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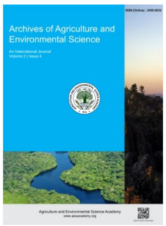

ORIGINAL RESEARCH ARTICLE

CrossMark

Assessment of vegetable production by adopting climate SMART agriculture technologies in Chormara, Nawalparasi district, Nepal

Sarthak Gaire* **and Shridhika Dahal**

Himalayan College of Agricultural Sciences and Technology, Kirtipur, Kathmandu, NEPAL
*Corresponding author' E-mail: sarthakgaire2020@gmail.com

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ABSTRACT

Vegetable production is an economic booster contributing around 9.71% to total Agricultural Gross Domestic Production. So, the research study was performed under the topic "Assessment of vegetable production adopting climate-smart agriculture technologies in Chormara, Nawalparasi district" from March- April 2021 to assess the production of selected vegetables i.e. Cucumber, Tomato, Bitter Gourd, Sponge Gourd, and Chilly adopting climate-smart agriculture technology among 100 households applying simple random sampling. The study revealed that 96% of the total respondents were being affected directly by the ongoing climate change and to tackle such scenario 88% of the total respondents were adopting climate SMART Agricultural technologies including mulching, drip irrigation, cultivation of vegetables under the semi-protected house, quality seeds, etc. to mitigate the negative impacts of climate change with increased crop production. To enhance the productivity of vegetables and meet the food security of the increasing global population, farmers were integrating organic and synthetic fertilizers to attain the sustainability of soil health. It was found that 76% of the surveyed farmers were going through market hindrances like lack of proper market, fluctuation in price structure, and poor marketing channel suggesting an immediate need for a proper marketing system in the study area. The highest net return of USD 17588.53 per hectare and B:C ratio of 5.88 in tomatoes illustrated economic viability in vegetable production. Although vegetable production and marketing in Chormara seem a profitable business, the study suggests an immediate need for adoption and scaling up of successful CSA practices, its extension and proper implementation along with the provision of effective marketing channel and setting of minimum prices for the vegetable products based on the cost of cultivation that may overcome the farmer's problems.

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INTRODUCTION

Agriculture is considered as in the context of Nepal a major economic driver providing approximately 65% of the country's employment and 30% of its gross domestic product comes from the agriculture sector (Agriculture and Food, 2020). Moreover, vegetable production encompasses 9.71% of total Agricultural Gross Domestic Product (GDP) (Karki, 2015). Vegetable farming in Nepal is not only the mainstay of its economy but also the way of life of rural farmers. However, the increasing concentration of CO_2 coupled with other greenhouse gases emission is causing climate change in the atmosphere affecting agriculture, forestry, human health, biodiversity, snow cover, and aquatic to mountain ecosystems. Evidence indicates that the climate in Nepal is already changing and the impacts are being felt in different regions (Karki and Gurung, 2012). The temperature has been increased by 1.8 °C during the last 32 years and the average temperature increase was recorded as 0.06°C per year (Malla, 2008). Global warming is now estimated to have severe impacts affecting agriculture, including temperature, precipitation, and glacial run-off (Funk *et al*., 2008; McCarthy *et al*., 2001). A study conducted by Nepal Climate Vulnerability Study Team (2009) revealed that the temperature is expected to increase by 0.5 - 2 °C in the year the 2030s and by 3 - 6.3°C in the year 22090s (Poudel, 2020). Since agriculture is climate dependent activity, it is going to be a victim of climate change through influences on crop yield and production to a great extent. The changing climatic situation has come up with multi-dimensional complications; crop failures, shortage of yields, reduction in quality through increasing pest and disease problems, etc. rendering vegetable cultivation unprofitable (Ayyogari *et al*., 2013). The alarming situation of climate change threatening the traditional way of farming necessities the creation of a sustainable agricultural approach to counter the impact of climate across the country (Malla, 2008). The surge of interest in climate change has now enhanced curiosity in agriculture in using climate SMART agriculture as a tool to counteract against it and at the same time improve soil properties and crop productivity. CSA is an applied arrangement of cultivating standards and practices that enhance profitability in an ecologically and socially supportable manner with an ability to manage the outcomes and effects of worldwide environmental change, protects natural resources thereby diminishing the consequences of climate change (Sullivan *et al*., 2013). So, by increasing the efficiency of available resources, a dynamic approach of CSA which guides the needed changes to ensure safeguard food security in the long term through making a significant contribution towards climate change mitigation is now mandatory. This is an approach to guide the management of agriculture in the era of climate change providing a possible solution that simultaneously addresses the issue of food security, climate change, and agricultural productivity (Kifle, 2021). It is one of the pioneer technologies which involves water SMART, market SMART, soil SMART and nutrient SMART technology and aids in maximum utilization of resources enhancing vegetable production qualitatively and quantitatively (Paudel *et al*., 2017).

