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# The Repercussions of Ukraine's Crisis on Food Security and the Possibility of Avoiding a Global Food Crisis

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***Abstract:*** Russia's recent invasion of Ukraine and the probable loss of Ukrainian exports could have a significant impact on global food prices. Developing countries that rely on food imports are the most vulnerable to food insecurity. They modify their consumption and trade patterns in response to price signals, whereas exporting countries increase production to meet demand. To prevent global food insecurity, we must be a part of our neighbors; by cutting-edge innovators leading the way to a new future of plant-based consumers. This research aims to improve global food security by developing a mathematical model that focuses on boosting the nutritional value of baked products made from a variety of grain crops while reducing dependency on wheat and lowering its cost.

***Keywords:*** Strengthen food security (SFS) as a mathematical model consists of two models: the first maximizes nutritional value, and the second minimizes production costs to strengthen food security (SFS).

## Introduction

The invasion of Ukraine by Russia comes at a time when global food and energy prices are already at record highs. Wheat prices have risen by approximately 110 percent in the last 18 months, corn and vegetable oil prices have risen 140 percent, and soybeans have risen by 90 percent. Due to increased global import demand, particularly from China, reduced global supplies due to Northern Hemisphere droughts in the summer of 2021, and tightened stockpiles in major exporting countries, since the second half of 2020, agricultural commodity prices have been climbing. These events took place as the world economy began to recover from the consequences of pandemic-prevention measures. As a result of the economic recovery, crude oil and natural gas prices began to rise. Fertilizers, other inputs, and transportation costs are all factors to consider. Agricultural exports across the Black Sea have been affected by Russia's invasion of Ukraine, increasing prices and worsening the high cost of energy and fertilizer. As a result of trade laws imposed in reaction to market volatility

caused by the war, including export bans, food prices are rising (even more) **(FAS 2022a).**

In response to market volatility caused by the war, trade laws, particularly export fixing, are driving up food prices even higher, with global wheat output adequate in 2020/21 and only 1% below consumption requirements in 2021/22. Despite this, as international trade has risen, wheat supplies among major world exporters have tightened in recent years. In 2021/22, the worldwide supply of major exports is predicted to be at a ten-year low, placing upward pressure on prices. In 2020 and '21, China's imports more than doubled as STCs assisted in the replacement and rebuilding of aging government stocks. In addition, it will increase demand for higher-quality wheat. Ukraine and Russia export wheat, corn, barley, sunflower oil, and flour in large quantities. The Russian invasion of Ukraine has hampered agricultural exports from the region and prompted fears about Black Sea supply, causing commodity prices to rise and market instability. As future contributions become more unpredictable, some countries have instituted internal export prohibitions or limitations, further limiting global availability and driving up prices.

Energy and food consume tremendous amounts of money in the poorest countries and families. Low-income consumers in import-dependent countries will be hurt the hardest, as drastically higher prices are likely to lead to fewer purchases and lower calorie consumption. Food assistance programs run by the government may help consumers in the short term. Higher commodity prices, on the other hand, will make it difficult to maintain support for those regimes. Countries with low foreign exchange reserves may struggle to meet import demands, especially if they rely heavily on imported fuel. In some locations, imports may be banned, requiring people to rely more on locally produced grains, tubers, and other goods. Shipping delays can also be a problem, particularly for markets that rely heavily on them. Buyers may be forced to seek out alternative suppliers, which will take time. These factors could lead to temporary shortages in some markets, and higher transportation costs lead to higher energy expenditures. Consumer spending in economies that rely largely on imported food will rise as a result of these changes.

According to simulations carried out by the **FAO** to analyze the potential repercussions of a severe drop in grain exports by the Russian Federation and Ukraine during the 2022/23 marketing season, these deficits may only be partially offset by alternate sources. Many of these origins' ability to increase output and shipments may be limited; the resulting global supply imbalance may push international food and feed prices up by 8 to 22% above current high levels (FAS 2022b).

