implementation of suitable practices of organic farming systems promote soil fertility and health due to versatile crop rotations, reduced application of synthetic chemical fertilizers and the absence of pesticides (Marinari et al., 2006; Birkhofer et al., 2008; Fliebach et al., 2007). Data from the National Soil Project revealed that soil organic matter (SOM) sequestration was higher in soils from organically managed farms as compared to conventionally managed farms across the United States (mean % SOM of 7.37 for conventional farm samples and 8.33 for organic samples) (Ghabbour et al., 2017). These findings were further supported from the results of ORGANIKO LIFE+ project monitoring program. In particular, our findings indicated that in barley fields the management system doesn't affect the chemical and physical characteristics of the soil meaning that the practices implemented in organic farming fields did not promote soil fertility (Table 1). However, there is an increasing trend of organic C in the fields despite its high variability. This is related to the application of organic amendments and the inclusion of green manures in the rotational scheme that some farmers adopted in their farming practices. On the contrary, in apple orchard soils organic farming had a significant effect on specific soil fertility indicators (Table 2). In effect, soil organic carbon, nitrogen-nitrate ions, as well as total nitrogen were higher in organic apple orchards soils. The higher values noticed are related to the different nutrient management system implemented. Farmers in organic farming apple orchards used manures and they did not use herbicides to control annual weeds. Instead, during spring and early summer, weeds were incorporated into the soil to reduce water competition. This practice increased easily decomposable organic matter creating therefore a substantial pool of easily available nitrogen forms, like nitrates and organic carbon.

Table 1. Three-year soil mean parameters examined in LIFE+ORGANIKO project in fields cultivated with barley as a main crop in the rotation scheme under organic farming plots (n=14) and under conventional farming (n=21).

	Barley					
	2015-2016					
	Conventional			**Organic**		
	Mean	**SD**	**CV (%)**	**Mean**	**SD**	**CV (%)**
pH	7.902 a	0.211	2.7	7.967 a	0.221	2.8
EC (dS/m)	2.441 a	0.330	7.4	2.319 a	0.214	6.3
Moisture	3.678 a	1.210	32.9	3.775 a	1.325	35.1
TKN (%)	0.163 a	0.023	14.1	0.174 a	0.011	6.3
N-NO_3 (ppm)	37.302	17.92	48.0	35.775	16.928	47.3
N-NH_4 (ppm)	0.111 a*	0.491	442.3	2.345 b**	3.693	157.5
P-Olsen (ppm)	42.034 a	21.23	50.5	56.38 a	11.23	19.9
$CaCO_3$ (%)	23.03 a	11.123	48.3	18.69 a	10.98	58.7
Organic C (%)	0.834 a	0.105	12.6	0.855 a	0.126	14.7
	2016-2017					
pH	8.19a	0.23	2.81	8.01a	0.24	2.99
EC (dS/m)	0.43a	0.22	51.1	0.49a	0.24	48.9
Moisture	3.83a	2.01	52.5	3.45a	1.78	46.4
TKN (%)	0.19a	0.08	42.1	0.21a	0.06	28
N-NO_3 (ppm)	68.25a	2.35	3.44	15.36b	1.87	12.1
N-NH_4 (ppm)	12.35a	0.58	4.69	24.56a	0.87	3.54
P-Olsen (ppm)	40.96a	1.69	4.13	57.71b	2.17	3.76
$CaCO_3$ (%)	29.24a	19.7	67.3	32.02a	20.37	63.61

Organic C (%)	1.46a	0.17	11.6	1.72a	0.11	6.39
	2017-2018					
pH	8.09a	0.21	2.60	8.08a	0.32	3.96
EC (dS/m)	0.42a	0.33	78.57	0.47a	0.57	121.28
Moisture	3.57a	2.08	58.26	3.68a	2.02	54.89
TKN (%)	0.16a	0.04	25.00	0.25a	0.08	32.00
N-NO_3 (ppm)	61.35b	3.58	5.84	24.87a	2.81	11.30
N-NH_4 (ppm)	10.48 a	0.98	9.35	35.26b	1.35	3.83
P-Olsen (ppm)	38.35 a	2.58	6.73	61.87 b	5.84	9.44
$CaCO_3$ (%)	31.20a	18.47	59.20	31.02 a	21.79	70.25
Organic C (%)	1.35 a	0.08	5.93	2.14 a	0.47	21.96

Table 2. Three-year soil mean data for the parameters examined in LIFE+ORGANIKO project in apple orchards under organic farming plots (n=8) and under conventional farming (n=7).

