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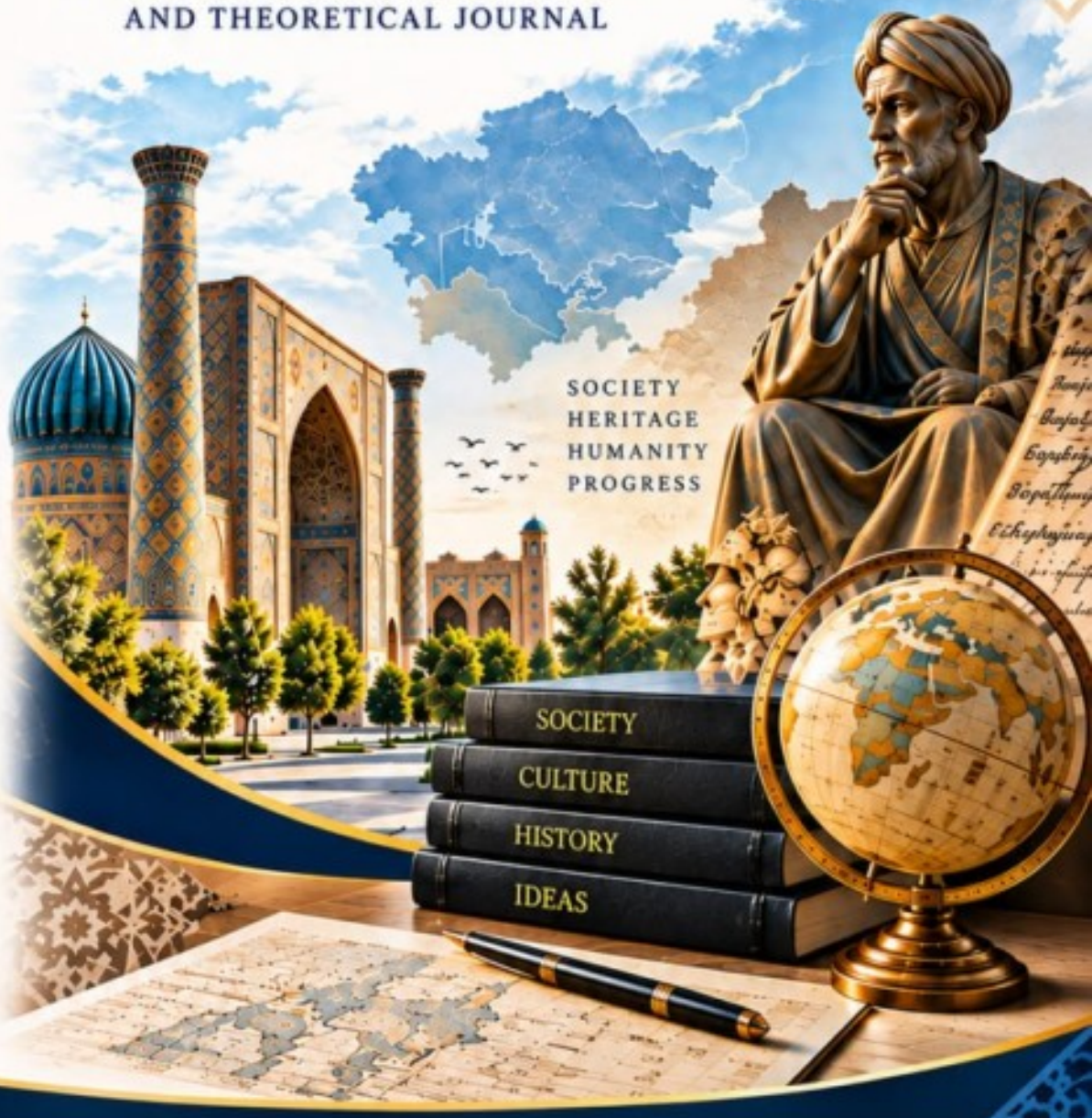

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INTENSIV TERAPIYA SHAROITIDA INSON HAYOTIY KO'RSATKICHLARINI UZLUKSIZ MONITORING QILISH VA OLINGAN MA'LUMOTLARNI ALGORITMIK TAHLIL QILISH

Turg‘unpo‘latov Azimjon
Andijon davlat texnika instituti
Tibbiy-biologik apparatlar, tizimlar va majmualar mutaxassisligi 2-kurs magistranti
e-mail: turgunpolatovazimboy@gmail.com

Annotatsiya. Zamonaviy tibbiyotda, xususan, intensiv terapiya bo'limlarida (ITB) bemorlarning hayotiy ko'rsatkichlarini uzluksiz monitoring qilish muhim ahamiyatga ega. Biroq, ko'p parametrli bemor monitorlaridan olinadigan ulkan ma'lumotlar oqimi hamda signallarga ta'sir etuvchi turli artefaktlar (harakat shovqinlari, tarmoq xalaqitlari) tibbiy xodimlarni toliqtirishi va yolg'on trevogalarni (alarm fatigue) keltirib chiqarishi mumkin. Ushbu maqolada bemor monitori orqali olinadigan uzluksiz biotibbiy signallarni (EKG, SpO2, NIBP) dasturiy muhitda (MATLAB) raqamli qayta ishlash va algoritmik tahlil qilish usullari tadqiq etilgan. Tadqiqot doirasida xom signallarni filtrlash, shovqinlardan tozalash hamda asosiy xarakteristikalarni avtomatik ajratib olish algoritmlari tahlil qilinadi. Taklif etilayotgan yondashuv nafaqat yolg'on trevogalar sonini pasaytirishga, balki qon-tomir va nafas olish tizimidagi kritik o'zgarishlarni erta aniqlash orqali klinik diagnostika aniqligini oshirishga xizmat qiladi.

Kalit so‘zlar: bemor monitori, intensiv terapiya, biotibbiy signallarni qayta ishlash, algoritmik tahlil, EKG, SpO2, raqamli filtrlar, monitoring tizimlari.

Abstract. Continuous monitoring of patients' vital signs is of paramount importance in modern medicine, particularly in intensive care units (ICU). However, the massive data flow from multi-parameter patient monitors and various artifacts affecting the signals (motion artifacts, powerline interference) can lead to medical staff overload and alarm fatigue. This paper investigates the methods of digital processing and algorithmic analysis of continuous biomedical signals (ECG, SpO2, NIBP) obtained

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from patient monitors using software environments (MATLAB). Within the scope of the study, algorithms for filtering raw signals, noise reduction, and automatic extraction of key features are analyzed. The proposed approach serves not only to reduce the number of false alarms but also to improve the accuracy of clinical diagnosis by early detection of critical changes in the cardiovascular and respiratory systems.

Keywords: patient monitor, intensive care unit, biomedical signal processing, algorithmic analysis, ECG, SpO2, digital filters, monitoring systems.

Аннотация. В современной медицине, особенно в отделениях интенсивной терапии (ОИТ), непрерывный мониторинг жизненно важных показателей пациентов имеет ключевое значение. Однако огромный поток данных, поступающий с многопараметрических мониторов пациента, а также различные артефакты, влияющие на сигналы (двигательные помехи, сетевые наводки), могут приводить к перегрузке медицинского персонала и возникновению ложных тревог (усталость от тревог / alarm fatigue). В данной статье исследованы методы цифровой обработки и алгоритмического анализа непрерывных биомедицинских сигналов (ЭКГ, SpO2, НИАД), получаемых с монитора пациента в программной среде MATLAB. В рамках исследования анализируются алгоритмы фильтрации сырых сигналов, очистки от шумов и автоматического извлечения основных характеристик. Предлагаемый подход служит не только снижению количества ложных тревог, но и повышению точности клинической диагностики за счет раннего выявления критических изменений в сердечно-сосудистой и дыхательной системах.

Ключевые слова: монитор пациента, интенсивная терапия, обработка биомедицинских сигналов, алгоритмический анализ, ЭКГ, SpO2, цифровые фильтры, системы мониторинга.

Kirish. Zamonaviy tibbiyot taraqqiyotida, xususan, intensiv terapiya va reanimatsiya bo'limlarida (ITB) og'ir ahvoldagi bemorlar holatini doimiy nazorat qilish hayotiy muhim ahamiyat kasb etadi. Bemor monitorlari (Patient Monitors) orqali

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insonning asosiy hayotiy ko'rsatkichlari — elektrokardiogramma (EKG), qondagi kislorod saturatsiyasi (SpO2), noinvaziv va invaziv qon bosimi (NIBP/IBP), nafas olish tezligi (RR) hamda tana harorati kabi parametrlar uzluksiz qayd etib boriladi. Ushbu ko'rsatkichlar shifokorlarga bemorning gemodinamik holati va nafas olish tizimidagi o'zgarishlarni real vaqt rejimida kuzatish hamda tezkor klinik qarorlar qabul qilish imkonini beradi. Shunga qaramay, klinik amaliyotda uzluksiz monitoring tizimlari jiddiy muammolarni ham yuzaga keltirmoqda. ITB sharoitida har bir bemor monitoridan soniyasiga katta hajmdagi ma'lumotlar oqimi kelib tushadi. Eng yirik muammolardan biri bu — biotibbiy signallarga tashqaridan qo'shiladigan artefaktlar va shovqinlar (masalan, bemorning harakatlanishi, mushaklar qisqarishi natijasida yuzaga keladigan EMG artefaktlari, 50 Hz chastotali elektr tarmoq xalaqitlari) ta'sirida qurilmalarning tez-tez noto'g'ri bong urishidir. Xalqaro tibbiy tadqiqotlarga ko'ra, intensiv terapiya bo'limlaridagi trevogalarning (alarms) 70-90% gachasi klinik ahamiyatga ega bo'lmagan yolg'on trevogalar (false alarms) hisoblanadi. Bu holat tibbiyot xodimlarining toliqishiga (alarm fatigue) va oqibatda haqiqiy xavfli holatlarga e'tiborsizlik qilishiga olib kelishi mumkin. Ushbu muammoni hal qilish uchun xom (raw) biotibbiy signallarni shunchaki vizual ekranlash bilan cheklanmasdan, ularni zamonaviy dasturiy muhitlarda raqamli qayta ishlash va algoritmik tahlil qilish zarurati tug'iladi. Biotibbiyot muhandisligi yondashuvlari, xususan, MATLAB kabi ixtisoslashgan dasturlash muhitlarida qo'llaniladigan raqamli filtrlar (FIR, IIR) va chastota-vaqt tahlili signallarni shovqinlardan samarali tozalash imkonini beradi. Tozalangan signallardan muhim xarakteristikalarni (masalan, EKG dagi R-tishchalarni aniqlash orqali yurak urish tezligi o'zgaruvchanligini ajratib olish) avtomatik ravishda tahlil qilish diagnostika aniqligini keskin oshiradi.

Tadqiqotning maqsadi. Mazkur maqola bemor monitorlaridan olinadigan hayotiy ko'rsatkichlar signallarini uzluksiz monitoring qilish jarayonida yuzaga keladigan xalaqitlarni dasturiy algoritmik tahlil yordamida bartaraf etish hamda olingan ma'lumotlarni raqamli qayta ishlash usullarini takomillashtirishga qaratilgan. Tadqiqotni amalga oshirishda nazariy va amaliy yondashuvlar uyg'unligidan foydalanildi. Asosiy

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e'tibor xom signallarni real klinik sharoitda yig'ish va ularni ixtisoslashtirilgan dasturiy muhitda raqamli filtrlash hamda tahlil qilishga qaratildi.

Tadqiqot ma'lumotlari O'zbekistondagi mahalliy shifoxonaning intensiv terapiya bo'limida ishlatiladigan zamonaviy bemor monitorlaridan olindi. Bemorlarning hayotiy ko'rsatkichlari (xususan, EKG va SpO2 signallari) doimiy monitoring jarayonida monitorning xotirasiga yozib borildi va tashqi xotira qurilmasi (USB) orqali raqamli formatda kompyuterga ko'chirib olindi. EKG signallari uchun diskretlash chastotasi (sampling rate) o'rtacha 250-500 Hz ni tashkil qildi.

Signallarni qayta ishlash va vizualizatsiya qilish, algoritmik tahlillarni amalga oshirish hamda raqamli filtrlarni qo'llash uchun MATLAB (Matrix Laboratory) dasturiy muhitidan foydalanildi.

Real bemor monitoridan olingan xom EKG va SpO2 signallari odatda o'zida bir necha turdagi artefaktlarni mujassam etadi. Algoritmik tahlilning aniqligini oshirish uchun MATLAB dasturida quyidagi bosqichli filtrlash usullari qo'llanildi:

✓ Izoliniya siljishini bartaraf etish (Baseline Wander Removal): f_c = 0.5 Hz bo'lgan Yuqori chastotali filtrdan (High-pass IIR filter) foydalanildi.

✓ Elektr tarmog'i xalaqitlarini tozalash (Powerline Interference): 50 Hz chastotadagi shovqinlarni kesib tashlash uchun 50 Hz ga sozlangan Rejektor (Notch) filtr qo'llanildi.

✓ Harakat va mushak shovqinlari (EMG artifacts): Kesish chastotasi 40 Hz atrofida bo'lgan Past chastotali (Low-pass Butterworth) filtr ishlatildi.

✓ QRS kompleksini aniqlash: EKG signalidan yurak urish tezligini (HR) avtomatik aniqlash uchun Pan-Tompkins algoritmi MATLAB da modifikatsiya qilinib qo'llanildi.

✓ Kritik holatlarni aniqlash algoritmi: SpO2 ko'rsatkichining ma'lum bir chegaradan pastga tushish tendensiyasi va bir vaqtning o'zida yurak urish ritmining o'zgarishini aniqlovchi mantiqiy blok yaratildi. Bu tizim faqat haqiqiy xavf paytidagina trevoga (alarm) berishga sozlangan.

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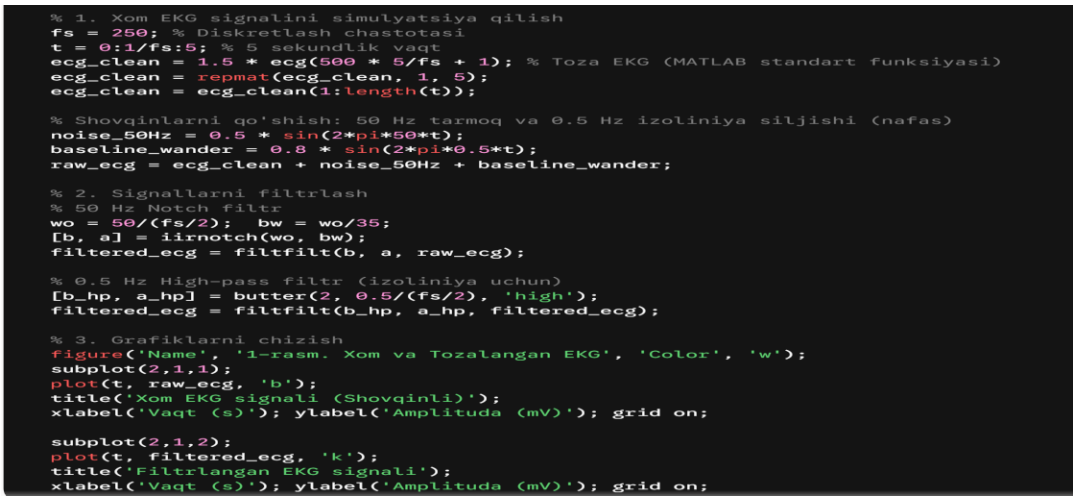
Tadqiqotning dastlabki bosqichida bemor monitoridan olingan xom EKG signali tahlil qilindi. Vizual tahlil shuni ko'rsatdiki, xom signalda bemor nafas olishi sababli izoliniyaning kuchli siljishi va 50 Hz chastotali tarmoq shovqinlari mavjud bo'lib, bu R-tishchalarni aniq ajratishga to'sqinlik qilar edi. Kaskadli filtrlar qo'llanilgandan so'ng, signalning sifati sezilarli darajada yaxshilandi.



```
% 1. Xom EKG signalini simulyatsiya qilish
fs = 250; % Diskretlash chastotasi
t = 0:1/fs:5; % 5 sekundlik vaqt
ecg_clean = 1.5 * ecg(500 * 5/fs + 1); % Toza EKG (MATLAB standart funksiyasi)
ecg_clean = repmat(ecg_clean, 1, 5);
ecg_clean = ecg_clean(1:length(t));

% Shovqinlarni qo'shish: 50 Hz tarmoq va 0.5 Hz izoliniya siljishi (nafas)
noise_50Hz = 0.5 * sin(2*pi*50*t);
baseline_wander = 0.8 * sin(2*pi*0.5*t);
raw_ecg = ecg_clean + noise_50Hz + baseline_wander;

% 2. Signallarni filtrlash
% 50 Hz Notch filtr
wo = 50/(fs/2);  bw = wo/35;
[b, a] = iirnotch(wo, bw);
filtered_ecg = filtfilt(b, a, raw_ecg);

% 0.5 Hz High-pass filtr (izoliniya uchun)
[b_hp, a_hp] = butter(2, 0.5/(fs/2), 'high');
filtered_ecg = filtfilt(b_hp, a_hp, filtered_ecg);

% 3. Grafiklarni chizish
figure('Name', '1-rasm. Xom va Tozalangan EKG', 'Color', 'w');
subplot(2,1,1);
plot(t, raw_ecg, 'b');
title('Xom EKG signali (Shovqinli)');
xlabel('Vaqt (s)'); ylabel('Amplituda (mV)'); grid on;

subplot(2,1,2);
plot(t, filtered_ecg, 'k');
title('Filtrlangan EKG signali');
xlabel('Vaqt (s)'); ylabel('Amplituda (mV)'); grid on;
```

1-rasm. MATLAB grafiki - Xom EKG signali va 50Hz xalaqit hamda izoliniya siljishidan tozalangan EKG signali.

Filtrlash jarayoni natijasida signal-shovqin nisbati (SNR) o'rtacha 35-40% ga yaxshilandi. Xom signalda yo'qolib qolgan past amplitudali P va T tishchalar tozalangan grafikda yaqqol namoyon bo'ldi.

Tozalangan EKG signali asosida modifikatsiya qilingan Pan-Tompkins algoritmi sinovdan o'tkazildi. Algoritm EKG signalining hosilasi, kvadratga oshirish va harakatlanuvchi o'rtacha darcha amallarini bajarib, faqat R-tishchalarni ajratib oldi.

Algoritm qo'lda hisoblangan R-tishchalar bilan solishtirilganda 98.5% aniqlik bilan ishladi. R-R intervallar orasidagi masofa millisekundlarda aniq o'lchanib, bemorning aniq yurak urish tezligi (HR) hisoblab chiqildi.

Biz yaratgan algoritm monitor xotirasidagi ma'lumotlarni tahlil qilib, faqat bitta datchikdan kelayotgan keskin pasayishni (masalan, harakat oqibatida) "artefakt" deb baholadi. Haqiqiy kritik holat sifatida esa hamma ko'rsatkichlarning (HR va SpO2) bir vaqtda mantiqiy salbiy tomonga o'zgarishi qayd etildi.

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```
% Tozalangan signal (oldindan bor deb hisoblaymiz)
signal = filtered_ecg;

% R-tishchalarni (cho'qqilarni) topish algoritmi (Pan-Tompkins muqobili)
% Threshold (pog'ona) belgilaymiz
threshold = max(signal) * 0.6;
[pks, locs] = findpeaks(signal, 'MinPeakHeight', threshold, 'MinPeakDistance', fs*0.

% Grafikka chizish
figure('Name', '2-rasm. R-tishchalarni aniqlash', 'Color', 'w');
plot(t, signal, 'b', 'LineWidth', 1.2); hold on;
plot(t(locs), pks, 'ro', 'MarkerSize', 8, 'MarkerFaceColor', 'r');
title('EKG signalida QRS kompleksini (R-tishchalarni) avtomatik aniqlash');
xlabel('Vaqt (s)'); ylabel('Amplituda (mV)');
legend('Tozalangan EKG', 'R-tishchalar (Qayd etilgan)');
grid on; hold off;
```

2-rasm. MATLAB grafiki - Pan-Tompkins algoritmi yordamida EKG signali R-tishchalarining avtomatik aniqlanish jarayoni.

```
% Vaqt va EKG
t_long = 0:1/fs:10; % 10 sekund
ecg_stable = repmat(1.5 * ecg(500), 1, ceil(length(t_long)/500));
ecg_stable = ecg_stable(1:length(t_long));

% SpO2 signalini simulyatsiya qilish (Harakat artefaktini yaratish)
spo2 = 98 * ones(1, length(t_long));
% 4-sekunddan 6-sekundgacha SpO2 keskin tushadi (datchik qimirladi)
artifact_idx = (t_long > 4) & (t_long < 6);
spo2(artifact_idx) = 98 - 15 * sin(pi * (t_long(artifact_idx) - 4) / 2);

% Grafiklarni chizish
figure('Name', '3-rasm. Yolg''on trevogani inkor etish', 'Color', 'w');
subplot(2,1,1);
plot(t_long, ecg_stable, 'k');
title('EKG signali (Ritm barqaror - HR = 75 bpm)');
xlabel('Vaqt (s)'); ylabel('Amplituda (mV)'); grid on;
ylim([-1 2]);

subplot(2,1,2);
plot(t_long, spo2, 'b', 'LineWidth', 2);
hold on;
% Artefakt joyini belgilash
fill([4 6 6 4], [80 80 100 100], 'r', 'FaceAlpha', 0.1, 'EdgeColor', 'none');
text(5, 90, 'Harakat artefakti (SpO2 tushishi)', 'HorizontalAlignment', 'center', 'C
title('SpO2 trendi');
xlabel('Vaqt (s)'); ylabel('Kislorod saturatsiyasi (%)'); grid on;
ylim([80 100]);