## Methodology

Given both nations' major positions in global food markets and Russia's prominence in transnational energy trade, the Russian invasion of Ukraine has significant consequences for food security around the world and in the region. The fight occurs at a moment when the world is encircled by a ring of fire, when climatic shocks, pollution, COVID-19, and rising costs are pushing millions closer to starvation. The global need for humanitarian help is bigger than ever, with 44 million people in 38 countries on the verge of hunger. As funding levels off due to donor countries' swelling treasuries and rising food costs, WFP has already had to lower rations for refugees and other vulnerable groups across East Africa as funding levels off. Food insecurity affects 16.2 million people in Yemen, for example. Food costs have climbed even more as the crisis in Ukraine has caused havoc in the global food and energy markets. Once passed on to local markets, these increases will limit people's access to food. They will increase WFP's operational costs at the same time, decreasing its responsiveness at a time when people need it the most (WFP 2022).

The Russian invasion of Ukraine has huge ramifications for global and regional food security, given both countries' prominent positions in global food markets and Russia's importance in transnational energy trade. The fight occurs at a moment when the world is encircled by a ring of fire, when climatic shocks, pollution, COVID-19, and rising costs are pushing millions closer to starvation. The global need for humanitarian help is bigger than ever, with 44 million people in 38 countries on the verge of hunger. Food costs have climbed even more as the crisis in Ukraine has caused havoc in the global food and energy markets. Once passed on to local markets, these increases will limit people's access to food. The conflict in Ukraine will have far-reaching ramifications far beyond its borders, aggravating hunger in some of the world's worst famines. Disruptions in Black Sea exports have immediate ramifications for countries that rely heavily on Russian and Ukrainian grain supplies. Beyond countries that receive grain from the Black Sea, those who rely on grain imports in general are the first to see domestic food costs rise as global grain markets rise, Imported grains such as wheat and maize account for 30% or more of dietary energy in more than 40 countries (WFP 2022).

This research intends to increase global food security by developing a mathematical model that focuses on boosting the nutritional value of baked goods created from a variety of grain crops, reducing dependency on wheat. This model combines two models: the first was designed to increase the nutritional value of baked goods while minimizing the focus entirely on the wheat component, and the second was created to lower their cost.

## Mathematical Model

Russia and Ukraine export one-fifth of the world's wheat. Ukraine exports 40% of its wheat and grain to the Middle East and Africa, where hunger is already a problem and future food shortages or price hikes threaten to push millions more people into poverty. Russia is also the world's leading fertilizer producer. Fertilizer price hikes contributed to a 30% increase in food prices last year, even before the crisis. The repercussions of rising food prices and staple crop shortages are already being felt in the Near East and North Africa region, according to the International Fund for Agricultural Development, and are spreading to the world's most vulnerable countries, including the Horn of Africa (IFAD). The United Nations' International Fund for Agricultural Development (IFAD) has also cautioned that the world's poorest people are the most vulnerable. This comes as the international community is growing increasingly concerned that the long-running conflict may worsen global hunger and poverty. The bloody battle in Ukraine is already a disaster for those directly involved, as well as a tragedy for the world's poorest people living in rural areas, who will be unable to bear higher prices for basic foodstuffs and agricultural inputs as a result of global trade disruptions. Price increases have already been observed, potentially leading to an increase in hunger and poverty, with serious consequences for global stability (IFAD 2022).

This research aims to enhance global food security by designing a mathematical model that focuses on increasing the nutritional value of baked products made from a variety of grain crops, thus reducing dependency on wheat. This model combines two models: the first was designed with the goal of boosting the nutritional content of baked goods while focusing on the wheat component as little as possible and the second was designed with the goal of lowering their cost.

**Strengthen food security (SFS) as a mathematical model - consists of:**

**Strengthen food security (SFS) = Minimize economical [Maximize nutritional (SFS)]**

**Strengthen food security (SFS) via maximizing the nutritional value:**

$$\text{Maxmize} \quad \text{SFS} = \sum_{y\,1\,=\,1}^{Zn} (\text{Nvy2} - \text{Nvy1}) \tag{1}$$

Zn: Total nutrition added from crops flour in nutritional value maximization scheme $Evy_1$: Nutritional value of the old nutritional value maximization scheme