	Apple orchards					
	2015-2016					
	Conventional			**Organic**		
	Mean	**SD**	**CV (%)**	**Mean**	**SD**	**CV (%)**
pH	7.187a	0.95	11.7	7.49a	0.342	4.6
EC (dS/m)	1.395a	0.065	4.7	2.32b	0.154	6.6
Moisture	4.236 a	0.52	12.3	3.73 a	0.954	25.5
TKN (%)	0.201 a	0.014	7.0	0.310 b	0.024	7.7
N-NO$_3$ (ppm)	46.001 a	4.25	9.2	63.19 b	6.31	10.0
N-NH$_4$ (ppm)	0	0	0	2.5*	7.070	282.8
P-Olsen (ppm)	72.35 a	29.32	40.5	79.01 a	62.05	78.5
CaCO$_3$ (%)	3.056 a	0.984	32.2	19.890 a	21.384	107.5
Organic C (%)	0.911 a	0.160	17.6	1.538 a	0.252	9.9
	2016-2017					
pH	7.33 a	0.93	12.69	7.55 a	0.79	10.46
EC (dS/m)	0.53 b	0.31	58.49	0.37 a	0.26	70.27
Moisture	5.96	1.82	30.54	5.2	2.59	49.81
TKN (%)	0.53	0.36	67.92	0.24	0.11	45.83
N-NO$_3$ (ppm)	112.25	5.35	4.77	17.36	3.02	17.40
N-NH$_4$ (ppm)	12.47	0.54	4.33	35.98	5.26	14.62
P-Olsen (ppm)	96.85	64.91	67.02	70.00	47.71	68.16
CaCO$_3$ (%)	13.97	15.59	111.60	17.32	18.71	108.03
Organic C (%)	1.24	0.15	12.10	3.44	0.11	3.20
	2017-2018					
pH	7.35a	0.68	9.25	7.62a	0.94	12.34
EC (dS/m)	0.52a	0.29	55.77	0.39a	0.25	64.10

Moisture	4.87a	2.01	41.27	5.39a	1.87	34.69
TKN (%)	0.42a	0.25	59.52	0.34a	0.12	35.29
N-NO_3 (ppm)	132.58b	9.84	7.42	87.14a	11.25	12.91
N-NH_4 (ppm)	29.68a	11.47	38.65	52.47b	8.14	15.51
P-Olsen (ppm)	108.54b	8.49	7.82	63.47a	5.78	9.11
$CaCO_3$ (%)	13.95a	15.84	113.55	17.55a	16.25	92.59
Organic C (%)	1.03a	0.21	20.39	3.54b	0.18	5.08

Organic soils also sequester more water. The presence of humic substances such as fulvic and humic acids allow the soil to hold more water. Organic soils have a higher average percentage of fulvic acid (0.65) as compared to conventional soils (0.26) and humic acid (4.1 for organic; 2.85 for conventional). Mean percentage humification (i.e., sequestration) was 45.6 for conventional soils and 57.3 for organic soils (Ghabbour et al. 2017). This is particularly important because with climate change, increased variability of rainfall is predicted to lead to greater risk of drought and flood, while higher temperatures will increase water demand (IPCC 2007). Consideration of this soil sequestered water (green water), changes significantly the predictions about water availability in 2050. When only blue water (fresh surface and groundwater) is taken into account, more than six billion people are predicted to experience water shortages in 2050 however, this number drops to about four billion when both blue and green water availability is taken into account (Rockström *et al*. 2009). On-farm management practices that increase SOM and thus green water, can significantly alter water shortages (Rost *et al*. 2009).