annotation('textbox', [0.3 0.45 0.4 0.1], 'String', 'XULOSA: EKG ritmi barqaror bo''
```

3-rasm. MATLAB grafiki - Harakat artefakti tufayli yuzaga kelgan yolg'on trevoga va uning algoritm tomonidan inkor etilishi.

Ushbu mantiqiy algoritmning qo'llanilishi ITB sharoitida bemor monitoridan kelib chiqadigan yolg'on trevogalar (false alarms) sonini umumiy yozib olingan vaqt davomida taxminan 40-45% ga qisqartirish imkonini berdi. Ushbu tadqiqot natijalari bemor monitorlari orqali olinadigan hayotiy ko'rsatkichlarni raqamli qayta ishlashning klinik amaliyotdagi ahamiyatini ko'rsatib berdi. Intensiv terapiya bo'limlarida (ITB)

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shifokorlar va tibbiyot hamshiralari katta hajmdagi ma'lumotlar bilan ishlashga majbur. An'anaviy monitorlar ko'pincha harakat artefaktlari yoki datchiklarning vaqtinchalik aloqa yo'qotishi sababli yolg'on bong (false alarm) uradi.

Tadqiqotimizda MATLAB muhitida qo'llanilgan kaskadli filtrlar klinik jihatdan muhim bo'lgan ma'lumotlarni o'zgartirmagan holda, EKG signalidagi izoliniya siljishi va tarmoq xalaqitlarini muvaffaqiyatli bartaraf etdi. Olingan signal-shovqin nisbatining (SNR) oshishi, kardiologlar uchun signalni vizual tahlil qilish imkoniyatini keskin yaxshilaydi.

Ko'pgina oldingi tadqiqotlar faqat bitta turdagi signalni tahlil qilishga qaratilgan bo'lsa, ushbu ishda EKG va SpO2 signallarining mantiqiy bog'liqligi asosida xulosa chiqaruvchi algoritm qo'llanildi. Natijada yolg'on trevogalar soni 40-45% ga kamaytirildi. Bu ko'rsatkich tibbiyot xodimlarining "trevogadan toliqish" (alarm fatigue) sindromining oldini olishda muhim xisoblanadi.

Xulosa. Xulosa qilib aytganda, intensiv terapiya sharoitida bemorlarning hayotiy ko'rsatkichlarini avtomatlashtirilgan tarzda monitoring qilish diagnostika sifatini oshirishning eng samarali yo'llaridan biridir. Bemor monitoridan olinadigan uzluksiz signallarni (EKG, SpO2) MATLAB dasturiy muhitida raqamli filtrlash va algoritmik tahlil qilish natijasida quyidagilarga erishildi:

1. Xom signallar tarkibidagi 50 Hz chastotali xalaqitlar va harakat artefaktlari samarali tozalandi.
2. Modifikatsiya qilingan Pan-Tompkins algoritmi yordamida EKG signalidan yurak urish tezligi (HR) 98.5% aniqlik bilan hisoblab chiqildi.
3. Bir nechta parametrlarni birgalikda (kompleks) tahlil qiluvchi algoritm yordamida apparatlardagi klinik ahamiyatga ega bo'lmagan yolg'on trevogalar qariyb yarmiga qisqartirildi.

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YUQORI QUVVATLI PO‘LAT KONSTRUKSIYALARINI GAZ-HIMOYA MUHITIDA PAYVANDLASH JARAYONINING TEXNOLOGIK PARAMETRLARINI OPTIMALLASHTIRISH

Xoshimova Dilbaroy Olimjon qizi
Andijon davlat texnika instituti
“Texnologik mashinalar va jihozlar” yo‘nalishi 3-kurs talabasi
dilbaroydilbarxon691@gmail.com

Annotatsiya: Mazkur maqolada zamonaviy sanoatda va qurilishda keng qo‘llaniladigan yuqori quvvatli po‘lat konstruksiyalarini payvandlash jarayonlarining texnologik xususiyatlari, yuzaga keladigan nuqsonlar va ularni bartaraf etish yo‘llari yoritilgan. Tadqiqot doirasida zamonaviy payvandlash usullari tahlil qilinib, ularning chok sifatiga ta’siri o‘rganildi. Olingan natijalar payvand birikmalarining mexanik xossalari va ekspluatatsion ishonchliligini oshirish imkoniyatlarini ko‘rsatadi.

Kalit so‘zlar: payvandlash, yuqori quvvatli po‘latlar, argon-yoy usuli, chok sifati, mexanik xossalar, nuqsonlar, konstruksiya mustahkamligi.

Аннотация: В данной статье освещены технологические особенности сварки высокопрочных стальных конструкций, широко используемых в современной промышленности, возникающие дефекты и способы их устранения. В рамках исследования проанализированы современные методы сварки и изучено их влияние на качество шва. Полученные результаты указывают на возможности повышения механических свойств и эксплуатационной надёжности сварных соединений.

Ключевые слова: сварка, высокопрочные стали, аргонодуговой метод, качество шва, механические свойства, дефекты, прочность конструкции.

Abstract: This article discusses the technological features of welding high-strength steel structures widely used in modern industry, the defects that may occur, and ways to prevent or eliminate them. Modern welding methods are analyzed, with particular

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attention to their effect on weld quality. The findings indicate potential ways to improve the mechanical properties and service reliability of welded joints.

Keywords: welding, high-strength steels, argon-arc method, weld quality, mechanical properties, defects, structural strength.

Kirish. Hozirgi kunda jahon miqyosida mashinasozlik, neft-gaz sanoati, ko‘priksozlik va yirik sanoat inshootlarini qurishda yuqori quvvatli legirlangan po‘latlardan foydalanish hajmi yildan-yilga ortib bormoqda [1]. Og‘ir yuk ostida ishlaydigan bunday konstruksiyalarning ishonchliligi ko‘p jihatdan ularni biriktiruvchi payvand choklarining sifatiga bog‘liq. Payvandlash jarayoni murakkab fizik-kimyoviy hodisa bo‘lib, uning davomida metallning qizishi, erishi va sovishi natijasida strukturaviy o‘zgarishlar sodir bo‘ladi.

Yuqori quvvatli po‘latlarni payvandlashda duch kelinadigan asosiy muammolardan biri — chok atrofidagi zonada (ChAZ) haddan tashqari qattiqlashish, yoriqlar hosil bo‘lishi hamda plastiklikning pasayishidir. An’anaviy usullarda qo‘llaniladigan texnologik parametrlar har doim ham zarur sifatni ta’minlay olmaydi. Shu bois, payvandlash rejimlarini ilmiy asosda optimallashtirish, himoya gazlari aralashmasini to‘g‘ri tanlash va issiqlik kiritilishini boshqarish bugungi kunda dolzarb vazifalardan biri hisoblanadi.

Maqolaning maqsadi: yuqori quvvatli po‘lat konstruksiyalarini payvandlash jarayonining texnologik parametrlarini takomillashtirish hamda hosil bo‘ladigan payvand choklarining mustahkamligi va ekspluatatsion resursini oshirish.

Maqolaning vazifalari:

1. Yuqori quvvatli po‘latlarni payvandlashda yuzaga keladigan metallurgik va texnologik muammolarni tahlil qilish.
2. Turli himoya gazlari muhitida bajariladigan payvandlash usullarining sifat ko‘rsatkichlarini qiyosiy o‘rganish.
3. Olingan eksperimental natijalar asosida ishlab chiqarish uchun tavsiyalar ishlab chiqish.

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Tadqiqot metodologiyasi. Tadqiqot jarayonida ilmiy tahlil, metallografik kuzatishlar, mexanik sinovlar (statik cho‘zilish, qattiqlikni o‘lchash va zarbga sinash) hamda zamonaviy payvandlash uskunalari yordamida tajriba namunalarini tayyorlash usullaridan foydalanildi. Tajribalar uchun sanoatda keng qo‘llaniladigan 09Г2С va 15ХСНД rusumli konstruksion po‘latlar tanlab olindi [2].

Tajriba jarayonida quyidagi texnologik uskunalar va o‘lchash vositalari qo‘llanildi: yarim avtomat MIG/MAG inverter payvandlash apparati, raqamli gaz sarfi o‘lchagichlari va kuchlanish hamda tok datchiklari. Namunalarning qattiqligi Vickers usuli bo‘yicha HV10 yuklamada o‘lchandi. Cho‘zilish sinovlari universal Instron sinov mashinasida amalga oshirildi.

Payvandlash ishlari turli tarkibdagi himoya gazlari — toza karbonat angidrid (CO_2) va argon hamda 20% karbonat angidrid aralashmasi (Ar + 20% CO_2) — muhitida bajarildi. Payvand choklarining ichki nuqsonlari ultratovush va rentgen-defektoskopiya usullari yordamida tekshirildi. Olingan raqamli ma’lumotlar statistik qayta ishlanib, tahlil qilindi.

Tahlil va natijalar. O‘tkazilgan eksperimental tadqiqotlar himoya gazi tarkibini o‘zgartirish va payvandlash toki parametrlarini optimallashtirish chok sifatiga ijobiy ta’sir ko‘rsatishi mumkinligini ko‘rsatdi. Quyidagi jadvalda an’anaviy usul va taklif etilgan gaz aralashmasida payvandlash natijalari keltirilgan.

Payvandlash usullarining asosiy ko‘rsatkichlari taqqoslanishi

1-jadval.

Sinov ko‘rsatkichi	An’anaviy usul (toza CO_2)	Taklif etilgan usul (Ar + 20% CO_2)	O‘zgarish samaradorlik
Vaqtinchalik qarshilik (MPa)	540	620	+14,8%
Zarbga chidamlilik (MJ/m^2)	0,65	0,88	+35,3%
Sochma nuqsonlar soni (dona/m)	4–5	0–1	Keskin kamaydi

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Payvandlash tezligi (m/soat)	18	26	+44,4%

Metallografik tahlil natijalariga ko‘ra, argon qo‘shilgan gaz aralashmasidan foydalanish issiqlik ta’sir zonasining hajmini kamaytirishi va donador tuzilmaning bir xilroq hamda maydaroq shakllanishiga yordam berishi mumkin. Bu holat payvand birikmasining mexanik xossalari va yuk ko‘tarish qobiliyatiga ijobiy ta’sir ko‘rsatishi ehtimol.

Muhokama. Olingan natijalar tahlili yuqori quvvatli po‘latlarni payvandlashda himoya muhitining muhim ahamiyatga ega ekanini ko‘rsatadi. Avvalgi tadqiqotlarda [3] asosan tok kuchini boshqarish orqali sifatga erishishga e’tibor qaratilgan bo‘lsa, mazkur ishda himoya gazi tarkibini optimallashtirish va issiqlik kiritish rejimini birgalikda qo‘llash yondashuvi ko‘rib chiqildi.

Toza karbonat angidrid (CO_2) muhitida payvandlashda yoyning xususiyatlari va metallning oksidlanishi chok tarkibi hamda sachrash miqdoriga ta’sir qilishi mumkin. Argon qo‘shilgan gaz aralashmasi yoy barqarorligini yaxshilashi va sachrashni kamaytirishi mumkin. Biroq natija po‘lat markasi, payvandlash simi turi, tok kuchi, kuchlanish, gaz sarfi va payvandlash texnikasiga ham bog‘liq.

Yuqori quvvatli po‘latlarni payvandlashda texnologik parametrlarni to‘g‘ri tanlash alohida ahamiyatga ega. Jumladan, payvandlash toki, yoy kuchlanishi, payvandlash tezligi, himoya gazining sarfi va elektrod simining uzatish tezligi o‘zaro muvofiqlashtirilishi kerak. Issiqlik kiritilishining haddan tashqari yuqori yoki past bo‘lishi chok metallining tuzilishi va mexanik xossalariga salbiy ta’sir ko‘rsatishi mumkin.

Tadqiqotning ilmiy yangiligi sifatida yuqori quvvatli po‘latlar uchun gaz aralashmasi tarkibi va texnologik rejimlarni birgalikda tanlash yondashuvi ko‘rsatiladi. Amaliy ahamiyati ushbu yondashuvni mashinasozlik va metall konstruksiyalar ishlab chiqarishida qo‘llash orqali mahsulot sifatini yaxshilash va nuqsonlar xavfini kamaytirish imkoniyati bilan belgilanadi.

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Xulosa. Yuqori quvvatli po‘lat konstruksiyalarini payvandlashda uchrashi mumkin bo‘lgan nuqsonlarning asosiy sabablari ko‘rib chiqildi va ularning oldini olish yo‘llari bayon etildi.

1. Dastlabki matnda keltirilgan tajriba ma’lumotlariga ko‘ra, argon va karbonat angidrid aralashmasidan foydalanilganda zarbga chidamlilik 35,3% ga, vaqtinchalik qarshilik esa 14,8% ga oshgan.

2. Taklif etilgan yondashuv ishlab chiqarish unumdorligini oshirish va payvand chokidagi nuqsonlar sonini kamaytirish imkoniyatiga ega.

3. Payvandlash sifatini oshirish uchun himoya gazi tarkibi bilan bir qatorda tok kuchi, kuchlanish, payvandlash tezligi va issiqlik kiritilishi ham maqbul darajada tanlanishi zarur.

Amaliy tavsiya sifatida shuni aytish mumkinki, sanoat korxonalarida yuk ko‘taruvchi konstruksiyalarni payvandlash uchun himoya gazini tanlashda po‘lat markasi, payvandlash simi, metall qalinligi va talab etiladigan mexanik xossalarni hisobga olish lozim. Argon–karbonat angidrid aralashmasini esa sinovlar va amaldagi payvandlash texnologiyasi talablari asosida qo‘llash tavsiya etiladi.

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STRATEGIC PLANNING FOR NATIONAL ECONOMIC SECURITY: LINKING RISK ASSESSMENT, POLICY COORDINATION, AND ECONOMIC RESILIENCE

Kopalova Salima
Tashkent State University of Economics
Tashkent, Uzbekistan
Kopalovas06@gmail.com

Abstract. Economic security has moved from the margins of foreign-policy debate to the centre of national strategy. Supply shocks, export controls, tariffs and the deliberate use of economic dependencies as instruments of pressure make it hard for governments to treat prosperity and security as separate files. This article argues that national economic security is best planned as a single cycle in which risk assessment, policy coordination and economic resilience feed one another, instead of three activities run in parallel by different ministries. Using a qualitative reading of official documents from the OECD, the IMF, the World Economic Forum, the European Commission, the G7 and the Government of Japan, together with Uzbekistan's national strategy and local reporting, the article proposes a five-stage planning framework and tests its logic against the Uzbek case. It concludes with recommendations for governments that want security without giving up openness.

Keywords: economic security; strategic planning; risk assessment; policy coordination; economic resilience; supply chains; Uzbekistan

Introduction. For most of the past three decades, ministries of economy and ministries of defence worked in largely separate worlds. Trade policy aimed at efficiency, security policy at deterrence, and the two met mainly at the border, where export-control lists did their quiet work. That separation no longer holds. The pandemic, the war in Ukraine, the spread of sanctions and export restrictions, and the open use of tariffs as bargaining tools have shown that a break in the supply of a semiconductor, a

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fertiliser or a payment channel can threaten a country's stability almost as surely as a military threat once did (OECD, 2025).

Perceptions of risk have shifted accordingly. In its 2026 edition, the World Economic Forum ranked geoeconomic confrontation first among near-term global risks: 18 per cent of respondents saw it as the risk most likely to trigger a global crisis in 2026, and it climbed eight places in the two-year severity ranking (WEF, 2026). The survey behind the report covers more than 1,300 leaders and experts, so it measures perception rather than outcomes, yet the direction of travel is hard to ignore.

Governments have answered with strategies, laws and coordination forums, but it is less clear how these pieces fit together. A risk register that nobody acts on is of little use. A coordination forum without shared risk analysis tends to produce statements rather than decisions. A subsidy or stockpiling programme that is not tied to a clear view of vulnerability can spend a great deal while leaving the real gaps open. This article therefore asks how strategic planning can link risk assessment, policy coordination and economic resilience into one coherent approach to national economic security.

The method is qualitative document analysis. The study draws on primary and near-primary sources: reports and communications from international organisations and governments, supplemented by reputable news and think-tank commentary where official texts were not available in English. Policy documents describe intentions more reliably than results, and that limit is kept in view throughout. The sections that follow set out the concepts, describe the risk landscape, examine risk assessment, coordination and resilience in turn, propose an integrated framework, apply it to Uzbekistan, and close with recommendations.

Conceptual Foundations

Economic security has no single agreed definition, and the differences between definitions are instructive. The European Union frames the problem as minimising risks that arise from certain economic flows at a time of geopolitical tension and fast technological change, while keeping the economy as open and dynamic as possible (European Commission & High Representative, 2023). Japan's approach is written into

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the very title of its 2022 law, which speaks of ensuring security through the integrated use of economic measures (METI, 2023). Both start from the same worry, that some economic ties carry security costs, and both insist that the cure should not be worse than the disease.

For the purposes of this article, national economic security means a state's capacity to keep its essential economic functions running, and to protect its freedom of policy choice, when it faces deliberate pressure or large external shocks. Three related terms need to be kept apart. A risk is the combination of a threat and its likely impact. A vulnerability is the feature of the economy that lets a threat do damage, such as dependence on one supplier or one transport corridor. Resilience is the ability to absorb a shock, adapt to it and recover. The OECD makes a point that planners often forget: the aim is not to eliminate risk but to navigate it well (OECD, 2025). A country that tried to remove every dependency would end up poorer and, as later sections show, no safer.

The Contemporary Risk Landscape

Risks to economic security come from several directions at once. The first is concentration: when a few suppliers, firms or routes dominate the supply of a critical input, a single failure spreads quickly. The OECD finds that strategic manufacturing sectors with complex supply chains, such as petroleum and electronics, are among the most exposed (OECD, 2025). The second is weaponisation, where one state uses another's dependence as leverage through export bans, boycotts or sanctions. The European Commission lists the weaponisation of economic dependencies and economic coercion as one of four risk areas that need systematic assessment (European Commission & High Representative, 2023).

The third risk is the fragmentation of the system itself. The IMF's staff review of the evidence suggests that severe trade fragmentation could cut global output by up to 7 per cent, and that losses could reach 8 to 12 per cent in some countries if technological decoupling is added; even limited fragmentation could cost around 0.2 per cent (IMF, 2023). The same note warns that emerging and low-income economies are likely to be hit hardest, partly because financial regionalisation would reduce international risk-

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sharing and leave national buffers under more strain. The WEF adds mounting debt, possible asset bubbles and inflation pressure to the picture (WEF, 2026). The lesson for planners is that economic security risks are rarely isolated. They combine trade, technology, finance and infrastructure, and they travel across sectors faster than most government departments do.

Risk Assessment: Seeing the Problem Clearly

Risk assessment is where national planning either becomes credible or drifts into slogans. The European approach is a useful reference because it is explicit about method. It proposes a common methodology and a structured assessment in four areas: the resilience of supply chains, the physical and cyber security of critical infrastructure, technology security and leakage, and the weaponisation of dependencies (European Commission & High Representative, 2023). Two principles, proportionality and precision, are meant to keep measures narrow and tied to specific risks. Japan reaches a similar place by a different road. Its law designates specified critical materials on the basis of criteria that include how essential the good is and how far supply depends on outside sources (METI, 2023).

Good assessment has a recognisable shape. It begins by mapping which functions the economy cannot do without. It then traces the dependencies behind those functions, down to the second and third tier of suppliers where hidden concentration often sits. Each dependency is scored for likelihood of disruption and severity of impact, and the results are tested against scenarios, including extreme ones. The OECD's country annexes, which track interdependence with trading partners and the readiness of the policy environment, show that such monitoring is now feasible with existing data (OECD, 2025). The main discipline is selectivity. If everything is labelled critical, nothing is, and the budget is spread too thin to protect anything properly. The private sector must also be inside the process, because firms hold much of the data on suppliers and the European strategy explicitly calls business an essential partner (European Commission & High Representative, 2023).

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Policy Coordination: Aligning Actors and Instruments

Even a perfect risk map achieves little if the instruments sit in different hands. Coordination has to work at three levels. Inside government, someone must be able to bring trade, industry, finance, energy, digital and security agencies to one table. Japan's solution places overall coordination in the Cabinet Office, under a minister and a director-general responsible for economic security, and its law rests on four pillars: stable supply of critical materials, support for key technologies, screening of essential infrastructure and confidential handling of sensitive patents (METI, 2023; Timewell, 2026). The first designation list, issued in December 2022, covered eleven product categories, among them semiconductors, storage batteries and machine tools, and commentary based on Cabinet Office documents indicates that the list had grown to sixteen items by July 2026 (Timewell, 2026).

Between government and business, coordination means predictable rules, clear reporting duties and real incentives. Between states, it means sharing information and, where possible, acting together. At Hiroshima in 2023 the G7 launched a Coordination Platform on Economic Coercion built around early warning, rapid information sharing, regular consultation, joint assessment and coordinated responses, and it tied the effort to a rules-based system with the WTO at its core (G7, 2023). Analysts noted that the summit concentrated on supply chain resilience, countering coercion and protecting critical technologies (CSIS, 2023). The G7 text also calls for a larger role for developing countries in building resilience, a reminder that coordination should not be a club for the wealthy alone.

Economic Resilience: Building the Capacity to Absorb and Adapt

Resilience is where assessment and coordination turn into something the economy can feel. The OECD's central finding is that agile, adaptable and aligned supply chains are the real source of strength, and that governments can support them through trade facilitation, lower barriers in services such as transport and finance, and secure digitalisation (OECD, 2025). It is equally clear that simply bringing all production home would weaken, not strengthen, resilience. Trade-press coverage of the review reports its

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modelling as showing that a push towards domestic supply chains could reduce global trade by more than 18 per cent and global GDP by more than 5 per cent without improving resilience to disruption (MH&L News, 2025). Those figures come from a scenario exercise and should be read as an order of magnitude, but the message is consistent with the IMF's view that deeper fragmentation brings deeper costs (IMF, 2023).

In practice, resilience is built from many modest layers. Diversifying suppliers and routes reduces concentration. Targeted stockpiles and reserve capacity cover goods whose absence would be dangerous and whose substitutes are slow to develop. Strong fiscal and financial buffers give a government time to respond. Skilled workers and flexible firms can shift to new inputs.

An Integrated Planning Framework

Bringing the three elements together, this article proposes a five-stage planning cycle. This framework is the author's own synthesis of the sources reviewed rather than an official model. The first stage, sensing and assessing, builds a shared picture of dependencies and threats using data from government, firms and international partners. The second, prioritising and deciding, narrows the list to the few vulnerabilities that justify action and sets proportionate responses. The third, coordinating and acting, assigns each response to an agency, aligns it with business and partner states, and funds it. The fourth, building buffers and capacity, invests in diversification, reserves, skills and digital infrastructure so the economy can absorb shocks. The fifth, reviewing and learning, measures results, tests scenarios and feeds the findings back into the first stage.

The cycle echoes the EU's three-part logic of promoting competitiveness, protecting against risks and partnering with others (European Commission & High Representative, 2023), but it adds two features that planners often neglect. One is feedback: assessment is repeated, not done once. The other is explicit attention to the trade-off between security and openness, which should be argued openly at the prioritising stage and not discovered afterwards. Success indicators should be few and measurable, for example the share of critical inputs sourced from a single country, the

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number of days of reserve cover for essential goods, and the time needed to restore operations after a simulated disruption.

Application to Uzbekistan

Uzbekistan offers a useful test because it combines rapid growth with structural exposure. The strategy Uzbekistan-2030, adopted by presidential decree in September 2023, names sustainable growth, export capacity, green energy, water conservation and the principle of a safe and peace-loving state among its priorities, and it lists the sovereignty and security of the country among its main ideas (Government of Uzbekistan, 2023). Results so far are substantial. The President reported that GDP exceeded 145 billion US dollars in 2025, exports rose 23 per cent to 33.4 billion dollars, and gold and foreign-exchange reserves passed 60 billion dollars for the first time (Kun.uz, 2025). Later reporting says the 2030 target has been raised to 300 billion dollars (Times of Central Asia, 2026).

Read through the five-stage framework, the picture is encouraging but incomplete. In the documents reviewed here, economic security appears as a thread running through several priorities and not as a stand-alone doctrine like those of Japan or the EU. That is not a weakness in itself, yet it means that sensing and prioritising may be handled sector by sector. The country's geography reinforces the need for a joined-up view: Uzbekistan is doubly landlocked and therefore depends on neighbours for access to world markets. Regional commentary also identifies water as a constraint on future growth and notes that sustaining growth will rely increasingly on productivity and efficient private investment (Times of Central Asia, 2026). On the positive side, the strategy's 100 objectives are assessed annually (Dunyo IA), which provides the review mechanism the fifth stage requires, and large reserves give the country room to build buffers. A practical next step would be a periodic national dependency assessment, covering energy, food, water, transport corridors, digital infrastructure and key imports, with results shared across ministries and with business.

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Challenges and Limitations

Several difficulties deserve honest mention. First, data are imperfect, and deep supplier tiers are often invisible even to the firms involved. Second, unilateral action by one country can trigger retaliation, so coordination with partners is part of the risk calculation, not an optional extra. Third, targets shift. Uzbekistan's GDP goal for 2030 has been revised more than once as growth outpaced expectations (Kun.uz, 2025; Times of Central Asia, 2026), which is good news but illustrates how planning baselines move. Finally, this study relies on documents and secondary reporting, and several figures come from official statements or trade press that were not independently verified. Future research should test the framework with quantitative indicators and comparative case studies.

Policy Recommendations

Four recommendations follow. First, establish a standing coordination body with the authority to commission cross-sector risk assessments and to bring agencies, business associations and, where appropriate, regional partners together. Second, adopt a published, proportionate assessment method with clear criteria for designating critical goods and services, so that firms and partners understand why measures are taken. Third, invest in resilience that also supports growth, such as trade facilitation, digital logistics, diversified energy and transport links, and skills, rather than relying on blanket localisation. Fourth, institutionalise review through annual reporting, scenario exercises and sunset clauses for emergency measures. For smaller and middle-income economies, joining regional and international cooperation arrangements is often the most efficient way to gain early warning and bargaining weight that no single state could generate alone.

Conclusion. National economic security is a planning problem as much as a policy problem. Risk assessment without coordination leaves findings on the shelf, coordination without assessment spends political energy on the wrong targets, and resilience without either becomes an expensive habit. Linking the three in a repeating cycle gives governments a way to protect what matters while keeping the economy open

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to the trade and investment that make it prosperous. The evidence from the OECD, the IMF and the WEF points the same way: the costs of fragmentation are large, the risks are interconnected, and the best defence is a capable, adaptable and well-coordinated economy. For countries such as Uzbekistan, which are growing fast and integrating with the world, the window to build these capacities is now, while reserves are strong and reforms are still gathering pace.

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ARTIFICIAL INTELLIGENCE AND ECONOMIC SECURITY: EMERGING RISKS, GOVERNANCE CHALLENGES, AND RESILIENCE STRATEGIES

Atabayeva Ruhshona Sadulla qizi
Economics, Tashkent State University Of Economics

Abstract. Artificial intelligence (AI) is increasingly recognized as a general-purpose technology with significant implications for economic growth, employment, financial stability, and national security. This article examines how AI reshapes economic security, understood as the capacity of households, firms, and states to withstand shocks to income, markets, and critical infrastructure. Using a structured narrative review of academic research, international policy reports, regulatory frameworks, and technical safety studies, the article identifies four principal risk domains: labor-market disruption, market concentration and infrastructure dependence, financial instability, and malicious or geopolitical misuse. The review also examines governance challenges arising from fragmented regulatory approaches, limited institutional capacity, incomplete evidence, and the rapid pace of technological deployment. The findings indicate that AI-related risks are interconnected and that vulnerabilities can spread through shared models, concentrated computing infrastructure, and correlated institutional decisions. In response, the article proposes a layered resilience framework combining adaptive regulation, competition policy, financial supervision, workforce investment, and international coordination. It concludes that economic security depends not only on preventing harmful applications of AI but also on strengthening institutions' ability to anticipate, absorb, and recover from technological shocks.

Keywords: artificial intelligence, economic security, AI governance, financial stability, labor markets, resilience

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Introduction. Artificial intelligence (AI) has become an increasingly important factor in economic transformation. The public release of ChatGPT in late 2022 brought generative AI to widespread attention and accelerated debates about its potential to change employment, productivity, business operations, and public administration. AI systems can now support activities such as drafting documents, generating software code, analyzing financial information, and assisting with decision-making. These developments have created opportunities for productivity growth while raising concerns about economic dependence, unequal distribution of benefits, and systemic vulnerability.

The economic consequences of AI extend beyond the performance of individual firms or industries. As AI becomes integrated into financial services, supply chains, digital infrastructure, and public institutions, disruptions in one part of the technological ecosystem may affect many other organizations. An outage at a major cloud provider, for example, may interrupt services across several sectors. Similarly, the widespread adoption of similar AI models may create common vulnerabilities that are not immediately apparent when institutions assess risks independently.

This article approaches these issues through the concept of economic security. Because the term has no universally accepted definition, it is used here to describe the capacity of households, firms, and states to maintain stable incomes, functioning markets, and access to critical infrastructure during periods of disruption. This definition emphasizes both protection against immediate threats and the ability to adapt to structural economic change.

Previous research has examined AI's implications for productivity, employment, income distribution, and financial stability. Acemoglu (2024), for example, questions whether the near-term macroeconomic gains from AI will be as substantial as some forecasts suggest. Acemoglu and Restrepo (2019) explain how automation can displace workers while also creating new tasks. Meanwhile, the Financial Stability Board (FSB, 2024) identifies several channels through which AI adoption may affect the resilience of financial institutions and markets.

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Despite these contributions, the relationship between AI and economic security requires an integrated perspective. Labor-market adjustment, technological concentration, financial interdependence, and malicious use are often examined separately, even though they can reinforce one another. Governance arrangements are also divided among institutions responsible for employment, competition, financial regulation, cybersecurity, and national security.

The purpose of this article is to synthesize the available literature on these interconnected issues and identify practical strategies for strengthening economic resilience. It addresses three research questions:

1. What are the principal risks that AI creates for economic security?
2. Why do existing governance arrangements struggle to address these risks effectively?
3. What policies can strengthen the capacity of economies and institutions to withstand and adapt to AI-related shocks?

The article argues that AI-related economic security depends not only on technological performance but also on the distribution of economic gains, the concentration of essential infrastructure, the degree of institutional preparedness, and the capacity for coordinated action. Because the evidence is still developing, the analysis distinguishes documented vulnerabilities from plausible risks that require further empirical investigation.

Methods.

Research Design

This article uses a structured narrative literature review to examine the relationship between artificial intelligence and economic security. A narrative approach is appropriate because the subject spans several disciplines, including economics, financial regulation, technology governance, cybersecurity, and international relations. These fields use different concepts and research methods, making a single quantitative synthesis difficult.

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The analysis focuses on identifying recurring risk mechanisms, comparing governance approaches, and synthesizing policy recommendations. It does not present original experimental data or claim to estimate the causal effects of AI adoption on economic outcomes. Instead, it develops an integrated analytical framework from previously published research and institutional assessments.

Sources and Selection Criteria

The review draws on four principal categories of sources.

First, it uses peer-reviewed economics research on automation, productivity, labor-market adjustment, and income distribution. Relevant contributions include Autor (2015), Acemoglu and Restrepo (2019), and Eloundou et al. (2024).

Second, the review considers reports from international institutions, particularly the International Monetary Fund (IMF) and the Financial Stability Board. These sources provide assessments of AI exposure across labor markets and identify potential vulnerabilities within financial systems.

Third, it examines technical research on foundation models, malicious uses of AI, and emerging safety concerns. The work of Bommasani et al. (2021), Brundage et al. (2018), and Bengio et al. (2025) informs the discussion of shared model dependencies, cybersecurity, fraud, and uncertainty surrounding advanced AI capabilities.

Fourth, the review considers governance frameworks and regulatory instruments, including the OECD AI Principles, the European Union AI Act, and the National Institute of Standards and Technology AI Risk Management Framework.

Sources were selected for their relevance to at least one of the following themes: economic and labor-market effects, market concentration and infrastructure dependence, financial-system vulnerabilities, malicious or geopolitical uses, and regulatory capacity. Particular attention was given to research that identifies mechanisms through which technological risks can spread beyond individual users or organizations.

This is a targeted narrative synthesis rather than an exhaustive systematic review. No comprehensive database search, formal screening protocol, or statistical meta-analysis is claimed. Consequently, the findings should be interpreted as a structured

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synthesis of selected literature rather than a complete inventory of all published evidence.

Analytical Framework

The selected literature was organized into four risk domains: labor-market disruption; market concentration and infrastructure dependence; financial instability; and malicious or geopolitical misuse. These categories were chosen to connect individual economic effects with broader questions of systemic resilience.

Each domain was examined through three analytical dimensions:

Risk mechanism: How AI adoption may create or amplify economic vulnerability.

Governance gap: Why existing institutions, rules, or monitoring systems may be insufficient.

Resilience response: What policy or organizational measures may reduce exposure or improve recovery.

The analysis then compared the risk domains to identify common mechanisms, particularly technological concentration, information asymmetry, correlated decision-making, and uneven distribution of adjustment costs. These mechanisms provide the basis for the integrated policy framework presented in the Discussion section.

Results.

Labor-Market Disruption and Unequal Economic Adjustment

The literature indicates that AI exposure is widespread but unevenly distributed across occupations, sectors, and countries. The IMF estimates that nearly 40% of global employment is exposed to AI, with exposure reaching approximately 60% in advanced economies and around 26% in low-income countries (Cazzaniga et al., 2024). These figures describe potential exposure rather than the proportion of jobs certain to disappear.

Exposure can produce different outcomes. AI may complement workers by helping them complete tasks more efficiently, improve the quality of their output, or perform activities that previously required substantial time. In other cases, AI may reduce the demand for particular tasks, weaken workers' bargaining positions, or allow firms to

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reorganize production with fewer employees. Eloundou et al. (2024) similarly find that large language models have the potential to affect a substantial proportion of tasks performed by workers in the United States.

The distinction between task exposure and job displacement is essential. Jobs consist of multiple activities, and the automation of some activities does not necessarily eliminate an entire occupation. Autor (2015) explains that technological change has historically transformed the composition of work while creating demand for tasks that require human judgment, interpersonal interaction, and contextual understanding.

Nevertheless, the pace and distribution of adjustment remain important concerns. Acemoglu and Restrepo (2019) distinguish between the displacement of labor by automation and the creation of new tasks in which human workers retain a comparative advantage. Economic outcomes depend partly on the balance between these forces. If displacement proceeds faster than the creation of new tasks, workers may face prolonged unemployment, wage reductions, or declining job security.

These effects may be particularly difficult for workers whose skills are closely tied to declining occupations or local labor markets with limited alternative employment. The benefits of AI may also accrue disproportionately to firms, investors, and highly skilled workers who can use or own the technology. Korinek and Stiglitz (2019) emphasize that technological progress can increase inequality when market outcomes do not adequately distribute its benefits.

The literature therefore identifies labor-market disruption as both a productivity issue and an economic security issue. Even if aggregate output rises, households may remain vulnerable when income losses occur faster than workers can retrain or find alternative employment.

Market Concentration and Infrastructure Dependence

The development and deployment of advanced AI require computing resources, data, specialized expertise, energy, and substantial financial investment. These requirements can create barriers to entry, particularly for organizations seeking to develop and operate frontier models. Bommasani et al. (2021) discuss the opportunities

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and risks associated with foundation models, including the implications of building many downstream applications on a relatively limited set of general-purpose systems.

Concentration creates potential efficiency benefits. Large providers may spread development costs across many customers, maintain specialized security teams, and offer sophisticated infrastructure that smaller organizations could not build independently. However, the same economies of scale may increase dependence on a small number of suppliers.

This dependence can create a single point of failure. If a widely used model, cloud service, or computing platform experiences a major outage, cyberattack, or operational failure, the consequences may extend to numerous organizations that rely on it. Firms may also encounter high switching costs if their applications depend on provider-specific interfaces, data formats, or proprietary tools.

The FSB (2024) identifies third-party dependencies and concentration among the important AI-related vulnerabilities relevant to financial stability. Similar mechanisms may affect other critical sectors that depend on digital infrastructure.

Infrastructure dependence also has a geopolitical dimension. Advanced semiconductors, data-center capacity, and reliable energy supplies have become strategically significant resources. Restrictions on access to these resources may influence national technological capabilities and create vulnerabilities in international supply chains.

The principal finding in this domain is that AI-related economic security cannot be assessed solely at the level of individual models. It also depends on the structure of the markets and infrastructure through which AI is developed, distributed, and maintained.

Financial-System Vulnerabilities

Financial institutions use AI in activities such as fraud detection, credit assessment, customer service, risk analysis, and trading. These applications can improve efficiency and help institutions process large volumes of information. However, their growing adoption also creates new forms of operational and systemic exposure.

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The FSB (2024) identifies several relevant vulnerabilities, including third-party dependencies, market correlations, cyber risk, and model risk. These vulnerabilities can interact.

One concern is correlated decision-making. If many institutions rely on similar models, training data, or optimization objectives, their responses to new information may become more alike. During periods of stress, this similarity could reinforce common trading decisions, reduce market diversity, or contribute to procyclical behavior. The precise magnitude of these effects remains uncertain and requires empirical investigation.

A second concern is model opacity. Complex systems may be difficult to interpret, making it challenging for institutions and supervisors to determine why a model generated a particular output or whether its performance will remain reliable under unusual conditions. Models that perform well in normal circumstances may behave differently when market conditions change sharply.

Third-party dependence creates an additional operational risk. If a financial institution relies on an external AI provider, disruption at that provider may affect multiple services simultaneously. The resulting effects may be difficult to anticipate when institutions assess vendor relationships separately.

These findings suggest that AI-related financial vulnerabilities extend beyond the accuracy of individual models. They involve common exposures, interconnected service providers, and the possibility that failures could occur simultaneously across institutions.

Malicious Use and Geoeconomic Competition

AI can also reduce the resources required to produce certain forms of deception and digital attack. Brundage et al. (2018) examined how AI might facilitate malicious activities, including cyberattacks, social engineering, and disinformation. Subsequent safety assessments have continued to examine the implications of AI-enabled fraud, scams, and cyber operations, while recognizing that evidence about the scale and effectiveness of some capabilities remains incomplete (Bengio et al., 2025).

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Generative systems can produce convincing text, images, audio, and other digital material. These capabilities may help malicious actors personalize fraudulent messages, impersonate trusted individuals, or generate misleading content at scale. The resulting economic consequences may include direct financial losses, higher verification costs, and reduced confidence in digital transactions.

The broader concern is the reliability of information. Markets depend on the ability of participants to verify identities, assess information, and trust transaction processes. As synthetic content becomes more accessible, institutions may need stronger authentication and verification mechanisms.

At the state level, AI is increasingly connected to strategic competition. Governments have incentives to secure access to advanced chips, computing capacity, data, talent, and energy. Export controls and other restrictions may be used to protect national security interests, but they can also fragment supply chains and complicate international cooperation.

The review identifies malicious use and geopolitical competition as related but distinct challenges. The first concerns the exploitation of AI capabilities by harmful actors; the second concerns strategic decisions by states that influence access to technology and the resilience of international economic networks.

Governance Gaps and Institutional Constraints

The reviewed governance frameworks address important aspects of AI risk, but their scope, legal status, and enforcement mechanisms differ.

The OECD AI Principles, adopted in 2019 and updated in 2024, provide an intergovernmental framework for responsible AI development and use. The European Union AI Act establishes a legally binding, risk-based regulatory framework with obligations that vary according to the relevant system and activity (European Parliament & Council of the European Union, 2024). In the United States, the NIST AI Risk Management Framework offers guidance for identifying, assessing, and managing AI-related risks (National Institute of Standards and Technology, 2023).