$Evy_2$: Nutritional value of the new nutritional value maximization scheme

**Subject to**

$$NVy = Qy \cdot Cn - Co \quad (2)$$

$$Qy = Ry \cdot Ay \quad (3)$$

$Q_y$ : Quantity of nutrition of crop flour $y_n$

$R_y$ : Nutritional value of crop flour $y_n$

$A_y$ : Total amount of crop flour $y_n$

$C_n$ : Total amount of crops flour $y_n$ in the new nutritional value maximization scheme

$C_o$ : Total amount of crops flour $y_n$ in the old nutritional value maximization scheme

**Strengthen food security (SFS) via minimizing production costs**

$$\text{Minimize} \quad SFS = \sum_{y\,1=1}^{Zn} (Nvy2 - Nvy1) \quad (4)$$

Zn : Total economic cost value of nutritional value maximization scheme

$Evy_1$ : Economic cost value of the old nutritional value maximization scheme

$Evy_2$ : Economic cost value of the new nutritional value maximization scheme

V : Total annual volume of water used in the scheme

**Subject to**

$$EVy = Qy \cdot Py - Cy \quad (5)$$

$$Qy = Ry \cdot Ay \quad (6)$$

$Q_y$ : Quantity of nutrition of crop flour $y_n$

$R_y$ : Nutritional value of crop flour $y_n$

$A_y$ : Total amount of crop flour $y_n$

$P_y$ : Marketing price of crop flour $y_n$

$C_y$ : Production costs dedicated to crop flour y

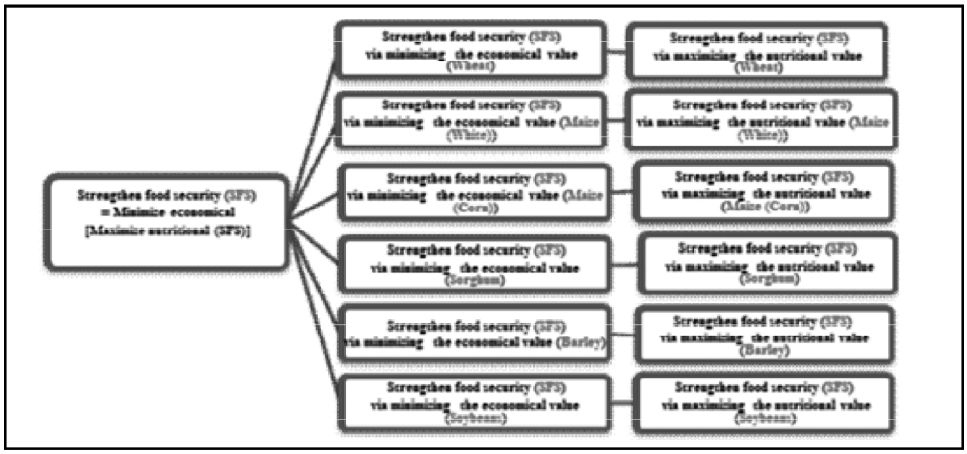
## Results and Discussion

Food security can be increased when everyone has physical and financial access to enough safe and nutritious food at all times to meet their nutritional needs and food preferences for a healthy and active lifestyle. Strengthen food security (**SFS**) is a mathematical model that was created

by combining two different models **(SFS 2022).** The first model focuses on improving the nutritional value of baked goods while minimizing the emphasis on the wheat component alone, and the second model focuses on cost reduction **(Figure 1).**

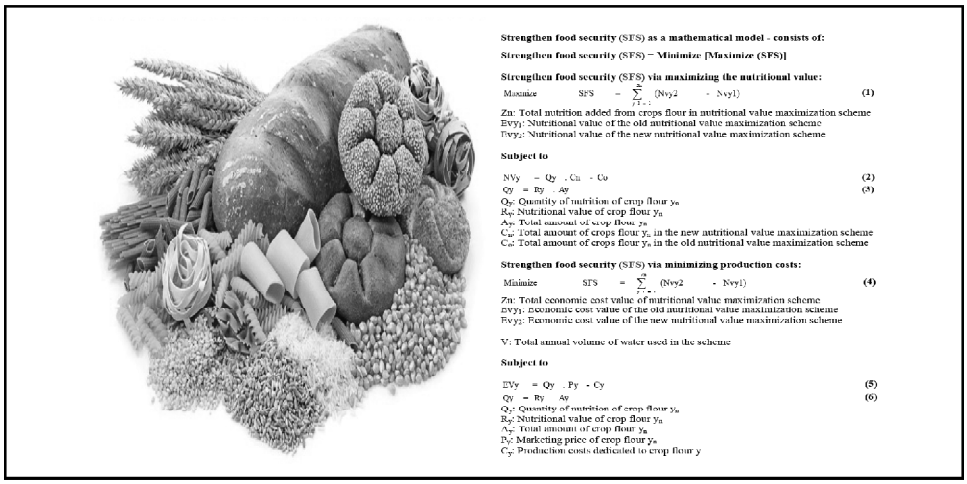
Several steps are taken to execute "Strengthen Food Security" as a mathematical model **(Figure 2).** The first phase focuses on increasing the nutritional content of baked goods while reducing the wheat component