(iii) Emissions of greenhouse gases

Agricultural activities are estimated to be responsible for 12–14% of global anthropogenic emissions of greenhouse gases, not including emissions that arise from land clearing (US-EPA 2006; IPCC 2007). Land-use change is the largest global cause of CO2 emissions, second only to burning fossil fuel for energy production. Some of this change is driven by conversion of natural landscapes to agriculture. This conversion leads to both above-ground carbon losses due to deforestation or other land clearing, and losses in soil carbon by as much as 50% and 75% in temperate and tropical regions, being over 50–100 years and 20–50 years, respectively. (Lal 2008*a*). This is confirmed by data from the LIFE+ORGANIKO project referenced above. Lab studies demonstrated that using composted organic matter reduces substantially N2O emissions while type of organic amendment determines also the emission rates and accumulation (Christodoulou et al., 2018; Anastopoulos et al., 2018). In particular, the application of compost in a microcosm study in a typical Cyprus soil under optimum water conditions (70% of the water holding capacity) had no effect on cumulative N2O emissions compared to soils treated with chemical fertilizers and plant residues (Table 3). In a similar study, it was demonstrated that ammonium nitrate stimulated N2O emissions from while citrus industry residues not (Figure 1).

Table 3. Cumulative N-N_2O emissions (μg/m^2) in a typical Cyprus soil treated with nutrient management practices a microcosm study. Different letters denote statistically significant differences between the means (n=5) at p=0.05

	Cumulative N-N_2O emissions (μg/m^2)
Control	8.39 a
Compost (CMP)	5.47 a
Ammonium Nitrate	266.17 c
Chickpea residues (GM1)	267.10 c
Chickpea residues (GM2)	21.63 b
ANOVA effects	
Treatment	***