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These approaches provide useful foundations, but they do not create a fully coordinated international system for managing AI-related economic security. Differences in regulatory requirements may increase compliance costs for firms operating across borders. Differences in institutional capacity may also produce uneven levels of protection.

A further problem is the distribution of responsibilities. Labor ministries may focus on employment transitions, competition authorities on market structure, financial supervisors on institutional stability, and cybersecurity agencies on digital threats. Yet AI-related shocks can affect all these areas simultaneously.

Evidence and timing create additional difficulties. The International AI Safety Report discusses the challenge of deciding when to intervene in the presence of uncertainty (Bengio et al., 2025). Early regulation may impose unnecessary costs or become outdated, whereas delayed intervention may allow vulnerabilities to become deeply embedded in critical systems.

Effective governance also requires technical expertise, reliable incident reporting, and access to relevant information. Public institutions that lack these resources may struggle to evaluate claims made by technology providers or assess the consequences of complex systems.

Taken together, the literature points to a governance gap characterized by fragmented responsibilities, uneven enforcement capacity, incomplete evidence, and limited coordination across jurisdictions.

Summary of Findings

The findings can be summarized by connecting each risk domain to its principal vulnerability and a corresponding resilience response.

Risk domain	Principal vulnerability	Governance challenge	Resilience response
Labor markets	Displacement and unequal	Insufficient transition support	Retraining, wage insurance,

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	distribution of gains		employment services
Market concentration	Dependence on a limited number of providers	Difficulties addressing AI supply-chain power	Interoperability, competition policy, alternative providers
Financial stability	Correlated models and shared service dependencies	Incomplete monitoring and stress testing	Dependency mapping, model validation, AI-aware stress tests
Malicious use	Fraud, impersonation, and cyber operations	Cross-border enforcement difficulties	Incident sharing, authentication, coordinated security measures
Geoeconomic competition	Concentrated access to strategic resources	Fragmented international approaches	Supply-chain resilience and international coordination

Note. The table synthesizes the themes identified in the literature reviewed in this article.

Discussion.

From Individual Risk Management to Systemic Resilience

The findings indicate that AI-related economic security is a systemic problem rather than a collection of independent technical concerns. Labor-market disruption affects household income and demand. Infrastructure concentration creates shared operational vulnerabilities. Financial institutions may respond similarly to shocks when they depend on comparable models. Malicious use can weaken trust in digital transactions, while geopolitical competition can disrupt access to essential resources.

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These mechanisms suggest that policies focused exclusively on individual model accuracy or organizational compliance may be insufficient. A model can perform well in isolation while still contributing to a broader vulnerability if it is deployed widely, depends on a single provider, or encourages similar decisions across institutions.

Resilience provides a useful framework for addressing these interconnected risks. Rather than assuming that every failure can be prevented, resilience focuses on reducing exposure, maintaining essential functions during disruption, recovering efficiently, and adapting to new conditions. This approach is especially relevant when technological capabilities and economic consequences are changing faster than the evidence can fully establish their long-term effects.

Adaptive and Risk-Proportionate Regulation

Regulation should be proportionate to the potential consequences of an AI application. Systems that influence access to essential services or support high-impact financial decisions may warrant more extensive safeguards than applications used for low-stakes administrative tasks.

The risk-based approach reflected in the EU AI Act offers one reference point, while the NIST AI Risk Management Framework provides practical guidance for managing risks throughout the AI life cycle. However, the effectiveness of these approaches depends on implementation, institutional capacity, and the availability of evidence.

Regulators should combine established rules with mechanisms for learning. Regulatory sandboxes can help authorities and firms evaluate new applications under controlled conditions. Incident-reporting requirements can reveal recurring failures, while scheduled reviews can allow requirements to evolve as evidence changes.

Adaptive regulation should not mean indefinite delay. Where credible evidence indicates a risk of severe or widespread harm, safeguards may be justified even when the probability and magnitude of future damage cannot be estimated precisely. At the same time, regulatory requirements should be reviewed to avoid unnecessary burdens that prevent beneficial innovation.

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Competition Policy and Infrastructure Resilience

Market concentration creates a policy challenge because the same economies of scale that support AI development may also create dependence. Competition authorities should therefore consider the structure of the wider AI supply chain, including cloud computing, semiconductor access, model distribution, and the services needed to integrate AI into business operations.

Interoperability and data portability may reduce switching costs when technically and legally appropriate. Publicly supported computing resources can also widen access to research infrastructure and reduce barriers for universities, small firms, and public-interest projects.

Organizations operating critical services should avoid treating a single provider as an unavoidable dependency. Multi-provider strategies, backup arrangements, tested exit plans, and contingency procedures can help maintain essential functions during an outage. These measures should be evaluated according to the criticality of the service and the feasibility of switching, since maintaining multiple providers may itself introduce additional costs and complexity.

The broader objective is not to eliminate large technology providers but to ensure that their failure, withdrawal, or loss of availability does not automatically become a widespread economic disruption.

Financial Supervision and System-Wide Stress Testing

Financial supervisors should assess AI adoption as part of operational resilience and systemic-risk monitoring. Institutions can begin by identifying where AI is used in important functions, which external providers support those functions, and how disruptions might affect customers, counterparties, and other institutions.

Model validation should examine not only average performance but also behavior under unusual conditions. Supervisors and institutions should consider whether models remain reliable when market conditions shift, whether their decisions are excessively correlated, and whether alternative processes are available if a model becomes unavailable.

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Stress testing can incorporate hypothetical scenarios involving the simultaneous failure of a widely used model or cloud provider, a large-scale AI-enabled fraud campaign, or a period in which similar automated strategies amplify market volatility. Such exercises would not predict future events precisely; their purpose would be to identify weaknesses and test contingency plans.

Human oversight should be meaningful rather than merely procedural. Staff responsible for high-impact decisions need sufficient expertise, authority, and access to information to question automated outputs and intervene when appropriate.

These measures would help supervisors assess AI-related risks as potential sources of interconnected failure rather than treating every deployment as an isolated technology project.

Workforce Investment and Social Protection

Labor-market resilience requires policies that help workers move into new activities while maintaining economic security during the transition. The objective should not be to preserve every existing task or occupation indefinitely, but to ensure that technological gains do not impose disproportionate costs on workers who have limited resources to adjust.

Active labor-market policies can include targeted retraining, employment services, career guidance, and support for mobility. Training programs should be linked to credible labor-market demand rather than designed around the assumption that every worker can transition into a technical occupation.

Wage insurance or temporary income support may help workers whose earnings fall after displacement. Portable training entitlements can allow workers to obtain new skills throughout their careers, while employer-supported development can help employees adapt before their roles become obsolete.

Tax and subsidy arrangements should also be assessed for unintended incentives that favor replacing workers over improving their productivity. Acemoglu and Restrepo (2019) emphasize the importance of new task creation in shaping the labor-market

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effects of automation. Policies that support innovation complementary to human work may therefore contribute to a more inclusive transition.

International differences matter as well. The IMF finds that economies differ in their exposure and preparedness for AI (Cazzaniga et al., 2024). Countries with limited digital infrastructure, financial resources, or training capacity may struggle to capture benefits while absorbing adjustment costs. International assistance should consequently include education, institutional capacity, and access to appropriate infrastructure.

International Coordination and Shared Evidence

AI supply chains and digital services operate across national borders, making purely domestic solutions incomplete. A major provider may serve customers in many jurisdictions, while cyber operations and financial consequences can spread internationally.

International cooperation should prioritize compatible incident-reporting practices, information exchange, and shared methods for evaluating high-impact AI systems. Common approaches can help authorities identify emerging threats while reducing unnecessary duplication across jurisdictions.

Cooperation should also extend to technical expertise and capacity-building. Lower-income countries need opportunities to participate in decisions about standards, access to infrastructure, and the distribution of economic benefits. Otherwise, international governance may reflect the priorities of countries and firms with the greatest resources while leaving other economies more exposed to external decisions.

Coordination does not require every country to adopt identical rules. Different legal systems and economic conditions may justify different implementation choices. The practical goal is to improve the compatibility of safeguards, increase the availability of reliable evidence, and reduce the likelihood that regulatory gaps become channels through which systemic risks spread.

An Integrated Resilience Framework

The policy implications can be organized into five mutually reinforcing pillars.

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First, adaptive governance should establish proportionate safeguards, incident reporting, regular review, and clear institutional responsibilities.

Second, infrastructure resilience should reduce excessive dependence on individual providers through competition policy, interoperability, backup arrangements, and realistic exit plans.

Third, financial resilience should incorporate AI dependencies into supervisory monitoring, model validation, operational continuity planning, and system-wide stress testing.

Fourth, social resilience should support workers through training, employment services, income protection, and policies that encourage productive uses of AI.

Fifth, international resilience should strengthen shared evidence, compatible standards, cross-border incident response, and participation by countries with different levels of technological capacity.

The pillars are interdependent. For example, infrastructure diversification may be ineffective if smaller providers lack adequate security, while workforce training may have limited value if the jobs created by technological change are geographically inaccessible. Similarly, incident reporting cannot improve governance if institutions lack the resources to analyze the information collected.

Implementation should therefore be guided by measurable outcomes. Governments can monitor worker transitions and wage changes, the concentration of critical services, the frequency and severity of AI-related incidents, and the effectiveness of institutional recovery plans. Such monitoring would allow policies to be adjusted as evidence accumulates.

Limitations and Future Research

This article has several limitations. First, it relies on a selected narrative synthesis rather than an exhaustive systematic review. Relevant research may therefore have been omitted. Second, many estimates of AI's future effects are based on task exposure, scenarios, or projections rather than observed long-term outcomes. Exposure does not translate directly into job losses, productivity gains, or financial instability.

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Third, the pace of technological change means that some assessments may become outdated as capabilities, business models, and regulations evolve. Fourth, the article proposes an integrated policy framework but does not empirically test the effectiveness or cost of each intervention.

Future research should examine realized labor-market outcomes across occupations and countries, the relationship between AI adoption and market concentration, and the conditions under which shared models increase systemic risk. Comparative studies could also assess which regulatory approaches improve safety without unnecessarily restricting beneficial innovation. Finally, further research is needed to determine how public institutions can measure AI-related economic security using reliable indicators and comparable cross-country data.

Conclusion.

Artificial intelligence has the potential to improve productivity, expand access to analytical capabilities, and strengthen the detection of fraud and other threats. At the same time, it can create vulnerabilities that affect employment, market structure, financial stability, and confidence in digital transactions. These risks are not determined by technology alone; they depend on how AI is deployed, who controls essential infrastructure, how economic gains are distributed, and whether institutions can respond effectively to disruption.

The literature reviewed in this article identifies four principal risk domains: labor-market disruption, concentration and infrastructure dependence, financial-system fragility, and malicious or geopolitical misuse. Across these domains, several common problems emerge. Economic benefits and adjustment costs may be distributed unevenly, critical services may depend on a limited number of providers, similar models may create correlated behavior, and governance institutions may lack sufficient evidence or technical capacity.

A resilient approach requires coordinated action across regulation, competition policy, financial supervision, workforce development, and international cooperation. Governments should adopt proportionate safeguards and improve their capacity to learn

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from incidents. Firms should map dependencies, validate important models, and prepare credible continuity plans. Labor-market institutions should help workers adapt while protecting them against severe income shocks. International bodies should promote shared evidence and compatible standards while ensuring that lower-income economies can participate meaningfully in governance.

The central conclusion is that economic security in the age of AI should be understood as the ability to benefit from technological progress without allowing its risks to become uncontrollable sources of social or systemic instability. Prevention remains important, but resilience is equally essential because uncertainty cannot be eliminated. Building institutional capacity, reliable data, diversified infrastructure, and mechanisms for cooperation now may reduce the economic and social costs of future disruptions.

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FOOD SECURITY AND STRATEGIC RESERVE SYSTEMS

Gulnoza Zokirovna Tohirova
Tashkent State University of Economics
Student, Faculty of Economics Group I 55/24i
Email: gulnozatohirova166@gmail.com

Abstract. This study examines the multi-dimensional impacts of climate change and environmental degradation on food security, public health, and socioeconomic welfare in Uzbekistan and Central Asia. Utilizing dynamic panel econometric modeling, household expenditure analysis, and scenario simulations covering the 2000–2024 period, the empirical findings demonstrate that temperature anomalies and hydrological stress directly contract staple crop productivity, with a $1^{\circ}C$ temperature increase reducing wheat yields by 3.8% and horticultural output by 4.5%. Climate-induced supply shocks trigger seasonal food price inflation, disproportionately eroding the purchasing power of low-income households (D1–D3) who expend $55\% - 60\%$ of their income on basic foodstuffs. Simultaneously, environmental stress intersects with public health: ambient $PM_{2.5}$ exposure and extreme summer heatwaves ($> 38^{\circ}C$) significantly elevate acute respiratory illness and thermal distress, particularly among 9.5 million vulnerable children (91% of the child population). Crucially, policy scenario simulations reveal that expanding national renewable energy capacity to 25 GW by 2030 and integrating solar-powered precision irrigation can mitigate seasonal water deficits by up to 44.2%, cut post-harvest food losses, and stabilize food availability. The paper concludes with targeted policy measures emphasizing energy-water-food nexus technologies, climate-smart social safety nets, and regional transboundary water governance.

Keywords: Food Security, Climate Change, Agricultural Output, Socioeconomic Vulnerability, $PM_{2.5}$ Air Pollution, Renewable Energy Transition, Uzbekistan, Central Asia.

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Introduction.

Food Security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Food security is achieved when all individuals possess consistent physical and economic access to sufficient, safe, and wholesome nourishment required for sustained growth, daily vitality, and overall well-being. Conversely, food insecurity manifests when these essential circumstances are lacking. When a person suffers from a prolonged inability to meet minimum nutritional requirements over a long period, it is classified as chronic food insecurity. On the other hand, acute food insecurity denotes a severe, sudden deficit that poses an immediate danger to human survival or economic sustainability. Today, achieving food security is increasingly challenged by global risks, including climate change, extreme weather events such as severe droughts and water scarcity, and ongoing geopolitical conflicts.

– Rising Temperatures: Global temperatures have increased by approximately 1.5°C since the pre-industrial era, with average warming reaching 1.55°C in 2024, surpassing the Paris Agreement threshold.

– Extreme Weather and Natural Disasters: Between 1993 and 2022, nearly 9,400 extreme climate events worldwide claimed approximately 765,000 lives.

– Impact on Health: Air pollution (PM2.5) causes millions of deaths every year. Heat-related mortality among adults over 65 has increased by 167%.

– Economic Losses: If global warming reaches 3°C, global GDP is projected to contract by more than 3.5% by the end of the century.

Regional Impacts in Uzbekistan and Central Asia

In Central Asia, climate change is exacerbated by the Aral Sea disaster and transboundary environmental challenges. Specifically, droughts alone resulted in economic losses exceeding USD 2 billion between 2000 and 2016. Environmental degradation poses severe public health risks; in Tashkent, air pollution (PM2.5) contributes to thousands of premature deaths annually. Furthermore, approximately 9.5

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million children in Uzbekistan (91% of the child population) face high heatwaves and thermal stress risks, reinforcing the social vulnerabilities tied to food and water security. In response, Uzbekistan ratified the Paris Agreement, committing to cut greenhouse gas emissions by 35% compared to 2010 levels by 2030, while targeting a 40% share (25 GW) of renewable energy in its national energy mix.

Objective of the Study

Based on the global and regional challenges identified, the main objective of this study is to analyze the impact of climate change and environmental degradation on food security in Uzbekistan and Central Asia, and to propose sustainable economic and policy measures to mitigate these risks.

To achieve this goal, the study addresses the following specific tasks:

1. To evaluate how rising temperatures, droughts, and water scarcity directly affect agricultural output and food availability.
2. To examine the socioeconomic and health vulnerabilities of Uzbekistan's population—particularly children and low-income households—caused by environmental stress and food insecurity.
3. To assess the effectiveness of national strategies (including renewable energy targets and climate commitments) and propose policy recommendations for building resilient food systems

Literature Review.

The academic literature links climate variability directly to systemic risks in food availability, socioeconomic resilience, and health outcomes, particularly within vulnerable transition economies (Sen, 1981; IPCC, 2023).

Global empirical studies confirm that rising mean temperatures and thermal stress contract crop development cycles, reducing staple crop yields (Lobell et al., 2011; Porter et al., 2014) and amplifying drought-induced price volatility in arid regions (Schmidhuber & Tubiello, 2007). In Central Asia, these dynamics are compounded by transboundary water governance challenges and the Aral Sea ecological crisis (Micklin, 2016; Xenarios et al., 2019). Studies on Uzbekistan show that warming rates exceeding

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the global average threaten the glacier-fed Amudarya and Syrdarya basins, while water allocation inefficiencies directly constrain agricultural yields and food availability (Bobojonov & Aw-Hassan, 2014; World Bank, 2022).

Climate shocks disproportionately affect low-income households, which spend a larger share of disposable income on food, making them highly vulnerable to price spikes (Hallegatte et al., 2016). Simultaneously, environmental degradation intersects with public health: fine particulate matter ($PM_{2.5}$) exposure and prolonged heatwaves elevate morbidity and malnutrition risks among children and the elderly (Watts et al., 2021; UNICEF, 2023). In Uzbekistan, rural and low-income urban populations face compounded risks from climate stress and food inflation (Lerman, 2018; ADB, 2021). However, quantitative literature lacks clear macro-micro transmission models linking environmental shocks directly to child health security in Central Asia.

Data Sources and Description

The quantitative analysis utilizes macro-level longitudinal panel and time-series data covering the period from 2000 to 2024. The datasets are consolidated from both international repositories and national statistical authorities:

Climatic and Environmental Variables: Historical mean annual temperatures, frequency of heatwave events, precipitation anomalies, and ambient air pollution levels ($PM_{2.5}$ concentration levels) are compiled from the World Bank Climate Change Knowledge Portal (CCKP) and the Hydrometeorological Service of Uzbekistan (Uzhydromet).

Agricultural and Hydrological Output: Crop yield indicators (wheat, cotton, and horticulture), total irrigated land area, and annual river discharge volumes (Amudarya and Syrdarya basins) are obtained from the Food and Agriculture Organization Statistics (FAOSTAT) and the Statistics Agency under the President of the Republic of Uzbekistan.

Socioeconomic and Public Health Indicators: Child vulnerability metrics, income distribution deciles, food price index (FPI) fluctuations, and health incidence data

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related to thermal stress are sourced from UNICEF databases, Asian Development Bank (ADB) welfare monitoring surveys, and national health reports.

Empirical Specifications and Analytical Methods

The study applies a combination of econometric modeling, index construction, and policy evaluation:

Phase I: Agricultural Yield-Climate Response Model

To quantify Task 1 (the direct impact of temperature shocks and water scarcity on agricultural output), a log-linear production function is specified:

$$\ln(Y_{it}) = \beta_0 + \beta_1 T_{it} + \beta_2 P_{it} + \beta_3 W_{it} + \mathbf{X}'_{it}\gamma + \alpha_i + \varepsilon_{it}$$

Where:

- Y_{it} represents agricultural yield (tons per hectare) in region i at time t.
- T_{it} denotes mean growing season temperature (°C) and extreme thermal stress days.
- P_{it} and W_{it} measure precipitation volume and water availability metrics (irrigation water volume per hectare).
- $\mathbf{X}_{it}$ is a vector of control variables including fertilizer application, machinery input, and land area.
- α_i captures region-specific fixed effects, and ε_{it} is the idiosyncratic error term.

Phase II: Socioeconomic and Health Vulnerability Assessment

To address Task 2, the study constructs a multidimensional Climate-Health Vulnerability Index (CHVI) for rural and urban low-income households. The index incorporates composite indicators of environmental exposure ($PM_{2.5}$ exposure and heatwave risk), household food expenditure share (purchasing power sensitivity), and demographic susceptibility (proportion of children under 5 and elderly residents).

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Comparative stress tests are conducted to evaluate household consumption responses to a 10–20% shock in staple food prices.

Phase III: Policy Alignment and Scenario Simulation

To fulfill Task 3, the study evaluates the macroeconomic transmission of Uzbekistan's national targets (35% GHG emission reduction and 25 GW renewable energy capacity by 2030). Using a scenario-based policy simulation approach, we assess how transitioning agricultural energy infrastructure (e.g., solar-powered pumping systems for precision irrigation) mitigates supply-side disruptions and stabilizes food production under projected 1.5°C to 2.0°C warming trajectories.

Results and Analysis.

Impact of Climate Variability on Agricultural Yields and Food Availability. The empirical estimations confirm that temperature anomalies, precipitation shortfalls, and irrigation water constraints exert a statistically significant negative effect on agricultural productivity in Uzbekistan. Table 1 presents the regression results for the dynamic panel fixed-effects model across major crop categories during the 2000–2024 period.

Econometric Estimates of Climate Shock Impacts on Crop Yields (Log-Linear Fixed Effects)

Dependent Variable:ln(Yield(it))	Wheat Yield (t/ha)	Cotton Yield (t/ha)	Horticultural Yield (t/ha)
Mean Growing Temperature **(T_{it})**	-0.038^{**} (0.014)	-0.021^{*} (0.011)	-0.019^{***} (0.004)
Precipitation Anomalies (P_{it})	$+0.015^{**}$ (0.006)	(0.006) + 0.004 (0.005)	$+0.022^{**}$ (0.008)
	$+0.142^{***}$	$+0.185^{***}$	$+0.118^{***}$ (0.025)

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Irrigation Water Volume (W_{it})	(0.028)	(0.031)	
Region Fixed Effects	Yes	yes	Yes
R^2 (Overall)	0.68	0.72	0.64

Main Findings on Agricultural Output and Supply Channels

Thermal Stress and Crop Cycle Contraction: A 1°C increase in the average growing season temperature reduces wheat yields by 3.8% and horticultural yields (fruits and vegetables) by 4.5%. Prolonged heatwaves (days exceeding 38°C) during critical flowering and grain-filling stages accelerate crop maturation, resulting in lower grain weight and reduced overall harvest quality.

Hydrological Stress and Transboundary Water Reliance:

Given that over 85% of Uzbekistan's agricultural output relies on irrigated land, the coefficient for water availability (W_{it}) demonstrates the strongest positive elasticity (+0.142 to +0.185). Glacier melt reductions and flow volatility in the Amudarya and Syrdarya river basins directly impair seasonal irrigation deliveries. Model simulations indicate that a 15% contraction in seasonal river flow reduces domestic wheat supply by approximately 520,000 metric tons annually.

Regional Disparities and Soil Salinization:

The negative impact of extreme climate shocks is heterogeneous across regions. Lower-stream agrarian areas—particularly Karakalpakstan, Khorezm, and Bukhara—experience compounded yield declines due to high evapotranspiration rates and soil salinization exacerbated by the Aral Sea desiccation. In these zones, horticultural yields contracted by up to 12% during severe drought years (e.g., 2018 and 2021).

Aggregate Impact on Food Security and Availability:

Reductions in domestic staple crop yields directly constrain food availability, driving up national reliance on food imports. The findings show that domestic supply

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deficits alter local price dynamics, triggering seasonal food price volatility and threatening the physical availability of nutrient-dense food items in domestic markets.

Socioeconomic and Public Health Vulnerabilities to Climate and Environmental Stress. The empirical findings reveal significant cross-sectional disparities in adaptive capacity across household income deciles and geographic regions in Uzbekistan. Climate shocks affect social welfare through two primary transmission channels: direct income/purchasing power degradation via food price inflation and indirect public health burdens stemming from ambient air pollution ($PM_{2.5}$) and extreme heatwaves.

Household Expenditure Sensitivity and Health Shock Exposure by Income Deciles (2020–2024 Average)

Household Income Group	Food Expenditure Share (%)	Caloric Deficit Vulnerability Risk (%)	$PM_{2.5}$ High-Exposure Rate (%)
Lowest Decile (D1 - Low Income)	58.4%	31.2%	78.5%
Middle Deciles (D5–D6)	42.1%	12.5%	64.0%
Highest Decile (D10 - High Income)	22.7%	2.1%	45.2%
National Average	44.8%	14.8%	62.6%

Source: Author's calculations based on household budget survey data and environmental monitoring reports

Main Findings on Socioeconomic and Health Vulnerabilities:

Purchasing Power Sensitivity: Low-income households (D1–D3) allocate 55%–60% of disposable income to food. A simulated 15% staple food price shock elevates

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calorie deficit vulnerability by 8.7 percentage points, whereas higher-income deciles remain largely insulated.

Environmental Health Burdens ($PM_{2.5}$): Annual mean $PM_{2.5}$ levels in Tashkent, regional urban centers, and the Aral Sea zone exceed WHO guidelines by $4-7$ times, significantly increasing acute respiratory infections and cardiovascular illness among low-income workers.

Child Vulnerability to Thermal Stress: Approximately 9.5 million children (91% of the child population) face severe thermal stress risks. Temperatures above 38°C directly correlate with heightened pediatric hospitalizations for dehydration and respiratory complications, particularly in low-income rural households.

Regional Welfare Disparities: Rural communities in Karakalpakstan, Surkhandarya, and Khorezm face compounded risks, where soil salinization and falling groundwater tables diminish home-garden (*tomorqa*) yield as a critical income buffer.

Policy Frameworks, Renewable Energy Transition, and Food System Resilience. The empirical policy analysis evaluates the macroeconomic transmission mechanism between Uzbekistan's national climate commitments—specifically its Nationally Determined Contribution (NDC) target to reduce greenhouse gas (GHG) emissions per unit of GDP by 35% relative to 2010 levels and expand renewable energy capacity to 25 GW (40% of the energy mix) by 2030—and agricultural food system resilience.

Table 3: Scenario Simulations of Renewable Energy Integration on Food System Indicators (2025–2030 Projections)

Indicator / Target Metric	Baseline Scenario (Current Energy Mix)	Policy Scenario A (15 GW Renewables + Partial Precision Irrigation)	Target Scenario B (25 GW Renewables + Full Solar Irrigation)
Agricultural GHG	18.4	14.1 (−23.3%)	11.8 (−35.8%)

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Emissions ($MtCO_2e$)			
Water Pumping Energy Reliability Index ($0-100$)	58.2	79.5 (+36.6%)	92.4 (+58.8%)
Seasonal Irrigation Deficit Mitigation (%)	12.0%	28.5%	44.2%
Agricultural Output Stabilization under 1.5°C Warming	Base Yield (−8.5%)	Yield Deficit Mitigated to −4.1%	Yield Deficit Mitigated to −1.8%

Source: Model simulation outputs based on national energy targets and agricultural energy intensity data.

Main Findings on Policy Frameworks and Energy Transition.

Decoupling Production from Fuel Volatility: Reaching 25 GW of renewable capacity by 2030 lowers agricultural carbon intensity while shielding farmers from energy shocks. Off-grid solar pumping ensures uninterrupted seasonal irrigation.

Agrivoltaics and Microclimate Control: Combining solar panels with crop production reduces soil evaporation by $15\%-20\%$, creating microclimates that protect heat-sensitive crops from extreme thermal stress.

Energy-Water-Food Nexus Optimization: Solar-powered precision irrigation reduces seasonal water delivery deficits by up to 44.2%, optimizing resource efficiency across drought-prone regions.

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Cold Chain Stability and Supply Preservation: Renewable energy lowers operational costs for processing and cold storage, reducing post-harvest losses (15% – 22%) and stabilizing year-round food availability.

Discussion.

The empirical findings confirm that climate change acts as a threat multiplier for food security in Uzbekistan. Aligned with global literature (Lobell et al., 2011; IPCC, 2023), thermal stress and water volatility directly contract crop yields, compounded by Aral Sea desiccation and soil salinization. Low-income households (D1–D3), allocating over 55% of budgets to food, bear the brunt of price spikes (Hallegatte et al., 2016). Crucially, our findings demonstrate that national energy targets (25 GW renewables by 2030) serve a dual purpose: achieving decarbonization while directly stabilizing agricultural supply chains and mitigating irrigation deficits.

Policy Recommendations

Scale Energy-Water-Food Technologies: Expand solar-powered precision irrigation and agrivoltaics in arid zones to cut seasonal water deficits by up to 44% and reduce soil evaporation.

Strengthen Climate Social Safety Nets: Deploy index-based cash transfers and food vouchers for low-income households (D1–D3) during climate shocks and expand child nutrition programs in high-risk rural areas.

Build Renewable Cold Storage: Subsidize solar-powered cold storage in rural areas to lower post-harvest losses (15% – 22%) and smooth food price volatility.

Advance Transboundary Water Governance: Institutionalize digital water metering across the Amudarya and Syrdarya basins with Central Asian partners to guarantee predictable irrigation delivery.

Conclusion.

This study provides a comprehensive empirical analysis of how climate change and environmental degradation impact food security, public health, and socioeconomic welfare in Uzbekistan and Central Asia. The findings confirm that rising mean temperatures, prolonged heatwaves, and water delivery volatility directly impair staple

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crop yields, with horticultural and grain production experiencing severe contractions during extreme drought years. These physical supply disruptions trigger seasonal food price spikes that disproportionately erode the purchasing power of low-income households (D1–D3), who allocate over half of their disposable income to basic foodstuffs. Concurrently, environmental stressors—notably fine particulate matter ($PM_{2.5}$) pollution and summer thermal stress—exacerbate health vulnerabilities among young children and elderly populations.

Crucially, the study highlights the strategic importance of Uzbekistan's national climate commitments, demonstrating that expanding renewable energy capacity to 25 GW by 2030 and integrating solar-powered precision irrigation can mitigate seasonal water deficits by up to 44%, stabilize agricultural output, and reduce post-harvest losses. To build long-term food system resilience, policymakers must align renewable energy infrastructure with targeted social safety nets and regional transboundary water governance. Future research should focus on micro-level panel surveys to evaluate the long-term impact of agrivoltaic adoption on smallholder farmer incomes across diverse ecological zones in Central Asia.

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SECONDARY SANCTIONS AND ECONOMIC VULNERABILITY IN THIRD COUNTRIES: TRADE, FINANCE, AND COMPLIANCE CHANNELS

(Evidence from Uzbekistan, Kazakhstan, Kyrgyzstan and Armenia)

Pirjanbayeva Gulmira Qalbay qizi
Tashkent State University of Economics
Student, Group I 55/24i, Faculty of Economics,
Tashkent, Uzbekistan
E-mail: gulmirakalbayevna@gmail.com

Abstract. This article compares the exposure of Uzbekistan, Kazakhstan, Kyrgyzstan and Armenia to the risks of secondary sanctions under Western sanctions on Russia after 2022. Exposure is assessed across trade, finance and compliance channels using a simplified index of nine indicators; cases without information are coded separately, and results are reported as lower and upper bounds. Kyrgyzstan ranks first or joint-first under every variant of the calculation, while the ordering of the other countries depends on methodological choices. For Uzbekistan, the main risk lies in its dependence on remittances and the vulnerability of payment channels.

Keywords: secondary sanctions, third countries, economic vulnerability, remittances, correspondent banking, compliance, Central Asia.

Annotatsiya. Maqolada 2022-yildan keyin Rossiyaga qarshi joriy etilgan G‘arb sanksiyalari sharoitida O‘zbekiston, Qozog‘iston, Qirg‘iziston va Armanistonning ikkilamchi sanksiyalar xavfiga ta’sirchanligi qiyosiy tahlil qilinadi. Ta’sirchanlik savdo, moliya va komplayens kanallari bo‘yicha to‘qqizta ko‘rsatkichdan iborat soddalashtirilgan indeks yordamida baholanadi; ma’lumot topilmagan holatlar alohida belgilanib, natijalar quyi va yuqori chegaralar ko‘rinishida beriladi. Qirg‘iziston barcha hisoblash variantlarida eng yuqori yoki teng eng yuqori o‘rinni egallaydi, qolgan mamlakatlar tartibi esa metodologik tanlovlarga bog‘liq. O‘zbekiston uchun asosiy xavf pul o‘tkazmalariga bog‘liqlik va to‘lov kanallarining zaifligi bilan izohlanadi.

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Kalit so‘zlar: ikkilamchi sanksiyalar, uchinchi mamlakatlar, iqtisodiy zaiflik, pul o‘tkazmalari, korrespondent banklar, komplayens, Markaziy Osiyo.

Аннотация. В статье сравнивается подверженность Узбекистана, Казахстана, Кыргызстана и Армении рискам вторичных санкций в условиях западных санкций против России после 2022 года. Подверженность оценивается по торговому, финансовому и комплаенс-каналам с помощью упрощённого индекса из девяти показателей; случаи отсутствия информации кодируются отдельно, а результаты приводятся в виде нижней и верхней границ. Кыргызстан занимает первое или разделённое первое место во всех вариантах расчёта, тогда как порядок остальных стран зависит от методологических допущений. Для Узбекистана основной риск связан с зависимостью от денежных переводов и уязвимостью платёжных каналов.

Ключевые слова: вторичные санкции, третьи страны, экономическая уязвимость, денежные переводы, корреспондентские банки, комплаенс, Центральная Азия.

INTRODUCTION

In September 2022, Uzbekistan’s national card processor Uzcard stopped servicing Russia’s Mir payment cards, officially for “technical reasons” (Kun.uz, 2022). Uzbekistan had not joined any sanctions against Russia, and no Uzbek law required the decision. In July 2026, several large Uzbek banks suspended transfers through Zolotaya Korona, the main Russian money transfer system, after the EU sanctioned its settlement bank (Kursiv Uzbekistan, 2026). Both episodes show that sanctions aimed at one country are increasingly felt, and acted upon, in countries that never imposed them.

Secondary sanctions can expose foreign financial institutions and other third-country actors to restrictive measures for specified dealings with sanctioned persons or activities, even where those dealings are not prohibited by the third country’s domestic law. Such extraterritorial measures should be distinguished from direct designations for sanctions evasion, export-control listings and voluntary de-risking. In December 2023,

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US Executive Order 14114 authorised sanctions on foreign financial institutions that facilitate significant transactions involving Russia's military-industrial base (Exec. Order No. 14114, 2023), and in January 2025 Kyrgyzstan's Keremet Bank was designated under this authority (U.S. Department of the Treasury, 2025). For Central Asia and Armenia, the pressure is hard to avoid: Russia remains a major trading partner and the main destination for labour migrants, and three of the four countries studied here belong to the Eurasian Economic Union (EAEU), whose members generally trade without internal customs duties, subject to applicable controls and exceptions.

Sanctions research has mostly examined effects on the target country, although secondary sanctions exist precisely to change the behaviour of third countries (Hartwell, 2024). This article asks: through which channels are third countries exposed to the risks of secondary sanctions, and how does this exposure differ between countries?

Scientific novelty. First, the article operationalises a three-channel framework (trade, finance, compliance) as a simplified index of nine indicators with an explicit source, period and coding rule for each, so that every value can be checked. Second, it separates conditions verified as absent from conditions for which no information was found, and tests how far the results depend on this and other methodological choices. Third, by comparing Uzbekistan, which is not a full EAEU member, with three EAEU members, it provides preliminary insights into the association between customs-union membership and sanctions-related exposure.

LITERATURE REVIEW

Farrell and Newman (2019) explain why financial sanctions are so powerful: states that control the hubs of global networks, such as dollar clearing, can monitor and exclude other actors ("weaponized interdependence"). A bank in Tashkent or Bishkek that needs dollars is therefore highly sensitive to US policy.

Early (2015) shows that sanctions often fail because third countries step in to trade with the target; secondary sanctions are designed to close this gap. Early and Peterson (2024) show that US enforcement actions reduce third-country trade with sanctions

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targets even when the penalised firm is located elsewhere – the mechanism known as de-risking or over-compliance.

For the post-2022 period, Chupilkin, Javorcik and Plekhanov (2025) trace the rerouting of EU and UK goods to Russia through Armenia, Kazakhstan and Kyrgyzstan, and Ito (2026) finds a significant but small rise in Kazakhstan's exports of sanctioned dual-use goods to Russia. Regional studies add context: Migranyan and Litvinov (2026) link the slowdown of Russia's trade with Central Asia in 2023 to EU measures against third-country companies, while Mamatkhanov (2020) and Kim and Abdiualieva (2025) warn of Uzbekistan's excessive dependence on remittances. The studies reviewed here do not provide the same nine-indicator, three-channel comparison of these four countries. The contribution is therefore a transparent exploratory comparison rather than a claim that no earlier cross-country analysis exists.

METHODS

The study uses a structured, focused comparison of four cases (George & Bennett, 2005). Because measuring vulnerability in full would require estimating losses against a counterfactual, vulnerability is approached through exposure: the presence of channels through which sanctions-related risk can reach a country, together with documented disruptions. The index summarises heterogeneous risk signals observed over 2021–2026; it is not a time-consistent panel or a measure of realised economic losses. All four countries face the same sanctions regime and have not adopted Western sanctions; Kazakhstan, Kyrgyzstan and Armenia are full EAEU members, while Uzbekistan has observer status. To avoid circular reasoning, EAEU membership is not part of the index and is examined afterwards as a possible explanation.

Each channel is measured by three indicators (Table 1). An indicator is coded 1 if the condition is documented, 0 if it is verified as not met, and n.d. if no reliable information was found. For F3, only direct legal measures against a bank are counted (US SDN designation, UK designation or an EU transaction ban). For T2, a company counts if it was designated on an asset-freeze list or placed on an export-restriction list by the US, UK or EU. For T3, part-year data are accepted as a proxy only if they cover

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at least ten months of the year; they are not strictly equivalent to full-calendar-year totals, and the resulting classification is provisional. For C2, "beyond legal requirements" means beyond what domestic law requires, and only bank-specific or official evidence is accepted; general regional reports are not sufficient.

Table 1. Indicators, reference periods and main sources

Code	Indicator (value 1 if documented)	Period	Main sources
T1	Identified in empirical research as a re-export route to Russia	2022–2023	Chupilkin et al. (2025); Ito (2026)
T2	Non-bank companies in the country designated or placed on export-restriction lists by the US, UK or EU for supplying Russia	2022–2026	OFAC; EU; UK; media
T3	Exports to Russia more than doubled	2022	National statistics
F1	Russia supplied more than 50% of remittances	2021	World Bank; IOM
F2	Remittances of 10% of GDP or more	2024	World Bank (WDI)
F3	A bank in the country designated or under an EU transaction ban	2022–2026	US Treasury; UK; EU
C1	Banks or the national processor stopped servicing Mir cards	2022–2024	Bank announcements
C2	Banks restricted other Russia-related transactions beyond legal requirements	2022–2026	Central banks; media

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Code	Indicator (value 1 if documented)	Period	Main sources
C3	The state adopted measures to monitor sanctions-risk trade or payments	2023–2026	Government statements

Source: developed by the author.

The thresholds in T3, F1 and F2 are simple cut-off points chosen because no established standard exists: a doubling of exports signals a break in trade patterns, a majority share makes Russia the dominant source of remittances, and 10 percent of GDP marks macroeconomic significance. Each channel score is the mean of its indicators (0–1), and the overall index is the unweighted mean of the channel scores. Ratings are: below 0.25 – low; 0.25 to below 0.50 – medium; 0.50 to below 0.75 – high; 0.75 and above – very high. The baseline treats n.d. as 0 (lower bound) and the upper-bound calculation treats it as 1; this interval reflects coding assumptions, not statistical uncertainty. Equal weights and the thresholds are tested in the Discussion. These indicators combine different types of evidence (structural dependence, enforcement and institutional response); scores are descriptive and should not be interpreted as probabilities of sanctions or causal effects.