As climate change is an emerging issue in the world which is one of the serious threats to agriculture and living security. At the same time, the Nepalese agriculture system is subsistence-dominated by small landholdings. More than 80% of the farmers have less than 0.5 hectares accounting for very few land holdings (CBS, 2011). This evidence suggested that there is a pressing need to provide adequate and effective knowledge on climate change issues to the rural farmers so that they acquire the expertise to impart Climate SMART Agriculture to build resilience to climate change and prioritize CSA technologies at different agro-ecological regions to develop climate-resilient agricultural systems in Nepal. Although studies and researches conducted on the production status of CSA are very limited in Nepal. So, this field-based study was undertaken to reveal facts regarding the real situation and status of vegetable production adopting CSA technologies by the farmers residing at Chormara which might be helpful in formulating plans, policies, and strategies for the improvement of the agricultural system of the country mobilizing modern technologies.

MATERIALS AND METHODS

Research description

The research was conducted at Chormara, Ward No. 6 and 8, Madyabindu which lies in Province-4 of Nawalparasi district of Nepal having geographical coordinates 27.35° North and 84.0° East. The climate of Chormara is sub-tropical with a low elevation of 180 masl. A total of 100 household respondents, 3 Focus Group Discussion (FGD), and 5 Key Informants (KI) of the proposed site were selected employing random sampling among the commercial farmers as a major source of information. The FGD was mainly done to check the reliability and validity of the collected information in the research. The primary source of information was obtained through personal observation, interview, and field survey through questionnaire along with a formal and informal discussion with the concerned farmers. Secondary information was collected through various published and unpublished sources such as journals, reports, books, internet, etc. For additional information, several concerned organizations such as Agriculture Knowledge Center (AKC) were contacted. The field survey was conducted from the 18th of March to the 10th of April, 2021.

Data analysis

Data entry and analysis were done by using the computer software package Microsoft Excel. Descriptive statistics like mean, percentage, and frequency were used to process the data. Analyzed data were then presented in tables, graphs, and figures as necessary. Socio-economic variables of the farmers were used for comparative descriptive analysis whereas economic variables to evaluate the comparative analysis of major 5 vegetables grown adopting Climate SMART Agriculture.

Comparative analysis of vegetable production

Cost of Production, Net returns, and Benefit-Cost ratio were considered as economic variables to evaluate the comparative analysis of major 5 vegetables grown adopting Climate SMART Agriculture. BCR is a ratio used in a cost-benefit analysis to summarize the overall relationship between the relative costs and benefits of a proposed project (Hayes, 2019). The value of return from the vegetable production was calculated based on the direct monetary value incurred at the local level. The B:C ratio was calculated using the following formula (Dhakal *et al*., 2019):

Benefit Cost Ratio (BCR)= Net returns/Total cost of production

Net returns = Price per unit of produced crop × Total quantity produced

Total cost = Total fixed cost + Total variable cost

RESULTS AND DISCUSSION

Effect of climate change

According to the respondents, climate change is affecting them in many ways. Changes in rainfall pattern, fluctuation in temperature, declining production, an infestation of pests and diseases, etc. were the major impacts of climate change in vegetable production thereby facing problems in making and livelihood improvement. The study revealed that 96% of the total respondents were getting affected personally by the impact of climate change and among them, 88% were in the favor of tackling climate change by adopting different CSA technologies like drip irrigation, mulching, tunnel plastics, etc. whereas 4% were totally unaware about the ongoing climate change. Along with the advancement of tools and technology farmers of Chormara were inclined towards CSA considering the impacts of climate change in agriculture. Climate change is also expected to increase the frequency of weather-related hazards including droughts and floods, etc. thereby affecting agricultural croplands and yields (Climate-Smart Agriculture in Nepal, 2017).