**Figure 1: Structure model of Strengthen food security (SFS) via mini economic of max nutrition value**




*Source:* (SFS model 2022)

**Figure 2: Structure model of Strengthen food security (SFS) as a mathematical model**




*Source:* (SFS model 2022)

and the second step focuses on lowering the cost while reducing the wheat component. The third step involves simulating the Enhancement of High-Efficiency Strengthened Food Security (**SFS**) program to reallocate crops based on productivity and control technological risks. To implement the strengthened food security (**SFS**) model, baseline data were collected through a detailed survey of crop inputs, which was based on completed statistics relating to the current economic situation and associated socio-economic aspects **(SFS 2022).** The Food and Agriculture Organization **(FAO, 2022)** provided crop data and expenditures, and the numbers included in this study are generic and combined data for the years 2021 and 2022. When evaluating an **SFS** model to reduce cost with less focus on the wheat component to simulate **SFS** to reallocate crops in line with production and control technical risks, it's important to remember the overall performance of the model **(Hamada 2020; Hamada 2023)**. The overall performance of the model can often be raised by decreasing the focus on the wheat component of the input or by increasing output.

Baked goods can be manufactured from a variety of crops to increase nutritional content while reducing the focus on the wheat component in the manufacturing process and lowering the cost of the baked goods. The baked goods were composed of wheat, maize, sorghum, barley, millet, rye, oats, and soybeans in proportions ranging from 50.00 percent, 7.00 percent, 2.50 percent, 6.50 percent, 2.50 percent, 4.00 percent, 25.00 percent, and 2.50 percent, as shown in **Table 1**, for 2.051 cents, down 22.47 percent, and with a higher nutritional value than wheat flour baked goods. **Table 2** also displays the final results' economic assessments, which are based on the **SFS** model's assessment and changes in the ingredients and nutritional values of baked products in season 2021/22, and this is their assessment based on the present grain trade scenario, **Figures 3 and 4** show changes in

**Table 1: Changes crops contents in Strengthen of Food Security (SFS) (Green is values that have increased, red are values that have decreased)**

| Crops contents in Strengthen of Food Security (**SFS**) | | | | |
|---|---|---|---|---|
| *Crops* | *Mean* | *SFS* | *Change* | *%* |
| Wheat | 90.000 | 45.000 | -45.000 | -50.00% |
| Maize (Corn) | 0.000 | 6.300 | 6.300 | 7.00% |
| Sorghum | 0.000 | 2.250 | 2.250 | 2.50% |
| Barley | 0.000 | 5.850 | 5.850 | 6.50% |
| Millet | 0.000 | 2.250 | 2.250 | 2.50% |
| Rye | 0.000 | 3.600 | 3.600 | 4.00% |
| Oats | 0.000 | 22.500 | 22.500 | 25.00% |
| Soybean | 0.000 | 2.250 | 2.250 | 2.50% |