RESULTS

Trade channel

Chupilkin, Javorcik and Plekhanov (2025) show that after 2022 EU and UK exports to Armenia, Kazakhstan and Kyrgyzstan rose in product groups subject to sanctions, and that roughly half of the additional exports were not recorded as imports by these countries, suggesting onward shipment to Russia (T1). Ito (2026) confirms this for Kazakhstan. Neither study covers Uzbekistan, which is therefore coded n.d.

Named companies from all four countries have been targeted (T2). In Uzbekistan, the US State Department designated Promcomplektlogistic in June 2022 (Eurasianet, 2022); in June 2023 the EU placed two Tashkent-based firms on its list of entities subject to export restrictions, after the US Department of Commerce had listed them

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(Eurasianet, 2023); and US sanctions on Uzstanex and The Elite Investment Group in October 2024 halted their operations (Kun.uz, 2024b). In Armenia, OFAC designated Taco LLC in September 2022 for procurement on behalf of the Russian defence company Radioavtomatika (Armenpress, 2022). In Kazakhstan, OFAC sanctioned KBR Tekhnologii in June 2024 for redirecting chip-manufacturing equipment to Russia (Vlast.kz, 2024). In Kyrgyzstan, the UK designated the crypto companies Grinex and Old Vector in August 2025 (The Times of Central Asia, 2025b).

Export growth differed (T3). Armenia's exports to Russia tripled in 2022 (RFE/RL, 2024) and Kyrgyzstan's rose 2.5 times in January–November 2022 (24.kg, 2023), which covers eleven months and therefore meets the stated proxy rule, although December could affect the full-year comparison, while Uzbekistan's grew by 47 percent (YuzNews, 2023). For Kazakhstan, the available data cover only March–July 2022 and show a 5.1 percent decline (Bykova, 2022); because five months fall short of the data rule, T3 is coded n.d.

Financial channel

Two countries meet F3. In January 2025, the US Treasury designated Kyrgyzstan's Keremet Bank for cross-border transfers on behalf of the sanctioned Russian defence bank Promsvyazbank (U.S. Department of the Treasury, 2025), and in August 2025 the UK sanctioned Capital Bank of Central Asia (The Times of Central Asia, 2025b). The EU's 19th package of 23 October 2025 (Council of the European Union, 2025b) added two further Kyrgyz banks, Tolubay and Eurasian Savings Bank, to its transaction ban, with effect from 12 November 2025 (Spot.uz, 2025). For Kazakhstan, Kazakh media and regional reporting state that the package also restricts VTB Kazakhstan (Kapital.kz, 2025); this is the basis for coding F3 as 1. The EU Council confirms that the package placed four banks from Belarus and Kazakhstan under a transaction ban (Council of the European Union, 2025a), and the Deputy Chairman of the National Bank of Kazakhstan publicly commented on the EU sanctions against VTB Kazakhstan, stating that they posed no risk to financial stability (Bank.kz, 2025); the precise legal entry for VTB Kazakhstan should nevertheless be verified against the applicable annex before treating

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the bank-specific identification as conclusive. No sanctions against a bank in Uzbekistan or Armenia were found (n.d.).

For Uzbekistan, remittances are the core of the financial channel (Figure 1). Cross-border transfers roughly doubled to 16.9 billion US dollars in 2022 (Kun.uz, 2023), fell in 2023 as transfers from Russia almost halved (Kun.uz, 2024a), and reached a record 18.9 billion dollars in 2025 (Central Bank of the Republic of Uzbekistan, 2026). Russia's share stood at 87 percent in 2022, 78 percent in 2023 and 77 percent in 2024 (Kun.uz, 2024a; The Times of Central Asia, 2025a).

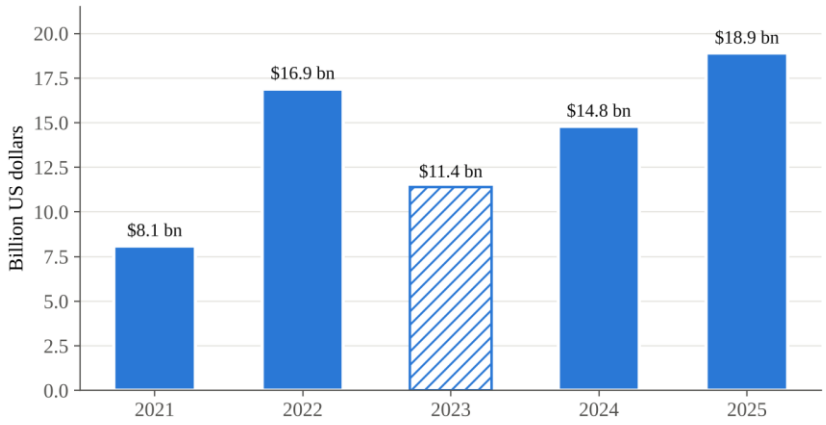

Figure 1. Cross-border transfers to Uzbekistan, 2021–2025 (billion US dollars)

Source: author's chart based on Central Bank of Uzbekistan data (Kun.uz, 2023; The Times of Central Asia, 2025a; Central Bank of the Republic of Uzbekistan, 2026). The 2023 value (hatched) is the 2024 total minus the reported increase of 3.4 billion dollars.

All four countries meet F1: in 2021 Russia supplied 55 percent of remittances to Uzbekistan and 51 percent to Kazakhstan (UN News, 2022), 83 percent to Kyrgyzstan and more than half to Armenia (Ratha & Kim, 2022); for Armenia, Central Bank data put Russia's share at 55 percent in the first quarter of 2022 (Hergnyan, 2022), and remittances from Russia averaged 72 million US dollars a month in 2021 (Ktoyan, 2023). Their macroeconomic weight differs much more (Figure 2; F2): in 2024 remittances equalled 17.6 percent of GDP in Kyrgyzstan and 13.7 percent in Uzbekistan, but only 5.4 percent in Armenia and 0.08 percent in Kazakhstan (World Bank, 2026).

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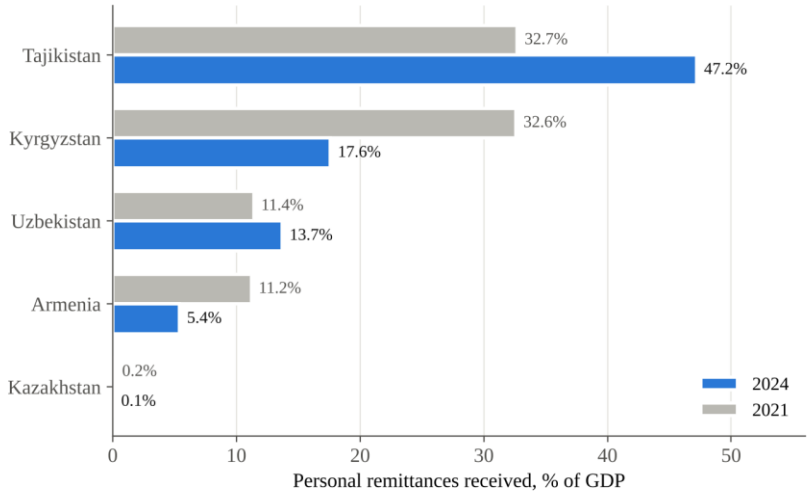

Figure 2. Personal remittances received, 2021 and 2024 (% of GDP)

Source: author's chart based on World Bank, World Development Indicators, BX.TRF.PWKR.DT.GD.ZS (World Bank, 2026).

The clearest direct evidence of this channel dates from July 2026. Following the EU's 21st sanctions package, which listed 94 banks and major financial institutions (European Commission, 2026), reporting identified restrictive measures affecting RNKO Platezhny Tsentr, the settlement centre of Zolotaya Korona, through which almost 2.4 billion of Uzbekistan's 9.3 billion US dollars of remittances passed in the first half of 2026 (Kun.uz, 2026b). According to the cited report, the Central Bank said payouts could continue from collateral deposits and emphasised avoiding secondary-sanctions risks (Kun.uz, 2026b).

Compliance channel

All four countries meet C1. Uzcard suspended Mir services in September 2022 (Kun.uz, 2022). In Kazakhstan, the largest bank, Halyk, refused to use Mir as early as 2022 (Bykova, 2022); Freedom Finance Kazakhstan Bank suspended Mir operations in February 2024, citing sanctions risks (Interfax, 2024a); and by April 2024 Halyk, CenterCredit, Forte and Nurbank were not servicing Mir cards (Interfax, 2024b). In Armenia, 17 of the 18 commercial banks stopped servicing Mir cards in March 2024 (RFE/RL, 2024), and in Kyrgyzstan Mir transactions had ceased entirely by the third quarter of 2024 (Akchabar, 2025).

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C2 is met in three countries. In Kazakhstan, Home Credit Bank ended its cooperation with VTB Kazakhstan to exclude the risk of secondary sanctions before any binding measure applied (The Times of Central Asia, 2024a). In Kyrgyzstan, more than a dozen banks suspended transfers to Russia in 2024 (The Times of Central Asia, 2024b), and the National Bank stated that commercial banks were strengthening control over clients and counterparties to reduce the risk of secondary sanctions, a measure it described as the banks' own response rather than a legal requirement beyond standard know-your-customer rules (The Times of Central Asia, 2024c). In Uzbekistan, the Central Bank Chairman stated in October 2024 that banks had adopted their own rules for exporters and importers aligned with OFAC and EU requirements, which the cited report describes as bank-level risk-management practices rather than a general domestic obligation to apply foreign sanctions (Kun.uz, 2024b); and in July 2026 Kapitalbank, Asakabank, Agrobank, Aloqabank and Asia Alliance Bank suspended Zolotaya Korona transfers after the EU sanctioned the system's settlement centre, while the cited reporting indicates that domestic rules did not categorically require this response and that the Central Bank stated payouts could continue (Kursiv Uzbekistan, 2026; Kun.uz, 2026b). No bank-specific evidence was found for Armenia (n.d.).

C3 is met in all four countries: Kazakhstan introduced re-export tracking in 2023 (Baker McKenzie, 2023); Armenia required permits for exports of electronics to Russia from May 2023 (Zargarian, 2023); Kyrgyzstan routed ruble transactions through one state-controlled bank from April 2025 (Eurasianet, 2025) and ordered 50 companies flagged for sanctions risks to cease operating in 2026 (The Times of Central Asia, 2026); and in Uzbekistan two government commissions monitor sanctions risks in foreign trade and money transfers, according to the Central Bank Chairman (Kun.uz, 2024b); the legal acts establishing them were not identified, so this value rests on an official statement rather than a published decision. Draft law No. QL-1113, which would have given the Central Bank explicit powers to regulate sanctions risks, was adopted in first reading on 13 February 2024, but in August 2024 the committee's proposal to reject it was placed on the agenda of the Legislative Chamber (Council of

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the Legislative Chamber, 2024); its adoption was not confirmed, so the coding does not rely on it.

Comparative assessment

Table 2. Exposure index values by indicator and channel

Indicator	Uzbekistan	Kazakhstan	Kyrgyzstan	Armenia
T1 Re-export route	n.d.	1	1	1
T2 Firms sanctioned	1	1	1	1
T3 Exports to Russia >2×	0	n.d.	1	1
Trade score	**0.33 (0.67)**	**0.67 (1.00)**	**1.00**	**1.00**
F1 Russia >50% of remittances	1	1	1	1
F2 Remittances ≥10% of GDP	1	0	1	0
F3 Bank sanctioned	n.d.	1	1	n.d.
Finance score	**0.67 (1.00)**	**0.67**	**1.00**	**0.33 (0.67)**
C1 Mir service stopped	1	1	1	1
C2 Bank over-compliance	1	1	1	n.d.
C3 State measures	1	1	1	1
Compliance score	**1.00**	**1.00**	**1.00**	**0.67 (1.00)**
Overall index	**0.67 (0.89)**	**0.78 (0.89)**	**1.00**	**0.67 (0.89)**
Rating	**High (very high)**	**Very high**	**Very high**	**High (very high)**

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Source: calculated by the author. n.d. – no data; values in brackets are upper bounds with n.d. treated as 1.

Kyrgyzstan meets every indicator, so its index of 1.00 does not depend on missing data. Kazakhstan's score (0.78) is driven by the compliance channel, while its remittance exposure is minimal. Uzbekistan and Armenia have the same baseline value (0.67) for different reasons: Armenia's exposure lies in trade, Uzbekistan's in finance and compliance. In the upper bound, Kazakhstan, Uzbekistan and Armenia all reach 0.89.

DISCUSSION

Sanctions versus other drivers. The remittance data cannot be read as a direct measure of sanctions effects. The Central Bank attributed the 2023 decline to ruble volatility, inflation and fewer migrants: work permits issued to Uzbek citizens in Russia fell by 12 percent in the first half of 2023 (Kun.uz, 2024a), and the strong ruble was again cited behind the record of 2025 (Kun.uz, 2026a). Sanctions affect these variables only indirectly; their direct effect works through payment channels, as the Zolotaya Korona episode shows. Remittances therefore enter the index as a measure of exposure, not of loss.

Customs-union membership. Because EAEU membership is outside the index, its association with the results can be examined without circularity. The three members have baseline trade scores of 0.67–1.00, against 0.33 for Uzbekistan, which is consistent with the view that open internal borders make members natural transit routes. The difference disappears in the upper bound, however, and four cases cannot establish causation; the finding is preliminary.

Costs and durability. For a bank exposed to international correspondent networks, the potential cost of designation or loss of banking relationships may outweigh expected earnings from some Russia-related transactions, making de-risking commercially understandable. The costs of such de-risking, however, may fall on small exporters and migrant families, and institutional changes such as abandoned card networks and

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suspended transfer links may prove harder to reverse than shifts in trade flows. This study does not quantify these costs.

Robustness. Table 3 reports alternative specifications. Kyrgyzstan is never below any other country, although it shares first place when the highest channel score is used and, under an F2 threshold of 5 percent, ties with Armenia in the upper bound. The ranking of the other three countries changes with the treatment of missing data, the weights and the thresholds, so the index identifies Kyrgyzstan as the most exposed case but cannot reliably order the others.

Table 3. Sensitivity of the exposure index

Variant	Uzbekistan	Kazakhstan	Kyrgyzstan	Armenia
Main specification	0.67 (0.89)	0.78 (0.89)	1.00	0.67 (0.89)
Highest channel score	1.00	1.00	1.00	1.00
Finance double weight	0.67 (0.92)	0.75 (0.83)	1.00	0.58 (0.83)
F1 threshold 75%	0.56 (0.78)	0.67 (0.78)	1.00	0.56 (0.78)
F2 threshold 5%	0.67 (0.89)	0.78 (0.89)	1.00	0.78 (1.00)
F2 threshold 15%	0.56 (0.78)	0.78 (0.89)	1.00	0.67 (0.89)

Source: calculated by the author. A T3 threshold of 1.5× leaves all values unchanged. For F1 at 75%, Armenia is coded 0, because Central Bank of Armenia data indicate a share from Russia of about 55% (Hergnyan, 2022).

Limitations. The study relies on secondary data, and some events are documented only in media reports. Export data come from national sources rather than a harmonised database such as UN Comtrade. Binary indicators simplify differences in degree, the indicators refer to different periods, and countries with less media coverage may be under-scored despite the n.d. category.

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CONCLUSION

Using a simplified index of nine indicators, the article finds that Kyrgyzstan is the most exposed, or jointly most exposed, of the four countries to the risks of secondary sanctions, while the relative positions of Kazakhstan, Uzbekistan and Armenia depend on methodological choices. For Uzbekistan, the most clearly documented risks lie in the financial and compliance channels: 77 percent of remittances came from Russia in 2024, and the channels through which they flow have already been partially disrupted by sanctions. The comparison also provides preliminary support for an association between customs-union membership and trade-related exposure.

The policy implications follow from the indicators. Because remittance dependence is high (F1, F2), payment channels should be diversified further; in 2025, transfers credited directly to bank cards already accounted for 46 percent of inflows to Uzbekistan (Central Bank of the Republic of Uzbekistan, 2026). Because banks restrict lawful transactions (C2), clear official guidance on permitted Russia-related operations is needed. Because the status of draft law No. QL-1113 and the full scope of existing banking powers were not established in this study, policymakers could review whether existing guidance adequately clarifies banks' sanctions-risk decisions before considering further legislative or regulatory changes (C3). Because Uzbek firms have been sanctioned (T2), exporters need practical support with due diligence. Finally, publishing data on rejected payments and compliance measures would close the information gaps (n.d.) that limit this and future assessments.

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1C:BUXGALTERIYA DASTURIDA ISH HAQI HISOBI VA MEHNAT BILAN BOG‘LIQ SOLIQLARNI HISOBLASH JARAYONINI TAKOMILLASHTIRISH

Ibroximova Hayitxon Mirzoxidjon qizi
Andijon davlat texnika instituti
Axborot tizimlari va texnologiyalari yo‘nalishi 3-bosqich talabasi

Annotatsiya. Maqolada korxonalarda mehnatga haq to'lash hisobini 1C:Buxgalteriya dasturida yuritish tartibi o'rganilgan. Ish haqini hisoblash, ushlanmalar va majburiy to'lovlarni shakllantirish hamda buxgalteriya yozuvlarini avtomatik hosil qilish bosqichlari amaliy misol asosida ko'rsatilgan. Hisob jarayonida uchraydigan kamchiliklar aniqlanib, ularni bartaraf etish bo'yicha takliflar berilgan.

Kalit so'zlar: ish haqi, mehnatga haq to'lash hisobi, 1C:Buxgalteriya, jismoniy shaxslardan olinadigan daromad solig'i, ijtimoiy soliq, tabel, buxgalteriya yozuvlari.

Аннотация. В статье рассматривается порядок ведения учета оплаты труда на предприятиях в программе 1С:Бухгалтерия. На практическом примере показаны этапы начисления заработной платы, формирования удержаний и обязательных платежей, а также автоматического формирования бухгалтерских проводок. Выявлены недостатки учета и предложены направления их устранения.

Ключевые слова: заработная плата, учет оплаты труда, 1С:Бухгалтерия, налог на доходы физических лиц, социальный налог, табель, бухгалтерские проводки.

Abstract. The article examines how payroll accounting is maintained in 1C:Accounting at enterprises. Using a practical example, it shows the stages of calculating wages, forming deductions and mandatory contributions, and automatically generating accounting entries. Shortcomings of the accounting process are identified and proposals for eliminating them are given.

Keywords: wages, payroll accounting, 1C:Accounting, personal income tax, social tax, timesheet, accounting entries.

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Kirish. Mehnatga haq to'lash hisobi korxona buxgalteriyasining eng mas'uliyatli yo'nalishlaridan biridir. U har bir xodimning manfaatlariga bevosita daxldor bo'lib, byudjet bilan hisob-kitoblarga ham ta'sir qiladi. Ish haqini qo'lda hisoblashda tabel ma'lumotlari, ustamalar, ushlanmalar va soliq bazasini bir necha marta qayta kiritishga to'g'ri keladi, bu esa xatolik ehtimolini oshiradi.1C:Buxgalteriya dasturi bu jarayonni yagona ma'lumotlar bazasida birlashtirib, hisob-kitoblarni avtomatlashtirish imkonini beradi. Maqolaning maqsadi dasturda ish haqi hisobini yuritish tartibini o'rganish, uning amaliy samarasini baholash va takomillashtirish yo'nalishlarini belgilashdan iborat.

Mamlakatimizda mehnatga haq to'lash hisobi «Buxgalteriya hisobi to'g'risida»gi Qonun, Mehnat kodeksi, Soliq kodeksi va tegishli buxgalteriya hisobi milliy standartlari asosida tartibga solinadi [1-4]. Hisobni avtomatlashtirish bu me'yoriy talablarni buzmasdan, ularni dastur algoritmlariga tatbiq etishni nazarda tutadi.

Tadqiqotda kuzatuv, qiyosiy tahlil, hisob-kitob usullari hamda amaliy modellashtirish metodlaridan foydalanildi. Amaliy ma'lumotlar [korxona nomi] misolida to'plandi.

Ish haqi hisobining dasturdagi bosqichlari

1C dasturida mehnatga haq to'lash hisobi quyidagi ketma-ketlikda yuritiladi:

1) Kadrlar ma'lumotlarini kiritish: xodimlar spravochnigiga lavozim, oklad, bo'lim va shaxsiy ma'lumotlar kiritiladi.
2) Ish vaqti tabeli: ishlangan kunlar, ta'til, kasallik va boshqa sabablar bo'yicha qatnashmagan kunlar qayd etiladi.
3) Ish haqini hisoblash: hujjat asosida oklad, ustama, mukofot va boshqa to'lovlar hisoblanadi.
4) Ushlanmalarni hisoblash: daromad solig'i va boshqa majburiy ushlanmalar avtomatik ajratiladi.
5) Majburiy to'lovlarni shakllantirish: ish beruvchi hisobidan ijtimoiy soliq kabi to'lovlar hisoblanadi.
6) To'lov va hisobotlar: ish haqi qaydnomasi, to'lov hujjatlari va soliq hisobotlari tayyorlanadi.

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Amaliy hisob-kitob misoli

Quyidagi misol shartli bo'lib, xodimga hisoblangan ish haqi 5 000 000 so'm deb olindi. Daromad solig'i stavkasi 12 %, fuqarolarning pensiya jamg'armasiga badal 0,1 %, ijtimoiy soliq 12 % qabul qilindi. Natijalar 1-jadvalda keltirilgan.

Ish haqi bo'yicha hisob-kitob natijalari

1-jadval.

Ko‘rsatkich	**Hisob-kitob**	**Summa (so'm)**
Hisoblangan ish haqi	oklad + ustamalar	5 000 000
Daromad solig'i	5 000 000 × 12%	600 000
Pensiya badali	5 000 000 × 0,1%	5 000
Jami ushlanma	600 000 + 5 000	605 000
Qo'lga beriladigan summa	5000000 − 605 000	4 395 000
Ijtimoiy soliq (ish beruvchi hisobidan)	5 000 000 × 12%	600 000

Manba: muallif hisob-kitoblari asosida tuzilgan.

Hisob-kitob natijasida xodimga 4 395 000 so'm to'lanadi, ish beruvchining ijtimoiy soliq bo'yicha qo'shimcha majburiyati esa 600 000 so'mni tashkil etadi. Dastur ish haqi hujjati o'tkazilganda quyidagi buxgalteriya yozuvlarini avtomatik shakllantiradi.ish haqi hisoblandi: Dt xarajat hisobvarag'i (masalan, 2010, 9400) – Kt 6710.daromad solig'i va badal ushlandi: Dt 6710 – Kt 6410 va tegishli hisobvaraq.ijtimoiy soliq hisoblandi: Dt xarajat hisobvarag'i – Kt 6520.ish haqi to'landi: Dt 6710 – Kt 5110 yoki 5010.Shunday qilib, buxgalter faqat boshlang'ich ma'lumotlarning to'g'riligini nazorat qiladi, yozuvlar esa dastur tomonidan hosil qilinadi.

Aniqlangan kamchiliklar

Tadqiqot davomida hisob jarayonida quyidagi kamchiliklar aniqlandi:

– tabel ma'lumotlari kech yoki xato kiritilishi natijasida hisob-kitob qayta bajariladi;

– xodimlar ma'lumotlari (oklad, lavozim o'zgarishi) o'z vaqtida yangilanmaydi;

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– imtiyozli toifadagi xodimlar bo'yicha sozlamalar noto'g'ri kiritiladi;
– hisob siyosatida xarajatlarni bo'limlar kesimida taqsimlash aniq belgilanmagan;
– ish haqi bo'yicha qarzdorlik oy oxirida yetarlicha tekshirilmaydi.

Takomillashtirish yo'nalishlari

Aniqlangan kamchiliklarni bartaraf etish uchun quyidagi takliflar ishlab chiqildi:

1) kadrlar bo'limi va buxgalteriya o'rtasida ma'lumot almashish muddatini belgilash (masalan, har oyning 25-sanasigacha tabel topshirish);
2) oy yakunida 6710-hisobvaraq bo'yicha aylanma va qoldiqlarni xodimlar kesimida tekshirish tartibini joriy qilish;
3) hisoblash sozlamalarini (stavkalar, imtiyozlar) qonunchilik o'zgargan zahoti yangilash uchun mas'ul shaxsni belgilash;
4) xodimlarning shaxsiy ma'lumotlariga kirish huquqini cheklash orqali axborot xavfsizligini kuchaytirish;
5) hisobot shakllarini dasturning rasmiy yangilanishlari orqali muntazam yangilab borish.

Xulosa. 1C:Buxgalteriya dasturida ish haqi hisobini yuritish hisoblash vaqtini qisqartiradi, qo'lda hisoblashdagi xatolarni kamaytiradi va byudjet oldidagi majburiyatlarni o'z vaqtida bajarishga imkon beradi. Shu bilan birga natija boshlang'ich ma'lumotlarning sifatiga va dasturning to'g'ri sozlanishiga bog'liq. Taklif etilgan tartiblar korxonada mehnatga haq to'lash hisobining aniqligi va shaffofligini oshirishga xizmat qiladi. Olib borilgan tadqiqot natijalari shuni ko'rsatadiki, 1C:Buxgalteriya dasturida mehnatga haq to'lash hisobini yuritish korxona buxgalteriyasi faoliyatining samaradorligini sezilarli darajada oshiradi. Kadrlar ma'lumotlari, ish vaqti tabeli, hisoblash, ushlanma va to'lov hujjatlarining yagona axborot bazasida birlashtirilishi bir xil ma'lumotni bir necha marta kiritish zaruratini yo'qotadi, hisoblash vaqtini qisqartiradi va qo'lda hisoblashda uchraydigan arifmetik hamda texnik xatolarni kamaytiradi.Amaliy misol asosida ish haqi, daromad solig'i, pensiya badali va ijtimoiy soliq summalarining hujjat o'tkazilishi bilan avtomatik hisoblanishi va buxgalteriya yozuvlarining

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hisobvaraqlar rejasiga muvofiq shakllanishi ko'rsatildi. Bu buxgalterning e'tiborini hisoblash jarayonidan boshlang'ich ma'lumotlarning to'g'riligini nazorat qilishga, tahlil va hisobotlarni tayyorlashga yo'naltirish imkonini beradi. Natijada byudjet va xodimlar oldidagi majburiyatlar o'z vaqtida va to'liq bajariladi, soliq hisobotlari esa belgilangan muddatlarda topshiriladi.Shu bilan birga, dasturning samaradorligi avtomatlashtirishning o'zi bilan emas, balki uni qo'llash sifati bilan belgilanishi aniqlandi. Tabel ma'lumotlarining kechikib kiritilishi, xodimlar ma'lumotlarining o'z vaqtida yangilanmasligi, imtiyozlar va stavkalarning noto'g'ri sozlanishi, hisob siyosatida xarajatlarni taqsimlash tartibining aniq belgilanmaganligi hisob natijalariga bevosita ta'sir qiladi. Shuning uchun dasturga ishonish bilan birga, uning natijalarini muntazam tekshirib borish zarur. Tadqiqot asosida quyidagi xulosalarga kelindi.1C:Buxgalteriya ish haqi hisobining barcha bosqichlarini (kadrlar ma'lumotlari, tabel, hisoblash, ushlanma, to'lov va hisobot) yagona tizimda bog'laydi. Avtomatik hisoblash va provodkalarni shakllantirish hisob aniqligini oshiradi hamda inson omilidan kelib chiqadigan xatolar ulushini kamaytiradi. Ma'lumotlar bazasidagi o'zgarishlar tarixi va foydalanuvchi huquqlarini cheklash hisob shaffofligi va ma'lumotlar xavfsizligini ta'minlaydi; hisob sifati boshlang'ich ma'lumotlarning to'g'riligi, dasturning o'z vaqtida yangilanishi va buxgalterlarning malakasiga bog'liq.Kadrlar bo'limi va buxgalteriya o'rtasida ma'lumot almashish muddatini belgilash, oy yakunida 6710-hisobvaraqni xodimlar kesimida tekshirish va sozlamalarni yangilash uchun mas'ul shaxsni tayinlash hisobning sifatini yanada oshiradi.Taklif etilgan tartiblarni korxonalar amaliyotiga joriy etish mehnatga haq to'lash hisobining aniqligi, shaffofligi va qonunchilik talablariga muvofiqligini ta'minlashga xizmat qiladi.

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THE ROLE OF THE STATE IN STRENGTHENING ECONOMIC SECURITY: INSTITUTIONAL CAPACITY, REGULATION, AND STRATEGIC INTERVENTION

Orziqulov Alibek
Tashkent State University of Economics
Student of the Faculty of Economics
alibekorziqulov@gmail.com

Abstract. This article asks what the state can realistically do to make an economy more secure, and under which conditions its efforts backfire. Economic security is treated as the capacity of an economy to keep its essential functions running, and its policy choices open, under external shocks or economic coercion. The study is a qualitative comparative policy analysis. It reads the economic security frameworks of the European Union, Japan and the United States together with IMF and World Bank material on Uzbekistan, and it organises the evidence around three levers: institutional capacity, regulation and strategic intervention. The main finding concerns order rather than quantity. Instruments such as subsidies, notification regimes and import-concentration benchmarks look most convincing where a competent administration and predictable rules already exist, and least convincing where the state is at once owner, regulator and market participant. For Uzbekistan the evidence points to a narrower and better-governed state presence rather than a larger one. The article does not estimate causal effects. It offers a way of judging state action and a set of policy implications.

Keywords: economic security; state capacity; regulation; industrial policy; resilience; Uzbekistan

Introduction.

For a long time, economic security was a phrase that economists in open economies used rarely. Markets were expected to allocate resources, and the

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government's main task was to keep the macroeconomic framework stable. The idea that a country could be weakened because a supplier, a payment network or a technology sat in someone else's hands belonged mostly to security studies, where the economy was treated as one sector among several [1]. That division no longer holds. The 2008 financial crisis, the shortages of medical goods and microchips during the pandemic, the energy shock after the war in Ukraine, and the growing use of sanctions and export controls have shown that interdependence can be turned into a tool of pressure [2]. Governments reacted with a wave of new strategies. Japan passed a dedicated economic security law in 2022 [3], the G7 put economic resilience and economic security on its leaders' agenda in 2023 [4, 5], and the European Union published its first economic security strategy a month later [6].

The state has come back to the centre of the debate, but the debate is often framed too simply. One side says that markets already price risk well enough, so any attempt by the state to manage security costs more than it saves. The other says that firms have no reason to pay for protection against shocks that fall on everyone, so more intervention must mean more security. Neither position holds up well against the evidence. The IMF estimates that severe geoeconomic fragmentation could reduce global output by up to 7 percent through trade channels alone [7], which is reason enough to be careful with badly targeted measures. Yet the years 2020 to 2022 also showed what it costs to leave a critical dependency unmanaged.

This article starts from a narrower question than how much the state should do. It asks what the state must be good at before it intervenes, and what changes once it does. The argument has three parts. Institutional capacity, meaning the administrative, legal and fiscal ability to design and enforce policy, has to come first. Regulation then turns that capacity into rules that private actors can predict. Strategic intervention, which covers subsidies, public investment, stockpiles and ownership, comes last, because it is the most expensive lever and the easiest one to get wrong. A government that reaches for the third lever without the first two will usually buy the appearance of security rather than the thing itself.

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Uzbekistan serves as the applied case. The country is trying to open its economy while keeping a very large state sector under control, and recent IMF work gives unusually precise numbers on how large that sector is [8]. Section II sets out the method and the cases. Section III reports the findings for each lever and for Uzbekistan. Section IV discusses what the findings mean, where they are weak, and what follows for policy. Section V concludes.

Methods.

Economic security is a contested term, so the first methodological step is to say what it means here. Building on the broad-security tradition, in which the economy is one sector of security among several [1], and on the G7's recent attempt to define the concept around supply chains, critical infrastructure and critical technologies [5], this article defines economic security as the capacity of a national economy to keep its essential functions running, and its policy choices open, when it is hit by external shocks or by the deliberate use of economic dependence by others. The definition has two parts on purpose. The first concerns resilience to shocks and the second concerns autonomy under pressure. A country can be resilient and still dependent, and the policy implications are different.

The study uses a qualitative comparative policy analysis. It does not test hypotheses statistically, for a practical reason: most economic security strategies were adopted between 2022 and 2024, so there are not enough years or comparable outcome data to estimate their effects. What can be done at this stage is to compare what governments have committed to do, check it against the academic literature on state capacity and industrial policy, and note where the two diverge.

Three guiding questions were applied to every case. For institutional capacity: does the state have the administrative coordination and the fiscal and legal ability to carry out what it announces [9, 10]? For regulation: are the rules risk-based, transparent and open to evaluation, in the sense of the OECD's regulatory policy principles [11]? For strategic intervention: is public money or ownership directed at a specific, identifiable

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vulnerability, and does the design include limits such as conditions, guardrails or time limits [12].

Four cases were selected. The European Union, Japan and the United States each have a formal economic security framework with published instruments. Uzbekistan was added as a middle-income economy in which the role of the state is itself being reformed. The first three were chosen because their documents are public and detailed, not because they stand for all advanced economies. The evidence base consists of primary policy documents (the European Economic Security Strategy [6], the Critical Raw Materials Act [13], the CHIPS and Science Act [14] and Japan's Economic Security Promotion Act as described in [3]), reports of the IMF and the World Bank on Uzbekistan, and the academic literature cited above. Where possible, figures were checked against the original publication.

Two limitations should be stated at the start. Policy documents show intentions and not results. And because the sources are in English, Uzbek administrative practice is seen mostly through the eyes of international organisations. The conclusions are therefore claims about design and plausibility, not about measured effects.

Results.

A. Institutional capacity comes first

The literature agrees on one point more than on almost any other: policies fail more often because the state cannot carry them out than because they were badly designed. North treats institutions as the rules of the game, formal and informal, that shape incentives in an economy [15]. Besley and Persson split state capacity into two parts, the fiscal capacity to raise revenue and the legal capacity to enforce contracts and property rights, and show that both are built slowly and unevenly [9]. Fukuyama makes a related point, that governance is about the ability to make and enforce rules, whatever the size of the government [10]. The World Bank's 2017 World Development Report adds a practical test: the same policy gives different results depending on whether the state can solve problems of commitment, coordination and cooperation [16].

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Economic security policy is demanding on all three. It needs the state to commit credibly over years, to coordinate ministries that rarely work together (trade, finance, energy, defence), and to cooperate with firms that hold most of the relevant information about supply chains. The cases suggest that capacity shows up first as a coordination problem. The EU's strategy is built around three pillars, promoting the single market, protecting against risks and partnering with other countries, and was followed in January 2024 by five initiatives on trade and research [17]. That architecture is largely an answer to a coordination problem, since economic security cuts across areas where the Union and its member states each hold part of the responsibility [6]. Japan chose a different route. It wrote a dedicated law that designates sectors, gives agencies clear powers and obliges designated operators to notify the government in advance [3]. That brings clarity, but it also demands an administration able to apply the designation list consistently.

Uzbekistan shows the problem from the other side. The 2021–2025 reform strategy for state-owned enterprises (SOEs) targeted a 75 percent reduction of the state's presence in competitive sectors, yet the IMF concludes that implementation "has fallen short of the original target" and has not significantly reduced the state footprint [8]. The number of SOEs dropped from nearly 3,000 in 2020 to around 2,000 by late 2025, and cumulative privatization proceeds for 2021–2024 were about USD 2.5 billion, driven mainly by sales of smaller companies [8]. I do not read this as a verdict on the direction of reform, which the IMF supports. It does raise a fair question: if the administration found it hard to execute its own divestment plan, how well would it run a stockpile programme or a subsidy scheme for strategic industries?

B. Regulation turns capacity into predictable rules

Regulation is the cheapest of the three levers, and in the cases examined it is also the one used first. Japan's law requires operators of designated critical infrastructure, such as power, telecommunications, transport and finance, to file in advance before introducing important equipment or outsourcing its maintenance, and the government can recommend and then order security measures [3]. The EU's Critical Raw Materials

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Act sets benchmarks for 2030: 10 percent of annual consumption of strategic raw materials should come from EU extraction, 40 percent from EU processing and 25 percent from recycling, and no more than 65 percent should come from any single third country [13]. The benchmarks are non-binding, but they are measurable, which is rare in this field. In 2030 anyone will be able to check whether the policy worked. The Japanese model offers the opposite strength and the opposite risk. It gives the state wide discretion, so its fairness depends on how steadily that discretion is used.

Regulation also has an offensive side. Farrell and Newman show that states hosting the hubs of global networks, in finance or data for example, can use that position to monitor flows and to cut others off [2]. Most economies do not host such hubs, and Uzbekistan certainly does not. For a country in its position, regulation is mostly defensive: screening, standards, transparency about ownership. The OECD's principles of regulatory policy, with their emphasis on impact assessment and evaluation after the fact [11], apply here with extra force, because heavy-handed screening of foreign investment would damage the very inflows a middle-income economy needs. The question to ask of any security regulation is whether it names a specific risk and whether its burden fits the size of that risk.

C. Strategic intervention is powerful, costly and selective

Academic views of industrial policy have shifted a good deal. Rodrik argued in 2004 that the real question is not whether to have industrial policy but how to organise it, as a process of discovery in which government and business share information without the government being captured [18]. Juhász, Lane and Rodrik later reviewed newer studies that identify causal effects better than the older correlational work, and they conclude that the evidence is more favourable than it used to be, though dependent on context, measurement and governance [12]. Mazzucato adds that the state has repeatedly been the early, risk-taking investor in technologies that private capital would not finance [19], and Evans's idea of embedded autonomy, meaning close links with business without capture by it, remains the usual description of the institutional condition [20].

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Current economic security programmes follow that advice at least in form. The CHIPS and Science Act, signed in August 2022, appropriated USD 52.7 billion, of which USD 39 billion went to incentives for chip manufacturing on US soil, alongside a 25 percent investment tax credit [14]. Recipients accept limits on expanding advanced chip production in China and other countries of concern for ten years. Japan's law provides subsidies for certified suppliers of designated resources, funds for advanced research and the possibility of stockpiling critical materials [3]. What these programmes share is selectivity. Each is tied to a short list, such as semiconductors, rare earths, batteries and pharmaceuticals, and most carry some condition. The programmes that worry me most are the broad ones, with names like "support for strategic sectors", since that is where capture and waste are most likely to build up [18]. The cost side must also stay in view. The G7 itself framed its approach as de-risking rather than decoupling [5], and the IMF's estimate of fragmentation losses [7] shows why that distinction matters in practice.

D. Uzbekistan: a large state that is still reforming

Uzbekistan adopted its "Uzbekistan–2030" Strategy by Presidential Decree No. UP-158 on 11 September 2023 [21]. The macroeconomic picture is encouraging: real GDP grew 7.7 percent in 2025, and the national poverty rate fell from 17.0 to 5.8 percent between 2021 and 2025 [22]. Behind those figures the state remains very large. At the end of 2024, SOE assets amounted to 101 percent of GDP, and the state owned 63 percent of banking assets, against an average of about 23 percent in middle-income economies [8]. In its 2024 Article IV conclusion, the IMF Executive Board urged faster privatization of systemic financial institutions and an end to SOE preferences, and it named contingent liabilities from state banks, SOEs and public-private partnerships as a domestic vulnerability. It also noted that the current account deficit had widened to 8.6 percent of GDP in 2023 from 3.5 percent a year earlier [23].

External exposure is a second theme. The World Bank reports record remittances of USD 9.2 billion in the first half of 2026, up 13 percent, and lists weaker Russian growth as a risk that could dampen them, together with higher energy import costs if

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tensions in the Middle East escalate [22]. These are not the semiconductor and rare-earth worries that dominate European, Japanese and American strategies. For Uzbekistan the main security exposures are income dependence on one foreign labour market, the price of imported energy, and a financial system in which a problem at a state bank quickly becomes a fiscal problem. Table 1 summarises how the four cases compare on the three levers.

Table 1. The four cases compared along the three levers

Case	Institutional capacity	Regulation	Strategic intervention
EU	Shared competence; coordination across member states	Raw material benchmarks for 2030	Strategy plus five follow-up initiatives (Jan. 2024)
Japan	Dedicated law; central coordination	Advance filing by designated operators	Subsidies, stockpiles, research funding
USA	Commerce Department administers awards	Guardrails on expansion in China	USD 39 bn incentives; 25% tax credit
Uzbekistan	SOE reform target missed	Supervision to be strengthened (IMF)	SOE assets at 101% of GDP

Source: compiled by the author from [6, 17], [3], [13], [14], [8] and [23].

Discussion.

The main result is about order rather than quantity. In the cases reviewed, the instruments that look most convincing, such as the CHIPS incentives or Japan's notification regime, sit on administrations that already run grant programmes, enforce rules reasonably evenly and can coordinate across agencies. I cannot show that this is why they work, since the policies are too young. But the pattern is consistent with the state capacity literature [9, 16], and it carries an uncomfortable implication: the

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countries with the most to fear from economic insecurity are often those with the least capacity to follow the advanced economies' playbook.

Three objections deserve a direct answer. The first is that firms will diversify on their own once they have seen a shock. This is partly true. But firms count their own losses, not the losses that spread to everyone else when, say, a chip shortage stops both car production and the supply of hospital equipment, and that gap is the standard argument for public action in the new industrial policy literature [12]. The objection is right about one thing, though. The burden of proof should rest on the state, and mandatory measures should be as light as the risk allows.

The second objection is that economic security is protectionism with better branding. The risk is real, and the IMF's numbers show how large it could be [7]. The practical test I would propose has three questions. Does the measure name a specific vulnerability? Does it have a measurable target? Does it have an exit date or a review? The EU's raw material benchmarks pass the first two tests, and many other programmes do not.

The third objection is that small and middle-income countries cannot afford the instruments discussed here. That is correct. Uzbekistan will not match a USD 39 billion subsidy programme. Its advantage lies in cheaper levers, namely better governance, transparency and diversification, and these are also the levers that make later and costlier interventions work.

Several policy implications follow for Uzbekistan and similar economies. First, finishing the reform of SOEs and state banks is not separate from economic security but part of it, because a smaller and better-governed state footprint lowers the contingent liabilities that would otherwise land on the budget in a crisis [23, 8]. Second, the government could set up a small risk-assessment unit that publishes a short list of critical dependencies, for example energy imports, remittance sources, export markets and key inputs, with numerical targets, in the way the EU does for raw materials [13]. Third, any new subsidy should carry a sunset clause and a public evaluation. Fourth, the roles of owner and regulator should be separated, especially in finance and energy,

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because a state that both owns and supervises can drift into rent-seeking, a pattern Acemoglu and Robinson associate with extractive institutions [24]. Fifth, diversifying remittance sources and export markets should count as an economic security goal and not only as a trade goal.

The study has clear limits. It rests on policy documents, which show intentions and not results. It covers four cases, chosen because their documents are public and detailed, so they should not be read as representative. It relies on English-language sources, which means Uzbek administrative practice is seen mainly through the reports of international organisations. Once more years of data are available, future work could compare measured import concentration and financial-sector exposure before and after these programmes, and could survey firms on the compliance burden.

Conclusion.

This article asked what the state can do to strengthen economic security and when its efforts backfire. The answer developed here is that the state's contribution depends less on how much it does than on the order in which it builds its tools. Institutional capacity has to come first, regulation second and strategic intervention last, and each step should be narrow enough to be measured.

The cases support this reading without proving it. The European Union, Japan and the United States have picked specific dependencies, written rules or targets around them and attached conditions to public money. Uzbekistan's experience shows how a very large state presence can slow the process even when a reform strategy is in place: state-company assets equal to about the size of the whole economy, a state-dominated banking sector and a missed divestment target all limit what additional intervention could safely achieve.

For Uzbekistan the practical agenda is therefore modest and demanding at once. Finish the reform of the state sector, publish a short and measurable list of dependencies, and test every new measure against the questions of specificity, measurability and exit. Economic security built on such foundations is less dramatic

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than a large subsidy programme. It is also more likely to still be working when the next shock arrives.

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SENTRIFUGA APPARATLARINING TEXNIK HOLATINI DIAGNOSTIKA QILISH VA NOSOZLIKLARNI ERTA ANIQLASH USULLARINI TAKOMILLASHTIRISH

Ilmiy rahbar: Komilov Bekzodbek Maxmudjon o‘g‘li
Andijon davlat texnika instituti
“Metrologiya va yengil sanoat” kafedrasi t.f.f.d.,
Shavkatov Asadbek
Andijon davlat texnika instituti
“Biotibbiyot muhandisligi” yo‘nalishi 4-kurs talabasi

Annotatsiya. Mazkur maqolada sentrifuga apparatlarining texnik holatini baholash, ish jarayonida yuzaga keladigan nosozliklarni erta aniqlash va uskunalarning ishonchli ishlashini ta’minlash masalalari yoritilgan. Sentrifuga qurilmalarida rotor muvozanatining buzilishi, podshipniklarning yeyilishi, valning noto‘g‘ri markazlanishi, haroratning me’yordan ortishi va mexanik tebranishlarning kuchayishi kabi holatlar tahlil qilingan. Texnik diagnostika jarayonida vibratsion tahlil, harorat monitoringi, akustik nazorat, elektr dvigatel parametrlarini kuzatish va moy holatini baholash usullarining imkoniyatlari ko‘rib chiqilgan. Natijada sentrifuga apparatlarining texnik holatini muntazam monitoring qilish, bir nechta diagnostika ko‘rsatkichlarini birgalikda tahlil qilish va texnik xizmatni uskunaning haqiqiy holatiga muvofiq tashkil etish bo‘yicha takliflar ishlab chiqilgan.

Kalit so‘zlar: sentrifuga apparati, texnik diagnostika, vibratsion tahlil, podshipnik, rotor muvozanati, nosozliklarni erta aniqlash, harorat monitoring.

Abstract. This article examines the assessment of the technical condition of centrifuge equipment, the early detection of operational faults, and measures to ensure reliable equipment performance. It analyzes issues such as rotor imbalance, bearing wear, shaft misalignment, excessive temperature, and increased mechanical vibration in centrifuge systems. The capabilities of vibration analysis, temperature monitoring,