The study showed that most of the farmers had been adopting CSA technologies to cope up with the existing climate change and its impact on agriculture. However, there is still confusion on practices and technologies adaptation in Climate smart Agriculture among the farmers (Rijal and Rijal, 2019). Moreover, realizing the negative impacts of ongoing climate change 80% of the farmers residing in Chormara are at the stage of adopting agriculture as a primary source of earning through adaptation of CSA practices. The above finding is supported by the literature were approximately 65% of the country's employment and 30% of its gross domestic product comes from the agriculture sector (Agriculture and Food, 2020).

Adoption of climate SMART agriculture

The proposed study site revealed that the areas of CSA have been increasing every year by the positive impact of these technologies on crop production, increased yield, reduced cost of cultivation, and at the same time with the increasing global climate change. Water conservation principle using a drip irrigation system, mulching, tunnel plastics, shade net, tractor, insect net, etc. were adopted by 85%, 86%, 44%, 34%, 49%, and 52% respectively (Figure 1 and 3) among the respondents followed by change in planting dates, change of crop varieties, cultivation under plastic tunnel and rainwater harvesting (Figure 2). The above findings are in line with the findings where the introduction of water management, the introduction of legumes as cover crop, mulching and crop rotation are key innovations in climate-smart agriculture to cope with environmental stress without compromising crop yield (Gairhe and Adhikari, 2018). In support with the above finding, an experiment on irrigation method on water usage efficiency revealed that water usage was 73% lower in drip irrigation systems with increased yields of nutritionally dense fodder species during dry season (Jha *et al.*, 2016). The study area was supplemented with the

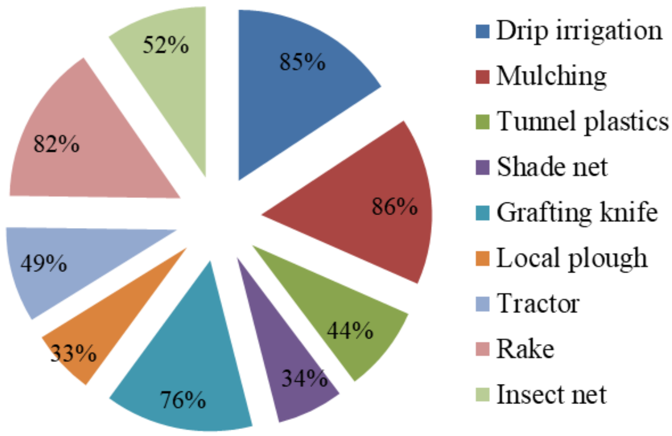

Figure 1. *Percentage of respondents holding farm assets adopting CSA in Chormara, Nawalparasi district.*