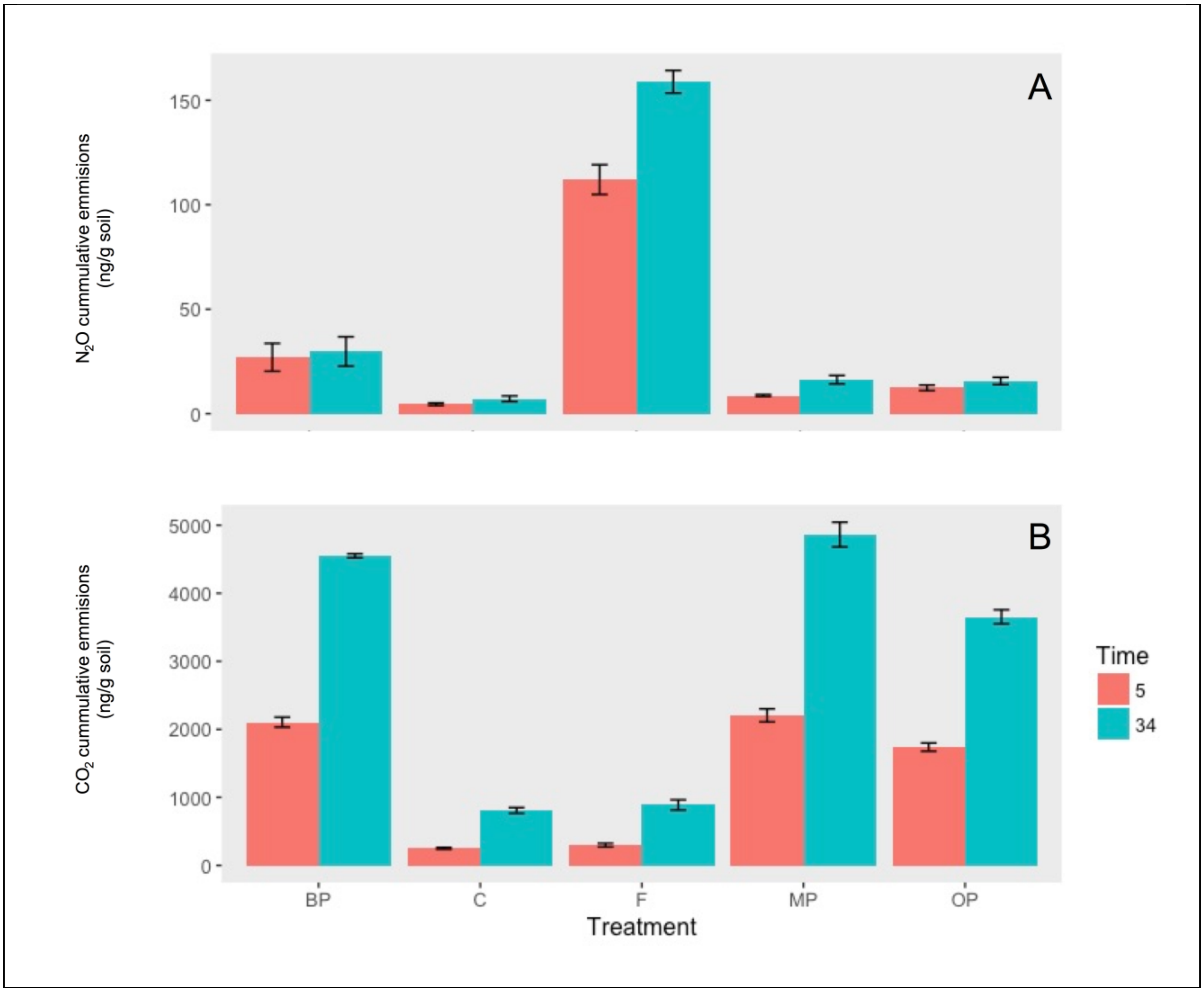

Figure 1 Cumulative N2O and CO2 emissions during time (5 and 34 days) from the different treatments: non-treated (Control) and treated soils with fertilizer (F), banana (BP) mandarin (MP) and orange peels (OP). Spreads in the bar plots denote standard error of the mean (n=3).

Agriculture is responsible for approximately 49 percent of global anthropogenic emissions of methane (CH4) and 66 percent of global annual emissions of nitrous oxide (N2O). (FAO 2003), N2O emissions occur naturally as a part of the soil nitrogen (N) cycle, but is often applied through the use of inorganic fertilizers and animal manure at levels higher than can be taken up by the plants. This leads to a significantly increased rate of gas emissions. Globally, only 50 percent of N applied as fertilizer is taken up by the crop, the rest being lost as N2O emissions (25%) and washed into waterways (20%). Only 2–5 percent is stored as soil N. (Galloway *et al.* 2004). In addition to direct N2O emissions, the production of synthetic nitrogen fertilizers is an energy-intensive process that produces additional greenhouse gases. Agricultural practices can effectively reduce or offset agricultural greenhouse gas emissions through a variety of processes (Drinkwater & Snapp 2007; Lal 2008*a*; Smith *et al*. 2008). A white paper, Regenerative Organic Agriculture and Climate Change: A Down-to-Earth Solution to Global Warming, also from the Rodale Institute, states that through regenerative organic agriculture which includes practices (at a minimum) such as perennialization of crops, leguminous cover crops to reduce the use of synthetic nitrogen fertilizers, residue mulching and composting, crop rotation to reduce degradation of subsurface carbon, and conservation tillage to conserve soil carbon, more than 40% of current annual CO2 emissions could be sequestered. If, at the same time, all global pasture was managed to a regenerative model with more effective manure management, an additional 71% could be sequestered, passing the 100% mark and contributing to a drawing down of excess greenhouse gases, helping to reverse the greenhouse effect. (Rodale 2014) (Drinkwater & Snapp 2007) (Lal 2008*a*). Another study found that conventional agriculture is responsible for 40% more greenhouse gases than organic agriculture and that soils from organic farms have 26% more potential for long-term carbon storage (carbon sequestration) than soils from conventional farms, along with 13 percent more soil organic matter (SOM) (Ghabbour et al. 2017).

Food choice also has a significant impact on greenhouse gas emissions. (Tables 2 and 3) The current (2013) average per capita global annual meat consumption is 43 kg and for dairy it is 85 kg. In order to avoid dangerous warming, consumption rates must fall from 43 kg to 22 kg by 2030, and then to 16 kg by 2050 for meat and from 85 kg to 57 kg by 2030 and to 33 kg by 2050 for dairy to avoid dangerous warming. For reference, the average annual per capita meat and dairy consumption currently resides at 115 kg and 255 kg for meat and dairy in the U.S and at 85 kg and 260 kg for meat and dairy in Western Europe. (Greenpeace 2018)