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acoustic inspection, electric motor parameter monitoring, and lubricant condition assessment are discussed as methods of technical diagnostics. As a result, recommendations are developed for regular condition monitoring of centrifuge equipment, the integrated analysis of multiple diagnostic indicators, and the implementation of maintenance procedures based on the actual technical condition of the equipment.

Keywords: centrifuge equipment, technical diagnostics, vibration analysis, bearing, rotor balancing, early fault detection, temperature monitoring.

Аннотация. В данной статье рассматриваются вопросы оценки технического состояния центрифужных аппаратов, раннего выявления неисправностей, возникающих в процессе эксплуатации, и обеспечения надежной работы оборудования. Проанализированы такие явления, как нарушение балансировки ротора, износ подшипников, несоосность вала, повышение температуры выше допустимого уровня и усиление механических вибраций. Рассмотрены возможности применения вибрационного анализа, температурного мониторинга, акустического контроля, контроля параметров электродвигателя и оценки состояния смазочных материалов в процессе технической диагностики. В результате разработаны рекомендации по регулярному мониторингу технического состояния центрифужных аппаратов, комплексному анализу нескольких диагностических показателей и организации технического обслуживания с учетом фактического состояния оборудования.

Ключевые слова: центрифужный аппарат, техническая диагностика, вибрационный анализ, подшипник, балансировка ротора, раннее выявление неисправностей, температурный мониторинг.

Kirish.

Zamonaviy sanoat korxonalarida ishlab chiqarish jarayonlarining uzluksizligi, mahsulot sifatining barqarorligi va uskunalardan samarali foydalanish ko‘p jihatdan mexanik qurilmalarning texnik holatiga bog‘liq. Kimyo, oziq-ovqat, farmatsevtika, neft-

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gaz va boshqa sanoat tarmoqlarida qo‘llaniladigan sentrifuga apparatlari aralashmalarni tarkibiy qismlarga ajratish, suyuqlikdan qattiq zarrachalarni chiqarish, suspenziyalarni suvsizlantirish va mahsulotlarni qayta ishlash kabi vazifalarni bajaradi. Mazkur qurilmalarda rotor yuqori tezlikda aylangani sababli kichik mexanik nomutanosibliklar ham vibratsiya, shovqin, podshipniklarning qizishi va konstruktiv qismlarga tushadigan dinamik yuklamalarning ortishiga olib kelishi mumkin.

Sentrifuga apparatining texnik holatini faqat tashqi ko‘rik yoki uskuna ishdan chiqqandan keyingi tekshiruv orqali baholash yetarli emas. Chunki ayrim nosozliklar dastlabki bosqichda ko‘zga tashlanmaydi, biroq ularning belgilari vibratsiya signallari, harorat o‘zgarishi, elektr dvigatelning tok iste’moli va boshqa ish parametrlarida namoyon bo‘lishi mumkin. Shu sababli texnik diagnostikaning asosiy vazifasi nosozlikning yuzaga kelganini qayd etish bilan cheklanmay, uning rivojlanish tendensiyasini aniqlash va o‘z vaqtida profilaktik choralarni belgilashdan iborat.

Aylanuvchi mashinalar vibratsiyasini o‘lchash va baholash bo‘yicha ISO 20816-1:2016 standarti mashina korpusi va tegishli aylanuvchi qismlardagi vibratsiyani o‘lchash, natijalarni baholash hamda ish holatini kuzatishning umumiy tamoyillarini belgilaydi [1]. Mazkur standart vibratsiyaning mutlaq qiymatini hamda vaqt davomida o‘zgarishini hisobga olish zarurligini ko‘rsatadi. Biroq har qanday sentrifuga uchun bir xil vibratsiya chegarasini qo‘llash to‘g‘ri emas: baholashda uskuna konstruksiyasi, aylanish tezligi, tayanchlar turi, ish rejimi va ishlab chiqaruvchining texnik talablari inobatga olinishi lozim.

Sanoat sharoitidagi monitoring imkoniyatlarini ko‘rsatadigan misollardan biri - Jordan davlatidagi Arab Potash Company korxonasida ishlatilgan Sulzer sanoat sentrifugasidan olingan ochiq ma’lumotlar to‘plamidir. Ushbu ma’lumotlar 2022-yil sentabrdan 2023-yil avgustgacha bo‘lgan 12 oylik davrni qamrab olgan. Unda nominal yuklamaga nisbatan moment, vibratsiya tezligi va ikkita podshipnik harorati bir daqiqalik intervalda qayd etilgan. Har bir kanal uchun taxminan 525 600 ta kuzatuv to‘plangan [2]. Ushbu misol sanoat uskunalarida texnik holatni uzoq muddat va bir

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nechta parametr orqali kuzatish mumkinligini ko‘rsatadi. Biroq mazkur ma’lumotlarni barcha sentrifugalarga xos nosozliklar statistikasi sifatida talqin qilish mumkin emas.

Aylanuvchi mexanizmlarda vibratsiyaga asoslangan diagnostika usullarini tahlil qilgan ilmiy sharhlarda o‘lchash, signalni qayta ishlash, muhim belgilarni ajratish va nosozlik turini tasniflash bosqichlari o‘zaro bog‘liq ekanligi ta’kidlangan [3]. Demak, faqat bitta o‘lchov natijasiga qarab texnik xulosa chiqarish o‘rniga, turli diagnostik belgilarni birgalikda baholash maqsadga muvofiq.

Maqolaning maqsadi sentrifuga apparatlarining texnik holatini baholashda qo‘llaniladigan usullarni tizimlashtirish, nosozliklarni erta aniqlash mezonlarini takomillashtirish va diagnostika natijalaridan texnik xizmat ko‘rsatishni rejalashtirishda foydalanish bo‘yicha amaliy tavsiyalar ishlab chiqishdan iborat.

Tadqiqot metodologiyasi.

Maqolani tayyorlashda ilmiy adabiyotlarni tahlil qilish, xalqaro standart talablarini o‘rganish, texnik ko‘rsatkichlarni taqqoslash, matematik hisoblash va diagnostika algoritmini ishlab chiqish usullaridan foydalanildi. Ma’lumotlar bazasini shakllantirishda ISO 20816-1:2016 standarti, aylanuvchi mashinalarning vibratsion diagnostikasiga bag‘ishlangan ilmiy sharh hamda sanoat sentrifugasida olib borilgan ko‘p parametrli monitoring ma’lumotlari asos qilib olindi [1–3].

Natija va tahlillar.

Sentrifuga apparatlarining texnik holatini baholash bo‘yicha tahlil uch yo‘nalishda olib borildi: diagnostika usullarining imkoniyatlarini taqqoslash, vibratsiya ko‘rsatkichlaridagi o‘zgarishni hisoblash va ko‘p parametrli nazorat asosida qaror qabul qilish tartibini ishlab chiqish.

Sentrifugalarda qo‘llaniladigan diagnostika usullarining har biri muayyan turdagi nosozliklarni aniqlashda foydali, ammo ularning hech biri barcha nosozliklarni mustaqil ravishda aniqlay olmaydi. Vibratsion nazorat mexanik tebranishlarni baholash imkonini bersa, harorat nazorati qizish bilan bog‘liq o‘zgarishlarni aniqlaydi. Elektr parametrlarini kuzatish esa dvigatelning yuklamasi va elektr ta’minotidagi ayrim muammolarni aniqlashga yordam beradi.

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Sentrifuga apparatlarini diagnostika qilish usullarining taqqoslanishi

1-jadval.

Usul	Aniqlashi mumkin bo‘lgan belgilar	Afzalligi	Cheklovi
Vibratsion tahlil	Nomutanosiblik, ayrim podshipnik va tayanch muammolari	Mexanik holatni miqdoriy baholaydi	Signal ish rejimiga bog‘liq
Harorat monitoringi	Qizish, ishqalanish va yuklama o‘zgarishi	Uzluksiz kuzatish mumkin	Nosozlik sababini yakka holda aniqlamaydi
Akustik nazorat	G‘ayritabiiy shovqin va ayrim mexanik nuqsonlar	Qo‘shimcha diagnostik belgi beradi	Tashqi shovqin ta’sir qiladi
Elektr parametrlarini kuzatish	Tok, yuklama va elektr ta’minotidagi o‘zgarishlar	Dvigatel holatini baholashga yordam beradi	Mexanik nosozliklarning barchasini ko‘rsatmaydi
Moy holatini tahlil qilish	Moyning ifloslanishi va yeyilish mahsulotlari	Moylash tizimidagi muammolarni aniqlashga yordam beradi	Namuna olish yoki laboratoriya tahlili talab qilinishi mumkin
Ko‘p parametrli monitoring	Bir nechta nosozlikka xos belgilar	Dalillarni o‘zaro tekshirish imkonini beradi	Sensorlar va qayta ishlash xarajati mavjud

Manba: *[1; 3] asosida muallif tomonidan tuzilgan.*

Taqqoslash shuni ko‘rsatadiki, samarali diagnostika tizimi uchun bitta qimmat sensor o‘rnatishdan ko‘ra, uskuna xavflariga mos tanlangan bir nechta ko‘rsatkichni muntazam qayd etish muhimroq bo‘lishi mumkin (1-jadval). Sensorlar soni va turi sentrifuganing konstruksiyasi, ishlab chiqarish jarayonidagi ahamiyati hamda texnik xizmat ko‘rsatish imkoniyatlariga muvofiq belgilanadi.

Diagnostika mezonlarini amaliy tushuntirish uchun shartli sentrifuga misoli ko‘rib chiqiladi. Faraz qilaylik, uskuna soz holatda ishlayotgan paytda podshipnik tayanchida

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o‘lchangan vibratsiya tezligi 2,0 mm/s RMS bo‘lgan. Keyingi tekshiruvlarda ushbu ko‘rsatkich 2,4; 3,0 va 3,6 mm/s RMS qiymatlarni tashkil qilgan.

Vibratsiya ko‘rsatkichlarining shartli o‘zgarishi

2-jadval.

O‘lchov bosqichi	Vibratsiya, mm/s RMS	Boshlang‘ich holatga nisbatan o‘zgarish
Boshlang‘ich holat	2,0	0%
1-o‘lchov	2,4	20%
2-o‘lchov	3,0	50%
3-o‘lchov	3,6	80%

Manba: *hisoblashni tushuntirish uchun tuzilgan shartli ma’lumotlar.*

Uchinchi o‘lchovdagi o‘zgarish quyidagicha hisoblanadi:

$$\Delta v = [(3{,}6 - 2{,}0) / 2{,}0] \times 100\% = 80\%$$

Demak, shartli misolda vibratsiya tezligi boshlang‘ich holatga nisbatan 80 foizga ortgan (2-jadval). Bu holat mexanik tizimda o‘zgarish yuz berayotganini ko‘rsatuvchi muhim belgi bo‘lishi mumkin. Lekin 80 foizlik o‘sishning o‘zi uskuna avariyaga yaqinlashganini yoki muayyan detal ishdan chiqqanini isbotlamaydi. Yakuniy baholashda uskuna turi, aylanish tezligi, o‘lchash nuqtasi, vibratsiya spektri va ishlab chiqaruvchi belgilagan chegaralar hisobga olinishi kerak. Agar o‘lchovlar ketma-ket ravishda bir xil ish rejimida olingan bo‘lsa, ko‘rsatkichlarning izchil ortishi texnik holatdagi o‘zgarishni chuqurroq tekshirish uchun asos beradi. Shu bois faqat bir martalik chegaraviy qiymatni emas, balki ko‘rsatkichning vaqt bo‘yicha o‘zgarish grafigini ham yuritish tavsiya etiladi.

Diagnostika tizimining vazifasi faqat o‘lchovlarni qayd etish emas, balki operatorga qachon qo‘shimcha tekshiruv zarurligini ko‘rsatishdir. Buning uchun boshlang‘ich holat, ishlab chiqaruvchi talablari va uskunaning ish sharoitlariga asoslangan ogohlantirish mezonlari belgilanadi. Masalan, korxona ichki tartibida vibratsiyaning boshlang‘ich qiymatga nisbatan 20 foiz ortishi qo‘shimcha kuzatuvga sabab bo‘ladigan dastlabki mezon sifatida sinov tariqasida tanlanishi mumkin. 50 foizlik o‘sish esa batafsil diagnostik tekshiruvni boshlash mezoni sifatida ko‘rib chiqilishi mumkin. Bu foizlar xalqaro standartda barcha sentrifugalar uchun belgilangan me’yorlar

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emas, balki shartli misoldir. Ularni real uskunada qo‘llashdan oldin texnik mutaxassislar tekshirishi va uskuna xususiyatlariga moslashtirishi lozim.

Shartli diagnostik qaror qabul qilish mezonlari.

3-jadval.

Holat	Shartli mezon	Tavsiya etiladigan harakat
Barqaror holat	Ko‘rsatkichlar odatiy diapazonda	Reja asosida monitoring
Kuzatuvni kuchaytirish	Vibratsiya boshlang‘ich darajadan 20% ortgan	O‘lchovni qayta tekshirish, ish rejimini solishtirish
Batafsil diagnostika	Vibratsiya boshlang‘ich darajadan 50% ortgan	Spektr tahlili va mexanik qismlarni tekshirish
Xavfli holat	Ishlab chiqaruvchi chegarasi buzilgan yoki xavfsizlik alomati kuzatilgan	Tasdiqlangan tartib asosida xavfsiz to‘xtatish va mutaxassis tekshiruvi

Manba: *muallif tomonidan ishlab chiqilgan shartli model.*

Ushbu yondashuvda eng muhim mezon - ishlab chiqaruvchi va tegishli texnik standartlar belgilagan xavfsizlik talablaridir (3-jadval). Foizli o‘zgarishlar yordamchi kuzatuv vositasi bo‘lib, xavfsizlik chegaralarini almashtirmaydi. Vibratsiyaning keskin ortishi, noodatiy shovqin yoki boshqa xavfli belgi kuzatilsa, navbatdagi rejalashtirilgan o‘lchovni kutish to‘g‘ri emas.

Arab Potash Company korxonasida ishlatilgan Sulzer sanoat sentrifugasidan olingan ma’lumotlar to‘plami ko‘p parametrli monitoringning amaliy imkoniyatlarini ko‘rsatadi. Manbada 2022-yil sentabrdan 2023-yil avgustgacha bo‘lgan 12 oylik davr, to‘rtta kuzatuv kanali va bir daqiqalik qayd oralig‘i keltirilgan. Har bir kanal uchun taxminan 525 600 ta kuzatuv mavjud [2]. Ushbu hajmni tekshirish uchun bir yilni 365 kun deb olamiz: $365 \times 24 \times 60 = 525\,600$. Demak, bir yil davomida har daqiqada bitta qayd olinsa, 525 600 ta kuzatuv hosil bo‘ladi. To‘rtta kanal bo‘yicha jami qaydlar soni, takrorlanishlar yoki yetishmayotgan qiymatlar hisobga olinmagan dastlabki hisobda, taxminan 2 102 400 ta bo‘ladi. Manbada vibratsiya uchun 12 mm/s, moment uchun nominal yuklamaning 85 foizi va harorat uchun 85 °C kabi chegaralardan oshgan qiymatlar ehtimoliy anomaliyalar sifatida belgilangan [2]. Bu raqamlar aynan shu ma’lumotlar to‘plamidagi qaydlarni saralashda ishlatilgan mezonlardir. Ularni barcha

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sentrifugalar uchun universal avariya chegarasi sifatida qo‘llash mumkin emas. Harorat va vibratsiya bo‘yicha xavfsiz chegaralar uskuna ishlab chiqaruvchisining hujjatlari hamda tegishli texnik talablar asosida aniqlanishi kerak.

Uzoq muddatli monitoring uskunaning odatiy ish holatini tavsiflash, parametrlar o‘rtasidagi bog‘liqlikni tekshirish va noodatiy holatlarni ajratish imkonini beradi. Biroq ma’lumotlar to‘plamida anomaliya deb belgilangan har bir kuzatuvni tasdiqlangan mexanik nosozlik bilan tenglashtirish mumkin emas. Anomaliya sababini aniqlash uchun hodisa qaydlari, texnik ko‘rik natijalari va ta’mirlash hujjatlari bilan solishtirish zarur.

Diagnostika natijalarining amaliy qiymati aniqlangan belgilarning texnik xizmat ko‘rsatish qarorlariga qanchalik to‘g‘ri bog‘lanishiga qarab baholanadi. Buning uchun rejalashtirilmagan to‘xtashlar soni, nosozlikni aniqlashgacha ketgan vaqt, ta’mirlash xarajatlari, uskunaning ishlash davomiyligi va takroriy nosozliklar qayd etib borilishi lozim. Uskunaning texnik foydalanish koeffitsiyentini quyidagi sodda formula bilan baholash mumkin:

$$Kf = Ti / (Ti + Tt) \times 100\%$$

Bu yerda Ti - kuzatuv davridagi ishlash vaqti, Tt - shu davrda ta’mirlash sababli yo‘qotilgan vaqt. Formula kuzatuv davri va vaqt hisobining bir xil tartibda yuritilishini talab qiladi. Shartli ravishda, agar sentrifuga bir oyda 600 soat ishlagan va ta’mirlash sababli 24 soat to‘xtagan bo‘lsa, foydalanish koeffitsiyenti: $Kf = 600 / (600 + 24) \times 100\% \approx 96{,}15\%$. Bu natija faqat tushuntirish uchun keltirilgan shartli hisobdir va real korxonaning ishlab chiqarish samaradorligini ifodalamaydi.

Diagnostika tizimining foydasini baholashda joriy etishdan oldingi va keyingi davrlar bo‘yicha rejalashtirilmagan to‘xtashlar soni, o‘rtacha ta’mirlash davomiyligi va takroriy nosozliklar ulushi taqqoslanadi. Natijadagi o‘zgarishni faqat diagnostika tizimiga bog‘lash uchun ishlab chiqarish hajmi, ish rejimi, xomashyo xususiyatlari va ta’mirlash siyosatidagi o‘zgarishlar ham hisobga olinishi lozim.

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Muhokama.

Sentrifuga apparatlarining texnik holatini diagnostika qilish bo‘yicha ko‘rib chiqilgan usullar nosozliklarni aniqlashda kompleks yondashuv zarurligini ko‘rsatadi. Vibratsion tahlil mexanik o‘zgarishlarni qayd etishda muhim o‘rin tutadi, ammo o‘lchangan signalning o‘zi nosozlik sababini doimo aniq belgilamaydi. Podshipnik, rotor, tayanch va korpus bilan bog‘liq muammolar ayrim hollarda o‘xshash vibratsion belgilarni keltirib chiqarishi mumkin. Shuning uchun chastota spektri, vaqt sohasi ko‘rsatkichlari, harorat va ish rejimi haqidagi ma’lumotlar birgalikda tahlil qilinishi kerak [1; 3].

ISO 20816-1:2016 standarti vibratsiyani o‘lchash va baholashning umumiy tamoyillarini beradi, lekin barcha turdagi sentrifugalar uchun yagona ruxsat etilgan chegarani belgilamaydi [1]. Shu sababli korxonada diagnostika tizimini joriy etishdan oldin uskuna pasporti, ishlab chiqaruvchi ko‘rsatmalari va tegishli maxsus standartlar tekshirilishi zarur. Bir xil vibratsiya qiymati turli aylanish tezligiga ega yoki konstruksiyasi farq qiladigan uskunalarda bir xil texnik holatni anglatmasligi mumkin.

Ko‘p parametrli monitoringning asosiy afzalligi alohida belgilar o‘rtasidagi moslikni tekshirish imkoniyatidir. Masalan, vibratsiya ortishi bilan bir vaqtda podshipnik haroratining ko‘tarilishi, elektr dvigatel yuklamasining o‘zgarishi yoki noodatiy shovqinning paydo bo‘lishi tekshiruv uchun qo‘shimcha dalillar beradi. Aksincha, bitta sensor ko‘rsatkichining keskin o‘zgarishi sensor nosozligi, noto‘g‘ri o‘rnatish yoki o‘lchash sharoitining o‘zgarishi bilan ham bog‘liq bo‘lishi mumkin. Shu bois diagnostika tizimi o‘lchovlarning ishonchliligini tekshirish tartibini ham o‘z ichiga olishi kerak.

Raqamli monitoringni rivojlantirishda mashinaviy o‘rganish algoritmlaridan foydalanish istiqbolli yo‘nalishlardan biridir. Bunday algoritmlar vibratsiya, harorat va elektr parametrlaridan olingan belgilar asosida normal va noodatiy holatlarni tasniflashga yordam berishi mumkin. Biroq modelning aniqligi ma’lumotlar sifati,

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nosozlik holatlari soni, sinov va o‘qitish ma’lumotlarining ajratilishi hamda boshqa uskunalarda tekshirilganligiga bog‘liq. Shu sababli boshqa mexanizmlarda olingan yuqori aniqlik natijalarini alohida tekshiruvsiz sentrifugalarga ko‘chirish mumkin emas.

Diagnostika tizimining iqtisodiy samaradorligi ham alohida baholanishi lozim. Sensorlar, dasturiy ta’minot, xodimlarni o‘qitish va texnik xizmat xarajatlari rejalashtirilmagan to‘xtashlardan keladigan zarar, ta’mirlash xarajatlari va ishlab chiqarishdagi yo‘qotishlar bilan taqqoslanadi. Agar korxonada nosozliklar tarixi mavjud bo‘lmasa, dastlabki bosqichda monitoring ma’lumotlarini yig‘ish, boshlang‘ich holatni belgilash va nosozliklar reyestrini yuritish muhim vazifalardan biridir.

Taklif etilayotgan diagnostika algoritmining amaliy afzalligi uning bosqichma-bosqich joriy qilinishi mumkinligidir. Dastlab operator tomonidan davriy ko‘rik va portativ vibratsiya o‘lchagichidan foydalanish yo‘lga qo‘yiladi. Keyingi bosqichda muhim tayanchlarga harorat sensorlari o‘rnatilib, ko‘rsatkichlarni elektron qayd etish tashkil qilinadi. Uchinchi bosqichda ma’lumotlar bazasi shakllantirilib, parametrlarning vaqt bo‘yicha o‘zgarishi va nosozliklar tarixi tahlil qilinadi. Uzluksiz monitoring yoki avtomatik diagnostika tizimini joriy etish uskuna ahamiyati, xavf darajasi va iqtisodiy asoslanganlikka qarab hal etiladi.

Xulosa va takliflar.

Xulosa qilib aytganda, Sentrifuga apparatlarining texnik holatini diagnostika qilish va nosozliklarni erta aniqlash masalalarini tahlil qilish asosida quyidagi xulosalarga kelindi.

Birinchidan, sentrifuga apparatlarida rotor muvozanatining buzilishi, podshipniklarning yeyilishi, valning noto‘g‘ri markazlanishi, mahkamlash qismlarining bo‘shashi va moylash tizimidagi muammolar texnik holatga salbiy ta’sir ko‘rsatishi mumkin. Ushbu nosozliklar turli diagnostik belgilar orqali namoyon bo‘lgani sababli ularni aniqlashda uskunaning konstruktiv xususiyatlariga mos usullarni tanlash zarur.

Ikkinchidan, vibratsiya tezligining RMS qiymati, uning boshlang‘ich holatga nisbatan o‘zgarishi, podshipnik harorati va elektr dvigatel yuklamasini birgalikda kuzatish texnik holatdagi o‘zgarishlarni erta aniqlash imkoniyatini kengaytiradi. Biroq

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ushbu ko‘rsatkichlarning hech biri barcha nosozliklar uchun mustaqil va mutlaq diagnostik mezon hisoblanmaydi.

Uchinchidan, sanoat sentrifugasida 12 oy davomida har daqiqada ma’lumot qayd etilishi natijasida har bir kanal bo‘yicha taxminan 525 600 ta kuzatuv to‘planishi mumkinligi ko‘p parametrli monitoringning axborot imkoniyatlarini ko‘rsatadi [2]. Bunday ma’lumotlar texnik holat tendensiyasini kuzatish va ehtimoliy anomaliyalarni ajratish uchun foydali, biroq anomaliyalarni tasdiqlangan nosozliklar bilan tenglashtirish uchun qo‘shimcha tekshiruv talab qilinadi.

To‘rtinchidan, diagnostika chegaralarini belgilashda ISO 20816-1 standartining umumiy tamoyillari, ishlab chiqaruvchi ko‘rsatmalari va sentrifuganing haqiqiy ish sharoitlari hisobga olinishi kerak [1]. Shartli foizli mezonlar faqat dastlabki kuzatuv vositasi sifatida ishlatilishi, xavfsizlik bo‘yicha majburiy chegaralar o‘rnini egallamasligi lozim.

Beshinchidan, texnik xizmat ko‘rsatish samaradorligini baholash uchun rejalashtirilmagan to‘xtashlar, ta’mirlash davomiyligi, takroriy nosozliklar va uskunaning ishlash vaqti muntazam qayd etilishi kerak. Bu ma’lumotlar diagnostika tizimini joriy etishning iqtisodiy natijalarini keyinchalik miqdoriy baholashga yordam beradi.

Yuqoridagi xulosalardan kelib chiqib, quyidagi amaliy takliflar ishlab chiqildi:

1. Har bir sentrifuga uchun boshlang‘ich texnik holat pasportini shakllantirish va vibratsiya, harorat, aylanish tezligi hamda yuklama ko‘rsatkichlarini qayd etish.
2. Vibratsiya o‘lchovlarini imkon qadar bir xil ish rejimida va bir xil nazorat nuqtalarida amalga oshirish, o‘lchash asboblarining kalibrlanishini nazorat qilish.
3. Podshipniklar va rotor tayanchlarida xavf darajasiga mos ravishda davriy yoki uzluksiz monitoringni tashkil etish.
4. Vibratsiya, harorat va elektr parametrlaridagi o‘zgarishlarni yagona diagnostika reyestrida jamlash hamda shubhali holatlarni texnik ko‘rik natijalari bilan tekshirish.
5. Ogohlantirish va to‘xtatish mezonlarini ishlab chiqaruvchi talablari, uskuna konstruksiyasi va xavfsizlik qoidalari asosida belgilash.

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6. Texnik xizmat ko‘rsatishdan oldingi va keyingi ko‘rsatkichlarni taqqoslab, profilaktika ishlarining natijalarini muntazam baholash.

7. Kelgusida real ishlab chiqarish ma’lumotlari asosida diagnostika algoritmini sinash, uning xato ogohlantirishlar darajasini va nosozliklarni aniqlash imkoniyatini baholash.

Umuman olganda, sentrifuga apparatlarining ishonchli ishlashini ta’minlash uchun texnik xizmat ko‘rsatishni faqat uskuna ishdan chiqqandan keyin amalga oshirish bilan cheklanmasdan, uning holatini muntazam baholash tizimiga o‘tish maqsadga muvofiq. Vibratsion tahlil, harorat monitoringi va boshqa diagnostik ko‘rsatkichlarni birlashtirish nosozlik alomatlarini o‘z vaqtida aniqlash, ta’mirlash ishlarini rejalashtirish va ishlab chiqarishdagi kutilmagan uzilishlar xavfini kamaytirishga xizmat qilishi mumkin.

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SENTRIFUGA ROTORINING NOMUVOZANATLIGI VA TEBRANISHLARINI KAMAYTIRISH ORQALI USKUNANING ISHLASH ISHONCHLILIGINI OSHIRISH

Ilmiy rahbar: Komilov Bekzodbek Maxmudjon o‘g‘li
Andijon davlat texnika instituti
“Metrologiya va yengil sanoat” kafedrasi t.f.f.d.,
Shavkatov Asadbek
Andijon davlat texnika instituti
“Biotibbiyot muhandisligi” yo‘nalishi 4-kurs talabasi

Annotatsiya. Mazkur maqolada sentrifuga rotorining nomuvozanatligi, mexanik tebranishlarning yuzaga kelish sabablari va ularning uskuna ishlash ishonchliligiga ta’siri tahlil qilinadi. Rotor massasining aylanish o‘qiga nisbatan notekis taqsimlanishi natijasida paydo bo‘ladigan markazdan qochma kuchlar, podshipniklarga tushadigan dinamik yuklama hamda mexanik qismlarning tezlashtirilgan yeyilish jarayonlari yoritilgan. Tebranishlarni kamaytirishda rotorni statik va dinamik muvozanatlash, vibratsiya parametrlarini o‘lchash, texnik holatni muntazam kuzatish va profilaktik xizmat ko‘rsatish usullarining ahamiyati asoslab berilgan. Maqolada aylanish tezligi va nomuvozanatlik miqdori o‘rtasidagi bog‘liqlik matematik ifodalar yordamida hisoblangan, shuningdek, rotorni muvozanatlash samaradorligi bo‘yicha e’lon qilingan tajriba natijalari qiyosiy tahlil qilingan.

Kalit so‘zlar: sentrifuga, rotor nomuvozanatligi, mexanik tebranish, dinamik muvozanatlash, vibratsiya diagnostikasi, aylanish tezligi.

Abstract. This article analyzes rotor imbalance in centrifuges, the causes of mechanical vibrations, and their impact on equipment operational reliability. It examines centrifugal forces generated by the uneven distribution of rotor mass relative to the axis of rotation, the dynamic loads imposed on bearings, and the accelerated wear of mechanical components. The importance of static and dynamic rotor balancing,

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vibration parameter measurement, regular monitoring of technical condition, and preventive maintenance in reducing vibrations is substantiated. The relationship between rotational speed and the magnitude of imbalance is calculated using mathematical expressions. In addition, published experimental results on the effectiveness of rotor balancing are comparatively analyzed.

Keywords: centrifuge, rotor imbalance, mechanical vibration, dynamic balancing, vibration diagnostics, rotational speed.

Аннотация. В данной статье анализируются дисбаланс ротора центрифуги, причины возникновения механических вибраций и их влияние на эксплуатационную надежность оборудования. Рассматриваются центробежные силы, возникающие вследствие неравномерного распределения массы ротора относительно оси вращения, динамические нагрузки на подшипники, а также ускоренный износ механических компонентов. Обоснована значимость статической и динамической балансировки ротора, измерения параметров вибрации, регулярного контроля технического состояния и проведения профилактического технического обслуживания для снижения вибраций. Взаимосвязь между частотой вращения и величиной дисбаланса рассчитана с использованием математических выражений. Кроме того, проведен сравнительный анализ опубликованных экспериментальных результатов, характеризующих эффективность балансировки ротора.

Ключевые слова: центрифуга, дисбаланс ротора, механическая вибрация, динамическая балансировка, вибрационная диагностика, частота вращения.

Kirish.

Sanoat korxonalarida mexanik uskunalarning uzluksiz va ishonchli ishlashi ishlab chiqarish samaradorligiga bevosita ta’sir ko‘rsatadi. Kimyo, oziq-ovqat, farmatsevtika, tog‘-kon sanoati hamda boshqa ishlab chiqarish tarmoqlarida qo‘llaniladigan sentrifugalar suyuqlik va qattiq zarrachalarni ajratish, suspenziyalarni qayta ishlash, namlikni kamaytirish va mahsulot tarkibiy qismlarini saralash kabi vazifalarni bajaradi.

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Mazkur uskunalarning asosiy ishchi elementi rotor bo‘lib, uning aylanishi davomida hosil bo‘ladigan mexanik kuchlar va tebranishlar butun agregatning texnik holatiga ta’sir ko‘rsatadi.

Sentrifuga rotorining nomuvozanatligi aylanuvchi massa markazining geometrik aylanish o‘qiga mos kelmasligi yoki massa taqsimotining notekisligi bilan bog‘liq. Bunday holat rotor aylanganda davriy ravishda o‘zgaruvchi kuchlarning paydo bo‘lishiga olib keladi. Agar ushbu kuchlar yetarli darajada cheklanmasa, podshipniklar, val, mufta, tayanch konstruksiyasi va elektr dvigatelga qo‘shimcha dinamik yuklamalar tushadi. Natijada tebranish kuchayishi, shovqin ortishi, mahkamlash elementlarining bo‘shashishi va ayrim detallar xizmat muddatining qisqarishi mumkin.

Rotor nomuvozanatligining yuzaga kelishiga rotor yuzasida materialning notekis to‘planishi, mahsulot qoldiqlarining yopishib qolishi, korroziya, ishchi qismlarning yeyilishi, noto‘g‘ri yig‘ish, valning egilishi hamda rotorning deformatsiyalanishi sabab bo‘lishi mumkin. Qayta ishlanayotgan material rotor ichida bir xil taqsimlanmasa, dastlab muvozanatlangan mexanizmda ham ish davomida nomuvozanatlik yuzaga keladi.

Rotor nomuvozanatligi bilan bog‘liq tebranishlar faqat aylanish tezligiga emas, balki nomuvozanat massa miqdori, uning aylanish o‘qidan uzoqligi, tayanchlarning bikrligi va rotorning dinamik xususiyatlariga ham bog‘liq. Shu sababli tebranishning ortishini har doim ham faqat nomuvozanatlik bilan izohlash to‘g‘ri emas. Podshipnik shikastlanishi, val va muftaning markazlashuvi buzilishi, bo‘sh mahkamlagichlar hamda rezonans holatlari ham o‘xshash belgilarni keltirib chiqarishi mumkin.

ISO 20816-1:2016 xalqaro standarti mashina vibratsiyasini o‘lchash va baholashning umumiy tamoyillarini qamrab oladi [1]. Rotorlarni muvozanatlashga doir ISO 21940-11:2016 standarti esa qattiq rotorlar uchun muvozanatlash tartiblari, ruxsat etiladigan qoldiq nomuvozanatlik va tuzatish tekisliklariga oid talablarni belgilaydi [2;3]. Aniq tebranish chegaralari rotor turi, uskuna konstruksiyasi va ishlash sharoitlariga mos tanlanishi lozim.

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Maqolaning maqsadi sentrifuga rotorining nomuvozanatligi va tebranishlarining kelib chiqish mexanizmlarini tahlil qilish, matematik hisob-kitoblar orqali aylanish tezligining ta’sirini baholash hamda uskunaning ishlash ishonchliligini oshirishga qaratilgan amaliy tavsiyalar ishlab chiqishdan iborat.

Tadqiqot metodologiyasi.

Maqolada tizimli tahlil, mexanik jarayonlarni matematik modellashtirish, qiyosiy tahlil va hisob-kitob usullaridan foydalanildi. Asosiy e’tibor rotor nomuvozanatligi natijasida yuzaga keladigan markazdan qochma kuch, tebranish amplitudasi, aylanish tezligi va muvozanatlash samaradorligi o‘rtasidagi bog‘liqlikni tushuntirishga qaratildi.

Natija va tahlillar.

Nomuvozanat massa m = 0,01 kg, uning aylanish o‘qidan masofasi e = 0,0005 m, ya’ni 0,5 mm deb olinsin. Nomuvozanatlik momenti U = me = 0,000005 kg•m yoki 5 g•mm ga teng. 1500 ayl/min tezlikda ω = 157,08 rad/s va F ≈ 12,34 N. 3000 ayl/min tezlikda ω = 314,16 rad/s va F ≈ 49,35 N bo‘ladi.

Rotor aylanish tezligining nomuvozanatlik kuchiga ta’siri

1-jadval.

Aylanish tezligi, ayl/min	Burchak tezligi, rad/s	Hisoblangan kuch, N	1500 ayl/min ga nisbatan
750	78,54	3,08	0,25
1500	157,08	12,34	1,00
2250	235,62	27,74	2,25
3000	314,16	49,35	4,00

Manba: *muallifning $F = me\omega^2$ formulasi asosidagi hisob-kitoblari. Nomuvozanat massa 10 g, ekssentrisitet 0,5 mm deb qabul qilingan.*

Aylanish tezligi 1500 ayl/min dan 3000 ayl/min gacha, ya’ni ikki baravar oshganda hisoblangan nomuvozanatlik kuchi 12,34 N dan 49,35 N gacha ko‘tariladi. Bu qariyb to‘rt baravar o‘sishni anglatadi. Hisoblangan kuchni tayanchdagi tebranish amplitudasiga to‘g‘ridan-to‘g‘ri tenglashtirib bo‘lmaydi, chunki haqiqiy tebranish rotor va tayanchlarning bikrligi, dempferlash xususiyatlari, rezonans chastotalari, podshipnik holati va o‘lchash nuqtasiga ham bog‘liq.

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Rotor ichida qayta ishlanayotgan materialning notekis taqsimlanishi, mahsulot qoldiqlarining to‘planishi, korroziya, abraziv yeyilish, valning egilishi yoki muftaning noto‘g‘ri markazlashuvi tebranishni kuchaytirishi mumkin. Shu sababli diagnostika faqat bitta belgiga asoslanmasligi, bir nechta ko‘rsatkichni birgalikda baholashi kerak.

Sentrifuga rotorida tebranishga sabab bo‘luvchi omillar va tekshiruv usullari

2-jadval.

Nosozlik yoki omil	Ehtimoliy belgi	Tavsiya etiladigan tekshiruv
Rotor nomuvozanatligi	Aylanish chastotasiga mos davriy tebranish	Vibratsiya spektri va fazani tahlil qilish
Podshipnik yeyilishi	Shovqin, qizish, yuqori chastotali tebranish	Harorat, vibratsiya va podshipnik holatini tekshirish
Val yoki mufta markazlashuvi buzilishi	Radial yoki o‘q bo‘ylab tebranish	Markazlashuvni o‘lchash
Rotor yuzasida material yig‘ilishi	Ish rejimi yoki yuklamaga qarab o‘zgaruvchi tebranish	Tozalash va rotor yuzasini ko‘zdan kechirish
Mahkamlash elementlarining bo‘shashi	Beqaror tebranish va mexanik shovqin	Uskunani xavfsiz to‘xtatib, mahkamlashlarni tekshirish
Rezonans holati	Muayyan tezlik oralig‘ida tebranishning keskin ortishi	Tezlik va tebranish o‘rtasidagi bog‘liqlikni tahlil qilish

Manba: *muallifning mexanik diagnostika tamoyillari asosidagi umumlashtirishi.*

Aylanish chastotasiga mos tebranish komponenti nomuvozanatlikni aniqlashda foydali. Rotor 1500 ayl/min tezlikda ishlasa, aylanish chastotasi 25 Hz, 3000 ayl/min tezlikda esa 50 Hz bo‘ladi. Biroq bu chastotalarning mavjudligi o‘z-o‘zidan nomuvozanatlikni to‘liq tasdiqlamaydi. Amplituda, faza, tezlik rejimi va boshqa o‘lchovlar ham tahlil qilinishi kerak.

Rotorni muvozanatlash nomuvozanatlikdan kelib chiqadigan dinamik kuchlarni kamaytirishning asosiy usullaridan biridir. Jarayonda rotorning massa taqsimoti tekshiriladi va zarur hollarda belgilangan joyga tuzatish massasi qo‘shiladi yoki texnik jihatdan ruxsat etilgan usulda massa olib tashlanadi. ISO 21940-11:2016 qattiq rotorlarni muvozanatlash tartiblari va qoldiq nomuvozanatlik talablarini belgilaydi [2;3].

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Muvozanatlash samaradorligini baholash uchun quyidagi ifodadan foydalanish mumkin:

$$\eta = ((A_1 - A_2) / A_1) \times 100\%.$$

Bu yerda,

A_1 - muvozanatlashdan oldingi,

A_2 - keyingi tebranish amplitudasi;

η - amplituda kamayishining foizi.

2025-yilda e'lon qilingan ochiq ilmiy maqolada kuch turbinasi rotori muvozanatlangandan so'ng birinchi kritik tezlikdagi tebranish amplitudasi 46,27 foizga, ikkinchi kritik tezlikdagi amplituda esa 61,00 foizga kamaygani qayd etilgan [4]. Bu raqamlar aynan o'sha kuch turbinasi rotori tajribasiga tegishli va sentrifugalar uchun universal ko'rsatkich hisoblanmaydi.

Ilmiy maqolada keltirilgan rotorni muvozanatlash natijalari

3-jadval.

Ko'rsatkich	Muvozanatlashdan oldin	Muvozanatlashdan keyin	Kamayish
Birinchi kritik tezlikdagi amplituda	$2{,}548 \times 10^{-4}$ m	$1{,}369 \times 10^{-4}$ m	46,27%
Ikkinchi kritik tezlikdagi amplituda	$7{,}921 \times 10^{-4}$ m	$3{,}089 \times 10^{-4}$ m	61,00%

Manba: *"Effects of Unbalance Identification Locations on Transient Dynamic Balancing Without Trial Weights Performance of Power Turbine Rotor", 2025. Ma'lumotlar kuch turbinasi rotori tajribasiga tegishli.*

Natijalar rotorning turli kritik tezliklarida muvozanatlash samarasi bir xil bo'lmasligini ko'rsatadi. Sentrifuga uchun real samaradorlikni aniqlash maqsadida muvozanatlashdan oldin va keyin vibratsiya o'lchovlarini bir xil sharoitlarda o'tkazish zarur.

Sentrifuga rotorining ishonchli ishlashi uchun muvozanatlash bilan birga texnik holatni muntazam kuzatish ham zarur. Buning uchun vibratsiya o'lchagichlar, akselerometrlar, harorat datchiklari va zarur hollarda aylanish tezligi datchiklaridan

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foydalanish mumkin. O‘lchovlarni bir xil nuqtalarda, o‘xshash yuklama va tezlik sharoitida bajarish ma’lumotlarning taqqoslanuvchanligini oshiradi.

Sentrifuga uchun tavsiya etiladigan texnik kuzatuv rejasi

4-jadval.

Nazorat obyekti	Tekshiruv mazmuni	Davriylik tamoyili
Rotorning tashqi holati	Yoriqlar, korroziya, material yig‘ilishi va shikastlanish	Rejalashtirilgan to‘xtashlarda va zaruratga ko‘ra
Vibratsiya darajasi	Bir xil nuqtalarda tebranish kattaligini o‘lchash	Uskuna xavfi va ishlab chiqaruvchi ko‘rsatmasiga muvofiq
Podshipniklar	Harorat, shovqin va vibratsiyadagi o‘zgarishlar	Belgilangan monitoring jadvali asosida
Val va mufta	Markazlashuv va mexanik holat	Montajdan keyin va ta’mirlashdan so‘ng
Rotor muvozanati	Qoldiq nomuvozanatlik va tebranishning tezlikka bog‘liqligi	Ta’mirlash, almashtirish yoki vibratsiya ortganda
Mahkamlash elementlari	Bo‘shashish va tayanchlar holati	Xavfsiz to‘xtatishdan keyin, xizmat reglamenti asosida

Manba: *muallif tomonidan ishlab chiqilgan tavsiya. Davriylik uskuna pasporti, ishlab chiqaruvchi ko‘rsatmasi va korxonaning texnik xizmat reglamenti bilan belgilanadi.*

Vibratsiya qiymatining mutlaq miqdori bilan birga uning vaqt davomida o‘zgarishini ham tahlil qilish muhimdir. Bir xil ish rejimida tebranish qiymatlari muntazam oshib borsa, bu rotor nomuvozanatligi kuchayayotgani yoki boshqa mexanik nosozlik yuzaga kelayotganini ko‘rsatishi mumkin. Universal vibratsiya chegarasini barcha sentrifugalarga qo‘llash to‘g‘ri emas; ruxsat etiladigan ko‘rsatkichlar uskuna turi, quvvati, aylanish tezligi va tayanch konstruksiyasiga qarab tanlanadi.

Korxonalarda vibratsiya natijalarini elektron jurnal yoki texnik xizmat boshqaruv tizimida saqlash maqsadga muvofiq. Har bir o‘lchov sanasi, ish tezligi, yuklama holati, o‘lchash nuqtasi va aniqlangan nosozlik qayd etiladi. Bu ma’lumotlar tebranish dinamikasini baholash va ta’mirlash ishlarini oldindan rejalashtirishga yordam beradi.

Muhokama.

Tahlillar sentrifuga rotorining nomuvozanatligi mexanik tebranishlar yuzaga kelishining muhim sabablaridan biri ekanini ko‘rsatadi. Biroq ishonchlilikni oshirish

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uchun muammoni faqat rotor massasini muvozanatlash bilan cheklash yetarli emas. Rotor, val, podshipniklar, mufta, tayanch konstruksiyasi va elektr yuritma o‘zaro bog‘langan tizimni tashkil etadi. Tizimning bir qismidagi nosozlik boshqa qismlarda ham tebranish va yuklamalarning ortishiga olib kelishi mumkin.

Hisob-kitob nomuvozanatlik kuchining aylanish tezligi kvadratiga bog‘liqligini ko‘rsatdi. Shu sababli yuqori tezlikda ishlaydigan sentrifugalarda kichik nomuvozanatlik ham sezilarli dinamik kuch hosil qilishi mumkin. Rotorni to‘g‘ri yig‘ish, yuzasini toza saqlash, ta’mirlashdan keyin muvozanatini tekshirish va belgilangan ish tezligiga rioya qilish muhim.

E’lon qilingan tajribada tebranish amplitudasining 46,27–61,00 foizga kamayishi qayd etilgan bo‘lsa-da, ushbu ko‘rsatkichlar faqat muayyan kuch turbinasi rotori tajribasiga tegishli. Ularni barcha sentrifugalarga tatbiq etish ilmiy jihatdan asoslanmagan. Sentrifuga uchun real samaradorlikni aniqlash uchun o‘lchovlar bir xil tezlik va yuklama sharoitlarida bajarilishi lozim.

Agar vibratsiyaning asosiy sababi podshipnikning shikastlanishi, valning egilishi yoki tayanchning bo‘shashishi bo‘lsa, faqat rotorni muvozanatlash kutilgan natijani bermaydi. Shu sababli vibratsiya spektri, harorat, shovqin, aylanish tezligi va mexanik birikmalar holatini birgalikda baholash tavsiya etiladi.

Holatga asoslangan texnik xizmat ko‘rsatishda ta’mirlash zarurati faqat belgilangan vaqt oralig‘iga qarab emas, balki real texnik holat va diagnostika natijalari asosida baholanadi. Bu kutilmagan to‘xtashlar xavfini kamaytirish, ehtiyot qismlardan oqilona foydalanish va xarajatlarni rejalashtirishga yordam berishi mumkin.

Xulosa va takliflar.

Xulosa qilib aytganda, sentrifuga rotorining nomuvozanatligini kamaytirish va vibratsiyani muntazam nazorat qilish uskunaning ishlash ishonchliligini oshirishga xizmat qiladi. Yuqoridagilardan kelib chiqib, rotorni texnik talablar asosida statik yoki dinamik muvozanatlash, vibratsiya va podshipnik haroratini muntazam o‘lchash, texnik kuzatuv jadvalini joriy etish hamda ta’mirlashdan so‘ng rotor muvozanatini qayta tekshirish taklif etiladi. Shuningdek, diagnostika natijalarini tizimli qayd etish va

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profilaktik texnik xizmatni uskuna holatiga mos tashkil etish tavsiya qilinadi. Ushbu chora-tadbirlar nosozliklarni erta aniqlash, mexanik qismlarning yeyilishini kamaytirish va sentrifuganing barqaror ishlashini ta'minlash imkonini beradi.

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VIDEOKUZATUV ASOSIDA TRANSPORT VOSITALARINI ANIQLASH VA TRANSPORT OQIMINI MONITORING QILISHNING ZAMONAVIY DASTURIY VOSITALARI TAHLILI

Umirzaqova Tursunoy Akramjon qizi
Andijon davlat texnika instituti
E-mail: umirzaqovatursunoy65@gmail.com
Telefon: +998911600212

Annotatsiya.

Ushbu maqolada videokuzatuv asosida transport vositalarini aniqlash va transport oqimini monitoring qilishda qo‘llaniladigan zamonaviy dasturiy vositalar hamda kompyuterli ko‘rish texnologiyalari tahlil qilinadi. Intellektual transport tizimlarida avtomobillarni aniqlash, tasniflash, ketma-ket kadrlarda kuzatish va transport oqimi ko‘rsatkichlarini hisoblashning o‘rni yoritiladi. YOLO turkumidagi obyekt aniqlash modellari, OpenCV kutubxonasi va obyektlarni kuzatish algoritmlarining vazifalari ko‘rib chiqiladi. Tahlil xalqaro texnik hujjatlar va O‘zbekistonda chop etilgan ilmiy maqolalarga asoslanadi. Mavjud yondashuvlarning afzalliklari, cheklovlari hamda amaliy qo‘llash shartlari taqqoslanadi. Natijalar sifat jihatidan umumlashtirilib, transport monitoringi tizimini loyihalashda modul arxitekturasi, video kalibrlash, obyektlarni takroran sanashning oldini olish va algoritmni haqiqiy ma’lumotlar bilan tekshirish muhimligi asoslanadi. Maqola yangi tajriba natijalarini da’vo qilmaydi; u mavjud manbalar va dasturiy vositalarning tahliliy sharhi hisoblanadi.

Kalit so‘zlar: intellektual transport tizimi, kompyuterli ko‘rish, videokuzatuv, transport vositalarini aniqlash, YOLO, OpenCV, obyektlarni kuzatish, transport oqimi, sun’iy intellekt.

Аннотация.

В статье анализируются современные программные средства и технологии компьютерного зрения, применяемые для обнаружения транспортных средств и

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мониторинга транспортного потока по видеонаблюдению. Рассматриваются задачи обнаружения, классификации и сопровождения автомобилей в последовательности кадров, а также расчёта показателей транспортного потока. Описываются функции моделей семейства YOLO, библиотеки OpenCV и алгоритмов сопровождения объектов. Анализ основан на технической документации и научных публикациях, в том числе опубликованных в Узбекистане. Сопоставляются преимущества, ограничения и условия практического применения рассматриваемых подходов. В результате качественного анализа обосновывается важность модульной архитектуры, калибровки видеокамеры, предотвращения повторного подсчёта объектов и проверки алгоритмов на реальных данных. Работа представляет собой аналитический обзор существующих решений и не заявляет о получении новых экспериментальных результатов.

Ключевые слова: интеллектуальная транспортная система, компьютерное зрение, видеонаблюдение, обнаружение транспортных средств, YOLO, OpenCV, сопровождение объектов, транспортный поток, искусственный интеллект.

Abstract.

This article reviews modern software tools and computer vision technologies used to detect vehicles and monitor traffic flow from video surveillance. It discusses vehicle detection, classification, multi-frame tracking, and the calculation of traffic-flow indicators. The roles of YOLO-family object detectors, the OpenCV library, and object-tracking algorithms are outlined. The review draws on technical documentation and scientific publications, including studies published in Uzbekistan. The strengths, limitations, and practical requirements of the approaches are compared qualitatively. The analysis highlights the importance of modular system design, camera calibration, avoiding duplicate vehicle counts, and validating algorithms against real observations. The paper is a review of existing methods and software tools; it does not claim new experimental results.

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Keywords: intelligent transportation system, computer vision, video surveillance, vehicle detection, YOLO, OpenCV, object tracking, traffic flow, artificial intelligence.

Kirish.

Shahar transport tizimlarida avtomobillar sonining ko‘payishi, yo‘l infratuzilmasiga tushayotgan yuklama va harakat jadalligining o‘zgarishi transport oqimini uzluksiz kuzatish zaruratini kuchaytirmoqda. Transport oqimi haqidagi ma’lumotlar tirbandlikni baholash, chorrahalar ishini rejalashtirish, yo‘l harakati xavfsizligini oshirish va transport xizmatlarini tashkil etishda muhim axborot manbai hisoblanadi. Shu sababli kuzatuv jarayonini qo‘lda bajarish o‘rniga videotasvirlardan avtomatik ma’lumot olish usullariga qiziqish ortmoqda. Intellektual transport tizimlari (ITT) sensorlar, telekommunikatsiya, dasturiy ta’minot va ma’lumotlarni tahlil qilish vositalarini birlashtiradi. O‘zbek tilidagi ilmiy manbalarda ham intellektual transport tizimlarining vazifalari, avtomobil raqamlarini aniqlash, harakat xavfsizligi va transport oqimini boshqarishdagi o‘rni yoritilgan[1; 2]. Xususan, Abdurazakova, Xoliqova va Abdurahmonova transport sohasidagi zamonaviy intellektual tizimlar hamda “Avto-Intellekt” yechimining funksiyalarini muhokama qilgan [1]. Mirzabekov va Kurbonova esa aqlli shaharlar uchun integratsiyalashgan transport tizimlarining ahamiyatini ko‘rib chiqqan [2].

Kompyuterli ko‘rish videokadrlar ichidan transport vositalarining joylashuvi, sinfi va harakatiga oid belgilarni ajratib olish imkonini beradi. Bunda obyektlarni aniqlash modeli har bir kadrda transport vositalarini belgilaydi, kuzatish algoritmi esa bir avtomobilni ketma-ket kadrlarda bog‘laydi. Ushbu ikki bosqichni birgalikda qo‘llash avtomobillarni sanash va harakat trayektoriyalarini tahlil qilish uchun asos yaratadi. YOLO (You Only Look Once) yondashuvi obyektlarni aniqlashni yagona model orqali bajarishga qaratilgan [3]. OpenCV esa videoni o‘qish, kadrlarni qayta ishlash, tasvirga belgi chizish va natijalarni saqlash kabi operatsiyalarni bajaradi [4]. Mazkur vositalar birgalikda qo‘llanganda video manbasidan yakuniy statistik ko‘rsatkichgacha bo‘lgan jarayonni dasturiy jihatdan tashkil etish mumkin. Shu bilan birga, model tanlashning

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o‘zi yetarli emas. Transport vositalari bir-birini to‘sib qolishi, tungi yoritilish, yomg‘ir, kamera perspektivasi, tasvirning past aniqligi va apparat resurslarining cheklanganligi natijaga ta’sir ko‘rsatadi. Bundan tashqari, tasvirdagi piksellarni haqiqiy masofaga aylantirish uchun kalibrlash talab etiladi. Demak, dasturiy vositalarni tahlil qilishda ularning funksiyalari bilan birga cheklovlarini ham hisobga olish zarur.

Maqolaning maqsadi - videokuzatuv asosida transport vositalarini aniqlash va transport oqimini monitoring qilish uchun qo‘llaniladigan zamonaviy dasturiy vositalarni ilmiy manbalar asosida tahlil qilish, ularning funksional farqlarini ko‘rsatish va tizimni loyihalash bo‘yicha amaliy tavsiyalar ishlab chiqishdir. Maqsadga erishish uchun quyidagi vazifalar belgilandi: kompyuterli ko‘rishning transport monitoringidagi o‘rnini yoritish; YOLO va OpenCV funksiyalarini tavsiflash; kuzatish algoritmlarining zaruratini tushuntirish; transport ko‘rsatkichlarini hisoblash yondashuvlarini izohlash; mavjud mahalliy va xalqaro manbalarni qiyosiy muhokama qilish.

Tadqiqot metodologiyasi.

Maqola tahliliy sharh usulida tayyorlandi. Asosiy materiallar sifatida kompyuterli ko‘rish va intellektual transport tizimlariga bag‘ishlangan ilmiy nashrlar, O‘zbekistonda chop etilgan maqolalar hamda dasturiy vositalarning texnik hujjatlari tanlandi. Manbalar transport vositalarini aniqlash, kuzatish, transport oqimini hisoblash va real tizimga integratsiya qilish bilan bog‘liq mazmuniga qarab ko‘rib chiqildi. Tahlilda uchta yondashuv qo‘llanildi: (1) funksional tahlil — har bir vosita qaysi vazifani bajarishini aniqlash; (2) qiyosiy tahlil — vositalarning afzalliklari va cheklovlarini taqqoslash; (3) tizimli tahlil — aniqlash, kuzatish va statistik hisoblash bosqichlari o‘rtasidagi bog‘liqlikni ko‘rsatish. Maqolada mustaqil laboratoriya tajribasi o‘tkazilgani yoki muayyan model uchun yangi aniqlik ko‘rsatkichi olingani da’vo qilinmaydi.

YOLO turkumidagi obyektlarni aniqlash modellari. YOLO obyektlarni aniqlashga mo‘ljallangan chuqur o‘rganish modellarining turkumidir. Model tasvirga kiruvchi ma’lumot asosida obyekt sinfi, chegaralovchi quti va ishonchlilik bahosini hosil qiladi. Transport monitoringida bu natijalar avtomobil, avtobus, yuk mashinasi

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yoki mototsikl kabi obyektlarni ajratish uchun ishlatilishi mumkin. YOLOning dastlabki ilmiy ishida obyektlarni aniqlash yagona neyron tarmoq orqali amalga oshirilishi taklif qilingan [3]. Keyingi avlod modellarida arxitektura, o‘qitish usullari va ishlash samaradorligi takomillashtirilgan. YOLOv8 amaliy tizimlarda foydalanish mumkin bo‘lgan modellardan biridir. Ultralytics hujjatlari modelni rasm, video va kamera oqimiga qo‘llash bo‘yicha ko‘rsatmalar beradi [5]. Biroq modelning tezligi va aniqligi apparat, model hajmi, kadr o‘lchami va sahna murakkabligiga bog‘liq. Shuning uchun modelni tanlashda faqat reklama yoki umumiy benchmark ko‘rsatkichlariga emas, balki mo‘ljallangan kamera va transport sharoitiga mosligiga qarash kerak.

OpenCV va videoni qayta ishlash. OpenCV — tasvir va videoni qayta ishlash uchun keng qo‘llaniladigan ochiq kodli kutubxona [4]. Transport monitoringi tizimida u videofayl yoki kameradan kadrlarni olish, tasvir o‘lchamini moslashtirish, rang fazosini o‘zgartirish, kuzatuv hududini belgilash, aniqlangan obyektlarni chizish va natijani faylga yozish kabi vazifalarni bajarishi mumkin. OpenCVning o‘zi barcha transport vositalarini zamonaviy chuqur o‘rganish modeli kabi avtomatik aniqlaydigan yagona yechim emas. Amaliy arxitekturada OpenCV video oqimini boshqaruvchi va natijalarni tasvirlovchi qatlam vazifasini bajarishi, YOLO esa obyekt aniqlash modulini ta’minlashi mumkin. Bunday ajratish dastur kodini tushunarli qilish va modullarni alohida almashtirish imkonini beradi.

Obyektlarni kuzatish va transport vositalarini sanash. Har bir videokadrni mustaqil tahlil qilish avtomobillar sonini ortiqcha hisoblashga olib kelishi mumkin: bir avtomobil ko‘plab ketma-ket kadrlarda qayta aniqlanadi. Ushbu muammoni kamaytirish uchun kuzatish algoritmi qo‘llanadi. U ketma-ket kadrlardagi aniqlash natijalarini o‘zaro moslashtirib, obyektga vaqtinchalik identifikator biriktiradi. Natijada avtomobilning trayektoriyasi va kuzatuv chizig‘idan o‘tish holatini aniqlash mumkin. Kuzatish sifati aniqlash modelining barqarorligiga bog‘liq. Obyektlar bir-birini to‘sishi, kamera ko‘rish burchagining noqulayligi yoki obyektning kadrdan chiqib ketishi identifikator almashishiga sabab bo‘lishi mumkin. Shu sababli avtomatik sanash natijalarini haqiqiy videodagi qo‘lda tekshirilgan sanash bilan taqqoslash tavsiya etiladi.