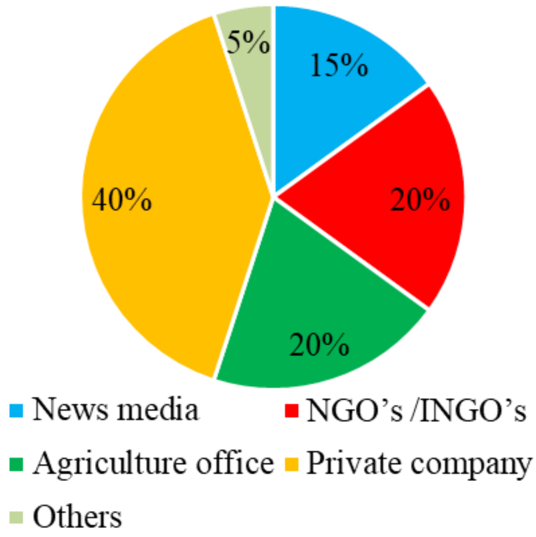

Figure 2. *Encouragement to adopt CSA in Chormara, Nawalparasi district.*

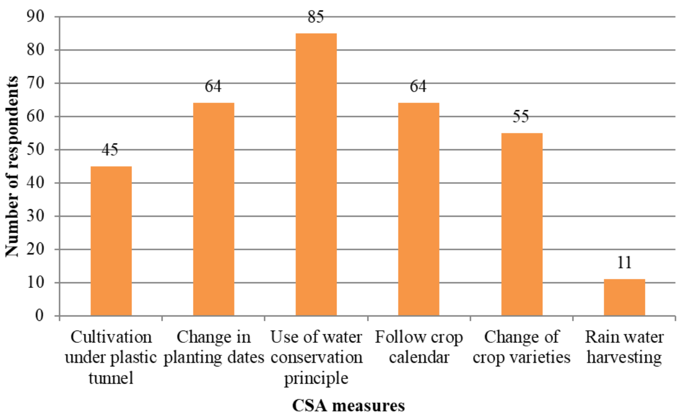

Figure 3. *Adoption measures of CSA adapted by the respondents in Chormara, Nawalparasi district.*

semi-protected house of about 12 m length and 6 m breadth constructed locally through the utilization of eco-friendly local resources i.e., bamboo. They also revealed that the utilization of local resources (bamboo) for the construction of the tunnel would minimize their economic burden for the construction, operation, and maintenance cost along with ecological sustainability.

The discussion held with KII and FGD even felt that there is a need to adopt CSA measures in a more scientific and systematic way to cope up with climate change and reduce its negative impact on agriculture. According to them, CSA technologies have been adopted by the farmers of the surveyed area for 2 years and have been continuing at a steady rate. The major differences on the quality and productivity of vegetables were experienced by them where the farmers were highly benefitted with enhanced livelihood and seem to be fully satisfied after adopting CSA. Having said that farmers were still facing problems in adopting CSA technologies. On the basis of severity, surveyed respondents of KI and FGD's ranked these problems from 1 to 5 as:

1. Unavailability of quality inputs like drip irrigation, mulching, seeds, fertilizers, etc. at an appropriate time and feasible rate.
2. Poor marketing infrastructure was identified to be the second major problem where fluctuation in product price, poor marketing channel and transportation, and influence of Indian market was experienced by the farmers of surveyed site.
3. The major problem reported by them was insect pest damage and disease incidence causing severe crop failure along with decreased yield.
4. The major problem was the lack of cold storage facility thereby resulting in postharvest losses.
5. There is still a large gap in the adoption and implementation of CSA technologies in a more scientific and appropriate way due to the lack of proper training on CSA by the farmers of the surveyed site.

Although all the components of CSA were not adopted by almost all the respondents but they were in the stage of adopting it as a smart tool for mitigating climate change. Since climate change is inevitable, farmers now realized the importance of agriculture and felt the necessity of developing a tool that will come up with the negative impacts of climate change without affecting agriculture production. Having said that, land is non-expandable but the population is. So, the fact of getting more productivity from a small piece of land motivates the farmers to adopt CSA technology. Moreover, CSA Technology is ecologically sound, economically viable and socially acceptable, attracting even the youths in the field of commercial agriculture. The complexity of ongoing climate change itself is posing a serious challenge in prioritizing the CSA policies/plans and practices in any agro-geological areas. Moreover, the poor economic condition and low access to technologies have created restrictions to invest in the CSA concept, policies/plans, and practices thereby adding challenges especially in developing countries like Nepal and India (Shirsath *et al.*, 2017). In addition to this, UNDP's Integrated Climate Risk Management Program (ICRMP) funded by Swedish Government and the Government of Nepal organized and provided training on offseason vegetable farming and plastic tunnel construction to mitigate the climate impact on agriculture (UNDP, 2018). Similarly, International Center for Integrated Mountain Development (ICIMOD) in collaboration with its partner Environment and Agricultural Policy Research, Extension, and Development (CEAPRED) developed Climate-Smart Village (CSV) approaches which provide communities tools to reduce the negative impact of climate change and promote sustainable agriculture development (ICIMOD and CEAPRED, 2015).

Inputs used

To increase the production and productivity of vegetable crops different organic and synthetic fertilizers, pesticides, insecticides, micronutrients, and vitamins, etc. were applied during vegetable production as shown in Table 1. The data showed that Urea, DAP, and MOP were frequently used fertilizers by almost all of the respondents due to their easy accessibility at an affordable price in most of the vegetables like cauliflower, cabbage, chilly, tomato, etc. Since farmers were fully aware that the sole application of chemical fertilizers is just a temporary solution to enhance crop production so the respondents were using organic fertilizers to maintain the sustainability of soil and to compen-

Table 1. Chemical fertilizers, organic fertilizers, pesticides, micro nutrients and vitamins used by the respondents in Chormara, Nawalparasi district.