Additionally, in order to meet rising demand of meat, production has shifted from pasture-based systems to confined systems (CAFOs- Concentrated Animal Feeding Operations). This presents a greater risk to water quality because of both increased volume of waste and likely contaminants (e.g., antibiotics and other veterinary drugs) that may have both environmental and public health importance. It is generally accepted that livestock waste management practices in CAFOs do not adequately or effectively protect water resources from contamination with excessive nutrients, microbial pathogens, and pharmaceuticals present in the waste. Impacts on surface and groundwater sources and wildlife have been documented in many agricultural areas in the United States with potential impacts on human and environmental health from long-term inadvertent exposure to water contaminated with pharmaceuticals and other compounds are a growing public concern, including antibiotic resistant infections. (Burkholder 2007)

Research findings from the Institute for Agriculture and Trade Policy suggested that together, the world's top five meat and dairy corporations are now responsible for more annual greenhouse gas emissions than Exxon, Shell or BP; it is expected that by 2050, global GHG emissions must be reduced by 38 billion tons to limit global warming to 1.5 degrees Celsius, and If emissions reductions in all other sectors follow that path while the meat and dairy industry's growth continues as projected, the livestock sector could consume 80% of the allowable GHG budget in just 32 years (IATP 2018).

Similarly, project findings from the Johns Hopkins Center for a Livable Future showed that if global trends in meat and dairy intake continue, global mean temperature rise will more than likely exceed 2° C, even with dramatic emissions reductions across non-agricultural sectors. Immediate and substantial reductions in wasted food and meat and dairy intake, particularly ruminant meat (e.g., beef and lamb), are imperative to mitigating catastrophic climate change (Kim et al. 2015).

(iv) Nutrient Cycling and Pollution

Organic systems also do not rely on pesticides (herbicides, insecticides, fungicides, etc.), many of which are toxic to humans and animals, or synthetically produced nitrogen fertilizers. Numerous studies have begun to capture the true extent of how low-level exposure to pesticides and nitrate pollution of surface water could be quietly causing serious health problems in our population and ecosystems services (HCWH 2017).

The two nutrients that most impact natural and agricultural ecosystems in terms of both degradation and production are nitrogen and phosphorus. Both are also heavily applied in agroecosystems and as a result, have greatly increased the amount of new nitrogen and phosphorus in the biosphere and have had complex, often harmful, effects on natural ecosystems (Vitousek *et al.* 1997). As stated earlier approximately 20 percent of N fertilizer applied in agricultural systems moves into fresh and groundwater systems, (Galloway *et al.* 2004) increasing groundwater pollution and nitrate levels in drinking water and eutrophication leading to increased frequency and severity of algal blooms, hypoxia and fish kills, and 'dead zones' in coastal marine ecosystems (Bouwman *et al.* 2009).

Common practices in organic agriculture such as cover cropping reduces standing pools of nitrate, reducing loss. Other good management practices include, legume intensification for biological nitrogen fixation and phosphorus-solubilizing properties, and diversifying crop rotations. This integrated management can reduce the need for surplus fertilizer application (Drinkwater & Snapp 2007).

Applications of agricultural pesticides and nutrients result in loss of biodiversity and degrades surface and groundwater provisioning ecosystems services but they also can have significant direct human health impacts. More than 17,000 pesticide products for agricultural and non-agricultural use are currently on the market and exposure to these chemicals has been linked to brain/ central nervous system disruption, breast, colon, lung, ovarian, pancreatic, kidney, testicular, and stomach and other cancers (Rodale 2012).

Atrazine, the second most commonly used pesticide in the U.S., was the most commonly detected pesticide contaminating drinking water in the United States as of 2001. (Gilliom, et al. 2001) Levels often the maximum contaminate level set by the EPA for drinking water and concentrations in all conventional samples exceeded 0.1 parts per billion, a concentration that has been shown to produce deformities in frogs due to its endocrine disrupting nature. (Rodale 2012) Additionally, Atrazine exposure at time of conception has been linked to lower math and reading skills in children. (Rodale 2012).