Data source: (1) MALR (2022) (2) ECAPMS (2022) (3) SFS **model (2022)**

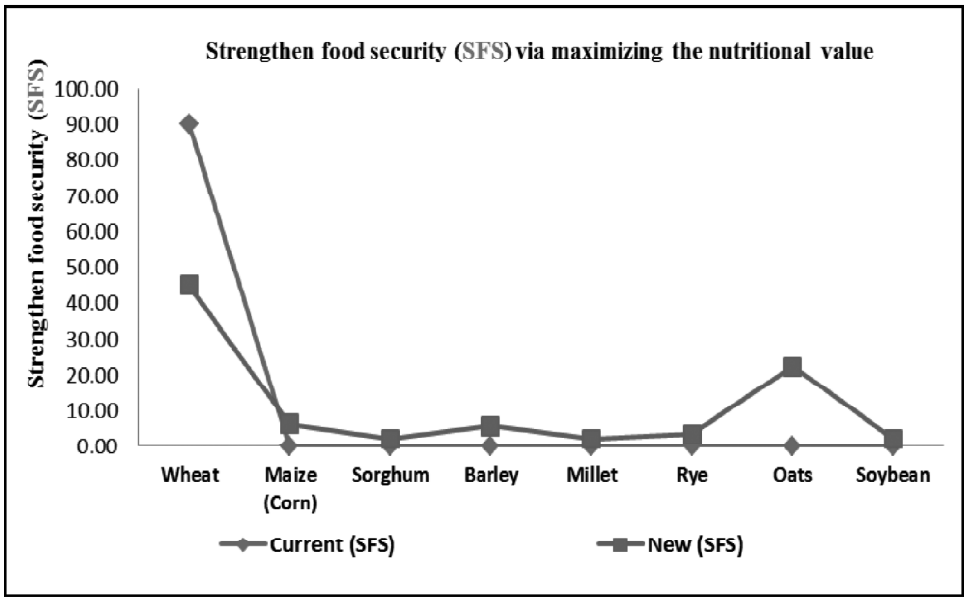
**Table 2: Changes crops contents in Strengthen of Food Security (SFS) (Green is values that have increased, red are values that have decreased)**

Crops contents in Strengthen of Food Security (**SFS**)

| | *Mean* | *SFS* | *Change* | *%* |
|---|---|---|---|---|
| Price (US$/cent) | 2.646 | 2.052 | -0.595 | -22.47% |
| weight of a loaf of bread | 90.000 | 90.000 | 0.000 | 0.00% |
| Energy (Kcals) | 320.400 | 308.651 | -11.750 | -3.67% |
| Moisture (g) | 9.000 | 11.052 | 2.052 | 22.80% |
| **Protein (g)** | 7.200 | 8.822 | 1.622 | 22.53% |
| Fat (g) | 1.800 | 2.702 | 0.902 | 50.13% |
| Mineral (g) | 0.900 | 1.332 | 0.432 | 48.00% |
| Carbohydrates (g) | 69.300 | 62.420 | -6.880 | -9.93% |
| Fiber (g) | 1.800 | 2.342 | 0.542 | 30.13% |
| Calcium (mg) | 33.300 | 31.599 | -1.701 | -5.11% |
| Phosphorus (mg) | 268.200 | 249.372 | -18.828 | -7.02% |
| Iron (mg) | 4.500 | 5.040 | 0.540 | 12.00% |

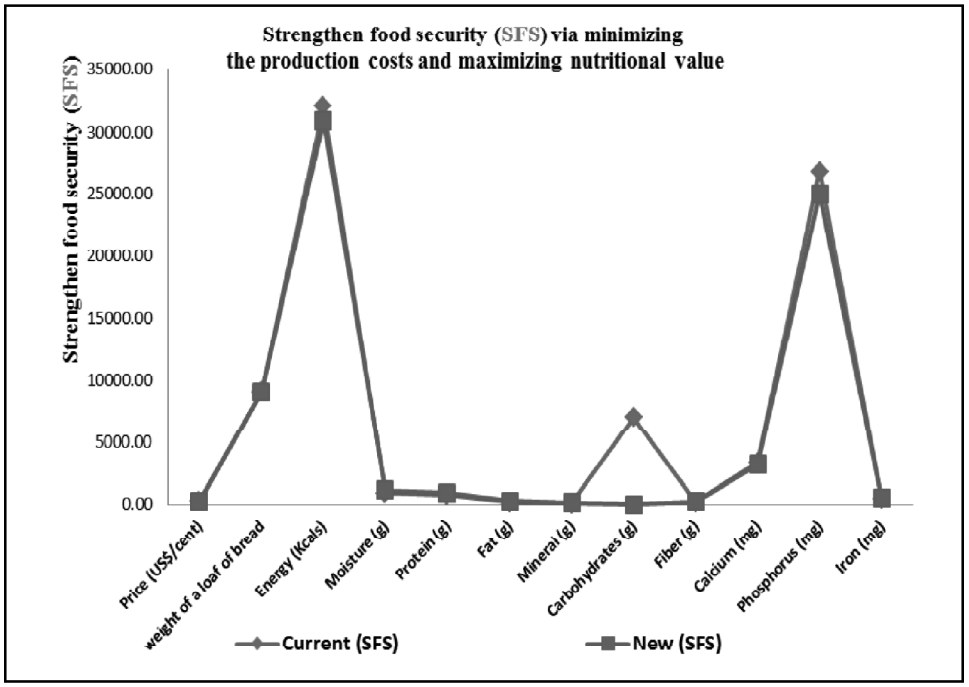
Data source: (1) MALR (2022) (2) ECAPMS (2022) (3) SFS **model (2022)**