S. N.	Chemical Fertilizers		Organic Fertilizers		Pesticides			Micro nutrients and Vitamins	
	Name	Frequency	Name	Frequency	Name	Amount	Interval (Days)	Name	Amount
1.	Urea	72	FYM	97	Gentostar	0.5g/l	15	New Start One	3-4gm/l
2.	DAP	66	Compost	97	Chungstop	1g/l	15	Plant Power	1.25ml/l
3.	MoP	66	Vermicompost	26	Agape	1g/l	21	Calcium add	5ml/l
4.	Super Phosphate	7	Poultry Manure	100	Rogor	3ml/l	15	Amino King	5ml/l
5.	Zinc	38	Biofertilizers	15	Range	3ml/l	21	HP 100	4ml/l
6.	Others	5	Others	65	Nemacode	3ml/l	20	Topalga	4ml/l
7.					S-300	3ml/l	14	Replex	3ml/l
8.					Mancozeb	3gm/l	15	Faster	2g/Plant
9.								Antivirus	1.25ml/l

Table 2. Chemical Cost of production of selected vegetables in Chormara, Nawalparasi district (In NRs/Hectare/season).

S. No.	Particulars	Cucumber (NRs.)	Bitter gourd (NRs.)	Tomato (NRs.)	Sponge gourd (NRs.)	Chilly (NRs.)
1.	Fixed cost					
2.	Land lease	29580	29580	29580	29580	29580
3.	Depreciation	2958	2958	2958	2958	2958
4.	Land tax	2958	2958	2958	2958	2958
5.	Repair and maintenance	4437	4141.2	3549.6	3845.4	4732.8
6.	Total fixed cost (A)	39933	39637.2	39045.6	39341.4	40228.8
7.	Variable cost					
8	Seed	2958	4437	7395	4732.8	5916
9.	Manure	41412	44370	59160	47328	59160
10.	Fertilizers	7395	7395	7395	7395	7395
11.	Micro nutrients and Vitamins	23664	17748	14790	20706	20706
12.	Pesticides	17748	20706	17748	14790	20706
13.	Labor	94656	88740	103530	94656	103530
14.	Tractor cost	35496	35496	35496	35496	35496
15.	Miscellaneous	59160	44370	59160	47328	53244
16.	Total variable cost (B)	282489	263262	304674	272431.8	306153
17.	Total cost of production (A+B) (NRs.)	322422	302899.2	343719.6	311773.2	346381.8
18.	Total cost of production (A+B) (USD)	2803.66	2633.90	2988.86	2711.07	3012.01

Note: $1 equals to NRs. 115

sate for the negative impacts of synthetic fertilizers. As per the availability, the use of organic manure varied from farmer to farmer as shown in Table 1. The discussion with Key Informants and Focus Group reported that the farmers of the study area were more inclined towards organic farming thereby cutting down the use of chemical pesticides. So besides using chemical pesticides, the farmer used to spray cow milk and water (100 ml cow milk + 1000 ml water) at 15 days intervals to minimize the incidence of virus especially in cucurbits like Cucumber, Sponge gourd, etc. Similarly, diluted cattle urine, Soap water were used to control the infestation of borers, aphids, etc. Also, the mechanical, physical, and botanical methods of pest control through the use of a yellow sticky trap, Pheromone lure, light trap, and use of jholmal, etc. were also employed by the farmers. An increasing interest among the farmers towards jholmal use is getting popular among women farmers as it can be produced locally at home (Agrawal *et al.*, 2018).

Encouragement to adopt climate SMART agriculture

Although, the concept of CSA is very new to the farmers of Nepal, but was in practice from the very early days considering the effect of ongoing climate change in the developed nations. Talking about the introduction and flourishment of CSA in the context of Nepal, mainly the private organizations are taking the lead. The term had been introduced to 40% of the respondents of the study site through private companies followed by NGO's/ INGO's and agriculture offices. 80% of the respondents had taken CSA technology trainings and were adopting this technology from the ground level (Figure 2). The trainings on nursery management, cultivation practices, and harvesting were mainly taken by the sample population. The result showed that the need for CSA has reached at its peak and its extension is utmost necessary at every corner of our country. Despite the fact that CSA has both threats and opportunities in the context of Nepal, however collaborative efforts of Planning, Research, Government policies, several NGO/INGOs programs would be needed to achieve CSA in reality and encourage the farmers on its adaptation (Rijal and Rijal, 2019).