Organophosphates in the urine of children can be as high up to 14 parts per billion which resolves when they were put on an organic diet. (Rodale 2012) However, these chemicals can remain in the environment for prolonged periods of time. Pesticides (including ones that have been banned for years) have been found in breast milk and umbilical cord blood. (Rodale 2012) Additionally, inactive ingredients in herbicide and pesticide brands have been found to be just as toxic, if not more so, than the active ingredients, and these ingredients aren't tested for human health impacts before being released. (Rodale 2012)

The most commonly used pesticide in the U.S. is glyphosate. Glyphosate-based herbicides, currently legal in our food at low levels, have been shown to cause DNA damage, infertility, low sperm count, and prostate or testicular cancer in rats. (Rodale 2012) Farmworkers are at an increased risk of acute pesticide poisoning and other pesticide-related illnesses, including some cancers; nervous system and reproductive disorders; and respiratory, skin, cardiac, liver, and kidney conditions. (Fitch et al. 2017) Glyphosate has been classified as "probably carcinogenic to humans" by the International Agency for Research on Cancer. In August of 2018, Monsanto was ordered to pay US$289 million to a groundskeeper with Hodgkin's lymphoma after a successful lawsuit based on this IARC premise. (Consumer Safety 2018) Residents living in proximity to industrial crop farms with high pesticide use are also at risk for many of these harms and (Harrison 2011) and children are especially sensitive to such pesticide exposure (Garry 2004) (Eskenazi et al. 1999).

Glyphosate has also been implicated in Celiac disease and non-celiac gluten sensitivity (gluten intolerance) which are associated with imbalances in gut bacteria that can be fully explained by the known effects of glyphosate on gut bacteria. (Samsel, Seneff 2013).

The use of certain pesticides has been implicated as a threat to other non-target organisms including birds, amphibians, aquatic organisms, and beneficial insects— especially pollinators (Horrigan 2002) (DeLorenzo 2001). Pesticides are one of the contributors to the rapidly declining populations of pollinators, threatening future food security given that 75% of crops worldwide depend on insect pollination (mostly by bees). (Potts et al. 2010) Theories have been put forward that chronic, sub-lethal pesticide exposure may compromise the health of individual bees, and ultimately lead to lethal impacts on colonies already weakened by disease. (Potts et al 2010) (Desneux, 2007).

The heavy use of agricultural fungicides has also been implicated in the rise of fungal resistance to anti-fungal medicines (through a similar mechanism as the development of antibiotic resistance), which has particularly serious consequences for immune-suppressed individuals. (McKie 2016).

Excess levels of nitrate in drinking water have been associated with birth defects following prenatal consumption (Brender 2013), blue baby syndrome, and with certain types of cancer among adult consumers (stomach, colorectal, non-Hodgkin lymphoma, thyroid, ovarian) (Gulis 2002) (Inoue Choi M, et al. 2015). Reactive nitrogen released into the lower atmosphere increases smog, particulate matter, and ground- level ozone pollution, which cause respiratory illnesses, reduced lung function, and premature deaths.

It's unclear whether or not chronic, low-level exposure to pesticides through conventionally-produced food consumption poses risks to health (Smith-Spangler, et al., 2010). However, it is theorized that there are possible synergistic and/or cumulative effects of consuming low-level amounts of multiple different pesticides, particularly those with a similar mechanism of action. (Curl et al. 2015) As such, limiting or avoiding pesticide exposure through food consumption or via use of insecticides at homes, yards and public space could potentially reduce health risks, until more data become available (HCWH 2017).

Conclusion

Providing organic meals to primary school children for the duration of their primary school years is cost-effective for diabetes and obesity prevention as well as having potential preventive benefits for certain types of cancer. Transition to organic diets (especially those that are mostly plant-based) and regenerative organic agriculture, has the potential to mitigate climate change and positively impact multiple ecosystems services.

It is evident that organic farming is an important agricultural system that is able to promote and sustain ecosystem functionality. The implementation of alternative nutrient management practices could reduce the emissions of greenhouse gases in arid and semi-arid areas. Indeed, organic farming through the reduction of external resources (i.e. nutrients and pesticides) could significantly alter soil functioning thereby increasing the biological activity and health of soils. Our findings through ORGANIKO denotes that the increase of agricultural land under organic farming scheme has the potential to improve soil fertility in the long term and substantially reduce GHG emissions for barley and apples.

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