**Figure 3 Changes Structure model of Strengthen food security (SFS) from 2020/ 2021-2021/2022 to SFS**




Data source: (1) MALR (2022) (2) ECAPMS (2022) (3) SFS model (2022)

**Figure 4 Changes Structure model of Strengthen food security (SFS) from 2020/ 2021-2021/2022 to SFS**




Data source: (1) MALR (2022) (2) ECAPMS (2022) (3) SFS model (2022)

ingredients and nutritional values of baked goods in the 2021/22 season for the Enhanced Food Security Model, in addition to changes in cost and nutritional components (**SFS**).

## Conclusion

The invasion of Ukraine by Russia comes at a time when global food and energy prices are already at record highs. Wheat prices have increased by approximately 110 percent in the last 18 months, while corn and vegetable oil prices have increased by 140 percent, and soybean prices have increased by 90 percent. Overall, agricultural commodity prices have risen since the second half of 2020, owing to increased worldwide import demand (particularly from China), reduced global supplies due to droughts in the Northern Hemisphere in the summer of 2021, and tightened stocks in major exporting countries. These events occurred just as the global economy was beginning to recover from the effects of pandemic-prevention measures. As a result of the economic recovery, crude oil and natural gas prices began to rise. Fertilizers, other inputs, and transportation expenses must all be

taken into account. Fertilizers, other inputs, and transportation costs all rose in tandem with energy prices. Agriculture product shipments across the Black Sea have been hindered by Russia's invasion of Ukraine, rising prices, and compounding high energy and fertilizer expenses. As a result of trade restrictions imposed in response to the war's market volatility, such as export prohibitions, food prices are rising even faster **(FAS 2022a).**

This research aims to improve global food security by constructing a mathematical model that focuses on increasing the nutritional value of baked products made from a variety of grain crops, thereby reducing reliance on wheat while lowering costs. The major goal of this model is to increase the nutritional value of baked goods made from a variety of grain crops to lessen the reliance on wheat in their production by improving the nutritional content of all of their components while lowering their prices. This model combines two models, the first of which was designed to enhance the product's nutritious content, and the second of which was designed to lower the product's costs.

The results of the evaluation of the Enhancement of Food Security Model (SFS) came to maximize the nutritional value of baked goods that will be manufactured from a mixture consisting of several different crops to reduce the focus on the wheat component in its manufacture while also lowering the cost of the baked goods. The baked goods are made up of wheat, maize, sorghum, barley, millet, rye, oats, and soybeans in proportions of 50.00 percent, 7.00%, 2.50%, 6.50%, 2.50%, 2.50%, 4.00%, 25.00%, and 2.50% plus a production cost of 2.051 cents, down 22.474 percent, and the nutritional value is higher than wheat flour baked goods.

The research suggests rationing wheat and flour intake to help bridge the nutritional gap in wheat and raise the percentage of self-sufficiency for this important commodity. This will be accomplished by changing present wheat and flour consumption patterns through nutritional awareness, as well as introducing partial wheat substitutes in the baked goods sector to relieve pressure on the wheat crop as the primary crop in the baked goods business.

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