Market analysis

The analysis revealed that 27% of the respondents just have enough produce for home consumption, 50% sold their products to local markets, 18% to the retailers, and only 5% of them were able to deliver the products to the wholesalers. The instability in the marketing system, price fluctuation, influence of the Indian market and poor marketing channels were posing a serious threat in the marketing of vegetable crops. In this regard, 76% of the total respondents were suggesting the need of a proper marketing system in the study area. 82% of the respondents were suffered from poor storage facility leading to heavy post-harvest losses. Similarly, no technical parameters were considered during grading except physical attributes: Color, shape, size, and sweetness

Such an improper marketing situation was responsible for post-harvest losses of most vegetable crops. The finding is in support of the literature where 5.4% of the post-harvest loss was recorded in tomatoes due to the unavailability of storage facilities (Parajuli *et al.*, 2018). The major aspects to be addressed in the marketing system by the policymakers encompass improvement of Market Information System, Market Infrastructures, and Waste management system as reported by the study conducted on vegetable markets in Kathmandu (RECPHEC, 2016).

Table 3. Benefit: Cost ratio of selected vegetables in Chormara, Nawalparasi district (In NRs/Hectare/season).

S.N.	Name of Vegetables	Cost of production (USD)	Selling price (USD)	Quantity (Kg)	Gross returns (USD)	Net returns (USD)	B:C ratio
1.	Cucumber	2803.66	0.52	35496	18519.65	15715.98	5.60
2.	Bitter Gourd	2633.90	0.60	29580	18005.21	15371.31	5.83
3.	Tomato	2988.86	0.34	59160	20577.39	17588.53	5.88
4.	Sponge Gourd	2711.07	0.52	35496	18505.56	15794.49	5.82
5.	Chilly	3012.01	0.78	20706	16204.69	13192.68	4.38

Comparative economic analysis of vegetable production

The relative economic analysis of selected vegetables was calculated on a yield basis as shown in Table 2. The cost of production of chilly was comparatively higher than the other vegetable crops. It may be attributed to higher fixed and variable costs incurred during chilly cultivation whereas the highest net returns of USD 17588.53 per hectare was achieved in tomato cultivation. The result obtained from the survey showed B:C ratio ranging from 4.38 – 5.88 (Table 3). The highest B:C ratio of 5.88 was obtained from tomato cultivation. The B:C ratio of the selected vegetables was greater than 1 suggesting that the cultivation of these vegetables adopting CSA technology is economically viable. The result is in agreement with the findings of Azumah *et al.*, 2020, where a BCR of 2.63 was obtained under climate change adaptation strategies in Ghana.

Conclusion

A study conducted at Chormara depicted that the adaptation of CSA technologies has been started by small farmers for vegetable production in order to mitigate the negative impacts of ongoing climate change. It had been found that the adoption of climate SMART Agriculture technologies increased the effectiveness and production of vegetables at Chormara, Nawalparasi as compared to earlier traditional practices of vegetable production. The B:C ratio greater than 1 in the selected vegetable crops recorded from the site concluded that the production of vegetables in the context of Nepal adopting CSA technologies is financially viable. Similarly, it also depicted that the youth could find better opportunities to explore agriculture at a national level and make agriculture a prestigious profession in near future. Although farmer's perception and knowledge towards climate SMART Agriculture technologies were found to be low but it could be upgraded with the introduction, demonstration, and implementation of CSA technologies and their related trainings at different agro-ecological zones of Nepal. This new intervention could minimize the import of vegetables, improve the soil environment, and build self-sufficiency in agriculture production, marketing, and consumption of vegetables at a national level. The result indicated that dissemination of CSA technology should be inbuilt as a major program activity by agriculture related organizations (GOs and I/NGOs) to capacitate the knowledge and skills of front line workers in agriculture sector.

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Conflict of interest

The author declares no conflicts of interest regarding the publication of this manuscript.

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