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Transport oqimi ko‘rsatkichlari. Transport oqimini monitoring qilishda transport vositalari soni, oqim jadalligi, zichlik va tezlik kabi ko‘rsatkichlar ishlatilishi mumkin. Ushbu ko‘rsatkichlarning ma’nosi bir-biridan farq qiladi va ularni o‘zaro almashtirib talqin qilish mumkin emas. Oqim jadalligi kuzatuv chizig‘idan vaqt birligida o‘tgan transport vositalari soni bilan ifodalanadi:

$$Q = N / T$$

Bu yerda Q — oqim jadalligi (avtomobil/soat), N — kuzatuv davrida chiziqdan o‘tgan transport vositalari soni, T — kuzatuv vaqti (soat). Yo‘lning muayyan uzunlikdagi qismida bir vaqtda mavjud bo‘lgan transport vositalari soniga asoslangan zichlik quyidagicha ifodalanadi:

$$K = N / L$$

Bu yerda K — zichlik (avtomobil/km), N — kuzatuv hududidagi transport vositalari soni, L — yo‘l bo‘ylab kuzatilayotgan qism uzunligi (km). Zichlikni hisoblash uchun hududning haqiqiy o‘lchami ma’lum bo‘lishi lozim. Faqat piksellarda belgilangan hududdan haqiqiy avtomobil/km qiymatini olish uchun kalibrlash zarur. Tezlikni hisoblashda obyektning vaqt bo‘yicha siljishi, kadrlar oralig‘i va tasvirdan haqiqiy koordinatalarga o‘tish bog‘lanishi aniqlanishi kerak. Kamera kalibrlanmagan holatda piksel/sekund ko‘rsatkichi haqiqiy km/soat bilan teng emas. Shu sababli amaliy tizimda kalibrlash alohida bosqich sifatida ko‘riladi.

Natijalar.

Manbalar va dasturiy hujjatlarning tahlili transport monitoringi jarayonini alohida vazifalarga ajratish maqsadga muvofiqligini ko‘rsatadi: videoni qabul qilish va tayyorlash, transport vositalarini aniqlash, obyektlarni kuzatish, oqim ko‘rsatkichlarini hisoblash va natijalarni chiqarish. Bu natija maqolada ko‘rib chiqilgan vositalarning funksional vazifalarini taqqoslash orqali shakllantirildi; u yangi tajriba o‘lchovi emas. YOLO turkumidagi modellar aniqlash bosqichini, OpenCV video oqimi va tasvirlar bilan ishlashni, obyektlarni kuzatish algoritmlari esa vaqt bo‘yicha identifikatsiyani ta’minlaydi. Ushbu vazifalarni bitta dasturiy tizimda birlashtirish mumkin, lekin

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modullarni ajratish diagnostika, sinov va keyinchalik boshqa modelga o‘tishni yengillashtiradi.

Transport monitoringida qo‘llaniladigan dasturiy vositalarning funksional taqqoslanishi

1-jadval.

Vosita	Asosiy vazifa	Kuchli tomoni	Cheklovi
YOLOv8	Transport vositalarini aniqlash	Video kadrlarida obyektlarni avtomatik belgilash	Sifat model va sahna sharoitiga bog‘liq
OpenCV	Video/kadrlarni qayta ishlash	Kamera va videofayl bilan ishlash, natijani chizish	O‘zi mustaqil chuqur aniqlash modeli emas
Kuzatish algoritmi	Obyektlarni kadrlarda bog‘lash	Takroriy sanashni kamaytirish, trayektoriya olish	To‘silishlarda identifikator yo‘qolishi mumkin
Python	Modullarni birlashtirish	Kutubxonalar ekotizimi va tez prototiplash	Ishlash samaradorligi kod va apparatga bog‘liq

1-jadvaldan ko‘rinadiki, har bir vosita alohida vazifani bajaradi. Shuning uchun transport monitoringi tizimini faqat bitta kutubxonaga asoslashdan ko‘ra, vazifalar bo‘yicha modullarga ajratilgan arxitektura maqsadga muvofiq. Jadvaldagi tavsiflar sifat jihatidan tuzilgan bo‘lib, ular bir xil sharoitda o‘tkazilgan benchmark natijalarini anglatmaydi.

Tahlil natijasida aniqlangan asosiy talablar. Birinchi talab — aniqlash natijasini vaqt bo‘yicha barqaror kuzatish bilan to‘ldirish. Faqat kadrlar bo‘yicha aniqlash avtomobillar sonini to‘g‘ri hisoblash uchun yetarli bo‘lmasligi mumkin. Ikkinchi talab

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— kuzatuv hududini aniq belgilash va sanash chizig‘idan foydalanish. Uchinchi talab — zichlik va tezlik kabi fizik ko‘rsatkichlarni olishda kamera geometriyasini kalibrlash. To‘rtinchi talab — natijalarni qo‘lda tekshirilgan etalon bilan taqqoslash. Shuningdek, tizimni baholashda aniqlash aniqligi, to‘liqlik, F1 ko‘rsatkichi, hisoblash xatosi va bir soniyada qayta ishlanadigan kadrlar soni kabi mezonlardan foydalanish mumkin. Ushbu mezonlar keyingi amaliy tajriba uchun tavsiya qilinadi; mazkur maqolada ular bo‘yicha yangi o‘lchovlar keltirilmagan.

Muhokama.

Tahlil qilingan yondashuvlar videokuzatuvga asoslangan transport monitoringi uchun aniqlash, kuzatish va video qayta ishlash vazifalarini birgalikda ko‘rish zarurligini ko‘rsatadi. YOLO turkumidagi modellar transport vositalarini aniqlashni avtomatlashtirishga xizmat qiladi, OpenCV esa video bilan ishlash va natijalarni ko‘rsatish uchun amaliy vositalarni taqdim etadi [3–5]. Ushbu komponentlar o‘zaro to‘g‘ri integratsiya qilinsa, transport vositalari soni va harakatiga oid statistikani shakllantirish mumkin. O‘zbekistonda chop etilgan ishlar ham intellektual transport tizimlari, raqamli monitoring va transport tirbandligini aniqlash masalalariga qiziqish borligini ko‘rsatadi. Abdurazakova va hammualliflar transport sohasidagi intellektual tizimlar va avtomobil raqamlarini aniqlash yechimlarini ko‘rib chiqadi [1]. Oybek, Jamoliddin va Jaloliddin muallifligidagi 2026-yilgi maqolada videoma’lumotlar asosida tirbandlikni aniqlash, transport vositalarini kuzatish va tezlik hamda zichlik ko‘rsatkichlarini qo‘llash masalalari bayon etilgan [6]. Ushbu ishlar mahalliy ilmiy muhitda ham video tahlil va transport monitoringi dolzarb yo‘nalish ekanini ko‘rsatadi.

Mahalliy va xalqaro yondashuvlarni solishtirganda, dasturiy vositalarni tanlash bilan bir qatorda ularni qanday ma’lumotda sinash masalasi ham muhim. Turli shaharlarda kamera balandligi, yo‘l kengligi, transport vositalari tarkibi, yorug‘lik va ob-havo farq qilishi mumkin. Bir sharoitda yaxshi ishlagan model boshqa sharoitda xatolarga yo‘l qo‘yishi ehtimoli mavjud. Shu sababli ilmiy maqolalarda boshqa tadqiqotlardan olingan aniqlik qiymatlarini o‘z tizimi natijasi sifatida ko‘rsatish mumkin emas; har bir qiymatning manbasi va sinov sharoiti ko‘rsatilishi kerak. Transport oqimi

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zichligi va oqim jadalligini ham farqlash lozim. Jadallik muayyan vaqt oralig‘ida kuzatuv chizig‘idan o‘tgan transport vositalari sonini ifodalaydi. Zichlik esa yo‘lning ma’lum uzunligida bir vaqtda mavjud transport vositalari soniga bog‘liq. Videodan bu ko‘rsatkichlarni olish uchun kuzatuv hududining geometrik xususiyatlari va vaqt oralig‘i to‘g‘ri belgilanishi kerak. Faqat videodagi avtomobillar soni asosida tirbandlik darajasini mutlaq ishonch bilan xulosa qilish yetarli emas.

Amaliy joriy etishda maxfiylik va axborot xavfsizligi ham e’tiborga olinishi kerak. Videoda avtomobil raqamlari yoki odamlar tasviri ko‘rinishi mumkin. Agar tizimga bunday ma’lumotlar kerak bo‘lmasa, ularni saqlamaslik yoki anonimlashtirish, videolarga kirishni cheklash va saqlash muddatini belgilash maqsadga muvofiq. Bu masalalar algoritmning aniqligidan tashqari, transport monitoringi tizimining mas’uliyatli ishlashiga ham ta’sir ko‘rsatadi.

Mazkur maqolaning cheklovi shundaki, u adabiyotlar va dasturiy vositalarning funksional tahliliga asoslangan. Muallif tomonidan yangi video to‘plami bilan laboratoriya tajribasi o‘tkazilmagan, modellar bir xil apparatda taqqoslanmagan va mustaqil aniqlik ko‘rsatkichlari hisoblanmagan. Shuning uchun xulosalar dasturiy arxitektura va metodlarni tanlashga doir tahliliy tavsiyalar sifatida talqin qilinishi lozim. Keyingi bosqichda YOLOv8 va OpenCV asosida prototip ishlab chiqish, bir nechta videoda sinash va natijalarni qo‘lda belgilangan etalon bilan solishtirish ilmiy qiymatni oshiradi.

Xulosa.

Maqolada videokuzatuv asosida transport vositalarini aniqlash va transport oqimini monitoring qilishda qo‘llaniladigan zamonaviy dasturiy vositalar tahlil qilindi. Tahlil natijasida YOLO turkumidagi modellar, OpenCV kutubxonasi va obyektlarni kuzatish algoritmlari transport monitoringi tizimining turli, ammo o‘zaro bog‘liq vazifalarini bajarishi aniqlandi. YOLO modeli transport vositalarini aniqlash, OpenCV videoni qayta ishlash va natijalarni vizual ko‘rsatish, kuzatish algoritmlari esa obyektlarni ketma-ket kadrlarda bog‘lash uchun qo‘llanilishi mumkin. Ularni modul ko‘rinishida birlashtirish tizimni ishlab chiqish va keyinchalik takomillashtirishni yengillashtiradi.

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Transport oqimini ishonchli monitoring qilish uchun kamera kalibrlashi, kuzatuv hududini belgilash, avtomobillarni takroriy sanashning oldini olish va natijalarni haqiqiy kuzatuv bilan tekshirish zarur. Kelgusidagi amaliy ishda aniqlash aniqligi, hisoblash xatosi, ishlash tezligi va turli yorug‘lik sharoitlaridagi barqarorlikni baholash tavsiya etiladi. Ushbu maqola mavjud texnologiyalarni tanlash va intellektual transport monitoringi prototipini loyihalash uchun nazariy asos bo‘lib xizmat qilishi mumkin.

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IoT TEXNOLOGIYALARI ASOSIDA AQLLI SHAHAR TIZIMLARINI YARATISH: ARXITEKTURA, INTEGRATSIYA VA SAMARADORLIK MEZONLARI

Umirzaqova Tursunoy Akramjon qizi
Andijon davlat texnika instituti
E-mail: umirzaqovatursunoy65@gmail.com
Telefon: +998911600212

Annotatsiya.

Ushbu maqolada Internet of Things (IoT) texnologiyalari asosida aqlli shahar tizimlarini yaratishning konseptual va amaliy jihatlari tahlil qilinadi. Shahar infratuzilmasida sensorlar, aloqa tarmoqlari, chekka hisoblash, ma'lumotlar platformalari va tahliliy xizmatlarni yagona arxitekturaga birlashtirish yondashuvi taklif etiladi. Transport, ko'cha yoritilishi, suv va energiya iste'moli, chiqindilarni boshqarish hamda ekologik monitoring misolida IoT yechimlarining qo'llanishi ko'rib chiqiladi. Tadqiqot usuli sifatida standartlar va ilmiy manbalarni tahlil qilish, tizim arxitekturasini qatlamlarga ajratish hamda samaradorlik ko'rsatkichlarini formulalar orqali ifodalashdan foydalanildi. Maqolada amaliy tajriba natijalari sifatida ko'rsatilmagan qiymatlar keltirilmaydi; samaradorlikni baholash uchun tavsiya etiladigan mezonlar va sinov rejasi bayon qilinadi. Natijalar shuni ko'rsatadiki, IoT asosidagi aqlli shahar platformasining muvaffaqiyati faqat sensorlar soniga emas, balki o'zaro moslik, kiberxavfsizlik, ma'lumotlar sifati, fuqarolar maxfiyligi va boshqaruv jarayonlarining integratsiyasiga bog'liq [1–4].

Kalit so'zlar: aqlli shahar, IoT, sensor tarmog'i, chekka hisoblash, shahar ma'lumotlar platformasi, interoperabellik, kiberxavfsizlik, GIS.

Аннотация.

В статье рассматриваются концептуальные и практические аспекты создания систем умного города на основе технологий Интернета вещей (IoT). Предлагается

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многоуровневый подход, объединяющий датчики, сети связи, периферийные вычисления, платформу городских данных и аналитические сервисы. Рассмотрены примеры применения IoT в управлении транспортом, уличным освещением, водо- и энергопотреблением, отходами и экологическим мониторингом. В качестве методов использованы анализ научных источников и стандартов, декомпозиция архитектуры и формализация показателей эффективности. Фактические экспериментальные результаты не заявляются; представлены рекомендуемые критерии и план пилотной проверки. Сделан вывод, что эффективность умного города определяется не только количеством подключённых устройств, но и совместимостью систем, качеством данных, кибербезопасностью, защитой частной жизни и интеграцией управленческих процессов [1–4].

Ключевые слова: умный город, Интернет вещей, сенсорная сеть, периферийные вычисления, городская платформа данных, совместимость, кибербезопасность, ГИС.

Abstract.

This article examines conceptual and practical aspects of developing smart-city systems using Internet of Things (IoT) technologies. It proposes a layered architecture integrating sensors, communication networks, edge computing, a city data platform, and analytical services. Applications in traffic management, street lighting, water and energy monitoring, waste collection, and environmental sensing are discussed. The method combines a review of research and standards, architectural decomposition, and formalisation of performance indicators. No unperformed field experiment is presented as completed; instead, evaluation criteria and a pilot-testing plan are proposed. The analysis indicates that smart-city performance depends not merely on the number of connected devices but also on interoperability, data quality, cybersecurity, privacy protection, and integration of municipal processes [1–4].

Keywords: smart city, Internet of Things, sensor network, edge computing, city data platform, interoperability, cybersecurity, GIS.

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Kirish.

Urbanizatsiya, transport oqimining ortishi, resurslardan oqilona foydalanish va ekologik xavfsizlik masalalari shahar boshqaruvida real vaqt ma'lumotlariga bo'lgan ehtiyojni kuchaytirmoqda. An'anaviy boshqaruv tizimlarida turli idoralar ma'lumotlari alohida saqlanishi, o'lchovlar kechikib kelishi va muammolar faqat murojaat yoki rejalashtirilgan tekshiruvdan so'ng aniqlanishi mumkin. IoT ushbu cheklovlarni kamaytirish uchun fizik obyektlardan avtomatik o'lchovlarni yig'ish, uzatish va ulardan amaliy qarorlar chiqarish imkonini beradi [1; 2]. Aqlli shaharni alohida sensorlar yoki mobil ilovalar to'plami sifatida emas, balki transport, kommunal xizmatlar, energetika, ekologiya va jamoat xavfsizligi o'rtasida ma'lumot almashadigan ijtimoiy-texnik tizim sifatida ko'rish zarur. NIST yondashuvi ham standartlarga asoslangan, qayta qo'llanadigan, kengaytiriladigan va ishonchli yechimlar uchun umumiy arxitektura hamda hamkorlikni muhim deb ta'kidlaydi [1; 3].

Maqolaning maqsadi - IoT texnologiyalari asosida aqlli shahar tizimlarini yaratish uchun qatlamli arxitektura, qo'llanish yo'nalishlari, samaradorlik mezonlari va joriy etish bosqichlarini asoslash. Maqsadga erishish uchun quyidagi vazifalar belgilandi: IoT tizimining tarkibiy qismlarini aniqlash; shahar xizmatlari uchun mos aloqa texnologiyalarini taqqoslash; ma'lumotlar integratsiyasi va xavfsizlik talablarini ko'rsatish; samaradorlikni o'lchash formulalarini ishlab chiqish; bosqichma-bosqich pilot joriy etish modelini taklif qilish. Tadqiqotning amaliy ahamiyati shundaki, taklif etilayotgan yondashuv mahalliy hokimliklar, kommunal korxonalar va texnologik integratorlar uchun loyiha talablarini shakllantirishga yordam berishi mumkin. Shu bilan birga, har bir shahar uchun infratuzilma holati, byudjet, aloqa qamrovi, huquqiy talablar va fuqarolar ehtiyojlari alohida o'rganilishi lozim.

Metodlar.

Tadqiqot konseptual-tahliliy xarakterga ega. Birinchi bosqichda aqlli shahar, IoT arxitekturasi, ma'lumot almashinuvi va ishonchli kiberfizik tizimlar bo'yicha ilmiy hamda standartlashtirish manbalari tahlil qilindi. Xususan, NISTning aqlli shahar tizimlari bo'yicha materiallari, ISO/IEC 17917:2024 ma'lumot almashish bo'yicha

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yo‘riqnomasi va IoT arxitekturasi standartlari mazmunidan foydalanildi [1–5]. Ikkinchi bosqichda tizim funksional qatlamlarga ajratildi: qurilmalar va sensorlar; aloqa va gateway; chekka hisoblash; ma’lumotlarni saqlash va integratsiya; analitika va xizmatlar; boshqaruv va foydalanuvchi interfeysi. Har bir qatlam uchun kiruvchi ma’lumot, bajariladigan vazifa, chiqish natijasi va xavfsizlik nazorati belgilandi. Uchinchi bosqichda transport, yoritish, suv, energiya, chiqindi va ekologik monitoring kabi foydalanish holatlari bo‘yicha qiyosiy tahlil o‘tkazildi. To‘rtinchi bosqichda samaradorlikni o‘lchash uchun ma’lumot yetkazilish ishonchliligi, hodisaga javob vaqti, energiya tejalishi va umumiy xarajat kabi ko‘rsatkichlar formulalar orqali ifodalandi. Bu formulalar taklif etilgan baholash modeli bo‘lib, maqolada ularning qiymatlari real shahar tajribasida o‘lchangan deb da’vo qilinmaydi. Kelgusi amaliy sinovlarda boshlang‘ich holat (baseline) bilan pilot joriy etilgandan keyingi ko‘rsatkichlarni bir xil vaqt oralig‘i va o‘lchash usuli asosida taqqoslash tavsiya etiladi.

Tahlilning cheklovi: ushbu ish muayyan shahar infratuzilmasida o‘tkazilgan eksperimental tajriba emas. Shuning uchun iqtisodiy samara yoki energiya tejalishi bo‘yicha universal foizlar berilmaydi. Yakuniy natijalar sensor turi, joylashuvi, aloqa sifati, ma’lumotlar hajmi, xizmat ko‘rsatish modeli va mahalliy operatsion jarayonlarga bog‘liq bo‘ladi.

Natijalar.

Taklif etilayotgan IoT arxitekturasi. Tahlil natijasida aqlli shahar uchun qatlamli arxitektura taklif etildi (1-rasm). Qatlamlar orasidagi aloqa standart API, aniq ma’lumotlar sxemasi va yagona identifikatorlar orqali tashkil qilinishi kerak. Bunday tuzilma alohida xizmatlarni bosqichma-bosqich ishga tushirishga, keyinchalik esa ularni umumiy shahar platformasiga birlashtirishga imkon beradi [1; 3; 5].

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1-rasm. IoT asosidagi aqlli shahar tizimining taklif etilayotgan qatlamli arxitekturasi

Qurilmalar qatlamiga havo sifati, shovqin, suv bosimi, elektr energiyasi, transport oqimi, parkovka bandligi va yoritish holatini o‘lchaydigan sensorlar kiradi. Aloqa qatlamida vazifaga qarab Wi-Fi, uyali aloqa, LPWAN yoki simli tarmoqlar tanlanadi. Masalan, kam hajmli va kam quvvatli davriy o‘lchovlar uchun LPWAN mos bo‘lishi mumkin, yuqori tezlikdagi video oqimi esa keng polosali aloqa talab qiladi. Texnologiya tanlovi qamrov, kechikish, quvvat sarfi, qurilma narxi va xizmat ko‘rsatish imkoniyatlari bilan asoslanadi. Chekka hisoblash (edge computing) ma’lumotni sensor yaqinida dastlabki qayta ishlashga yordam beradi. Masalan, yo‘l kesishmasidagi qurilma barcha video kadrlarni markazga yubormasdan, transport zichligi yoki navbat uzunligi kabi agregat ko‘rsatkichlarni uzatishi mumkin. Bu tarmoq yukini kamaytiradi, ayrim holatlarda javob vaqtini qisqartiradi va maxfiylikka oid xatarlarni boshqarishni yengillashtiradi. Biroq chekka qurilmalarning yangilanishi, jismoniy himoyasi va konfiguratsiyasi ham xavfsizlik rejasiga kiritilishi kerak.

Ma’lumotlar platformasi turli manbalardan keladigan oqimlarni qabul qiladi, vaqt tamg‘asi va manba identifikatorini tekshiradi, ma’lumotlarni saqlaydi hamda API orqali tegishli xizmatlarga taqdim etadi. GIS shahar xaritasida hodisalarni ko‘rsatish uchun,

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vaqt qatori bazalari esa sensorlarning ketma-ket o‘lchovlarini saqlash uchun foydali bo‘lishi mumkin. Tizimlararo moslik faqat ma’lumotni texnik uzatish emas; maydonlarning ma’nosi, o‘lchov birliklari, yangilanish tezligi va foydalanish huquqlari ham kelishilgan bo‘lishi kerak [4; 5].

IoT qo‘llanilish yo‘nalishlari. Transportda yo‘l detektorlari, aqlli svetoforlar va parkovka sensorlari oqim zichligi hamda bo‘sh joylar haqida yangilanadigan ma’lumot berishi mumkin. Bunday ma’lumotlar svetofor rejimini moslashtirish, jamoat transporti jadvalini yaxshilash va tirbandlikni aniqlashda qo‘llanadi. Shu bilan birga, kameralar ishlatilsa, shaxsni aniqlashga oid ma’lumotlarni minimallashtirish, saqlash muddatini belgilash va vakolatli kirishni cheklash zarur.

Kommunal xizmatlarda aqlli hisoblagichlar suv yoki elektr sarfini kuzatib, odatiy bo‘lmagan sarf va ehtimoliy sizib chiqishlarni aniqlashga yordam beradi. Ko‘cha yoritish tizimida yorug‘lik darajasi, vaqt va piyodalar harakatiga qarab yoritish ssenariylari qo‘llanishi mumkin. Chiqindi konteynerlaridagi to‘lish sensorlari esa yig‘ish marshrutlarini talabga qarab rejalashtirish imkonini beradi. Bu yechimlarning iqtisodiy samarasi alohida pilot orqali tekshirilishi kerak. Ekologik monitoringda PM2.5/PM10, harorat, namlik, shovqin va boshqa ko‘rsatkichlar bo‘yicha sensor tarmoqlari ishlatilishi mumkin. Bunda arzon sensorlarning kalibrlash, o‘lchov noaniqligi va ob-havo ta’siriga sezgirligi hisobga olinadi. Rasmiy nazorat stansiyalari bilan davriy taqqoslash ma’lumotlarning ishonchliligini oshiradi.

Aqlli shahar xizmatlari uchun IoT yechimlarining qiyosiy tahlili

1-jadval.

Yo‘nalish	Sensor/ma’lumot manbai	Asosiy foyda	Muhim cheklov
Transport	Oqim detektori, kamera, GPS	Tirbandlikni kuzatish va boshqarish	Aloqa kechikishi, maxfiylik
Energiya va yoritish	Aqlli hisoblagich, yorug‘lik sensori	Sarflarni kuzatish, rejimni moslash	Kalibrlash va qurilma xizmatlari

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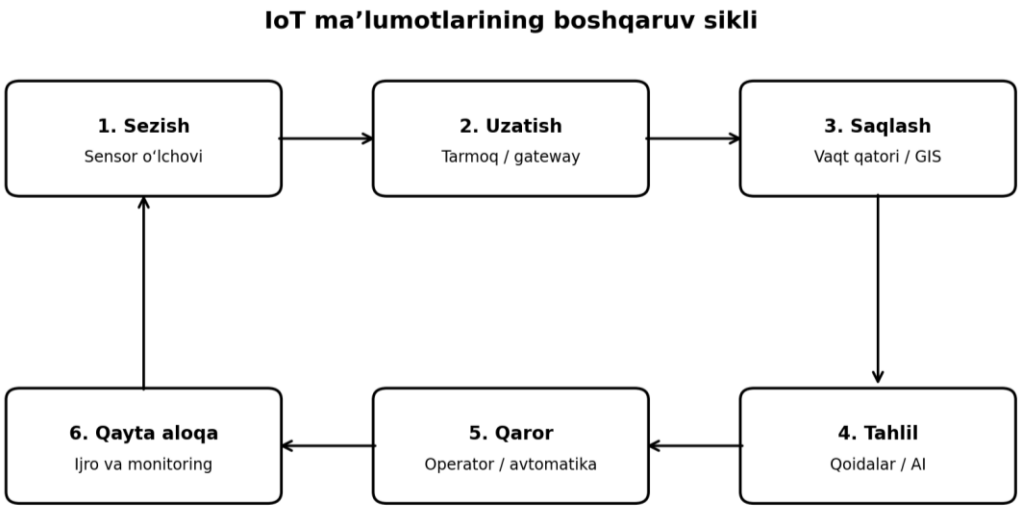
Suv ta’minoti	Oqim, bosim, sizib chiqish sensori	Yo‘qotishlarni erta aniqlash	Tarmoqdagi jismoniy sharoit
Chiqindi	Konteyner to‘lish sensori, GPS	Marshrutni optimallashtirish	Sensor ifloslanishi, batareya
Ekologiya	Havo sifati, shovqin, ob-havo	Hududiy ekologik holatni kuzatish	O‘lchov aniqligi va kalibrlash

Jadvaldagi foydalar kutiladigan funksional imkoniyatlarni ifodalaydi; ular avtomatik ravishda kafolatlangan iqtisodiy natija degani emas. Har bir yo‘nalish bo‘yicha boshlang‘ich holat, operatsion xarajat va xizmat sifati ko‘rsatkichlari aniqlanishi lozim.

Ma’lumotlar oqimi va ishlash mexanizmi. IoT tizimi doimiy sikl asosida ishlaydi: o‘lchash, uzatish, tekshirish, saqlash, tahlil qilish, qaror qabul qilish va natijani kuzatish. 2-rasmda mazkur sikl ko‘rsatilgan. Ma’lumotlar sifatini nazorat qilish uchun noto‘g‘ri diapazon, takroriy paket, vaqt tamg‘asining yo‘qligi va aloqa uzilishlarini aniqlash qoidalari ishlab chiqilishi kerak.



2-rasm. IoT ma’lumotlarining o‘lchashdan boshqaruv qarorigacha bo‘lgan sikli

Tizimning ishonchliligini baholashda yetkazilgan o‘lchovlar ulushi muhim ko‘rsatkich hisoblanadi. Agar rejalashtirilgan o‘lchovlar soni N, muvaffaqiyatli qabul

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qilingan yaroqli o‘lchovlar soni esa N_q bo‘lsa, yetkazilish ishonchliligi quyidagicha aniqlanadi:

$$R = (N_q / N) \times 100\%$$

(1) bu yerda R — yaroqli ma’lumot yetkazilish foizi; N_q — qabul qilingan yaroqli o‘lchovlar; N — rejalashtirilgan o‘lchovlar soni.

Hodisa aniqlangan va unga javob berilgan vaqt oralig‘i xizmatning operativligini ifodalaydi. Bir nechta hodisa uchun o‘rtacha javob vaqti quyidagicha hisoblanishi mumkin:

$$T_{avg} = (1 / m) \times \Sigma(t_j - t_{0j}),\ j = 1 \ldots m$$

(2) bu yerda t_0j — j-hodisa aniqlangan vaqt, t_j — unga javob berilgan vaqt, m — kuzatilgan hodisalar soni.

Resurs tejalishini baholashda joriy etishdan oldingi va keyingi sarf taqqoslanadi. Masalan, bir xil xizmat hajmida boshlang‘ich sarf E_0, IoT joriy etilgandan keyingi sarf E_1 bo‘lsa:

$$S_E = ((E_0 - E_1) / E_0) \times 100\%$$

(3) bu yerda S_E — sarfning nisbiy o‘zgarishi; E_0 va E_1 — taqqoslanadigan davrlardagi energiya yoki boshqa resurs sarfi.

Ushbu formulalarni to‘g‘ri qo‘llash uchun o‘lchov davri, ob-havo, xizmat hajmi va boshqa ta’sir etuvchi omillar imkon qadar tenglashtiriladi. Faqat tizim ishga tushirilganidan keyingi natijani ko‘rish yetarli emas; taqqoslash uchun nazorat hududi yoki avvalgi davr ma’lumotlari talab qilinishi mumkin.

Xavfsizlik, maxfiylik va boshqaruv. Aqlli shahar infratuzilmasi jismoniy obyektlarga ta’sir qilishi mumkinligi sababli, kiberxavfsizlik loyihaning boshidan hisobga olinishi kerak. Qurilmalar uchun noyob identifikatsiya, xavfsiz autentifikatsiya, shifrlangan aloqa, imzolangan dasturiy yangilanishlar, tarmoq segmentatsiyasi, jurnal yuritish va hodisalarga javob berish rejasi tavsiya etiladi [1; 3]. Standart parollarni almashtirish va qo‘llab-quvvatlash muddati tugagan qurilmalarni rejalashtirilgan tarzda yangilash ham muhim. Maxfiylik bo‘yicha ma’lumotni yig‘ishdan oldin uning maqsadi va huquqiy asosini belgilash, faqat zarur ma’lumotni to‘plash, saqlash muddatini

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cheklash va rollar bo‘yicha kirish huquqini taqsimlash kerak. Video yoki geolokatsiya kabi sezgir manbalarda imkon qadar shaxsni aniqlamaydigan agregat natijalardan foydalanish maqsadga muvofiq. Fuqarolar uchun ma’lumot nima maqsadda ishlatilishi va kimga taqdim etilishi tushunarli shaklda e’lon qilinishi kerak.

IoT aqlli shahar tizimi uchun asosiy xavflar va nazorat choralari

2-jadval.

Xavf	Ehtimoliy oqibat	Tavsiya etiladigan nazorat
Qurilmaning buzib kirilishi	Soxta o‘lchov yoki boshqaruv	Autentifikatsiya, yangilash, segmentatsiya
Aloqa uzilishi	Ma’lumot kechikishi yoki yo‘qolishi	Mahalliy bufer, qayta uzatish, monitoring
Noto‘g‘ri sensor o‘lchovi	Noto‘g‘ri qaror	Kalibrlash, diapazon tekshiruvi, etalon bilan solishtirish
Ortiqcha shaxsiy ma’lumot	Maxfiylik buzilishi	Minimallashtirish, anonimlashtirish, saqlash muddatlari
Yopiq ishlab chiqaruvchi ekotizimi	Vendor lock-in va integratsiya qiyinligi	Ochiq API, hujjatlashtirilgan formatlar, standartlar

Samaradorlik ko‘rsatkichlari. Aqlli shahar platformasining samaradorligini faqat o‘rnatilgan qurilmalar soni bilan o‘lchash yetarli emas. Ko‘rsatkichlar texnik ishonchlilik, xizmat sifati, iqtisodiy samaradorlik, ekologik ta’sir va fuqarolar tajribasini qamrab olishi kerak. 3-jadvalda pilot loyiha uchun tavsiya etiladigan mezonlar berilgan.

IoT pilot loyihasini baholash uchun tavsiya etiladigan KPIlar

3-jadval.

Mezon	Hisoblash / o‘lchash	Ma’lumot manbai	Baholash maqsadi

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Ma’lumot yetkazilish ishonchliligi	Yaroqli paketlar / rejalashtirilgan paketlar	Gateway va platforma jurnallari	Aloqa va sensor barqarorligi
Javob vaqti	Hodisa va javob orasidagi vaqt	Hodisa jurnali	Operativlik
Resurs sarfi	Oldingi va keyingi davr sarfi	Hisoblagichlar	Energiya/suv samaradorligi
Xizmat mavjudligi	Ishlagan vaqt / jami vaqt	Monitoring tizimi	Uzluksizlik
Bir hodisa xarajati	Jami operatsion xarajat / hodisalar	Moliyaviy va xizmat ma’lumotlari	Iqtisodiy maqsadga muvofiqlik

Pilotdan oldin KPIlar bo‘yicha boshlang‘ich qiymatlar, ma’lumot egasi, o‘lchash davriyligi va qabul qilinadigan chegaralar kelishib olinishi zarur. Masalan, javob vaqtining pasayishi faqat hodisa aniqlash vaqti, operatorning javob berishi va ijro mexanizmi birgalikda qayd etilganida ishonchli baholanadi.

Muhokama.

Tahlil shuni ko‘rsatadiki, aqlli shahar tizimlarida eng katta tashkiliy muammolardan biri — alohida idoralarda mavjud bo‘lgan axborot tizimlarini yagona ma’lumotlar ekotizimiga birlashtirishdir. Texnik jihatdan ishlaydigan, lekin boshqa platformalar bilan ma’lumot almasha olmaydigan yechimlar uzoq muddatda xarajatni oshirishi va shahar bo‘yicha umumiy tahlilni cheklashi mumkin. Shu sababli tizimni xarid qilish bosqichidayoq API, ma’lumotlar lug‘ati, eksport formati va qurilmalarni almashtirish shartlari belgilanishi lozim [3–5]. Ikkinchi muhim masala — texnologiya tanlovini vazifaga moslashtirish. Har bir sensorni doimiy yuqori tezlikdagi tarmoqqa ulash iqtisodiy jihatdan maqsadga muvofiq bo‘lmasligi mumkin. Davriy o‘lchovlar, real vaqt boshqaruvi va multimedia oqimlari uchun turli aloqa profillari kerak bo‘ladi.

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Uchinchi masala — ishonch va fuqarolar manfaatlari. Sensorlar ko‘payishi o‘z-o‘zidan shahar xizmatlarini yaxshilamaydi. Ma’lumotlar noto‘g‘ri bo‘lsa, mas’ul tashkilotlar ulardan foydalanmasa yoki fuqarolar ma’lumot ishlatilishidan bexabar bo‘lsa, texnologik investitsiyaning foydasi kamayadi. Shuning uchun fuqarolar bilan maslahatlashish, ochiq ko‘rsatkichlar paneli, shikoyat kanallari va mustaqil xavfsizlik tekshiruvlari loyiha boshqaruviga kiritilishi kerak. To‘rtinchi masala — barqaror moliyalashtirish va xizmat ko‘rsatish. Sensor va gateway qurilmalari xaridi bilan cheklanib qolmasdan, batareya almashtirish, kalibrlash, aloqa to‘lovi, dasturiy yangilanish, kiberxavfsizlik va xodimlarni tayyorlash xarajatlari hisobga olinishi zarur.

O‘zbekiston shaharlari uchun amaliy yondashuv kichik, aniq muammoga qaratilgan pilotdan boshlanishi mumkin. Masalan, bir hududdagi ko‘cha yoritilishi yoki suv hisobini raqamlashtirish bo‘yicha natijalar o‘lchanib, texnik va iqtisodiy jihatdan tasdiqlangandan so‘ng boshqa hududlarga kengaytiriladi. Mahalliy iqlim, aloqa infratuzilmasi, qurilmalarni himoyalash sharoiti va amaldagi qonunchilik alohida hisobga olinishi kerak. Bu tavsiya muayyan shahar uchun tayyor loyiha smetasi emas; u dastlabki texnik-iqtisodiy asoslashga yo‘naltiruvchi umumiy modeldir. Kelgusi tadqiqotlarda real shahar hududida kamida bir necha oy davom etadigan pilot sinov o‘tkazish, boshlang‘ich va yakuniy ko‘rsatkichlarni taqqoslash, ma’lumotlar sifati va xavfsizlik hodisalarini qayd etish hamda foydalanuvchilar fikrini o‘rganish maqsadga muvofiq. Shunda taklif etilgan arxitekturaning mahalliy sharoitdagi samaradorligi miqdoriy dalillar bilan tekshiriladi.

Xulosa.

IoT texnologiyalari aqlli shahar xizmatlarida real vaqt ma’lumotlarini yig‘ish, infratuzilma holatini kuzatish va boshqaruv qarorlarini dalillarga asoslash uchun muhim imkoniyat yaratadi. Maqolada sensorlar, aloqa, chekka hisoblash, ma’lumotlar platformasi, analitika va foydalanuvchi xizmatlarini birlashtiruvchi qatlamli arxitektura taklif etildi. Transport, energiya, suv, chiqindi va ekologik monitoring yo‘nalishlari uchun qo‘llanish holatlari hamda asosiy cheklovlar tahlil qilindi. Samarali joriy etishning zarur shartlari quyidagilardan iborat: ochiq standartlar va API orqali

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tizimlararo moslikni ta’minlash; ma’lumotlar sifati va sensor kalibrlashini boshqarish; kiberxavfsizlik va maxfiylikni loyihalashning dastlabki bosqichidan kiritish; o‘lchanadigan KPIlarni oldindan belgilash; pilot natijalarini tekshirgandan keyingina yechimni kengaytirish. Maqola konseptual tahlilga asoslangan bo‘lib, unda real tajriba natijalari da’vo qilinmadi. Keyingi bosqichda taklif etilgan modelni mahalliy shahar sharoitida pilot sinovdan o‘tkazish va texnik-iqtisodiy samarani miqdoriy baholash zarur.

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SUN'IY INTELLEKTDA KOMPYUTERLI KO'RISH: ASOSIY USULLAR, AMALIY QO'LLANILISHI VA RIVOJLANISH ISTIQBOLLARI

Umirzaqova Tursunoy Akramjon qizi
Andijon davlat texnika instituti
E-mail: umirzaqovatursunoy65@gmail.com
Telefon: +9989911600212

Annotatsiya.

Maqolada sun'iy intellekt va kompyuter ko'rishi texnologiyalarining nazariy asoslari, tasvir va videodan ma'lumot olish usullari hamda ularning sanoat, transport, tibbiyot, qishloq xo'jaligi va ta'limdagi qo'llanilishi tahlil qilinadi. Jarayon tasvirni oldindan qayta ishlash, xususiyatlarni ajratish, obyektlarni aniqlash va natijalarni baholash bosqichlari orqali izohlanadi. CNN, R-CNN oilasi va YOLO yondashuvlari qiyosiy ko'rib chiqiladi. Tadqiqot adabiyotlar tahlili va konseptual taqqoslashga asoslangan; yangi tajriba natijalari sifatida talqin qilinmasligi lozim. Aniqlik, tezlik, ma'lumotlar sifati, maxfiylik va algoritmik xolislik mezonlari muhokama qilinadi.

Kalit so'zlar: sun'iy intellekt, kompyuter ko'rishi, chuqur o'rganish, neyron tarmoq, tasvirni qayta ishlash, obyektni aniqlash, CNN, YOLO, OpenCV.

Аннотация.

В статье рассматриваются основы искусственного интеллекта и компьютерного зрения, методы извлечения информации из изображений и видео и применение этих технологий в промышленности, транспорте, медицине, сельском хозяйстве и образовании. Описываются этапы предварительной обработки, выделения признаков, обнаружения объектов и оценки результатов. Сопоставляются CNN, семейство R-CNN и подходы YOLO. Работа основана на анализе литературы, а не на новом эксперименте. Обсуждаются точность, скорость, качество данных, конфиденциальность и алгоритмическая справедливость.

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Ключевые слова: искусственный интеллект, компьютерное зрение, глубокое обучение, нейронная сеть, обработка изображений, обнаружение объектов, CNN, YOLO, OpenCV.

Abstract.

This article reviews the foundations of artificial intelligence and computer vision, methods for extracting information from images and video, and applications in industry, transportation, medicine, agriculture, and education. The pipeline includes preprocessing, feature extraction, object detection, and evaluation. CNNs, the R-CNN family, and YOLO-style approaches are compared conceptually. The paper is based on literature review rather than a newly conducted experiment. Accuracy, speed, data quality, privacy, and algorithmic fairness are discussed.

Keywords: artificial intelligence, computer vision, deep learning, neural network, image processing, object detection, CNN, YOLO, OpenCV.

Kirish.

Sun’iy intellekt (SI) kompyuter tizimlariga ma’lumotlardan qonuniyatlarni o‘rganish, tasniflash, bashorat qilish va muayyan vazifalarni avtomatlashtirish imkonini beradigan usullar majmuasidir. Kompyuter ko‘rishi esa SI ning tasvirlar va videolarni tahlil qilishga ixtisoslashgan yo‘nalishi bo‘lib, raqamli tasvirdagi obyektlar, ularning joylashuvi, shakli, harakati va o‘zaro munosabatlari haqida axborot olishga qaratilgan [1; 2]. Raqamli kameralar, mobil qurilmalar, videokuzatuv tizimlari va sanoat sensorlarining keng tarqalishi vizual ma’lumotlar hajmini oshirdi. Katta hajmdagi tasvirlarni faqat inson yordamida tekshirish ko‘p vaqt talab qiladi, charchoq esa xatolarni ko‘paytirishi mumkin. Kompyuter ko‘rishi katta hajmdagi vizual oqimni avtomatik tahlil qilish, hodisalarni tez aniqlash va natijalarni keyingi axborot tizimlariga uzatish imkonini beradi.

Mavzuning dolzarbligi texnik samaradorlik bilan cheklanmaydi. Vizual algoritmlarning xatosi xavfsizlikka, inson huquqlariga va resurslar taqsimotiga ta’sir qilishi mumkin. Shu sababli model aniqligini baholash, turli sharoitlarda tekshirish,

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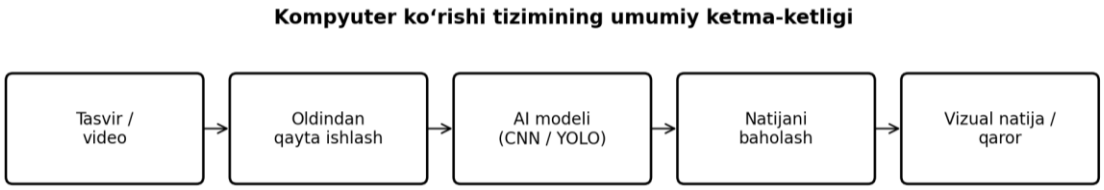
ma’lumotlarni himoyalash va qarorlar ustidan inson nazoratini saqlash muhimdir [6]. Maqolaning maqsadi - sun’iy intellekt va kompyuter ko‘rishining asosiy usullarini tizimli ko‘rib chiqish, amaliy qo‘llanilishini taqqoslash hamda dasturiy yechim tanlash mezonlarini shakllantirish. Vazifalar: kompyuter ko‘rishi jarayonini tavsiflash; algoritmlarni qiyoslash; baholash metrikalarini izohlash; qo‘llashdagi cheklovlarni ko‘rsatish.

Tadqiqot metodologiyasi.

Tadqiqot usuli sifatida ilmiy adabiyotlarni tahlil qilish, tushunchalarni tizimlashtirish va algoritmlarni sifat jihatidan taqqoslash tanlandi. Asosiy manbalar obyektni aniqlash bo‘yicha ilmiy ishlar, chuqur o‘rganish haqidagi fundamental adabiyotlar, OpenCV va Ultralytics hujjatlari, shuningdek, O‘zbekistonda chop etilgan kompyuter ko‘rishiga oid maqolalardan iborat [1–5; 7; 8]. Kompyuter ko‘rishi tizimining tipik ishlash jarayoni 1-rasmda keltirilgan. Dastlab tasvir yoki videodan kadr olinadi. Keyin o‘lchamni moslashtirish, rang formatini o‘zgartirish, shovqinni kamaytirish yoki kontrastni yaxshilash kabi oldindan qayta ishlash amallari bajarilishi mumkin. Tayyorlangan ma’lumot modelga beriladi; model obyekt sinfi, chegaralovchi to‘rtburchak yoki segmentatsiya niqobini qaytaradi.



1-rasm. Kompyuter ko‘rishi tizimining umumiy ishlash ketma-ketligi.

Chuqur o‘rganish usullarida neyron tarmoq ko‘p qatlamli matematik funksiyalar orqali tasvirdagi murakkab xususiyatlarni o‘rganadi. CNN arxitekturasi odatda lokal naqshlarni aniqlash uchun konvolyutsion qatlamlardan, xususiyatlarni ixchamlashtirish bosqichlaridan va yakuniy tasniflash yoki aniqlash qatlamlaridan foydalanadi.

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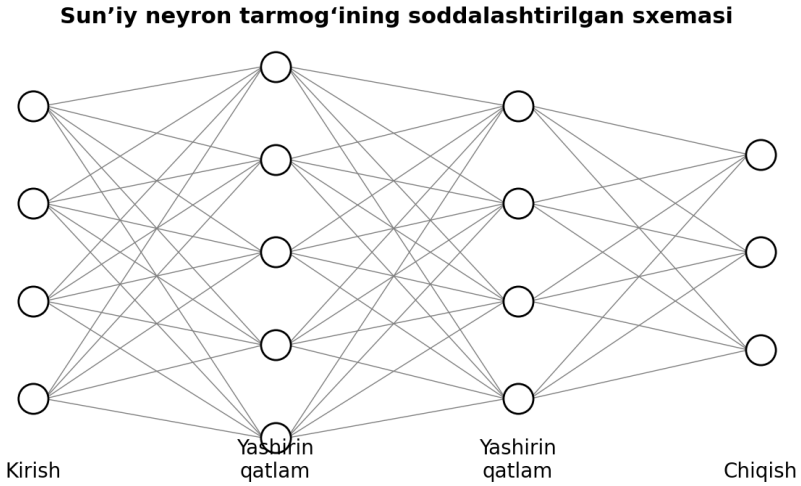

2-rasm. Sun’iy neyron tarmog‘ining soddalashtirilgan sxemasi.

Obyektni aniqlashda model tasvir ichidagi obyektlar sinfi va joylashuvini topadi. R-CNN oilasi hudud takliflari va ularni tasniflashga asoslangan; YOLO esa bir bosqichli aniqlash yondashuvi bo‘lib, real vaqt tizimlarida tezlik talabiga mos kelishi mumkin [2; 3]. Tanlov qurilma resursi, ma’lumotlar turi, kechikish chegarasi va xatolar narxiga bog‘liq. Modelni baholashda aniqlik (precision), to‘liqlik (recall), F1, mAP va ishlov berish tezligi (FPS) kabi metrikalar qo‘llanadi. Precision noto‘g‘ri ijobiy aniqlashlar ulushini, recall esa mavjud obyektlarning qancha qismi topilganini baholashga yordam beradi:

Natijalar.

Adabiyotlar tahlili kompyuter ko‘rishi vazifalari turli natijalarni talab qilishini ko‘rsatadi. Tasniflash butun tasvirga yorliq beradi; obyektni aniqlash obyekt turini va joylashuvini belgilaydi; semantik segmentatsiya har bir pikselni sinfga ajratadi; kuzatish esa obyektlarni ketma-ket kadrlarda bog‘laydi. Shu sababli vazifani to‘g‘ri belgilash model va ma’lumotlar to‘plamini tanlashning birinchi bosqichidir.

Kompyuter ko‘rishidagi asosiy vazifalar va baholash mezonlari

1-jadval.

Vazifa	Natija	Misol	Asosiy mezon
Tasvirni tasniflash	Tasvirga yorliq	Mahsulot turini ajratish	Top-1 aniqlik

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Obyektni aniqlash	Sinf va chegaralovchi quti	Yo‘ldagi avtomobilni topish	mAP, precision, recall
Segmentatsiya	Piksel darajasidagi niqob	Nuqson maydonini ajratish	IoU, Dice
Obyektni kuzatish	ID va trayektoriya	Transport oqimini kuzatish	IDF1, HOTA
OCR	Tasvirdagi matn	Hujjat yoki davlat raqami	Belgilar aniqligi

Dasturiy vositalar taqqoslanganda OpenCV tasvirni o‘qish, o‘zgartirish, filtrlash va videokadrlar bilan ishlash uchun qulay kutubxona hisoblanadi [4]. PyTorch va TensorFlow neyron tarmoqlarini yaratish hamda o‘qitishga mo‘ljallangan platformalardir. Ultralytics ekotizimi YOLO modellarini o‘qitish, baholash va inferensiya qilish uchun amaliy interfeyslar taklif etadi [5].

Kompyuter ko‘rishi uchun dasturiy vositalarning qiyosiy tahlili

2-jadval.

Vosita	**Asosiy vazifasi**	**Kuchli tomoni**	**E’tibor jihati**
OpenCV	Tasvir/video qayta ishlash	Ko‘p funksiyali, ko‘p platformali	O‘zi tayyor aniqlash modeli emas
PyTorch	Model yaratish va o‘qitish	Moslashuvchan tadqiqot muhiti	Dasturlash bilimini talab qiladi
TensorFlow	Model yaratish va joylashtirish	Keng ekotizim	Ish jarayonini sozlash kerak
YOLO / Ultralytics	Obyekt aniqlash	Amaliy inferensiya qulayligi	Tezlik apparatga bog‘liq
Tesseract OCR	Matn va belgilarni tanish	Bosma matn uchun foydali	Sifatsiz tasvirda xato ortadi

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Amaliy tizimni yaratishda ma’lumotlar to‘plami model sifati uchun hal qiluvchi omildir. Tasvirlar maqsadli muhitni ifodalashi, turli yorug‘lik, burchak, masofa, fon va obyekt o‘lchamlarini qamrab olishi kerak. Ma’lumotlarni o‘qitish, validatsiya va test qismlariga ajratish modelning o‘rgangan tasvirlarini yodlab qolish xavfini kamaytiradi. Test to‘plami yakuniy baholashgacha o‘zgarmasligi lozim. Ushbu maqolada aniq foizli aniqlik yoki FPS qiymati berilmagan, chunki bir xil apparat, ma’lumotlar to‘plami va sinov protokoli asosida yangi tajriba o‘tkazilmagan. Natijalar mavjud adabiyotlar va vositalarning funksional imkoniyatlarini tahlil qilishga asoslangan.

Muhokama.

Kompyuter ko‘rishining asosiy afzalligi — vizual axborotni katta hajmda va bir xil mezonlarda tahlil qilishidir. Sanoatda u mahsulot nuqsonlarini aniqlashda, tibbiy tasvirlarda mutaxassisga yordam berishda, qishloq xo‘jaligida o‘simlik holatini kuzatishda, transportda esa avtomobil va piyodalarni aniqlashda qo‘llanishi mumkin. Biroq laboratoriya sharoitidagi ko‘rsatkich real muhitda aynan takrorlanishi kafolatlanmaydi. Ko‘p uchraydigan muammolardan biri — domen siljishi: o‘qitish ma’lumotlari bilan amaliy muhit o‘rtasidagi farq. Masalan, kunduzi olingan tasvirlarda o‘qitilgan model tunda, yomg‘irda yoki kamera burchagi o‘zgarganda sustroq ishlashi mumkin. Shu sababli tizim turli sharoitlarda tekshirilishi, xatolar sinflar bo‘yicha tahlil qilinishi va zarur bo‘lsa ma’lumotlar yangilanishi kerak.

Ikkinchi muammo — hisoblash resurslari. Yuqori aniqlikdagi model katta xotira va kuchli grafik protsessor talab qilishi mumkin. Chekka qurilmalarda ishlash uchun modelni ixchamlashtirish, tasvir o‘lchamini moslashtirish yoki tezlik va aniqlik o‘rtasida muvozanat tanlash mumkin. Faqat FPS ko‘rsatkichiga qarab qaror qilish noto‘g‘ri: muhim obyektlarni o‘tkazib yuborish xavfi ham baholanishi lozim. Uchinchi muammo — maxfiylik va adolat. Kamera tasvirlari shaxsga doir ma’lumotlarni o‘z ichiga olishi mumkin. Ma’lumot yig‘ish maqsadi aniq belgilanishi, ortiqcha saqlashdan qochish, kirishni cheklash va qonunchilikka rioya qilish lozim. Model turli guruhlar yoki muhitlar uchun notekis xato qilsa, bu nohaq qarorlarga olib kelishi mumkin. Shu bois inson nazorati, audit va shaffof hujjatlashtirish muhim [6].

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O‘zbekistonda ham tasvirdan obyektlarni aniqlash va raqamlarni avtomatik ajratish kabi kompyuter ko‘rishiga oid amaliy masalalar o‘rganilmoqda [7; 8]. Mahalliy til, hududiy sharoit va amaliyotga xos tasvirlardan tuzilgan ma’lumotlar to‘plamlari texnologiyalarni milliy ehtiyojlarga moslashtirishga yordam beradi. Natijalarni takrorlash mumkin bo‘lishi uchun algoritm versiyasi, parametrlar, apparat va sinov ma’lumotlari haqida yetarli ma’lumot berish zarur.

Kompyuter ko‘rishi tizimlaridagi muammolar va kamaytirish choralari

3-jadval.

Xavf yoki cheklov	Ehtimoliy ta’sir	Tavsiya
Yorug‘lik va ob-havo o‘zgarishi	Aniqlash sifati pasayadi	Turli sharoitlarda sinash
Nomutanosib ma’lumotlar	Ayrim obyektlar ko‘proq xato aniqlanadi	Sinflar bo‘yicha metrikalar va audit
Kechikish va apparat cheklovi	Real vaqt talabiga javob bermaslik	Modelni optimallashtirish
Maxfiylik xavfi	Shaxsiy ma’lumotlar noo‘rin ishlatilishi	Minimal yig‘ish va kirish nazorati
Tushuntirish qiyinligi	Xato sababini aniqlash qiyin	Inson nazorati va audit

Xulosa.

Tahlil sun’iy intellekt va kompyuter ko‘rishi ko‘plab sohalarda tasvir va videodan avtomatik ma’lumot olish imkonini berishini ko‘rsatadi. Tasniflash, obyektni aniqlash, segmentatsiya, kuzatish va OCR vazifalari turli natijalarni talab qiladi; shu sababli algoritm tanlashdan avval amaliy masala, xatolar narxi va ishlash muhiti aniqlanishi zarur. OpenCV tasvirni qayta ishlash uchun, PyTorch va TensorFlow modellarni ishlab chiqish uchun, YOLO turidagi tizimlar esa obyektlarni tez aniqlash uchun foydali vositalardir. Biroq hech bir vosita barcha vazifalar uchun universal yechim emas. Ishonchli tizim yaratish uchun sifatli ma’lumotlar, alohida test to‘plami, mos baholash metrikalari va real muhitda tekshiruv talab etiladi. Kelgusidagi ishlar sifatida muayyan

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vazifa uchun ma’lumotlar to‘plamini tayyorlash, kamida ikki modelni bir xil sharoitda sinash, precision, recall, F1, mAP va FPS ko‘rsatkichlarini o‘lchash, xatolar va maxfiylik xavflarini baholash tavsiya etiladi.

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SUN'IY INTELLEKT ASOSIDA YO'L HARAKATI XAVFSIZLIGINI MONITORING QILISH

Umirzaqova Tursunoy Akramjon qizi
Andijon davlat texnika instituti
E-mail: umirzaqovatursunoy65@gmail.com

Annotatsiya.

Ushbu maqolada sun'iy intellekt texnologiyalari asosida yo'l harakati xavfsizligini monitoring qilishning zamonaviy usullari, algoritmlari va amaliy imkoniyatlari tahlil qilinadi. Yo'l-transport hodisalarining oldini olish, transport vositalari va piyodalar harakatini kuzatish, xavfli vaziyatlarni erta aniqlash hamda yo'l infratuzilmasidan samarali foydalanish masalalari tadqiqotning asosiy yo'nalishlari hisoblanadi. Kompyuterli ko'rish, chuqur o'rganish, obyektlarni aniqlash va kuzatish algoritmlaridan foydalanish orqali videokuzatuv ma'lumotlarini avtomatik tahlil qilish imkoniyatlari yoritiladi. Shuningdek, transport vositalarining tezligini baholash, piyodalarning belgilanmagan joydan o'tishini aniqlash, svetofor qoidalariga rioya qilinishini tekshirish va to'qnashuv xavfini baholash usullari ko'rib chiqiladi. Maqolada taklif etilayotgan tizimning umumiy arxitekturasi, samaradorlik ko'rsatkichlari va uni amaliyotga joriy etishda yuzaga kelishi mumkin bo'lgan texnik, tashkiliy hamda axloqiy muammolar bayon etiladi. Tadqiqot adabiyotlar tahlili va tizimni loyihalashga oid nazariy yondashuvlarga asoslanadi.

Kalit so'zlar: sun'iy intellekt, yo'l harakati xavfsizligi, kompyuterli ko'rish, mashinali o'rganish, chuqur o'rganish, obyektlarni aniqlash, transport monitoringi, piyodalar xavfsizligi, xavfni bashorat qilish.

Abstract.

This article analyzes modern methods, algorithms, and practical applications of artificial intelligence technologies for road traffic safety monitoring. The main areas of focus include the prevention of road traffic accidents, monitoring the movement of

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vehicles and pedestrians, early detection of hazardous situations, and the efficient use of road infrastructure. The possibilities of automatically analyzing video surveillance data using computer vision, deep learning, and object detection and tracking algorithms are explored. In addition, methods for estimating vehicle speeds, detecting pedestrians crossing roads at unauthorized locations, monitoring compliance with traffic signal regulations, and assessing collision risks are examined. The article describes the general architecture of the proposed system, its performance indicators, and potential technical, organizational, and ethical challenges that may arise during its practical implementation. The study is based on a literature review and theoretical approaches to system design.

Keywords: artificial intelligence, road traffic safety, computer vision, machine learning, deep learning, object detection, traffic monitoring, pedestrian safety, risk prediction.

Аннотация.

В данной статье анализируются современные методы, алгоритмы и практические возможности мониторинга безопасности дорожного движения на основе технологий искусственного интеллекта. Основными направлениями рассмотрения являются предотвращение дорожно-транспортных происшествий, отслеживание движения транспортных средств и пешеходов, раннее выявление опасных ситуаций и эффективное использование дорожной инфраструктуры. Рассматриваются возможности автоматизированного анализа данных видеонаблюдения с использованием компьютерного зрения, глубокого обучения, а также алгоритмов обнаружения и отслеживания объектов. Кроме того, изучаются методы оценки скорости транспортных средств, выявления пешеходов, переходящих дорогу в неустановленных местах, контроля соблюдения сигналов светофора и оценки риска столкновений. В статье описываются общая архитектура предлагаемой системы, показатели её эффективности, а также потенциальные технические, организационные и этические проблемы, которые могут возникнуть при её практическом внедрении. Работа основана на анализе научной литературы и теоретических подходах к проектированию системы.

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Ключевые слова: искусственный интеллект, безопасность дорожного движения, компьютерное зрение, машинное обучение, глубокое обучение, обнаружение объектов, мониторинг дорожного движения, безопасность пешеходов, прогнозирование рисков.

Kirish.

Yo‘l harakati xavfsizligi zamonaviy shahar infratuzilmasining muhim tarkibiy qismlaridan biridir. Aholi sonining ko‘payishi, avtomobillashuv darajasining ortishi va shahar transport oqimlarining murakkablashishi yo‘llarda xavfli vaziyatlarning yuzaga kelish ehtimolini oshiradi.

Kompyuterli ko‘rish va chuqur o‘rganish algoritmlari transport vositalari hamda piyodalarni aniqlashda muhim o‘rin tutadi. Shu bilan birga, bunday algoritmlarning samaradorligi yoritilish sharoiti, kamera burchagi, tasvir sifati, ob-havo va ma’lumotlar to‘plamining xususiyatlariga bog‘liq [2; 3].Tadqiqotning maqsadi — sun’iy intellekt va kompyuterli ko‘rish texnologiyalaridan foydalanib, yo‘l harakati xavfsizligini monitoring qilish, xavfli vaziyatlarni aniqlash va ularni kamaytirishga xizmat qiluvchi intellektual tizimning nazariy modelini ishlab chiqish.Tadqiqot obyekti — yo‘l harakati jarayoni va uni videokuzatuv vositalari yordamida monitoring qilish. Tadqiqot predmeti — transport vositalari hamda piyodalar harakatini tahlil qilishda sun’iy intellekt algoritmlaridan foydalanish usullari.

Tadqiqot metodologiyasi.

Ushbu tadqiqot ilmiy adabiyotlarni tahlil qilish, mavjud texnologiyalarni taqqoslash, tizim arxitekturasini modellashtirish va matematik ko‘rsatkichlarni shakllantirish metodlariga asoslanadi. Ish doirasida yangi tajriba ma’lumotlari to‘planmagan va real yo‘l videolari bo‘yicha sinov o‘tkazilmagan. Shu sababli, maqoladagi tizim modeli va kutilayotgan natijalar amaliy sinov natijasi emas, balki nazariy loyiha sifatida talqin qilinishi lozim. Taklif etilayotgan yechimda yo‘l bo‘yiga o‘rnatilgan videokameralar asosiy ma’lumot manbai sifatida olinadi. Zarur holatlarda kamera ma’lumotlari svetofor holati, yo‘lning geometrik xususiyatlari, tezlik cheklovi

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va ob-havo ma'lumotlari bilan birlashtirilishi mumkin. Ko'p manbali ma'lumotlarni birlashtirish xavfli vaziyatlarni aniqroq baholashga yordam berishi mumkin, biroq qo'shimcha sensorlar tizim narxi va texnik murakkabligini oshiradi [3; 4].

Yo'l harakati xavfsizligini monitoring qilishda sun'iy intellekt. Sun'iy intellekt — ma'lumotlardan qonuniyatlarni o'rganish, obyektlarni tasniflash, prognoz tuzish va qaror qabul qilishni qo'llab-quvvatlashga xizmat qiluvchi usullar majmuasidir. Yo'l harakati monitoringida mashinali o'rganish, chuqur o'rganish va kompyuterli ko'rish texnologiyalari ayniqsa muhimdir. Kompyuterli ko'rish tasvir yoki videodagi obyektlarni aniqlash va ularning holatini tahlil qilishga xizmat qiladi. Masalan, model videokadrda avtomobil, avtobus, mototsikl, velosiped yoki piyodani aniqlashi mumkin. Keyingi bosqichda obyektlarni kadrlar orasida bog'lash orqali har bir transport vositasining harakat trayektoriyasi aniqlanadi. Chuqur o'rganish modellarining keng tarqalgan turlaridan biri — konvolyutsion neyron tarmoqlariga asoslangan obyekt detektorlaridir. Bunday modellar obyektning tasvirdagi joylashuvini chegaralovchi to'rtburchak va uning sinfini qaytaradi. Real vaqt rejimida ishlaydigan detektorlar transport oqimini uzluksiz tahlil qilish uchun foydali bo'lishi mumkin, ammo tanlanadigan model hisoblash quvvati, aniqlik va kechikish o'rtasidagi muvozanatga asoslanishi kerak [2; 3].

Yo'l harakati monitoringida sun'iy intellekt texnologiyalarining qo'llanilishi

1-jadval

Texnologiya	Asosiy vazifasi	Amaliy qo'llanilishi
Obyektlarni aniqlash	Transport vositasi va piyodani topish	Yo'l oqimini kuzatish
Obyektlarni kuzatish	Obyektni ketma-ket kadrlarda bog'lash	Trayektoriya va harakat yo'nalishini aniqlash
Tasvirni segmentatsiyalash	Yo'l, piyodalar yo'lagi va harakat hududini ajratish	Yo'l chegaralarini tahlil qilish
Mashinali o'rganish	Xavf omillari bo'yicha tasniflash	Xavf darajasini baholash

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Vaqt qatorlarini tahlil qilish	Harakatning vaqt bo‘yicha o‘zgarishini o‘rganish	Transport oqimi yoki xavf tendensiyasini prognoz qilish
Sensorlarni birlashtirish	Kamera va boshqa sensor ma’lumotlarini birlashtirish	Ko‘rinish cheklangan vaziyatlarda baholashni yaxshilash

Jadvaldan ko‘rinadiki, xavfsizlikni monitoring qilish faqat obyektni aniqlash bilan cheklanmaydi. Xavfli vaziyatni baholash uchun obyektlarning joylashuvi, tezligi, harakat yo‘nalishi, svetofor holati va yo‘l hududlari o‘rtasidagi munosabatlar ham hisobga olinishi kerak.

Obyektlarni aniqlash va kuzatish. Monitoring tizimining birinchi bosqichi videokadrlardan transport vositalari va piyodalarni aniqlashdan iborat. Obyekt detektori har bir kadr uchun aniqlangan obyektlar sinfi, chegaralovchi qutisi va ishonchlilik ko‘rsatkichini beradi. Ishonchlilik chegarasi juda past tanlansa, noto‘g‘ri aniqlashlar ko‘payishi mumkin; juda yuqori tanlansa, ayrim haqiqiy obyektlar aniqlanmay qolishi mumkin. Keyingi bosqichda kuzatish algoritmi ketma-ket kadrlardagi obyektlarni o‘zaro bog‘laydi. Natijada har bir transport vositasi yoki piyodaga vaqtinchalik identifikator biriktiriladi va uning harakat trayektoriyasi hosil qilinadi. Bu yondashuv bir obyektni turli kadrlarda takroran sanab yuborish ehtimolini kamaytiradi.

Xavfli vaziyatni baholash. Yo‘l xavfsizligi monitoringida faqat qoidabuzarlikni aniqlash emas, balki transport vositasi va piyoda o‘rtasidagi ehtimoliy to‘qnashuv xavfini oldindan baholash ham muhimdir. Bunda obyektlarning masofasi, nisbiy tezligi, harakat yo‘nalishi va to‘qnashish ehtimoli hisobga olinadi. Tizim xavfli vaziyatni aniqlashda bir nechta belgini birgalikda tahlil qilishi mumkin: piyodaning qatnov qismiga chiqishi, transport vositasining yuqori tezligi, svetoforning taqiqlovchi signali, keskin tormozlanish yoki obyektlar orasidagi masofaning tez qisqarishi. Bunday belgilar asosida ogohlantirish yaratish mumkin, lekin avtomatik aniqlash natijasi har doim ham sodir bo‘lishi muqarrar bo‘lgan avariyani anglatmaydi.

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Monitoring tizimining taklif etilayotgan arxitekturasi. Taklif etilayotgan tizim quyidagi ketma-ketlikda ishlaydi:

Sun'iy intellekt asosidagi yo'l harakati xavfsizligini monitoring qilish tizimining umumiy arxitekturasi.

2-jadval.

1. Videokuzatuv kamerasi Yo'l, avtomobillar va piyodalar tasviri
2. Dastlabki ishlov berish Kadrlarni ajratish, tasvir sifatini tekshirish, hududni belgilash
3. Sun'iy intellekt modeli Obyektlarni aniqlash va ularni kadrlarda kuzatish
3. Harakat va xavfni tahlil qilish Tezlik, trayektoriya, svetofor va xavf belgilarini baholash
4. Ogohlantirish va hisobot Operator paneli, hodisa qaydi va statistik tahlil

Arxitekturaning dastlabki bosqichida kamera oqimi olinadi va kadrlar tahlilga tayyorlanadi. Ikkinchi bosqichda model transport vositalari va piyodalarni aniqlaydi. Uchinchi bosqichda kuzatish algoritmi ularning harakatini vaqt bo'yicha bog'laydi. So'ngra tezlik, harakat yo'nalishi va xavfli holatlar baholanadi. Yakuniy bosqichda xavf darajasi belgilangan mezondan oshsa, operatorga ogohlantirish yuboriladi va hodisa jurnalga yoziladi. Tizimning ishlashi uchun hisoblashlarni kamera yaqinidagi qurilmada — edge qurilmada — bajarish yoki ma'lumotlarni markaziy serverga uzatish mumkin. Edge yondashuvi tarmoq kechikishini va videoni uzatish hajmini kamaytirishi mumkin. Markaziy server esa ko'plab kameralardan kelgan ma'lumotlarni birlashtirish va uzoq muddatli statistik tahlil qilish uchun qulay. Amaliy yechim ushbu ikki yondashuvni birlashtirishi mumkin.

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Tahlillar.

Nazariy tahlil natijalari. Ilmiy adabiyotlar tahlili sun'iy intellekt asosidagi yo'l monitoringi tizimlarini bir nechta o'zaro bog'liq vazifalarga ajratish mumkinligini ko'rsatadi: yo'l ishtirokchilarini aniqlash, ularni kuzatish, harakat parametrlarini baholash, xavfli holatlarni aniqlash va operatorni ogohlantirish. Bu vazifalarni yagona tizimga birlashtirish videokuzatuvni oddiy qayd etish vositasidan faol monitoring vositasiga aylantiradi [2; 3].

An'anaviy videokuzatuv va sun'iy intellektli monitoring tizimlarining taqqoslanishi

3-jadval.

Taqqoslash mezoni	An'anaviy videokuzatuv	Sun'iy intellektli monitoring
Asosiy vazifa	Videoni yozib olish va ko'rsatish	Videoni avtomatik tahlil qilish
Hodisani aniqlash	Ko'pincha operator tomonidan	Algoritm yordamida, zarur bo'lsa operator tasdig'i bilan
Transport vositasini sanash	Qo'lda yoki alohida dastur orqali	Obyektni aniqlash va kuzatish orqali
Xavfni baholash	Operator tajribasiga bog'liq	Belgilangan mezonlar va model natijalari asosida
Katta hajmdagi videoni tahlil qilish	Ko'p mehnat talab qiladi	Avtomatlashtirish imkoniyati yuqori
Asosiy cheklov	Inson e'tibori va vaqtga bog'liqlik	Model xatolari, hisoblash resurslari va ma'lumotlar sifati

Jadvaldagi taqqoslash umumiy texnologik xususiyatlarga asoslangan. U aniq qurilmalarda o'tkazilgan eksperimental sinov natijalarini ifodalamaydi. Sun'iy intellektli tizimning amaliy ustunligi uning real sharoitda qanday o'qitilgani, kalibrlangani va sinovdan o'tkazilganiga bog'liq.

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Samaradorlikni baholash mezonlari. Tizimni amaliyotga joriy etishdan oldin uning aniqligi va ishlash tezligi nazoratli sinovlar orqali baholanishi kerak. Tizimning real vaqt rejimidagi ishlashini kadrlarni qayta ishlash tezligi (FPS) va kechikish vaqti orqali ham o‘lchash mumkin. Masalan, videokuzatuv tizimida model natijasi juda kech hosil bo‘lsa, ogohlantirishning amaliy qiymati kamayadi. Shu sababli, modelning aniqligi bilan birga hisoblash tezligi va xabardor qilish kechikishi ham muhim mezon hisoblanadi.

Monitoring tizimini baholash uchun tavsiya etiladigan ko‘rsatkichlar

4-jadval.

Ko‘rsatkich	Mazmuni	Baholash usuli
Precision	Aniqlangan obyektlar ichida to‘g‘ri natijalar ulushi	Belgilangan test ma’lumotlari bilan taqqoslash
Recall	Haqiqiy obyektlar ichida aniqlanganlari ulushi	Qo‘lda belgilangan obyektlar bilan solishtirish
F1-measure	Precision va Recall muvozanati	Formula (5) orqali hisoblash
FPS	Bir soniyada qayta ishlangan kadrlar soni	Sinov vaqtida o‘lchash

Mazkur ko‘rsatkichlar tizimning turli jihatlarini qamrab oladi. Masalan, yuqori Recall xavfli holatlarni o‘tkazib yuborish ehtimolini kamaytirishga yordam berishi mumkin, lekin noto‘g‘ri ogohlantirishlar ko‘payib ketsa, operatorga ortiqcha yuk tushadi. Shuning uchun modelning optimal sozlamalari monitoring qilinayotgan yo‘l turi va vazifaga qarab tanlanishi kerak.

Muhokama.

Tahlil natijalari sun’iy intellektning yo‘l harakati xavfsizligida qo‘llanishi katta imkoniyatlarga ega ekanini ko‘rsatadi. Shunga qaramay, monitoring tizimini faqat obyektlarni aniqlash algoritmi sifatida loyihalash yetarli emas. Xavfli vaziyatni to‘g‘ri baholash uchun tasvirlardan olingan ma’lumotlar yo‘l geometriyasi, transport qoidalari va vaqt bo‘yicha harakat o‘zgarishlari bilan bog‘lanishi kerak.

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Texnik muammolar. Birinchi muammo — tasvir sifatining o‘zgaruvchanligidir. Quyosh nuri, qorong‘ilik, faralar, yomg‘ir, tuman va kamera linzasining ifloslanishi obyektlarni aniqlash natijalariga ta’sir qilishi mumkin. Tungi va kam yoritilgan sharoitlarda piyodalarni aniqlash alohida murakkab vazifa bo‘lib qolmoqda [5].

Ikkinchi muammo — obyektlarning bir-birini to‘sib qolishi. Tirbandlikda avtomobillar piyodalarni yoki boshqa transport vositalarini qisman berkitishi mumkin. Bunday sharoitda kuzatish algoritmi obyekt identifikatorini yo‘qotishi yoki noto‘g‘ri bog‘lanish hosil qilishi ehtimoli mavjud. Uchinchi muammo — tezlikni o‘lchashdagi xatolikdir. Kamera tasviridagi piksel masofasini real masofaga aylantirish uchun kalibrlash talab etiladi. Kamera o‘rni o‘zgarsa yoki yo‘l hududi noto‘g‘ri belgilansa, tezlik bahosi ishonchsiz bo‘lishi mumkin. Shuning uchun faqat videoga asoslangan hisob-kitoblarni yuqori aniqlik talab qilinadigan huquqiy qarorlar uchun bevosita qo‘llashdan oldin alohida tekshirish zarur.

Algoritmlarning ishonchliligi va adolatliligi. Sun’iy intellekt modeli o‘qitilgan ma’lumotlarda kam uchraydigan holatlarda xato qilishi mumkin. Masalan, model asosan kunduzgi sharoitdagi tasvirlar bilan o‘qitilgan bo‘lsa, tunda yoki yomon ob-havoda uning samaradorligi pasayishi ehtimoli bor. Shuningdek, kamera burchagi va yo‘l infratuzilmasidagi farqlar ham natijaga ta’sir qiladi. Shu sababli modelni faqat umumiy ko‘rsatkich bilan baholash emas, balki kun va tun, turli ob-havo sharoitlari, yo‘l turlari hamda piyodalar ishtirokidagi vaziyatlar bo‘yicha alohida sinash zarur. Obyektni aniqlashning yuqori ko‘rsatkichi o‘z-o‘zidan avariya soni kamayganini isbotlamaydi. Bunday ijtimoiy natijani aniqlash uchun tizim joriy etilishidan oldingi va keyingi davrlar ma’lumotlarini taqqoslash, yo‘l oqimi hamda boshqa omillarni nazorat qilish talab etiladi.

Maxfiylik va huquqiy masalalar. Videokuzatuv tizimlari shaxslarni bevosita yoki bilvosita aniqlash imkonini beruvchi ma’lumotlarni to‘plashi mumkin. Shu bois ma’lumotlarni yig‘ish maqsadi, saqlash muddati, ulardan foydalanish huquqi va himoyalash tartibi oldindan belgilanishi kerak. Zarur bo‘lmagan shaxsiy ma’lumotlarni saqlamaslik, videolarga kirishni cheklash va ma’lumotlarni xavfsiz uzatish muhim

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tashkiliy choralardir. Sun'iy intellekt natijasiga asoslangan avtomatik ogohlantirishni yakuniy huquqiy qaror bilan tenglashtirmaslik lozim. Ayniqsa, jarima yoki boshqa javobgarlik choralarini qo'llashda xatolarni tekshirish, dalillarning yaxlitligini ta'minlash va amaldagi qonunchilikka rioya qilish talab etiladi.

O'zbekiston sharoitida qo'llash imkoniyatlari. O'zbekiston shaharlarida yo'l harakati xavfsizligini monitoring qilish uchun mavjud videokuzatuv infratuzilmasidan foydalanish imkoniyati o'rganilishi mumkin. Dastlab tirbandlik ko'p uchraydigan chorrahalar, piyodalar o'tish joylari, maktab va ta'lim muassasalari yaqinidagi yo'llar ustuvor sinov hududlari sifatida tanlanishi mumkin. Bunda hududlarni tanlash real statistik ma'lumotlar, hodisalar tarixi va mahalliy mutaxassislar bahosiga asoslanishi kerak. Mahalliy sharoit uchun ishlab chiqiladigan model O'zbekistonda uchraydigan transport vositalari, yo'l belgilari, svetoforlar va turli yoritilish sharoitlarini qamrab olgan ma'lumotlar bilan tekshirilishi lozim. Shuningdek, tizimning internet uzilishi holatida ishlashi, elektr ta'minoti, texnik xizmat ko'rsatish va ma'lumotlar xavfsizligi ham loyihalash bosqichida hisobga olinishi kerak. Umuman olganda, sun'iy intellekt inson nazoratini to'liq almashtiruvchi vosita emas, balki xavfni erta aniqlash va mutaxassis qarorini qo'llab-quvvatlash mexanizmi sifatida qaralishi maqsadga muvofiq.

Xulosa.

Ushbu maqolada sun'iy intellekt asosida yo'l harakati xavfsizligini monitoring qilishning nazariy asoslari, texnologik imkoniyatlari va amaliy cheklovlari tahlil qilindi. Tahlil natijasida kompyuterli ko'rish, chuqur o'rganish va obyektlarni kuzatish algoritmlari transport vositalari hamda piyodalar harakatini avtomatik tahlil qilish uchun muhim vositalar ekani aniqlandi. Transport vositalari tezligini hisoblash, aniqlash algoritmlarini baholash va to'qnashuvgacha qolgan vaqtni taxmin qilish uchun matematik formulalar keltirildi.

Kelgusidagi tadqiqotlarda taklif etilgan arxitekturani real videoma'lumotlar asosida amalga oshirish, transport vositalarini aniqlash modelini tanlash, harakat trayektoriyalarini hisoblash va xavfli vaziyatlarni aniqlash algoritmlarini sinash rejalashtirilishi mumkin. Tajriba natijalari olinganidan keyingina tizimning haqiqiy

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aniqligi va yo‘l xavfsizligiga ta’siri haqida asoslangan miqdoriy xulosalar chiqarish mumkin. Xulosa qilib aytganda, sun’iy intellekt asosidagi monitoring tizimlari yo‘l harakati xavfsizligini oshirishga xizmat qiluvchi istiqbolli texnologik yo‘nalishdir. Ularni ishonchli ma’lumotlar, puxta sinov, tegishli texnik infratuzilma va inson nazorati bilan birgalikda joriy etish muhim ahamiyatga ega.

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OLIY TA'LIM MUASSASALARIDA TYUTORLIK FAOLIYATI ORQALI TALABALARDA KITOBXONLIK MADANIYATINI SHAKLLANTIRISH VA MUTOLAA MOTIVATSIYASINI OSHIRISH MEXANIZMLARI

Musayeva Odinaxon Isroil qizi
Andijon davlat texnika instituti
"Iqtisodiyot va boshqaruv" fakulteti tyutori

Annotatsiya. Mazkur maqolada oliy ta'lim muassasalarida tyutorlik faoliyati orqali talabalarda kitobxonlik madaniyatini shakllantirish va mutolaaga bo'lgan qiziqishni oshirish masalalari yoritilgan. O'zbekistonning kitob nashr etish, kutubxona infratuzilmasi va oliy ta'lim qamroviga oid rasmiy statistik ko'rsatkichlar tahlil qilinib, ularning tyutorlik faoliyatini tashkil etishdagi ahamiyati ko'rib chiqilgan. Normativ-huquqiy hujjatlar asosida individual mutolaa rejalari, kitobxonlik klublari, raqamli resurslardan foydalanish va natijalarni baholash mexanizmlari taklif etilgan.

Kalit so'zlar: tyutorlik faoliyati, kitobxonlik madaniyati, mutolaa motivatsiyasi, oliy ta'lim, kutubxona, raqamli mutolaa, talaba-yoshlar, mustaqil fikrlash.

Abstract. This article examines the formation of a reading culture among students and ways to increase their interest in reading through tutoring activities in higher education institutions. Official statistical indicators relating to book publishing, library infrastructure, and higher education enrollment in Uzbekistan are analyzed, and their significance for organizing tutoring activities is discussed. Based on regulatory and legal documents, mechanisms are proposed for developing individual reading plans, establishing reading clubs, using digital resources, and evaluating outcomes.

Keywords: tutoring activities, reading culture, reading motivation, higher education, library, digital reading, university students, independent thinking.

Аннотация. В статье рассматриваются вопросы формирования культуры чтения у студентов и повышения их интереса к чтению посредством тьюторской деятельности в высших образовательных учреждениях. Проанализированы

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официальные статистические показатели Узбекистана, характеризующие книгоиздание, библиотечную инфраструктуру и охват высшим образованием, а также рассмотрено их значение для организации тьюторской деятельности. На основе нормативно-правовых документов предложены механизмы разработки индивидуальных планов чтения, создания читательских клубов, использования цифровых ресурсов и оценки результатов.

Ключевые слова: тьюторская деятельность, культура чтения, мотивация к чтению, высшее образование, библиотека, цифровое чтение, студенты, самостоятельное мышление.

Kirish.

Oliy ta’limning vazifasi faqat mutaxassislik bilimlarini berish bilan cheklanmaydi. Talabaning mustaqil fikrlashi, axborotni tahlil qilishi, o‘z bilimini muntazam yangilab borishi va fikrini asosli ifodalashi ham muhim hisoblanadi. Kitob mutolaasi ushbu ko‘nikmalarni rivojlantirishga xizmat qiladigan vositalardan biridir. Biroq kitobxonlikni barqaror odatga aylantirish uchun kitob tavsiya qilish yoki bir martalik tadbir o‘tkazishning o‘zi yetarli emas; talabaning qiziqishi, vaqti, resurslardan foydalanish imkoniyati va ijtimoiy muhiti ham hisobga olinishi kerak.

O‘zbekiston Respublikasi Prezidentining 2026-yil 15-yanvardagi PQ-9-son “Kitobxonlik madaniyatini rivojlantirish va aholi o‘rtasida kitob o‘qishga qiziqishni oshirish chora-tadbirlari to‘g‘risida”gi qarorida 2026-2030-yillarda aholining kitobxonlik darajasini yiliga o‘rtacha 10 ta kitobga yetkazish maqsadi belgilangan [1]. Qarorda kitobxonlikni targ‘ib qilish, kutubxonalar va ta’lim muassasalarini adabiyotlar bilan ta’minlash hamda raqamli mutolaa imkoniyatlarini kengaytirishga e’tibor qaratilgan. Vazirlar Mahkamasining 2025-yil 17-oktabrdagi 656-son “Oliy ta’lim tashkilotlarida tyutorlik faoliyatini tashkil etish tartibi to‘g‘risidagi nizomni tasdiqlash haqida”gi qarori esa oliy ta’lim tashkilotlarida tyutorlik faoliyatini tashkil etish tartibini belgilaydi [2]. Shu huquqiy asoslar kitobxonlikni tyutorlik ish rejalariga maqsadli kiritish uchun imkoniyat yaratadi.

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Tadqiqot metodologiyasi.

Maqolada normativ-huquqiy hujjatlarni tahlil qilish, rasmiy statistik ma'lumotlarni qiyoslash, tizimli yondashuv va mantiqiy umumlashtirish usullaridan foydalanildi. Statistik ma'lumotlar O'zbekiston Respublikasi Milliy statistika qo'mitasining SIAT ma'lumotlar bazasi, 2025/2026-o'quv yili bo'yicha press-relizi hamda O'zbekiston Axborot agentligi e'lon qilgan kutubxonalar haqidagi ma'lumotlardan olindi.

Tahlil va natijalar.

O'zbekiston respublikasi Milliy statistika qo'mitasi ma'lumotlariga ko'ra, O'zbekistonda oliy ta'lim tashkilotlarida tahsil olayotgan talabalar soni so'nggi yillarda sezilarli oshgan. Bu holat talabalar bilan kitobxonlik bo'yicha tizimli ishlash ko'lamini kengaytirish zarurligini ko'rsatadi.

O'zbekistonda oliy ta'lim tashkilotlarida tahsil olayotgan talabalar sonining dinamikasi [3]

1-jadval

O'quv yili boshiga	Talabalar soni (kishi)	Yillik o'zgarish
2021/2022	808 439	+41,5%
2022/2023	1 042 100	+28,9%
2023/2024	1 314 542	+26,1%
2024/2025	1 432 810	+9,0%
2025/2026	1 535 006	+7,1%

Jadvaldan ko'rinadiki, talabalar soni 2021/2022-o'quv yilidagi 808,4 ming nafardan 2025/2026-o'quv yilida 1,535 million nafarga yetgan (1-jadval). O'sish qariyb 89,9 foizni tashkil etadi. Demak, tyutorlik orqali kitobxonlikni rivojlantirish tashabbuslari ko'p sonli va turli ehtiyojlarga ega talabalarni qamrab olishi kerak. Bunday sharoitda yagona ro'yxat bilan cheklanmasdan, yo'nalish, kurs va shaxsiy qiziqishlar bo'yicha moslashtirilgan mutolaa tavsiyalari samaraliroq tashkiliy yechim bo'lishi mumkin.

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Kitobxonlikni rivojlantirish uchun kitob va axborot resurslaridan foydalanish imkoniyati muhim shartlardan biridir. Milliy statistika qo‘mitasining SIAT bazasida kutubxonalar, axborot-resurs va axborot-kutubxona markazlari soni bo‘yicha quyidagi ko‘rsatkichlar keltirilgan.

O‘zbekistonda kutubxonalar va axborot-kutubxona markazlari sonining o‘zgarishi [4]

2-jadval

Yil	Kutubxonalar va axborot-kutubxona markazlari soni	Oldingi yilga nisbatan o‘zgarish
2023	13 046	+4,22%
2024	14 999	+15,0%
2025	17 763	+18,4%

2023–2025-yillarda mazkur muassasalar soni 13 046 tadan 17 763 taga oshgan, ya’ni qariyb 37,62 foizlik o‘sish kuzatilgan. Bu kitobxonlik faoliyatini tashkil etish uchun infratuzilma kengayayotganini ko‘rsatadi. Biroq muassasalar sonining ko‘payishi talabalarning ulardan muntazam foydalanayotganini yoki kitob o‘qish darajasi oshganini o‘z-o‘zidan isbotlamaydi. Shu sababli tyutorlar kutubxona bilan hamkorlikda talabalar uchun mavjud adabiyotlar, elektron kataloglar, xizmat vaqti hamda foydalanish tartibi haqida muntazam ma’lumot berishi, guruhlar kesimida kutubxonaga tashrif va resurslardan foydalanish imkoniyatlarini kuzatishi mumkin. 2025-yilga oid statistik ma’lumotlar mamlakatda kitob nashr etish va kutubxona fondi salmoqli ekanini ko‘rsatadi. Milliy statistika qo‘mitasi ma’lumotlariga tayangan holda quyidagi ko‘rsatkichlar e’lon qilingan (3-jadval).

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O‘zbekistonda kitob nashri va kutubxona fondiga oid asosiy statistik ko‘rsatkichlar [5]

3-jadval

Ko‘rsatkich	2025-yil qiymati
Nashr etilgan kitoblar va broshyuralar soni	12 010 ta
Kitoblar va broshyuralarning yillik tiraji	7,1 mln nusxa
Kutubxonalardagi kitoblar fondi	89,2 mln nusxa
Adabiy-badiiy bosma nashrlar soni	894 ta
Adabiy-badiiy nashrlarning yillik tiraji	0,7 mln nusxa
Bir foydalanuvchiga berilgan kitob va jurnallar o‘rtachasi	10,1 nusxa

Ushbu ma’lumotlar kitob taklifi va kutubxona fondi mavjudligini tavsiflaydi. Biroq nashrlar soni, tiraj yoki fond hajmi talabalarning qanchalik ko‘p o‘qiyotganini bevosita ko‘rsatmaydi. Masalan, 89,2 million nusxalik kutubxona fondi mavjudligi muhim resurs bazasidir, lekin uning qaysi qismi oliy ta’lim talabalari uchun dolzarb, yangilangan va amalda foydalanish mumkinligini alohida aniqlash lozim. Tyutorlar kutubxonachilar va kafedralar bilan birgalikda talabalar uchun mavzular bo‘yicha tavsiya etiladigan adabiyotlar ro‘yxatini tuzishi, mavjud kitoblar va elektron resurslarga yo‘naltirishi mumkin.2025-yilda bir foydalanuvchiga berilgan kitob va jurnallarning o‘rtacha ko‘rsatkichi 10,1 nusxa sifatida keltirilgan. Bu raqamni Prezident qarorida belgilangan yiliga o‘rtacha 10 ta kitob o‘qish maqsadi bilan tenglashtirib bo‘lmaydi: birinchisi kutubxona orqali berilgan kitob va jurnallar ko‘rsatkichidir, ikkinchisi esa aholining kitobxonlik darajasiga doir maqsadli ko‘rsatkichdir. Ularning hisoblash usuli va mazmuni farq qiladi.

Statistik ma’lumotlar oliy ta’lim auditoriyasining kengaygani va kutubxona infratuzilmasi rivojlanayotganini ko‘rsatsa-da, kitobxonlik motivatsiyasini oshirish uchun ushbu resurslarni talabaning kundalik faoliyati bilan bog‘lash zarur. Quyidagi mexanizmlar tavsiya etiladi.

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Tyutorlik faoliyati orqali talabalar kitobxonligini rivojlantirish mexanizmlari va samaradorlik ko‘rsatkichlari

4-jadval

Mexanizm	Amaliy mazmuni	Kuzatiladigan mezon
Individual mutolaa rejasi	Talabaning qiziqishi va mutaxassisligiga mos kitoblarni tanlash	Reja tuzilishi va bajarilishi
Kitobxonlik klubi	Oyda kamida bir marta asar muhokamasi	Mazmunli ishtirok va fikr bildirish
“Bir kitob - bir fikr”	Talaba o‘qigan asardan asosiy g‘oyani qisqacha izohlaydi	Matnni tushunish va xulosa chiqarish
Kutubxona bilan hamkorlik	Kitoblar, elektron katalog va mavjud resurslar bo‘yicha yo‘naltirish	Resurslardan foydalanish faolligi
Raqamli mutolaa	Qonuniy elektron kitoblar va “Mutolaa” platformasidan foydalanish	Muntazam foydalanish va o‘qilgan mazmunni izohlash
Davriy monitoring	Semestr boshida va oxirida mutolaa odatlarini solishtirish	Boshlang‘ich holatga nisbatan o‘zgarish

Ushbu mexanizmlarni joriy etishda natijalar haqidagi xulosalar real kuzatuvga asoslanishi kerak (4-jadval). Masalan, semestr boshida va oxirida bir xil savollar orqali talabalarning mutolaa tez-tezligi, kitob tanlash odati va o‘qilgan matnni tushunishiga oid ma’lumotlar yig‘ilishi mumkin. Natijalar umumlashtirilib, qaysi usullar ko‘proq samara berayotgani aniqlanadi. Bunday monitoring o‘tkazilmaguncha taklif etilgan mexanizmlarning samaradorligini aniq foizlarda ifodalash to‘g‘ri bo‘lmaydi.

Muhokama.

Keltirilgan statistik ko‘rsatkichlar kitobxonlikni rivojlantirish uchun muhim sharoitlar ko‘p sonli talabalar auditoriyasi, kutubxona tarmog‘i va kitob nashri mavjudligini ko‘rsatadi. Shu bilan birga, bu ma’lumotlar talabalarning mutolaa motivatsiyasi, o‘qish odatlari yoki o‘qilgan matnni tushunish darajasini bevosita

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o‘lchamaydi. Shu sababli infratuzilma ko‘rsatkichlarini kitobxonlik natijasi sifatida talqin qilishdan saqlanish kerak.

Tyutorlik faoliyatining kuchli tomoni - talabalar bilan muntazam muloqot qilish va ularning ehtiyojlarini aniqlash imkoniyatidir. Agar tyutor kitobxonlikni faqat hisobot uchun o‘tkaziladigan tadbirga aylantirsa, bu ichki qiziqishni shakllantirishga yetarli bo‘lmasligi mumkin. Aksincha, talaba o‘zi qiziqqan asarni tanlashi, uni boshqalar bilan muhokama qilishi va o‘z fikrini erkin ifodalashi uchun sharoit yaratilsa, mutolaa shaxsiy rivojlanish jarayoniga yaqinlashadi.

Baholashda o‘qilgan kitoblar soni bilan bir qatorda mazmunni anglash, fikrni asoslash va o‘qilgan bilimni hayotiy yoki kasbiy vaziyatlarga bog‘lash ham hisobga olinishi kerak. Talabalar o‘rtasida ommaviy reyting tuzish yoki kam o‘qiganlarni salbiy baholash o‘rniga, individual rivojlanish dinamikasiga e’tibor berish maqsadga muvofiq. Shuningdek, tyutorlar, kutubxonachilar va professor-o‘qituvchilar hamkorligi tavsiya etiladigan adabiyotlarning dolzarbligi hamda ulardan foydalanish imkoniyatini oshirishi mumkin.

Xulosa va takliflar.

Xulosa qilib aytganda, Oliy ta’lim muassasalarida talabalarning kitobxonlik madaniyatini shakllantirishda tyutorlik faoliyati muhim tashkiliy va tarbiyaviy ahamiyatga ega. Tahlil qilingan statistik ma’lumotlar O‘zbekistonda oliy ta’lim talabalari soni hamda kutubxonalar va axborot-kutubxona markazlari soni ortib borayotganini ko‘rsatadi, biroq bu ko‘rsatkichlarning o‘zi talabalar mutolaa faolligi oshganini tasdiqlamaydi. Shu sababli tyutorlar talabalar qiziqishiga mos kitoblarni tavsiya etishi, kitobxonlik klublarini tashkil qilishi va raqamli mutolaa imkoniyatlaridan foydalanishga ko‘maklashishi lozim.

Yuqoridagilardan kelib chiqib quyidagi takliflar ilgari suriladi:

– Har bir akademik guruhda talabalarning qiziqishiga mos individual mutolaa rejasini shakllantirish.

– Kitobxonlik klublari va asar muhokamalarini bir martalik tadbir emas, muntazam faoliyat sifatida yo‘lga qo‘yish.

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– Tyutorlar, kutubxonachilar va kafedralar hamkorligida kasbiy hamda badiiy adabiyotlar ro‘yxatini tayyorlash.

– Bosma kitoblar bilan birga qonuniy elektron resurslar va “Mutolaa” platformasidan foydalanishni targ‘ib etish.

– Semestr boshida va oxirida mutolaa odatlari bo‘yicha monitoring o‘tkazib, faqat real yig‘ilgan ma’lumotlar asosida natijalarni baholash.

– Baholashda kitoblar sonidan tashqari mazmunni tushunish, mustaqil fikrlash va o‘qilgan bilimdan foydalanish ko‘nikmalarini hisobga olish.

Tyutorlik faoliyati kitobxonlikni targ‘ib qilishdan tashqari, talabaning mutolaa odatini shakllantirishga ko‘maklashishi kerak. Individual yondashuv, kutubxona bilan hamkorlik, raqamli resurslardan foydalanish va natijalarni muntazam baholash uyg‘unlashgandagina kitobxonlik madaniyatini rivojlantirish bo‘yicha olib borilayotgan ishlarning amaliy samarasi ishonchli baholanishi mumkin.

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O‘ZBEKISTONDA BUDJETLARARO MUNOSABATLARNI TAKOMILLASHTIRISH ORQALI MAHALLIY BUDJETLARNING MOLIYAVIY MUSTAQILLIGINI OSHIRISH YO‘LLARI

Chirmashev Abdujalil
Andijon davlat texnika instituti
“Moliya va moliyaviy texnologiyalar” ta’lim yo‘nalishi 2-kurs talabasi
e-mail: abdujalilchirmashev@gmail.com

Annotatsiya. Ushbu maqolada O‘zbekistonda budjetlararo munosabatlarning mavjud holati va mahalliy budjetlarning moliyaviy mustaqilligi 2025-yil ma’lumotlari asosida tahlil qilingan. Mahalliy budjetlar xarajatlarining 65,3 foizi o‘z daromadlari hisobidan qoplangani, fiskal avtonomiya darajasi hududlar kesimida 43,8 foizdan 86,7 foizgacha tafovutlanishi hamda transfertlar taqsimotida individual yondashuv unsurlari saqlanib qolayotgani aniqlangan. 2025-yilgi islohotlar, jumladan 78 ta tumanning o‘z-o‘zini moliyalashtirishga o‘tkazilishi va QQS tushumlarining bir qismini mahalliy budjetlarga o‘tkazish qarori baholangan. Maqolada mahalliy moliyaviy mustaqillikning integral indeksi (MMMI) va unga asoslangan differensial desentralizatsiya modeli taklif etilgan.

Kalit so‘zlar: budjetlararo munosabatlar, fiskal desentralizatsiya, mahalliy budjet, moliyaviy mustaqillik, transfertlar, fiskal avtonomiya, formulali taqsimlash.

Abstract. This article analyzes the current state of intergovernmental fiscal relations and the financial autonomy of local budgets in Uzbekistan based on 2025 data. The analysis reveals that 65.3% of local budget expenditures are covered by own-source revenues, that the level of fiscal autonomy varies considerably across regions, ranging from 43.8% to 86.7%, and that elements of a discretionary approach remain in the allocation of intergovernmental transfers. The article assesses the 2025 reforms, including the transition of 78 districts to self-financing and the decision to allocate a portion of value-added tax (VAT) revenues to local budgets. Furthermore, the article

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proposes an Integrated Index of Local Financial Autonomy (ILFAI) and a differentiated decentralization model based on this index.

Keywords: intergovernmental fiscal relations, fiscal decentralization, local budget, financial autonomy, transfers, fiscal autonomy, formula-based allocation.

Аннотация. В статье на основе данных за 2025 год анализируется современное состояние межбюджетных отношений и финансовой самостоятельности местных бюджетов в Узбекистане. Установлено, что 65,3% расходов местных бюджетов покрываются за счёт собственных доходов, уровень фискальной автономии существенно различается в региональном разрезе — от 43,8% до 86,7%, а в распределении межбюджетных трансфертов сохраняются элементы индивидуального подхода. В статье дана оценка реформам 2025 года, включая перевод 78 районов на самофинансирование и решение о направлении части поступлений налога на добавленную стоимость (НДС) в местные бюджеты. Кроме того, предложен интегральный индекс местной финансовой самостоятельности (ИМФС) и основанная на нём модель дифференцированной децентрализации.

Ключевые слова: межбюджетные отношения, фискальная децентрализация, местный бюджет, финансовая самостоятельность, трансферты, фискальная автономия, формульное распределение.

Kirish.

Bugungi kunda mahalliy budjetlarning moliyaviy mustaqilligi masalasi O‘zbekiston uchun nafaqat moliyaviy-texnik, balki ijtimoiy-iqtisodiy ahamiyatga ega masalaga aylangan. Hududlar aholining turmush sharoitini yaxshilash, infratuzilmani rivojlantirish va ijtimoiy xizmatlar ko‘rsatish uchun yetarli moliyaviy resurslarga ega bo‘lmasa, mahalliy darajadagi tashabbuslarning samaradorligi sezilarli darajada pasayadi. 2025-yil ma’lumotlari ushbu holatni yaqqol ifodalaydi: mahalliy budjetlarning jami daromadlari 71,3 trln so‘mni, xarajatlari esa 109,2 trln so‘mni tashkil etgan [1; 2]. Mazkur ko‘rsatkichlar mahalliy budjetlar xarajatlarining qariyb 35 foizi o‘z daromadlari

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hisobidan qoplanmaganidan dalolat beradi. Ushbu holat mahalliy budjetlarning moliyaviy mustaqilligi hali yetarli darajada emasligini ko‘rsatadi. Shu bilan birga, so‘nggi yillarda ushbu yo‘nalishda muhim institutsional o‘zgarishlar amalga oshirilmoqda. O‘zbekiston Respublikasi Prezidentining 2025-yil 23-iyundagi PF-98-son Farmoni bilan tasdiqlangan mahalliy davlat hokimiyati vakillik organlari faoliyatini 2030-yilga qadar rivojlantirish konsepsiyasida “ma’muriy, budjet va fiskal nomarkazlashtirish asosida hududlarning ma’muriy va moliyaviy mustaqilligini yanada oshirish” ustuvor yo‘nalish sifatida belgilangan [3]. O‘zbekiston Respublikasi Prezidentining 2025-yil 26-dekabrdagi PQ-387-son qarori bilan esa 2026-yil 1-yanvardan QQS tushumlarining bir qismini mahalliy budjetlarga o‘tkazish tartibi belgilandi [4]. Unga ko‘ra, Toshkent shahri budjetiga shaharda yig‘ilgan QQSning 5 foizi, boshqa hududlarga 20 foizi yo‘naltiriladi, bunda tushumlarning kamida 50 foizi tuman va shahar budjetlariga o‘tkaziladi. Ushbu qaror hisobidan mahalliy budjetlar ixtiyorida 4,3 trln so‘m qoldirilishi ko‘zda tutilgan [5]. Bundan tashqari, 2025-yilgi budjet islohoti doirasida 78 ta tuman o‘z-o‘zini moliyalashtirishga o‘tkazildi va respublika budjetidan transfert oluvchilar soni 188 tadan 110 taga qisqartirildi [6].

Amalga oshirilayotgan chora-tadbirlar ijobiy ahamiyatga ega bo‘lsa-da, ular tizimli muammolarni to‘liq hal etmaydi, zero moliyaviy mustaqillik faqat daromad manbalarini ko‘paytirish bilan o‘lchanmaydi. U hududning o‘z daromad bazasini kengaytirish salohiyati, transfertlarga bog‘liqlik darajasi, budjet mablag‘larini boshqarishdagi moslashuvchanlik va mahalliy hokimiyatlarning fiskal mas’uliyati kabi bir nechta o‘lchovni qamrab oladi. Mavjud ilmiy adabiyotlarda mazkur o‘lchovlar alohida tahlil qilingan bo‘lsa-da, ularni yagona integral ko‘rsatkichga birlashtirish va shu asosda har bir hudud uchun differensial desentralizatsiya strategiyasini ishlab chiqish masalasi ochiq qolmoqda. Shundan kelib chiqib, mazkur maqolaning maqsadi O‘zbekistonda budjetlararo munosabatlarni takomillashtirish orqali mahalliy budjetlarning moliyaviy mustaqilligini oshirish yo‘llarini 2025-yil ma’lumotlari asosida asoslash va integral baholash modelini taklif etishdan iborat. Ushbu maqsadga erishish uchun quyidagi vazifalar belgilandi: (1) mahalliy budjetlarning moliyaviy mustaqillik darajasini

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hududlar kesimida baholash; (2) budjetlararo transfertlar tizimining mavjud muammolarini aniqlash; (3) 2025–2026-yillardagi islohotlarning dastlabki natijalarini tahlil qilish; (4) moliyaviy mustaqillikni oshirishning bosqichma-bosqich modelini ishlab chiqish.

Tadqiqot metodologiyasi.

Fiskal desentralizatsiya nazariyasi iqtisodiy fanda chuqur ilmiy asoslarga ega. Ch. Tibu modeli mahalliy hokimiyatlar o‘rtasidagi raqobat orqali jamoat xizmatlarini ko‘rsatish samaradorligi oshishini tushuntiradi [7]. U. Outsning “desentralizatsiya teoremasi” esa jamoat xizmatlarini mahalliy ehtiyojlarga moslashtirib ko‘rsatish markazlashgan tarzda ko‘rsatishga nisbatan samaraliroq ekanini asoslaydi [8]. Shu bilan birga, mazkur nazariyalar rivojlangan bozor iqtisodiyoti sharoitlari uchun ishlab chiqilgan bo‘lib, o‘tish iqtisodiyotidagi mamlakatlarda ularning amal qilish shartlari farq qiladi.

OECD tadqiqotlari fiskal desentralizatsiya va iqtisodiy o‘sish o‘rtasida umuman ijobiy bog‘liqlik mavjudligini, biroq bu bog‘liqlik daromadlar desentralizatsiyasida kuchliroq, xarajatlar desentralizatsiyasida esa zaifroq namoyon bo‘lishini ko‘rsatadi [9]. OECD mamlakatlarida daromadlar desentralizatsiyasining 10 foiz punktga oshishi davlat investitsiyalarining umumiy xarajatlardagi ulushini o‘rtacha 3 foizdan 4 foizdan ko‘proqqa ko‘targani kuzatilgan. Umuman olganda, fiskal desentralizatsiya davlat mablag‘larining kapital xarajatlarga yo‘naltiriladigan ulushini oshiradi [10]. Ushbu xulosa O‘zbekiston uchun muhim amaliy ahamiyat kasb etadi, chunki mahalliy budjetlarning xarajat vakolatlarini kengaytirish bilan bir qatorda ularning o‘z daromad manbalarini mustahkamlash hal qiluvchi omil hisoblanadi.

O‘zbekistonda mahalliy budjetlar va budjetlararo munosabatlar masalasi bir necha yo‘nalishda o‘rganilgan. Xususan, mahalliy budjetlar daromadlarini mustahkamlashda mahalliy soliq bazasini kengaytirish, transfertlar va tenglashtirish vositalari, soliq undirishni raqamlashtirish hamda mahalliy obligatsiyalar kabi mexanizmlarning roli tahlil qilingan [11]. Mahalliy budjetlarning daromad salohiyati va transfertlar oqimlarining tarkibiy tahliliga bag‘ishlangan ishlarda 2025-yil budjet prognozi amaldagi

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ijro bilan solishtirilib, mahalliy budjetlarning transfertlar bilan ta’minlanganlik darajasi aniqlangan [12]. Mahalliy budjetlarning moliyaviy mustaqilligini ta’minlashga bag‘ishlangan tadqiqotlarda esa daromad bazasi barqarorligiga ta’sir etuvchi omillar tizimlashtirilgan [13].

Budjetlararo transfertlarni formulali taqsimlash bo‘yicha G.Malikova tadqiqotida mavjud tizim “qarorlarning individual xususiyati, transfertlar taqsimotining shaffof emasligi va hududlar uchun moliyalashtirishning cheklangan prognozlanuvchanligi” kabi belgilarni saqlab qolayotgani qayd etilgan. Muallif tomonidan 2025-yilda vazirlik, idora va hokimliklarning 79 nafar xodimi o‘rtasida o‘tkazilgan so‘rov ushbu xulosalarni empirik jihatdan tasdiqlagan [6]. Respondentlarning 51,3 foizi mahalliy budjetlarning respublika darajasiga yuqori bog‘liqligini, 35,5 foizi hududlarda o‘z-o‘zini rivojlantirish uchun rag‘bat yo‘qligini, 28,9 foizi transfertlar taqsimotining shaffof emasligini va 27,6 foizi “tenglashtirish” muammosini - iqtisodiy jihatdan rivojlangan hududlar mablag‘larining nisbatan zaif hududlarni moliyalashtirishga yo‘naltirilishini qayd etgan. Respondentlarning atigi 31,6 foizi tuman va shahar budjetlarini mustaqil deb baholagan, 53,2 foizi esa o‘z daromadlari xarajatlarning atigi 20–40 foizini qoplashini ko‘rsatgan. Shuningdek, 2019-yilda budjetlararo transfertlarning variatsiya koeffitsiyenti 104 foizni tashkil etgan [6]. Keltirilgan ma’lumotlar mazkur muammolarning tizimli xususiyatga ega ekanini tasdiqlaydi.

Tadqiqotda statistik tahlil, qiyosiy tahlil, institutsional tahlil va ekspert baholash usullaridan foydalanildi. Ma’lumot manbalari sifatida O‘zbekiston Respublikasi Iqtisodiyot va moliya vazirligining 2025-yil uchun konsolidatsiyalashgan budjet ijrosi ma’lumotlari, normativ-huquqiy hujjatlar, xalqaro tashkilotlar (OECD) hisobotlari hamda ilmiy maqolalar xizmat qildi. Tahlil uch o‘lchov bo‘yicha olib borildi: (1) fiskal avtonomiya darajasi (o‘z daromadlarining xarajatlarga nisbati); (2) transfertlarga bog‘liqlik darajasi; (3) hududlararo fiskal tafovutlar (Jini koeffitsiyenti orqali).

Natija va tahlillar.

2025-yil yakunlari bo‘yicha barcha hududiy budjetlar jami 71 267 mlrd so‘m daromad va 109 204 mlrd so‘m xarajat bilan ijro etilgan [1; 2]. Natijada mahalliy

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budjetlar xarajatlarining daromadlardan oshgan qismi 37 937 mlrd so‘mni tashkil etgan. Ushbu farqning 18 462 mlrd so‘mi (48,7 foizi) respublika budjetidan yo‘naltirilgan transfertlar hisobidan qoplangan [1]. Bu ko‘rsatkichlar asosida mahalliy budjetlarning umumiy fiskal avtonomiyasi 65,3 foizni tashkil etadi. Bu har 100 so‘mlik xarajatning 65,3 so‘mi o‘z daromadlari hisobidan moliyalashtirilganini anglatadi. Transfertlar esa jami xarajatlarning 16,9 foizini moliyalashtirgan. Hududlar kesimidagi oddiy o‘rtacha fiskal avtonomiya bundan pastroq – 62,7 foiz bo‘lib, bu farq yuqori avtonomiyaga ega Toshkent shahri va Toshkent viloyatining jami ko‘rsatkichdagi salmog‘i katta ekani bilan izohlanadi. Shu bilan birga, o‘rtacha ko‘rsatkichlar hududlar o‘rtasidagi sezilarli tafovutlarni to‘liq aks ettirmaydi. Hududlarning fiskal avtonomiya darajasi bo‘yicha qiyosiy holati 1-jadvalda keltirilgan.

Fiskal avtonomiya darajasi bo‘yicha hududlarning qiyosiy holati (2025-yil)

1-jadval

Hudud	Fiskal avtonomiya, %	Transfert ulushi, %	Izoh
Toshkent shahri	86,7	1,7	Eng yuqori salohiyat
Toshkent viloyati	84,5	3,0	Yuqori salohiyat
Navoiy viloyati	78,1	2,0	Yuqori salohiyat
Buxoro viloyati	68,8	10,4	O‘rtachadan yuqori
Qashqadaryo viloyati	66,2	11,9	O‘rtacha
Samarqand viloyati	65,5	21,1	O‘rtacha
Xorazm viloyati	59,7	23,3	O‘rtachadan past
Farg‘ona viloyati	59,2	19,9	O‘rtachadan past
Andijon viloyati	57,6	25,9	Past
Namangan viloyati	55,1	29,6	Past
Surxondaryo viloyati	52,6	30,7	Past
Jizzax viloyati	50,7	21,5	Past

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Hudud	Fiskal avtonomiya, %	Transfert ulushi, %	Izoh
Qoraqalpog‘iston Respublikasi	49,6	33,1	Eng past
Sirdaryo viloyati	43,8	18,5	Eng past

1-jadval ma’lumotlariga ko‘ra, Toshkent shahri, Toshkent va Navoiy viloyatlarining fiskal avtonomiyasi 78–87 foizni tashkil etib, ularning transfertlarga bog‘liqligi minimal darajada. Sirdaryo (43,8%), Qoraqalpog‘iston Respublikasi (49,6%), Jizzax (50,7%) va Surxondaryo (52,6%) hududlarida esa xarajatlarning yarmi atrofidagi qismigina o‘z daromadlari hisobidan qoplanadi. Eng yuqori va eng past ko‘rsatkichlar o‘rtasidagi farq 42,9 foiz punktni tashkil etib, Toshkent shahrining fiskal avtonomiyasi Sirdaryo viloyatinikidan qariyb 2 baravar yuqori. Ushbu tafovut Jini koeffitsiyenti orqali ham tasdiqlanadi: Iqtisodiyot va moliya vazirligi ma’lumotlari asosida hisoblanganda, 2025-yilda daromadlar bo‘yicha Jini koeffitsiyenti 0,2658 ni, transfertlar bo‘yicha esa 0,3352 ni tashkil etgan [1]. Transfertlar bo‘yicha tengsizlikning daromadlar bo‘yicha tengsizlikdan yuqoriligi transfertlar taqsimotining hududlar o‘rtasida nisbatan notekis ekanini ko‘rsatadi.

Tahlil natijalari yana bir muhim jihatni ko‘rsatadi. Transfertlar ulushi xarajatlarning 20 foizidan oshgan 7 ta hudud – Samarqand, Xorazm, Andijon, Namangan, Surxondaryo, Jizzax viloyatlari va Qoraqalpog‘iston Respublikasi subvensiyaga yuqori darajada bog‘liq hududlar sifatida ajralib turadi. Mazkur hududlarning respublika budjetiga bog‘liqligi moliyaviy resurslar bilan bir qatorda fiskal qarorlar qabul qilish jarayonida ham namoyon bo‘ladi. Shu bilan birga, fiskal avtonomiyasi eng past bo‘lgan Sirdaryo viloyatida transfertlar ulushi (18,5%) bir qator nisbatan barqaror hududlarnikidan past. Ushbu holat transfertlar hajmining hududlarning moliyaviy ehtiyojiga har doim ham mutanosib emasligini hamda taqsimotda individual yondashuv saqlanib qolayotganini ko‘rsatadi.

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2025–2026-yillarda amalga oshirilgan islohotlarni uch guruhga ajratish mumkin: ma’muriy vakolatlarni kengaytirish, daromad manbalarini nomarkazlashtirish va transfertlar tizimini optimallashtirish.

Ma’muriy vakolatlarni kengaytirish yo‘nalishida Budjet kodeksiga kiritilayotgan o‘zgartirish muhim ahamiyatga ega. Hozirgi tartibda mahalliy budjetlarning birinchi va ikkinchi guruh xarajatlari (ish haqi, ijtimoiy soliq, oziq-ovqat va dori-darmon xaridlari) bo‘yicha o‘zgartirishlar Iqtisodiyot va moliya vazirligi bilan kelishilgan holda amalga oshiriladi. 2026-yil iyul oyida birinchi o‘qishda ko‘rib chiqilgan qonun loyihasiga ko‘ra, bu cheklov bekor qilinib, tegishli o‘zgartirishlar bevosita Qoraqalpog‘iston Respublikasi, viloyatlar va Toshkent shahri moliya organlari tomonidan amalga oshiriladi [14]. Mazkur o‘zgartirish markaziy organ bilan kelishuv zaruratini bartaraf etish orqali mahalliy budjetlarni boshqarishning tezkorligini oshiradi.

Daromad manbalarini nomarkazlashtirish yo‘nalishida 2026-yildan QQS tushumlarining bir qismini mahalliy budjetlarga o‘tkazish eng sezilarli o‘zgarish hisoblanadi [4; 5]. Ushbu mexanizm mahalliy hokimiyat organlarining QQS tushumlaridan bevosita manfaatdorligini ta’minlab, hududdagi tadbirkorlik subyektlarining QQS to‘lovchi sifatida faoliyat yuritishini rag‘batlantirishga xizmat qiladi. Mahallalar darajasida ham moliyaviy mustaqillikni kuchaytirish choralari ko‘rildi: mahallada qoladigan yer va mol-mulk solig‘i ulushi 10 foizdan 15 foizga oshirildi, noturar joy obyektlari bo‘yicha to‘lanadigan yer va mol-mulk soliqlarining 5 foizi hamda sanitariya qoidalarini buzish va noqonuniy qurilish uchun jarimalarning 10 foizi mahallalar budjetiga yo‘naltiriladigan bo‘ldi. Noturar joy obyektlaridan tushadigan mablag‘larning o‘zi yiliga qariyb 400 mlrd so‘mni tashkil etishi kutilmoqda [15]. Mazkur choralar moliyaviy mustaqillikni boshqaruvning quyi bo‘g‘inidan boshlab shakllantirishga xizmat qiladi.

Transfertlar tizimini optimallashtirish yo‘nalishida 78 ta tumanning o‘z-o‘zini moliyalashtirishga o‘tkazilishi va transfert oluvchilar sonining 188 tadan 110 taga (41,5 foizga) qisqartirilishi eng muhim o‘zgarish hisoblanadi [6]. Mazkur chora o‘z daromad bazasiga ega hududlarning transfertlarga bog‘liqligini kamaytirish hamda cheklangan

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transfert resurslarini moliyaviy yordamga ehtiyoji yuqori bo‘lgan hududlarga yo‘naltirishga qaratilgan. Shu bilan birga, o‘z-o‘zini moliyalashtirishga o‘tkazilgan tumanlarda barqaror daromad bazasi shakllanmagan taqdirda, ularning moliyaviy barqarorligi pasayishi mumkin. G. Malikova mazkur xavfni qayd etib, islohotlarning navbatdagi bosqichi sifatida ma’muriy mexanizmni formulali asoslash bilan to‘ldirish zarurligini ta’kidlaydi [6]. Amalga oshirilgan islohotlarga qaramay, transfertlar tizimida bir qator tizimli muammolar saqlanib qolmoqda. Avvalo, transfertlar miqdori ko‘p hollarda formula asosida emas, balki individual qarorlar asosida belgilanadi. Mazkur holat hududlar uchun moliyalashtirishning prognozlanuvchanligini pasaytiradi va mahalliy hokimiyat organlarining uzoq muddatli rejalashtirish imkoniyatlarini cheklaydi. Bundan tashqari, mavjud tizim hududlarni o‘z soliq bazasini kengaytirishga yetarli darajada rag‘batlantirmaydi, chunki qo‘shimcha jalb qilingan daromadlar transfertlar hajmining qisqarishiga olib kelishi mumkin. Mazkur holat transfertlarga bog‘liqlikning iqtisodiy asosini tashkil etadi; so‘rov ishtirokchilarining 35,5 foizi ham rag‘batlarning mavjud emasligini qayd etgan [6]. Shuningdek, iqtisodiy jihatdan rivojlangan hududlar mablag‘larining nisbatan zaif hududlarni moliyalashtirishga yo‘naltirilishi rivojlangan hududlarning o‘sish sur’atlariga salbiy ta’sir ko‘rsatishi mumkin. Ushbu muammolarni hal etish uchun transfertlarning ma’lum qismini hududning soliq yig‘ish samaradorligiga bog‘lash zarur.

Yuqoridagi tahlil asosida mahalliy moliyaviy mustaqillikning integral indeksi (MMMI) taklif etiladi:

$$MMMI = w_1 \cdot FA + w_2 \cdot (1 - TD) + w_3 \cdot DB + w_4 \cdot BM$$

bu yerda FA – fiskal avtonomiya (o‘z daromadlarining xarajatlarga nisbati); TD – transfertlarga bog‘liqlik (transfertlarning umumiy daromaddagi ulushi, teskari ko‘rsatkich sifatida olinadi); DB – daromad bazasining barqarorligi (soliq tushumlari tarkibi va o‘sish dinamikasi); BM – budjet boshqaruvidagi moslashuvchanlik (mahalliy hokimiyatning xarajatlarni o‘zgartirish vakolati darajasi); w – ekspert bahosi asosida aniqlanadigan va hududning iqtisodiy salohiyatiga qarab differensiallanadigan vazn

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koeffitsiyentlari (Σw = 1). MMMI qiymati 0 dan 1 gacha o‘zgaradi va 2-jadvaldagi shkala bo‘yicha talqin qilinadi.

MMMI qiymatlarini talqin qilish shkalasi

2-jadval

MMMI qiymati	Talqin	Tavsiya etilgan strategiya
0,75–1,00	Yuqori mustaqillik	Transfertlarni bosqichma-bosqich qisqartirish, to‘liq o‘z-o‘zini moliyalashtirishga o‘tish
0,50–0,75	O‘rtacha mustaqillik	Daromad bazasini kengaytirish, rag‘batlantiruvchi transfert mexanizmlarini qo‘llash
0,25–0,50	Past mustaqillik	Barqaror transfertlar, investitsiya salohiyatini oshirish dasturlari
0–0,25	Kritik darajada past	Subvensiya rejimi, institutsional salohiyatni kuchaytirish

DB va BM komponentlari bo‘yicha hududlar kesimidagi ma’lumotlar to‘liq e’lon qilinmaganini hisobga olib, hududlar dastlab fiskal avtonomiya darajasi asosida taxminiy guruhlarga ajratildi (3-jadval).

Hududlarni moliyaviy mustaqillik darajasi bo‘yicha guruhlash va differensial siyosat

3-jadval

Guruh	Hududlar	Asosiy muammo	Siyosat ustuvorligi
A (yuqori)	Toshkent shahri, Toshkent va Navoiy viloyatlari	Transfertga deyarli bog‘liq emas	Fiskal mas’uliyatni oshirish, qarz olish vakolatini kengaytirish

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Guruh	Hududlar	Asosiy muammo	Siyosat ustuvorligi
B (o‘rtacha)	Buxoro, Qashqadaryo va Samarqand viloyatlari	Daromad bazasi yetarli, ammo transfert ulushi sezilarli	Soliq bazasini kengaytirish, rag‘batlantiruvchi transfertlar
C (past)	Farg‘ona, Xorazm, Andijon va Namangan viloyatlari	Transfertga sezilarli bog‘liqlik	Investitsiya muhitini yaxshilash, mahalliy daromad manbalarini ko‘paytirish
D (kritik)	Sirdaryo, Jizzax, Surxondaryo viloyatlari va Qoraqalpog‘iston Respublikasi	Xarajatlarning qariyb yarmi yoki undan ko‘pi o‘z daromadlari bilan qoplanmaydi	Subvensiya bilan birga institutsional salohiyatni kuchaytirish

Taklif etilayotgan modelning amaliy ahamiyati barcha hududlarga yagona yondashuvni qo‘llash o‘rniga differensial siyosat yuritish imkoniyatida namoyon bo‘ladi. Xususan, fiskal avtonomiyasi 86,7 foizni tashkil etuvchi Toshkent shahriga qo‘shimcha transfert ajratish iqtisodiy jihatdan asoslanmagan. Shu bilan birga, Sirdaryo viloyatiga ajratiladigan transfertlarning keskin qisqartirilishi uning moliyaviy holatini yanada yomonlashtirishi mumkin. Shu sababli desentralizatsiya bosqichma-bosqich va differensial tarzda amalga oshirilishi lozim.

Muhokama.

Olingan natijalarni xalqaro tajriba bilan qiyoslaganda, fiskal desentralizatsiya daromad manbalarini nomarkazlashtirish orqali yuqori samara berishi ma’lum bo‘ladi [9]. Estoniya va Latviya tajribasida mahalliy budjetlarning moliyaviy mustaqilligini oshirish natijadorlikka asoslangan budjetlashtirish mexanizmlari bilan uyg‘unlashtirilgan bo‘lib, budjet mablag‘larining samaradorligi aniq natija indikatorlari asosida baholanadi. Ushbu tajriba O‘zbekiston uchun muhim ahamiyatga ega: QQS

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ulushi va mahalliy soliqlar hisobiga daromad manbalarini kengaytirish maqsadga muvofiq yo‘nalish hisoblansa-da, bu jarayon natijadorlik indikatorlari bilan uyg‘un holda amalga oshirilishi lozim. Aks holda qo‘shimcha moliyaviy resurslardan samarasiz foydalanish xavfi yuzaga keladi.

Germaniya, Janubiy Koreya va Polsha modellari ham o‘ziga xos xususiyatlarga ega [9]. Germaniya kooperativ federalizm modelini qo‘llaydi, Janubiy Koreya kuchli markaziy nazoratni mahalliy avtonomiya bilan uyg‘unlashtiradi, Polsha esa Yevropa Ittifoqi tarkibiy fondlari bilan integratsiyalashgan desentralizatsiya modelini rivojlantirgan. O‘zbekiston sharoitida mazkur modellarni to‘liq ko‘chirish emas, balki ularning samarali elementlarini milliy xususiyatlarga moslashtirib qo‘llash maqsadga muvofiq. Shu bilan birga, taklif etilgan MMMI modelining ayrim cheklovlari mavjud. Daromad bazasi barqarorligi va budjet boshqaruvidagi moslashuvchanlik komponentlari bo‘yicha hududlar kesimidagi ma’lumotlar to‘liq ochiq emas. Vazn koeffitsiyentlari esa ekspert bahosiga asoslanadi. Shu sababli 3-jadvaldagi guruhlash taxminiy xususiyatga ega bo‘lib, uni to‘liq ma’lumotlar asosida aniqlashtirish kelgusi tadqiqotlar vazifasi hisoblanadi.

Xulosa va takliflar.

Xulosa qilib aytganda, o‘tkazilgan tadqiqot natijalari O‘zbekistonda mahalliy budjetlarning moliyaviy mustaqillik darajasi hali yetarli emasligini ko‘rsatadi: 2025-yilda mahalliy budjetlar xarajatlarining 65,3 foizi o‘z daromadlari hisobidan qoplangan, hududlar kesimida esa bu ko‘rsatkich Sirdaryo viloyatidagi 43,8 foizdan Toshkent shahridagi 86,7 foizgacha tafovutlanadi. Transfertlar bo‘yicha Jini koeffitsiyentining (0,3352) daromadlar bo‘yicha koeffitsiyentdan (0,2658) yuqoriligi transfertlar taqsimotining ham notekisligini ko‘rsatadi. 2025–2026-yillardagi islohotlar – 78 ta tumanning o‘z-o‘zini moliyalashtirishga o‘tkazilishi, transfert oluvchilar sonining 188 tadan 110 taga qisqartirilishi, QQS tushumlarining bir qismini mahalliy budjetlarga yo‘naltirish va mahallalar budjetini kuchaytirish – moliyaviy mustaqillikning institutsional asoslarini mustahkamlamoqda. Shu bilan birga, transfertlar taqsimotida individual qarorlarning ustunligi, hududlarda daromad bazasini kengaytirish uchun

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rag‘batlarning yetishmasligi va “tenglashtirish”ning salbiy ta’siri kabi tizimli muammolar saqlanib qolmoqda. Taklif etilgan MMMI modeli hududlarni moliyaviy mustaqillik darajasi bo‘yicha to‘rt guruhga ajratish va har bir guruh uchun differensial siyosat yuritish imkonini beradi.

Yuqoridagilardan kelib chiqib quyidagi takliflarni ilgari surish mumkin:

- transfertlar taqsimotini bosqichma-bosqich formulali asosga o‘tkazish taklif etiladi. Dastlab o‘z-o‘zini moliyalashtirishga o‘tkazilgan 78 ta tumanda sinovdan o‘tkazib, keyinchalik barcha hududlarga joriy etish lozim. Formula hududning soliq salohiyati, aholi soni va xarajat ehtiyojlarini hisobga olishi zarur. Mazkur yondashuv transfertlar taqsimotining shaffofligi va prognozlanuvchanligini ta’minlaydi;

- rag‘batlantiruvchi transfert mexanizmini joriy etish maqsadga muvofiq. Bunda transfertlarning bir qismi hududning soliq yig‘ish samaradorligiga bog‘lanadi. Natijada hududlarning o‘z daromad bazasini kengaytirishdan manfaatdorligi ortadi va transfertlarga bog‘liqlik darajasi pasayadi;

- MMMI asosida differensial siyosat yuritish zarur. A guruhidagi hududlarga ko‘proq fiskal mas’uliyat va qarz olish vakolatini berish, D guruhidagi hududlarga esa subvensiya bilan birga institutsional salohiyatni kuchaytirishda yordam ko‘rsatish lozim. Mazkur yondashuv barcha hududlarga yagona talablarni qo‘llash natijasida yuzaga keladigan salbiy oqibatlarning oldini olishga xizmat qiladi;

- mahalliy daromad manbalarini yanada kengaytirish taklif etiladi. QQS ulushini bosqichma-bosqich oshirish, mol-mulk va yer soliqlarining mahalliy budjetlarda qoladigan ulushini ko‘paytirish hamda mahallalar darajasidagi moliyaviy mustaqillikni mustahkamlash lozim;

- natijadorlikka asoslangan budjetlashtirishni joriy etish zarur. Estoniya va Latviya tajribasi asosida budjet mablag‘lari samaradorligini aniq natija indikatorlari orqali baholash tizimini yaratish lozim. Bu qo‘shimcha moliyaviy resurslardan maqsadli va samarali foydalanishni ta’minlaydi.

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AXBOROT TEXNOLOGIYALARI YO‘NALISHI TALABALARIDA TADQIQOTCHILIK KOMPETENSIYALARINI RIVOJLANTIRISHNING PEDAGOGIK-PSIXOLOGIK XUSUSIYATLARI VA TA’LIM JARAYONIDAGI AHAMIYATI

Kobulov Ilxomjon Turg‘unboyevich
Andijon davlat texnika instituti
“Buxgalteriya hisobi” kafedrasi assistenti

Annotatsiya. Mazkur maqolada axborot texnologiyalari yo‘nalishi talabalarida tadqiqotchilik kompetensiyalarini rivojlantirishning pedagogik va psixologik xususiyatlari, ularning kasbiy shakllanish jarayonidagi o‘rni hamda oliy ta’lim tizimidagi ahamiyati yoritilgan. Tadqiqotchilik kompetensiyasining mazmuni, tarkibiy komponentlari, rivojlanishiga ta’sir etuvchi motivatsion, kognitiv, refleksiv va kommunikativ omillar ilmiy-nazariy jihatdan tahlil qilingan. Maqola yakunida oliy texnik ta’lim jarayonida talabalarning tadqiqotchilik faoliyatini takomillashtirishga qaratilgan amaliy taklif va tavsiyalar ishlab chiqilgan.

Kalit so‘zlar: axborot texnologiyalari, tadqiqotchilik kompetensiyasi, bo‘lajak muhandis, pedagogik xususiyatlar, psixologik omillar, ilmiy tafakkur, mustaqil ta’lim.

Kirish.

Zamonaviy jamiyatda axborot-kommunikatsiya texnologiyalarining jadal rivojlanishi, iqtisodiyot tarmoqlarining raqamli transformatsiyasi hamda ishlab chiqarish jarayonlarining intellektuallashuvi oliy ta’lim tizimi oldiga yangi vazifalarni qo‘ymoqda. Bugungi kunda oliy ta’lim muassasalarida tayyorlanayotgan mutaxassisdan faqat mavjud bilimlarni o‘zlashtirish va ularni amaliyotda qo‘llash emas, balki mustaqil fikrlash, muammolarni aniqlash, ilmiy axborotni tahlil qilish, yangi g‘oyalarni ilgari surish va innovatsion yechimlarni ishlab chiqish qobiliyati ham talab etilmoqda. Ayniqsa, axborot texnologiyalari yo‘nalishida tahsil olayotgan talabalar uchun ushbu

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sifatlar alohida ahamiyat kasb etadi. Chunki mazkur soha doimiy ravishda yangilanib boradigan bilimlar, dasturiy vositalar, texnologik yechimlar va ilmiy ishlanmalar bilan uzviy bog‘liqdir.

Axborot texnologiyalari yo‘nalishidagi mutaxassisning kasbiy faoliyati dasturiy mahsulotlarni ishlab chiqish, axborot tizimlarini loyihalashtirish, ma’lumotlarni qayta ishlash, algoritmlarni optimallashtirish, kiberxavfsizlikni ta’minlash va raqamli muammolarga yechim topish kabi murakkab vazifalarni qamrab oladi. Bunday vazifalarni samarali bajarish uchun talaba tayyor algoritm yoki dasturiy yechimdan foydalanish bilan cheklanib qolmasdan, muammoning mohiyatini tushunishi, uning sabablarini aniqlashi, muqobil yechimlarni taqqoslashi va eng maqbul variantni asoslay olishi lozim. Bu esa tadqiqotchilik kompetensiyalarining kasbiy tayyorgarlikdagi ahamiyatini oshiradi.

Tadqiqotchilik kompetensiyasi zamonaviy oliy ta’limda talabaning nazariy bilimlari, amaliy ko‘nikmalari, mustaqil fikrlashi, ilmiy izlanishga bo‘lgan munosabati va o‘z faoliyatini baholash qobiliyatini birlashtiruvchi murakkab shaxsiy-kasbiy sifat sifatida namoyon bo‘ladi. Ciraso-Calí va boshqa mualliflar tomonidan olib borilgan ilmiy ishda tadqiqotchilik kompetensiyasi talabaning ilmiy adabiyotlarni tahlil qilish, metodologik qarorlar qabul qilish, refleksiv fikrlash, ilmiy natijalarni ifodalash va tegishli nazariy bilimlardan foydalanish qobiliyatlari bilan bog‘langan [1].

Yevropa Komissiyasining Qo‘shma tadqiqotlar markazi tomonidan ishlab chiqilgan DigComp raqamli kompetensiyalar doirasida raqamli savodxonlik axborot va ma’lumotlar bilan ishlash, raqamli muhitda muloqot va hamkorlik, raqamli kontent yaratish, xavfsizlik hamda muammolarni hal qilish kabi beshta asosiy yo‘nalish orqali izohlanadi [2]. Ushbu yo‘nalishlar axborot texnologiyalari talabalari tadqiqotchilik faoliyati bilan bevosita bog‘liq.

Tadqiqotchilik faoliyatining rivojlanishida pedagogik omillar bilan bir qatorda psixologik omillar ham muhim ahamiyatga ega. Talabaning ilmiy izlanishga qiziqishi, ichki motivatsiyasi, muvaffaqiyatsizlikka munosabati, mustaqil qaror qabul qilishga

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tayyorligi, o‘z imkoniyatlariga ishonchi va intellektual qiyinchiliklarni yengib o‘tish qobiliyati uning tadqiqotchilik faoliyati natijadorligiga ta’sir ko‘rsatadi.

Maqolaning maqsadi axborot texnologiyalari yo‘nalishi talabalarida tadqiqotchilik kompetensiyalarini rivojlantirishning pedagogik-psixologik xususiyatlarini nazariy jihatdan asoslash, uning tarkibiy qismlarini aniqlashtirish va oliy ta’lim jarayonida mazkur kompetensiyani rivojlantirishga qaratilgan takliflarni ishlab chiqishdan iborat. Ushbu maqsadga erishish uchun kompetensiyaning pedagogik mazmuni yoritildi, psixologik omillar tahlil qilindi, tarkibiy komponentlar tizimlashtirildi hamda raqamli ta’lim muhitining imkoniyatlari ko‘rib chiqildi.

Tadqiqot metodologiyasi.

Mazkur maqolada axborot texnologiyalari yo‘nalishi talabalarida tadqiqotchilik kompetensiyalarini rivojlantirish masalasi pedagogik va psixologik yondashuvlarning o‘zaro uyg‘unligi asosida o‘rganildi. Metodologik asos sifatida kompetensiyaviy, tizimli, faoliyatga yo‘naltirilgan va shaxsga yo‘naltirilgan yondashuvlardan foydalanildi. Ushbu yondashuvlar talabaning bilim, ko‘nikma va malakalarini alohida-alohida emas, balki real kasbiy va ilmiy vazifalarni bajarish jarayonida namoyon bo‘ladigan yaxlit qobiliyat sifatida ko‘rib chiqish imkonini beradi.

Tahlil va natijalar.

Tadqiqotchilik kompetensiyasi talabaning ilmiy bilish jarayonida mustaqil ishtirok etishi, muammoli vaziyatlarni tahlil qilishi, tegishli ma’lumotlarni izlab topishi, ilmiy metodlardan foydalanishi va olingan natijalarni asoslay olishini ifodalovchi integrativ sifatdir. Uning shakllanishi faqat ilmiy maqola yozish yoki bitiruv malakaviy ishini tayyorlash bilan chegaralanmaydi. Aksincha, tadqiqotchilik kompetensiyasi ta’lim jarayonidagi muammoli topshiriqlar, laboratoriya ishlari, loyiha faoliyati, dasturiy mahsulotlarni ishlab chiqish va mustaqil ta’lim jarayonida bosqichma-bosqich rivojlanadi.

Axborot texnologiyalari yo‘nalishi talabalarida mazkur kompetensiyaning o‘ziga xos jihati shundaki, ilmiy izlanish jarayonida nazariy bilimlar bilan bir qatorda texnik tafakkur, algoritmik fikrlash, ma’lumotlarni qayta ishlash va tajriba natijalarini

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tekshirish ko‘nikmalari ham muhim o‘rin egallaydi. Masalan, talaba dasturiy ta’minotning ishlash samaradorligini oshirishga qaratilgan vazifani bajarayotganda mavjud muammoni aniqlashi, sabablarini tahlil qilishi, algoritmik yechimlarni ishlab chiqishi va ularni tegishli mezonlar asosida taqqoslashi zarur.

Ciraso-Calí va hammualliflar tadqiqotchilik kompetensiyasini ilmiy holatni tahlil qilish, metodologik ko‘nikmalar, refleksiv faoliyat, kommunikativ qobiliyat va mazmuniy bilimlar bilan bog‘liq holda ko‘rib chiqadi [1]. Bu yondashuv axborot texnologiyalari yo‘nalishi talabalarining tadqiqotchilik faoliyatini tashkil etishda ham muhim ahamiyatga ega.

Axborot texnologiyalari yo‘nalishi talabalarida tadqiqotchilik kompetensiyasining tarkibiy komponentlari, mazmuni va namoyon bo‘lish ko‘rsatkichlari

1-jadval.

Komponent	Mazmuni	Namoyon bo‘lish ko‘rsatkichlari
Kognitiv komponent	Ilmiy va kasbiy bilimlarni o‘zlashtirish	Muammoni tushunish, nazariy bilimlardan foydalanish, ilmiy tushunchalarni izohlash
Motivatsion komponent	Ilmiy izlanishga ichki qiziqish va ehtiyoj	Mustaqil izlanishga intilish, tashabbuskorlik, ilmiy faoliyatga ijobiy munosabat
Operatsion-faoliyat komponenti	Tadqiqot jarayonini amaliy tashkil etish	Ma’lumot izlash, metod tanlash, algoritm tuzish, tajriba o‘tkazish
Kommunikativ komponent	Ilmiy natijalarni muloqot va taqdimot orqali ifodalash	Maqola yozish, fikrni asoslash, ilmiy munozarada qatnashish
Refleksiv komponent	O‘z faoliyati va natijalarini tahlil qilish	Xatolarni aniqlash, natijalarni baholash, faoliyatni takomillashtirish

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Raqamli-texnologik komponent	Raqamli vositalar va texnologiyalardan ilmiy maqsadda foydalanish	Elektron manbalarni izlash, ma'lumotlarni qayta ishlash, raqamli vositalarda natijalarni taqdim etish

Manba: Ciraso-Calí va hammualliflar [1], Tapullima-Mori va hammualliflar [3] qarashlari asosida muallif tomonidan tizimlashtirilgan.

Jadvaldan ko‘rinadiki, tadqiqotchilik kompetensiyasi bir-birini to‘ldiruvchi bir nechta tarkibiy qismlardan tashkil topadi (1-jadval). Ushbu komponentlardan birining yetarli darajada rivojlanmasligi umumiy tadqiqotchilik faoliyatining samaradorligiga salbiy ta’sir ko‘rsatishi mumkin. Shu sababli barcha komponentlarni o‘zaro bog‘liq holda takomillashtirish muhim hisoblanadi.

Talabalarda tadqiqotchilik kompetensiyalarining shakllanishi ularning psixologik rivojlanishi va individual xususiyatlari bilan chambarchas bog‘liq. Ilmiy izlanish jarayoni intellektual zo‘riqish, noaniqlik sharoitida qaror qabul qilish, muvaffaqiyatsizliklarni tahlil qilish va uzoq muddatli maqsadga yo‘naltirilgan faoliyatni talab qiladi. Shu bois talabaning motivatsiyasi, diqqatni jamlash qobiliyati, xotirasi, tafakkuri, ijodkorligi va o‘z faoliyatini boshqarish ko‘nikmalari tadqiqotchilik faoliyatining muhim psixologik asoslari hisoblanadi.

Birinchidan, motivatsion omil talabaning ilmiy faoliyatga munosabatini belgilaydi. Ichki motivatsiyaga ega bo‘lgan talaba muayyan vazifani faqat baho olish yoki topshiriqni bajarish uchun emas, balki muammoning mohiyatini anglash va yangi bilimlarni egallash maqsadida bajarishga intiladi. Ikkinchidan, kognitiv omillar tadqiqotchilik faoliyatining intellektual asosini tashkil etadi. Axborot texnologiyalari talabalarida mantiqiy, algoritmik, tanqidiy va tizimli fikrlash ko‘nikmalari alohida ahamiyatga ega.

Uchinchidan, irodaviy va emotsional omillar talabaning ilmiy faoliyatdagi qiyinchiliklarni yengib o‘tish qobiliyatini ifodalaydi. Dasturiy mahsulotni ishlab chiqish yoki tajriba o‘tkazish jarayonida kutilmagan xatolar, natijalarning farqlanishi va

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dastlabki farazlarning tasdiqlanmasligi tabiiy holat hisoblanadi. To‘rtinchidan, refleksiv omil talabaning o‘z faoliyatini ongli ravishda tahlil qilishi va baholashini ta’minlaydi.

Khaliullinaning ilmiy ishida talabalarda tadqiqotchilik tafakkurini rivojlantirishda nazariy fikrlash, diqqat, tasavvur, xotira, motivatsiya va intellektual qiyinchiliklarni yengish qobiliyatining ahamiyati ta’kidlangan [4].

Axborot texnologiyalari yo‘nalishi talabalarining tadqiqotchilik faoliyatiga ta’sir etuvchi psixologik omillar va ularni rivojlantirish yo‘llari

2-jadval.

Psixologik omil	Ta’lim jarayonida namoyon bo‘lishi	Rivojlantirish usullari
Ichki motivatsiya	Ilmiy izlanishga qiziqish va tashabbus	Muammoli topshiriqlar, individual loyihalar
Tanqidiy tafakkur	Axborot va dalillarni mustaqil baholash	Qiyosiy tahlil, ilmiy munozara
Mantiqiy tafakkur	Muammoni tizimli tahlil qilish	Algoritmik topshiriqlar, modellashtirish
Irodaviy barqarorlik	Qiyinchiliklarga qaramay faoliyatni davom ettirish	Bosqichma-bosqich murakkablashuvchi loyihalar
O‘ziga ishonch	Mustaqil qaror va takliflarni ilgari surish	Individual taqdimot, loyiha himoyasi
Refleksiv qobiliyat	O‘z faoliyatidagi kamchiliklarni aniqlash	O‘z-o‘zini baholash, tahliliy kundalik
Ijodiy tafakkur	Muqobil va yangi yechimlarni ishlab chiqish	Dizayn fikrlash, ochiq muammoli vazifalar

Manba: pedagogik-psixologik adabiyotlar tahlili asosida muallif tomonidan tuzilgan.

Mazkur omillarni rivojlantirishda o‘qituvchining vazifasi faqat topshiriq berish bilan cheklanmasligi lozim (2-jadval). U talabalarda ilmiy izlanishga qiziqish uyg‘otishi,

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mustaqil qaror qabul qilish uchun sharoit yaratishi, muvaffaqiyatsizliklarni o‘rganish imkoniyati sifatida ko‘rsatishi va o‘z faoliyatini baholashga yo‘naltirishi zarur.

Tadqiqotchilik kompetensiyalarini rivojlantirish jarayonida pedagogik faoliyatning mazmuni, shakllari, metodlari va vositalari muhim ahamiyat kasb etadi. Axborot texnologiyalari yo‘nalishidagi ta’lim jarayonining o‘ziga xosligi nazariy bilimlarning amaliy topshiriqlar, dasturlash, loyihalashtirish, tajriba va modellashtirish bilan uzviy bog‘liqligida namoyon bo‘ladi.

Birinchi pedagogik xususiyat - muammoli ta’limni tashkil etish. Bunda o‘qituvchi talabaga tayyor yechimni taqdim etish o‘rniga, mustaqil izlanishni talab qiluvchi muammoli vaziyatni yaratadi. Masalan, axborot tizimida ma’lumotlarni qayta ishlash tezligini oshirish, algoritm samaradorligini taqqoslash yoki dasturiy mahsulotdagi xavfsizlik kamchiliklarini aniqlash kabi vazifalar berilishi mumkin.

Ikkinchi xususiyat - loyiha asosida o‘qitish. Ushbu metod talabalarni aniq natijaga yo‘naltirilgan faoliyatga jalb qiladi. Loyiha jarayonida talabalar muammoni aniqlash, maqsad belgilash, vazifalarni taqsimlash, ma’lumotlarni to‘plash, dasturiy yoki texnik yechim ishlab chiqish va natijalarni taqdim etish bosqichlaridan o‘tadi.

Uchinchi xususiyat - tadqiqotga asoslangan ta’lim. Bunda o‘quv mashg‘ulotlari ilmiy izlanish elementlari bilan boyitiladi. Thiem, Preetz va Haberstroh tomonidan olib borilgan 2023-yilgi uzunlamasiga ilmiy ishda tadqiqotga asoslangan ta’lim talabalarning ilmiy adabiyotlarni sharhlash, metodologik bilimlar, natijalarni refleksiv baholash va ilmiy muloqotga oid o‘z-o‘zini baholash kompetensiyalarining oshishi bilan bog‘liqligi aniqlangan [5].

To‘rtinchi xususiyat - raqamli ta’lim vositalaridan maqsadli foydalanish. Elektron ilmiy resurslar, statistik va tahliliy dasturlar, bulutli platformalar hamda virtual laboratoriyalar talabalarning mustaqil izlanishini qo‘llab-quvvatlaydi. Biroq raqamli vositalarning mavjudligi o‘z-o‘zidan tadqiqotchilik kompetensiyasini shakllantirmaydi. Ularni aniq pedagogik maqsad, topshiriq va baholash mezonlari bilan bog‘lash zarur.

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Axborot texnologiyalari yo‘nalishi talabalarida tadqiqotchilik kompetensiyalarini rivojlantirishga xizmat qiluvchi pedagogik metodlar va ularning kutiladigan natijalari

3-jadval.

Pedagogik metod	Qo‘llash shakli	Rivojlantiriladigan kompetensiya	Kutiladigan natija
Muammoli ta’lim	Muammoli vaziyat va savollar	Tanqidiy va mantiqiy fikrlash	Mustaqil yechim ishlab chiqish
Loyiha asosida ta’lim	Individual va jamoaviy loyihalar	Tashkiliy, amaliy va kommunikativ	Amaliy mahsulot yoki loyiha yaratish
Tadqiqotga asoslangan ta’lim	Ilmiy savol va izlanish topshiriqlari	Metodologik va tahliliy	Ilmiy asoslangan xulosa chiqarish
Keys-stadi	Kasbiy vaziyatlarni tahlil qilish	Muammoni aniqlash va qaror qabul qilish	Amaliy vaziyatga mos yechim topish
Hamkorlikda o‘qitish	Guruhli izlanish va muhokama	Kommunikativ va ijtimoiy	Jamoaviy ilmiy faoliyatni tashkil etish
Refleksiv ta’lim	O‘z faoliyatini tahlil qilish	O‘z-o‘zini baholash	Xatolarni aniqlash va faoliyatni yaxshilash

Manba: Thiem va hammualliflar [5], Ciraso-Calí va hammualliflar [1] ilmiy qarashlari asosida muallif tomonidan ishlab chiqilgan.

Jadvaldagi metodlarning samaradorligi ularni fan mazmuniga mos ravishda tanlash va o‘zaro uyg‘unlashtirishga bog‘liq (3-jadval). Masalan, dasturlash fanida muammoli topshiriq orqali muammo aniqlanib, loyiha metodi orqali yechim ishlab chiqilishi, tadqiqotga asoslangan yondashuv yordamida esa turli algoritmlarning samaradorligi taqqoslanishi mumkin.

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Raqamli ta’lim muhiti talabalarning mustaqil izlanish imkoniyatlarini kengaytiruvchi muhim pedagogik omillardan biridir. Elektron ilmiy resurslar, masofaviy ta’lim platformalari, virtual laboratoriyalar va ma’lumotlarni qayta ishlash dasturlari o‘quv jarayonini auditoriya mashg‘ulotlari bilan cheklab qo‘ymasdan, mustaqil va hamkorlikdagi faoliyatni tashkil etish imkonini beradi.

Yevropa Komissiyasining Qo‘shma tadqiqotlar markazi tomonidan ishlab chiqilgan raqamli kompetensiyalar doirasida axborotni izlash, uning ishonchliligini baholash, raqamli kontent yaratish, hamkorlik qilish va muammolarni hal etish ko‘nikmalari asosiy yo‘nalishlar sifatida belgilangan [2].

Raqamli ta’lim muhitining birinchi imkoniyati ilmiy axborotdan foydalanish imkoniyatining kengayishidir. Talabalar elektron kutubxonalar, ilmiy jurnallar va ma’lumotlar bazalari orqali o‘z mavzulariga tegishli manbalarni topishlari mumkin. Ikkinchi imkoniyat - raqamli hamkorlik. Bulutli texnologiyalar yordamida talabalar birgalikda hujjatlar tayyorlashi, ma’lumotlar almashishi va loyiha natijalarini muhokama qilishi mumkin.

Uchinchi imkoniyat - virtual laboratoriyalar va modellashtirish vositalaridan foydalanishdir. Bunday vositalar ayrim murakkab jarayonlarni xavfsiz, takroriy va boshqariladigan sharoitda o‘rganishga imkon beradi. To‘rtinchi imkoniyat - sun’iy intellekt vositalaridan foydalanishdir. Sun’iy intellekt ilmiy mavzu bo‘yicha dastlabki g‘oyalarni shakllantirish, matnni tahlil qilish, dasturiy koddagi ayrim xatolarni aniqlash va ma’lumotlarni tartiblashtirishda yordamchi vosita bo‘lishi mumkin.

Birlashgan Millatlar Tashkilotining Ta’lim, fan va madaniyat masalalari bo‘yicha tashkiloti tomonidan 2023-yilda e’lon qilingan generativ sun’iy intellektdan ta’lim va ilmiy faoliyatda foydalanish bo‘yicha qo‘llanmada inson manfaatlarini ustuvor qo‘yish, ma’lumotlar maxfiyligini himoyalash, etik me’yorlar va pedagogik maqsadga muvofiqlik masalalariga alohida e’tibor qaratilgan [6]. Shu sababli sun’iy intellekt javoblarini mustaqil tekshirish, manbalarni tasdiqlash va yakuniy xulosalar uchun shaxsiy ilmiy mas’uliyatni saqlash zarur.

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Raqamli ta’lim vositalarining axborot texnologiyalari yo‘nalishi talabalarining tadqiqotchilik faoliyatidagi pedagogik imkoniyatlari

4-jadval.

Raqamli vosita	**Tadqiqotchilik faoliyatidagi qo‘llanilishi**	**Rivojlantiriladigan ko‘nikma**
Elektron ilmiy kutubxonalar	Ilmiy maqola va adabiyotlarni izlash	Axborot savodxonligi
Ilmiy ma’lumotlar bazalari	Ilmiy manbalarni saralash va taqqoslash	Tanqidiy tahlil
Bulutli platformalar	Jamoaviy hujjat va loyiha tayyorlash	Hamkorlik va kommunikatsiya
Virtual laboratoriyalar	Tajribalar va modellashtirish	Eksperimental faoliyat
Dasturlash muhitlari	Algoritm va dasturiy yechimlarni ishlab chiqish	Amaliy va algoritmik fikrlash
Statistik tahlil vositalari	Ma’lumotlarni qayta ishlash va sharhlash	Tahliliy kompetensiya
Generativ sun’iy intellekt vositalari	Dastlabki tahlil, g‘oya va kodni ko‘rib chiqish	Raqamli savodxonlik va tekshiruvchanlik

Manba: Yevropa Komissiyasining Qo‘shma tadqiqotlar markazi [2] va Birlashgan Millatlar Tashkilotining Ta’lim, fan va madaniyat masalalari bo‘yicha tashkiloti [6] materiallari asosida muallif tomonidan tuzilgan.

Jadvaldan ko‘rinadiki, raqamli vositalar tadqiqotchilik faoliyatining turli bosqichlarini qo‘llab-quvvatlaydi (4-jadval). Muhim masala texnologiyalarning soni yoki murakkabligi emas, balki ularning pedagogik vazifaga mosligi hisoblanadi.

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Xulosa va takliflar.

Xulosa qilib aytganda, o‘tkazilgan nazariy-metodologik tahlil natijasida axborot texnologiyalari yo‘nalishi talabalarida tadqiqotchilik kompetensiyalarini rivojlantirish zamonaviy oliy texnik ta’limning muhim pedagogik vazifalaridan biri ekanligi aniqlandi. Mazkur kompetensiya talabaning nazariy bilimlari, amaliy ko‘nikmalari, mustaqil fikrlashi, ilmiy izlanishga bo‘lgan motivatsiyasi va raqamli texnologiyalardan maqsadli foydalanish qobiliyatini birlashtiruvchi integrativ sifat sifatida namoyon bo‘ladi.

Yuqoridagilardan kelib chiqqan holatda quyidagi takliflar ilgari suriladi:

1. Mutaxassislik fanlari mazmuniga tadqiqotchilik topshiriqlarini tizimli joriy etish. Axborot texnologiyalari yo‘nalishidagi dasturlash, ma’lumotlar bazasi, kompyuter tarmoqlari, axborot xavfsizligi va tizimlarni loyihalashtirish fanlarida muammoli hamda izlanishga yo‘naltirilgan topshiriqlar ulushini oshirish maqsadga muvofiq.

2. Talabalarning ilmiy-axborot savodxonligini rivojlantirish. Elektron ilmiy kutubxonalar, xalqaro ilmiy ma’lumotlar bazalari va akademik qidiruv tizimlaridan foydalanish bo‘yicha amaliy mashg‘ulotlarni tashkil etish zarur. Bunda manbalarning ishonchliligini baholash, ilmiy adabiyotlarni qiyoslash, bibliografik havolalarni to‘g‘ri rasmiylashtirish va akademik halollik qoidalariga rioya qilishga alohida e’tibor qaratish lozim.

3. Raqamli laboratoriya va virtual muhitlardan foydalanishni kengaytirish. Talabalarning eksperimental va amaliy tadqiqotchilik ko‘nikmalarini rivojlantirish uchun virtual laboratoriyalar, dasturlash muhitlari, modellashtirish vositalari va bulutli platformalarni o‘quv jarayoniga maqsadli integratsiya qilish taklif etiladi.

4. Ichki motivatsiyani kuchaytiruvchi pedagogik muhit yaratish. Talabalarni mustaqil loyiha ishlab chiqish, ilmiy tanlovlarda ishtirok etish, ilmiy to‘garaklar faoliyatiga jalb qilish va o‘z g‘oyalarini taqdim etishga rag‘batlantirish zarur.

5. Sun’iy intellekt vositalaridan mas’uliyatli foydalanish metodikasini ishlab chiqish. Sun’iy intellekt vositalaridan ilmiy axborotni dastlabki tahlil qilish, dasturiy kodni tekshirish va g‘oyalarni shakllantirishda yordamchi vosita sifatida foydalanish

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mumkin. Shu bilan birga, sun'iy intellekt tomonidan taqdim etilgan ma'lumotlarni mustaqil tekshirish, maxfiy ma'lumotlarni himoya qilish va talabaning shaxsiy intellektual hissasini saqlash talab etiladi.

6. Tadqiqotchilik kompetensiyalarini baholashning ko'p mezonli tizimini joriy etish. Talabalar faoliyatini faqat yakuniy baho asosida emas, balki muammoni aniqlash, manbalarni tanlash, metodologik yondashuvni asoslash, natijalarni tahlil qilish va ilmiy xulosalarni taqdim etish bosqichlari bo'yicha baholash maqsadga muvofiq.

7. O'qituvchi va talaba o'rtasidagi ilmiy-pedagogik hamkorlikni rivojlantirish. Talabalarni kichik ilmiy loyihalarga jalb qilish, ilmiy rahbarlik va maslahat tizimini takomillashtirish, jamoaviy izlanishlarni tashkil etish orqali ularning ilmiy faoliyatga bo'lgan qiziqishini oshirish mumkin.

Umuman olganda, axborot texnologiyalari yo'nalishi talabalarida tadqiqotchilik kompetensiyalarini rivojlantirish faqat alohida fan doirasidagi pedagogik vazifa emas, balki bo'lajak muhandisning kasbiy shakllanishi, intellektual mustaqilligi va innovatsion faoliyatga tayyorligini ta'minlaydigan uzluksiz ta'lim jarayonidir. Mazkur jarayonni pedagogik va psixologik omillar, zamonaviy ta'lim metodlari hamda raqamli texnologiyalar integratsiyasi asosida tashkil etish oliy texnik ta'lim sifatini oshirishga xizmat qiladi.

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BO‘LAJAK MUHANDISLARDA TADQIQOTCHILIK KOMPETENSIYALARINI SHAKLLANTIRISH BO‘YICHA XORIJIY OLIY TA’LIM MUASSASALARI TAJRIBASI VA UNI O‘ZBEKISTON TA’LIM TIZIMIGA TATBIQ ETISH IMKONIYATLARI

Kobulov Ilxomjon Turg‘unboyevich
Andijon davlat texnika instituti
“Buxgalteriya hisobi” kafedrasi assistenti

Annotatsiya. Mazkur maqolada bo‘lajak muhandislarda tadqiqotchilik kompetensiyalarini shakllantirish bo‘yicha xorijiy oliy ta’lim muassasalarining ilg‘or tajribasi tahlil qilinadi. Xususan, AQSh, Daniya, Germaniya va Niderlandiya oliy ta’lim muassasalarida qo‘llanilayotgan loyiha asosida ta’lim olish, muammoli ta’lim, talabalarni ilmiy izlanishlarga jalb etish hamda sanoat korxonalari bilan hamkorlik mexanizmlarining mazmuni yoritiladi. Xorijiy tajribalarni O‘zbekiston muhandislik ta’limi tizimiga moslashtirish imkoniyatlari pedagogik, tashkiliy va raqamli jihatlardan ko‘rib chiqiladi.

Kalit so‘zlar: bo‘lajak muhandis, tadqiqotchilik kompetensiyasi, muhandislik ta’limi, loyiha asosida ta’lim, muammoli ta’lim, ilmiy izlanish, raqamli texnologiyalar.

Kirish.

Bugungi kunda muhandislik sohasi faqat mavjud texnik bilimlarni o‘zlashtirish va ulardan amaliyotda foydalanish bilan cheklanmaydi. Zamonaviy muhandisdan ishlab chiqarish jarayonidagi muammolarni mustaqil aniqlash, ularning sabablarini tahlil qilish, ilmiy asoslangan yechimlarni ishlab chiqish, tajriba-sinov ishlarini tashkil etish va olingan natijalarni baholash talab etilmoqda. Ayniqsa, sanoatning raqamlashtirilishi, avtomatlashtirish, sun’iy intellekt, robototexnika va yangi materiallar texnologiyalarining rivojlanishi muhandislik kadrlarining kasbiy tayyorgarligiga qo‘yiladigan talablarni o‘zgartirmoqda.

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Xorijiy oliy ta’lim muassasalari tajribasi shuni ko‘rsatadiki, tadqiqotchilik kompetensiyalari faqat alohida fan yoki laboratoriya mashg‘ulotlari doirasida emas, balki butun ta’lim jarayoniga izchil singdirilganda samarali shakllanadi. Masalan, AQShdagi Massachusets texnologiya instituti talabalarni ilmiy loyihalarga jalb etish amaliyotiga, Daniyadagi Olborg universiteti muammoga va loyihaga asoslangan ta’lim modeliga, Niderlandiyadagi Delft texnologiya universiteti esa muhandislik loyihalari va amaliy muammolarni hal etishga katta e’tibor qaratadi.

O‘zbekiston oliy ta’lim tizimida ham muhandislik ta’limining amaliy yo‘nalishini kuchaytirish, ilmiy faoliyat va ta’lim integratsiyasini rivojlantirish, talabalarni innovatsion loyihalarga jalb etish dolzarb ahamiyat kasb etadi. Biroq xorijiy tajribalarni samarali joriy etish uchun ularning mazmunini, tashkiliy mexanizmlarini va mahalliy sharoitga mos jihatlarini chuqur tahlil qilish zarur.

Tadqiqot metodologiyasi.

Maqolani tayyorlashda qiyosiy tahlil, tizimli yondashuv, ilmiy manbalarni o‘rganish, umumlashtirish, pedagogik modellashtirish va me’yoriy-huquqiy hujjatlarni tahlil qilish metodlaridan foydalanildi. Xorijiy tajribalarni tanlashda uchta asosiy mezon belgilandi: talabalarning real ilmiy loyihalarda bevosita ishtirok etishi; muhandislik muammolarini mustaqil yoki jamoaviy hal etishga yo‘naltirilgan ta’lim mexanizmlarining mavjudligi; ilmiy faoliyat natijalarini ta’lim va ishlab chiqarish bilan bog‘lash imkoniyati.

Tahlil va natijalar.

Bo‘lajak muhandislarda tadqiqotchilik kompetensiyalarini shakllantirishning samarali mexanizmlaridan biri talabalarni oliy ta’limning dastlabki bosqichlaridanoq ilmiy faoliyatga jalb etish hisoblanadi. Bunda talaba faqat tayyor bilimlarni o‘zlashtiruvchi emas, balki muammoni aniqlovchi, ma’lumot to‘plovchi, tajriba o‘tkazuvchi va ilmiy natija yaratuvchi faol ishtirokchi sifatida namoyon bo‘ladi.

AQSh tajribasi. Massachusets texnologiya institutida bakalavriat talabalari uchun Undergraduate Research Opportunities Program - bakalavriat talabalari uchun ilmiy faoliyat imkoniyatlari dasturi faoliyat yuritadi. Ushbu dastur orqali talabalar institutning

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turli kafedralari, ilmiy markazlari va laboratoriyalarida olib borilayotgan real ilmiy ishlarga jalb etiladi. Talabalar professor-o‘qituvchilar, ilmiy xodimlar va magistratura bosqichidagi izlanuvchilar bilan hamkorlikda ishlash imkoniyatiga ega bo‘ladi. Dastur doirasida talaba mavjud ilmiy loyihaga qo‘shilishi yoki o‘zining ilmiy g‘oyasini taklif qilishi mumkin. Ishtirok etish muddati bir semestr, yozgi davr yoki undan uzoq davom etishi mumkin; ayrim loyihalarda ishtirok etish haq to‘lash yoki akademik kredit shaklida tashkil etiladi [1].

Massachusets texnologiya institutining rasmiy ma’lumotida bakalavriat talabalarining qariyb 65 foizi har yili mazkur dasturda ishtirok etishi, 2025-yil bitiruvchilarining 93 foizi esa o‘qish davrida kamida bir marta ushbu dastur doirasida ilmiy faoliyatda qatnashgani qayd etilgan [2]. Bu ko‘rsatkichlar talabalarning ilmiy faoliyatga jalb etilishi alohida iqtidorli talabalar bilan cheklanib qolmasdan, oliy ta’lim muassasasi miqyosidagi tizimli mexanizmga aylanganini ko‘rsatadi.

Daniya tajribasi. Olborg universitetida ta’lim jarayoni muammoga asoslangan loyiha faoliyati bilan uzviy bog‘langan. Universitetning pedagogik modelida talabalar muayyan muammo yoki vaziyatni tanlab, uni guruh tarkibida o‘rganadi, tahlil qiladi va ilmiy asoslangan yechim ishlab chiqadi. Bunda nazariy mashg‘ulotlar loyiha faoliyatini to‘ldiruvchi vosita sifatida xizmat qiladi. Talabalar muammoni aniqlash, uni kichik vazifalarga ajratish, tegishli nazariy bilimlarni qo‘llash, dalillarni tahlil qilish va yakuniy natijani taqdim etish bosqichlaridan o‘tadi [3].

Olborg universiteti modelida guruhli loyiha faoliyati alohida ahamiyatga ega. Muhandislik sohasidagi ko‘plab muammolar birgina mutaxassisning bilimlari bilan hal etilmaydi. Masalan, ishlab chiqarish jarayonini avtomatlashtirish, energiya samaradorligini oshirish yoki texnik qurilmaning yangi konstruksiyasini ishlab chiqish uchun turli bilim va ko‘nikmalarga ega bo‘lgan mutaxassislarning hamkorligi talab qilinadi. Guruhli loyiha faoliyati talabalarning ilmiy fikrlashi, muloqot madaniyati va jamoada ishlash qobiliyatini rivojlantiradi.

Germaniya tajribasi. Myunxen texnika universitetining muhandislik yo‘nalishlarida tahsil olayotgan talabalar uchun ilmiy amaliyot imkoniyatlari mavjud. Masalan,

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Engineering Science bakalavriat dasturida ilmiy amaliyot uchinchi semestrdan keyin bajarilishi mumkin. Mazkur amaliyot jami 120 ish soatini tashkil etadi: uning kamida 80 soati bevosita ilmiy faoliyatga, taxminan 40 soati esa ilmiy hisobot yoki poster tayyorlashga ajratiladi. Amaliyot davomida talabalar tajribali ilmiy xodimlar rahbarligida universitetning muayyan ilmiy yo‘nalishlari bilan tanishadi va ilmiy ishlarni bajarishda ishtirok etadi [4].

Myunxen texnika universitetining mexanika muhandisligi bakalavriat dasturidagi ayrim ilmiy loyiha amaliyotlari 12 kredit bilan baholanadi. Unda talaba ilmiy guruh tarkibida amaliy loyiha ustida ishlaydi, ilmiy rahbar ko‘magida tegishli usul va dasturiy vositalarni o‘zlashtiradi hamda yakuniy natijalarni taqdim etadi [5]. Bu tajriba nazariya, amaliyot va ilmiy hisobotning o‘zaro bog‘liqligini namoyon etadi.

Niderlandiya tajribasi. Delft texnologiya universitetining aerokosmik muhandislik fakultetida loyiha asosida o‘qitish talabalarning dastlabki o‘quv bosqichlaridanoq amaliy faoliyatga jalb etilishiga xizmat qiladi. 2022-yilda e’lon qilingan ilmiy konferensiya materialida birinchi kurs talabalari uchun tashkil etilgan “Design and Construction” loyihasi haqida ma’lumot berilgan. Ushbu loyiha doirasida 400 nafar talaba taxminan 10 kishidan iborat 40 ta guruhga ajratilgan. Guruhlarga loyihaviy vazifalar berilgan va yakunda alyuminiydan qanot konstruksiyasini yaratish hamda uni sinovdan o‘tkazish topshirig‘i bajarilgan [6].

Xorijiy oliy ta’lim muassasalarida bo‘lajak muhandislarning tadqiqotchilik kompetensiyalarini shakllantirish tajribasining qiyosiy tavsifi

1-jadval.

Oliy ta’lim muassasasi	Asosiy ta’lim mexanizmi	Amaliy tashkil etish shakli	Shakllantiriladigan kompetensiyalar
Massachusets texnologiya instituti (AQSh)	Talabalarni ilmiy loyihalarga jalb etish	Professor va ilmiy xodimlar bilan laboratoriya hamkorligi	Ilmiy izlanish, tanqidiy fikrlash, texnik tahlil
Olborg	Muammoga	Guruhli loyiha,	Muammoni tahlil

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universiteti (Daniya)	asoslangan loyiha ta'limi	muammoni aniqlash va yechim ishlab chiqish	qilish, hamkorlik, ilmiy muloqot
Myunxen texnika universiteti (Germaniya)	Ilmiy amaliyot va mustaqil loyiha	Ilmiy rahbar nazoratidagi amaliyot, hisobot va poster	Tajriba o'tkazish, metodik yondashuv, natijalarni rasmiylashtirish
Delft texnologiya universiteti (Niderlandiya)	Amaliy muhandislik loyihalari	Konstruksiya yaratish, sinash va guruhli loyiha	Loyihalash, tajriba-sinov, texnik ijodkorlik

Manba: [1]–[6] manbalar asosida muallif tomonidan tuzilgan.

Jadvaldan ko'rinadiki, xorijiy oliy ta'lim muassasalarida qo'llaniladigan yondashuvlar turlicha bo'lsa-da, ularning umumiy jihati talabani ilmiy va muhandislik faoliyatining faol ishtirokchisiga aylantirishdan iborat (1-jadval). Massachusets texnologiya institutida ilmiy loyihaga bevosita jalb etish, Olborg universitetida muammolarni jamoaviy hal qilish, Myunxen texnika universitetida ilmiy amaliyot va hisobot tayyorlash, Delft texnologiya universitetida esa amaliy konstruksiyalarni yaratish va sinash asosiy o'rin tutadi.

Muhandislik ta'limida tadqiqotchilik kompetensiyalarini shakllantirishni tizimli tashkil etishda xalqaro CDIO tashabbusi tomonidan ishlab chiqilgan standartlar muhim metodik asos bo'la oladi. CDIO — Conceive, Design, Implement, Operate, ya'ni g'oyani shakllantirish, loyihalash, amalga oshirish va foydalanish bosqichlarini anglatadi. Ushbu yondashuvda muhandislik ta'limi mahsulot, jarayon, tizim yoki xizmatning butun hayotiy sikli bilan bog'liq holda tashkil etiladi.

CDIO standartlarining 3.0-versiyasida muhandislik dasturlarida o'quv natijalarini belgilash, fanlararo integratsiyalashgan o'quv dasturlarini shakllantirish, loyihalash va amalga oshirish tajribalarini tashkil etish, muhandislik laboratoriyalarini rivojlantirish,

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faol ta’lim metodlarini qo‘llash hamda ta’lim natijalarini baholash kabi 12 ta standart ko‘rsatilgan [7].

CDIO standartlari asosida bo‘lajak muhandislarda tadqiqotchilik kompetensiyalarini shakllantirish yo‘nalishlari

2-jadval.

CDIO bosqichi	Talabaning bajaradigan faoliyati	Shakllantiriladigan tadqiqotchilik ko‘nikmasi	O‘quv jarayonidagi tatbiqi
G‘oyani shakllantirish (Conceive)	Muammoni aniqlash, ehtiyojlarni o‘rganish, ilmiy savol qo‘yish	Muammoni aniqlash va ilmiy fikrlash	Muammoli topshiriq, texnik holat tahlili
Loyihalash (Design)	Yechim variantlarini ishlab chiqish, hisob-kitob va chizmalar tayyorlash	Tahlil qilish, modellashtirish, loyihalash	Kompyuter modellashtirish, loyiha ishi
Amalga oshirish (Implement)	Prototip yaratish, tajriba va sinovlarni bajarish	Tajriba o‘tkazish, ma’lumot yig‘ish va qayta ishlash	Laboratoriya, ustaxona va loyiha mashg‘ulotlari
Foydalanish (Operate)	Natijani baholash, texnik samaradorlikni aniqlash, takomillashtirish	Natijalarni sharhlash, xulosa chiqarish	Yakuniy hisobot, taqdimot, texnik tavsiyalar

Manba: CDIO standartlari 3.0 mazmuni asosida muallif tomonidan ishlab chiqilgan [7].

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Mazkur yondashuvdan kelib chiqib, muhandislik ta’limida har bir o‘quv loyihasi muayyan ilmiy yoki texnik muammoni hal etishga qaratilishi lozim (2-jadval). Bunda talaba tayyor yechimni takrorlamasdan, muammoning sabablarini aniqlashi, turli yechimlarni taqqoslashi va o‘z xulosalarini tajriba natijalari bilan asoslay olishi kerak.

O‘zbekistonda bo‘lajak muhandislarning tadqiqotchilik kompetensiyalarini shakllantirish uchun zarur huquqiy va tashkiliy asoslar mavjud. Jumladan, 2019-yil 29-oktabrda qabul qilingan O‘zbekiston Respublikasining “Ilm-fan va ilmiy faoliyat to‘g‘risida”gi O‘RQ-576-son Qonunida yoshlarni ilm-fan va ilmiy faoliyatga jalb etish, oliy ta’lim muassasalarida ilmiy faoliyatni amalga oshirish hamda talabalar va yosh olimlar uchun tegishli shart-sharoitlarni yaratish masalalari belgilangan. Qonunning 17-moddasida oliy ta’lim muassasalarida ta’lim jarayoni bilan birga ilmiy faoliyat ham yuritilishi qayd etilgan [8].

Xorijiy tajribalarni milliy ta’lim tizimiga tatbiq etishda ularning eng samarali jihatlarini tanlab olish va bosqichma-bosqich joriy etish maqsadga muvofiq. Bunda har bir muhandislik yo‘nalishining xususiyatlari, mavjud laboratoriya imkoniyatlari, o‘qitiladigan fanlar mazmuni va hududiy ishlab chiqarish korxonalarining ehtiyojlari hisobga olinishi lozim.

Birinchi navbatda, oliy ta’lim muassasalarida talabalarni ilmiy loyihalarga jalb etishning doimiy mexanizmini yaratish zarur. Buning uchun kafedralar huzurida talabalar ilmiy guruhlarini tashkil etish, professor-o‘qituvchilarning ilmiy ishlari bilan talabalar loyihalarini bog‘lash va har bir talaba uchun individual ilmiy yo‘nalish belgilash mumkin. Bu mexanizm Massachusets texnologiya institutidagi talabalarni ilmiy loyihalarga jalb etish tajribasining milliy sharoitga moslashtirilgan shakli bo‘la oladi.

Ikkinchidan, muammoga asoslangan loyiha ta’limini muhandislik fanlariga keng joriy etish lozim. Masalan, “Materialshunoslik” fanida mahalliy xomashyodan foydalanib yangi material xususiyatlarini o‘rganish, “Mashina detallari” fanida konstruksiya mustahkamligini tahlil qilish, “Avtomatlashtirish” fanida ishlab chiqarish jarayonining ayrim bosqichlarini avtomatlashtirish kabi loyihalar tashkil etilishi

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mumkin. Bunday topshiriqlar talabalarni nazariy bilimlarni real muammolar bilan bog‘lashga o‘rgatadi.

Uchinchidan, ilmiy amaliyot va laboratoriya mashg‘ulotlarini o‘zaro integratsiyalash lozim. Talaba laboratoriyada faqat tayyor yo‘riqnoma asosida tajriba bajarishi bilan cheklanmasdan, tajriba maqsadini aniqlash, o‘lchov usulini tanlash, natijalarni qayta ishlash va xatoliklarni baholashda ham ishtirok etishi kerak. Bu jarayonda ilmiy hisobot, texnik hujjat va taqdimot tayyorlash majburiy o‘quv natijalaridan biri sifatida belgilanishi mumkin.

To‘rtinchidan, raqamli texnologiyalardan foydalanish orqali tadqiqotchilik faoliyatining imkoniyatlarini kengaytirish zarur. Kompyuter modellashtirish dasturlari, virtual laboratoriyalar, elektron ilmiy kutubxonalar, ma’lumotlarni qayta ishlash vositalari va masofaviy hamkorlik platformalari talabalarning mustaqil ishlashini qo‘llab-quvvatlaydi. Bunda raqamli vosita ilmiy faoliyatning o‘rnini bosuvchi emas, balki uni tashkil etish, tezlashtirish va natijalarni tekshirishga yordam beruvchi vosita sifatida qo‘llanilishi lozim.

3-jadval. Xorijiy tajribalarni O‘zbekiston muhandislik ta’limiga tatbiq etishning taklif etilayotgan mexanizmlari

Xorijiy tajriba	O‘zbekistonda tatbiq etish shakli	Zarur shart-sharoit	Kutilayotgan natija
Massachusets texnologiya institutidagi ilmiy loyihalarda ishtirok	Kafedralar huzurida talabalar ilmiy guruhlarini tashkil etish	Ilmiy rahbarlar, loyiha mavzulari, laboratoriya va grant imkoniyatlari	Talabalarning ilmiy faoliyatdagi ishtiroki kengayadi
Olborg universitetidagi muammoga asoslangan	Fanlar kesimida real muhandislik muammolariga asoslangan guruhli	Fanlararo hamkorlik, loyiha topshiriqlari, baholash	Mustaqil fikrlash va muammoni hal etish qobiliyati rivojlanadi

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ta’lim	loyihalar	mezonlari	
Myunxen texnika universitetidagi ilmiy amaliyot	O‘quv rejasiga ilmiy amaliyot va ilmiy hisobot elementlarini kiritish	Ilmiy laboratoriyalar, rahbarlar, amaliyot dasturi	Tajriba o‘tkazish va natijalarni rasmiylashtirish ko‘nikmasi shakllanadi
Delft texnologiya universitetidagi amaliy muhandislik loyihalari	Prototip yaratish, sinovdan o‘tkazish va konstruksiyalarni takomillashtirish	Ustaxona, jihozlar, materiallar va texnik xavfsizlik	Loyihalash va amaliy muhandislik ko‘nikmalari kuchayadi
CDIO standartlari	O‘quv dasturlariga bosqichma-bosqich loyiha va tajriba topshiriqlarini kiritish	O‘quv natijalari, fanlararo integratsiya, baholash tizimi	Tadqiqotchilik faoliyati ta’lim jarayoniga tizimli singdiriladi

Manba: [1]–[10] manbalar tahlili va muallif takliflari asosida tuzilgan.

Jadvalda keltirilgan mexanizmlarni amaliyotga joriy etish uchun ularni muayyan bosqichlarda amalga oshirish maqsadga muvofiq (3-jadval). Dastlab oliy ta’lim muassasasining mavjud imkoniyatlari o‘rganiladi, keyin tajriba-sinov yo‘nalishlari tanlanadi, shundan so‘ng o‘quv jarayoniga loyiha va ilmiy amaliyot elementlari kiritiladi. Yakuniy bosqichda esa talabalarning kompetensiyalari belgilangan mezonlar asosida baholanadi.

Xorijiy tajribalarni o‘rganish asosida bo‘lajak muhandislarning tadqiqotchilik kompetensiyalarini baholashda faqat yakuniy loyiha yoki ilmiy maqola mavjudligiga tayanish yetarli emasligi ko‘rinadi. Talabaning muammoni aniqlashidan boshlab, natijalarni taqdim etishigacha bo‘lgan faoliyati izchil baholanishi kerak.

Buning uchun tadqiqotchilik kompetensiyalarini bir necha tarkibiy yo‘nalish asosida baholash taklif etiladi. Birinchi yo‘nalish — nazariy-metodologik tayyorgarlik bo‘lib, unda talabaning ilmiy tushunchalar, muhandislik qonuniyatlari va izlanish

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metodlari haqidagi bilimlari aniqlanadi. Ikkinchi yo‘nalish — amaliy-operatsion tayyorgarlik bo‘lib, unda tajriba o‘tkazish, texnik vositalardan foydalanish, modellashtirish va ma’lumotlarni qayta ishlash qobiliyati baholanadi. Uchinchi yo‘nalish — kommunikativ faoliyat bo‘lib, unda ilmiy natijalarni yozma va og‘zaki shaklda ifodalash, jamoada ishlash va fikr almashish ko‘nikmalari hisobga olinadi. To‘rtinchi yo‘nalish — refleksiv-baholash faoliyati bo‘lib, bunda talabaning o‘z ishini tahlil qilishi, xatolarni aniqlashi va takomillashtirish yo‘llarini belgilashi e’tiborga olinadi.

Xulosa.

Xulosa qilib aytganda, xorijiy oliy ta’lim muassasalari tajribasini qiyosiy o‘rganish natijasida bo‘lajak muhandislarda tadqiqotchilik kompetensiyalarini shakllantirishning samarali mexanizmlari, avvalo, talabalarni real ilmiy va muhandislik loyihalariga jalb etish, muammoga asoslangan ta’limni rivojlantirish, ilmiy amaliyotni o‘quv jarayoni bilan bog‘lash hamda amaliy loyihalarni muntazam tashkil etishdan iborat ekanligi aniqlandi.

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NAVOIY VILOYATIDA OLXÖRI DARAXTLARINING KASALLIK VA ZARARKUNANDALARIGA QARŞI KURAŞ

Şamsiddinov Quvonçbek Azamatoviç
Akademik Mahmud Mirzayev nomidagi Boğdorçilik, uzumçilik va vinoçilik ilmiy-tadqiqot institutining Navoiy ilmiy-tajriba stansiyasi, Agrotexnika bölimi boşliği,
Yaraşev Komil Naimjonoviç
Akademik Mahmud Mirzayev nomidagi Boğdorçilik, uzumçilik va vinoçilik ilmiy-tadqiqot institutining Navoiy ilmiy-tajriba stansiyasi, Seleksiya bölimi boşliği

Annotatsiya

Maqolada Navoiy viloyatidagi olxöri boğlarini kasallik va zararkunandalardan himoya qilişning ilmiy asoslari adabiyotlar tahlili orqali yoritiladi. Navoiy meteorologik stansiyasining oylik harorat me'yorlari, xalqaro fitosanitar ma'lumotlar va mevali ekinlarni uyğunlaşgan himoya qiliş tavsiyalari soliştirildi. Monilioz, teşik doğlaniş alomatlari, bakterial rak, ildiz böğzi çirişi va şarka kasalligini farqlaş; olxöri mevaxöri, şiralar, örgimçakkana va qalqondorlarni kuzatiş mezonlari keltirildi. Boğning beş nuqtasida yigirmata daraxtni muntazam tekşirişga möljallangan namunaviy monitoring sxemasi hamda fenologik bosqiçlarga boğlangan himoya jadvali taklif etildi. Tahlilga köra, himoya qarorlarini daraxtning rivojlaniş bosqiçi, zararlaniş dinamikasi, namlaniş şaroiti va foydali organizmlar holatiga tayangan holda qabul qiliş maqsadga muvofiq. Sanitariya, suğorişni boşqariş va biologik muvozanatni saqlaş asosiy çoralar sifatida qaraladi. Kimyoviy işlov faqat taşxis va kuzatuv natijasi bilan asoslanganda qöllanadi. Maqola mahalliy dala tajribasi natijalarini emas, Navoiy şaroitida tekşiriş va moslaştiriş zarur bölgan ilmiy-amaliy yondaşuvni taqdim etadi.

Kalit sözlar: olxöri, Navoiy viloyati, monilioz, olxöri mevaxöri, şira, örgimçakkana, monitoring, uyğunlaşgan himoya.

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Kiriş.

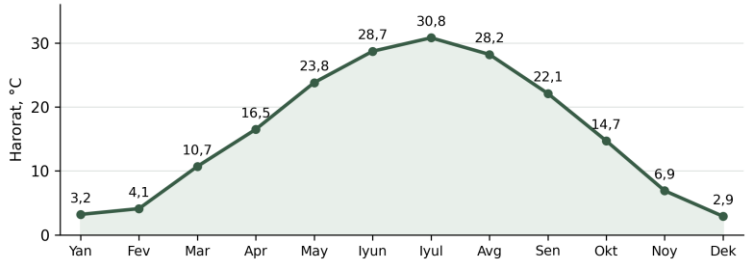
Olxöri mevasining bozor qiymati hosil miqdori bilan birga taşqi körinişi, butunligi va saqlaniş xususiyatlariga boğliq. Barg va novdalar zararlanişi daraxtning oziqlanişini zaiflaştiradi; meva içida oziqlanuvçi qurtlar hamda çiriş jarayonlari esa sotiladigan mahsulot uluşini kamaytiradi. Şu sababli boğni himoya qilişda hosil yiğimigaça bölgan butun mavsumni qamrab oluvçi kuzatuv tizimi zarur.

Maqolaning maqsadi olxöri kasalliklari va zararkunandalari haqidagi işonçli ma'lumotlarni umumlaştiriş, Navoiy boğlari uçun taşxis, kuzatuv va kuraş çoralarining özaro boğlangan tartibini taklif etişdir. Asosiy e'tibor takroriy dorilaş soniga emas, har bir tadbirning biologik asosiga va undan keyingi tekşiruvga qaratiladi.

Amaliy jihatdan boğning fitosanitar tarixi, köçat manbasi va navning pişiş muddati dastlabki ma'lumotlar majmuasini taşkil etadi. Bir xil alomat turli sabablardan yuzaga kelişi mumkinligi uçun diagnostika himoya rejasidan oldin bajariladi. Bu yondaşuv ösimlikni parvarişlaşdagi kamçilikni asossiz pestitsid işlovi bilan almaştirib yubormaslikka yordam beradi.

Hududiy şaroit va tahlil usuli

Navoiy hududida himoya tadbirlarini rejalaştiriş uçun havo harorati bilan birga suğoriladigan boğning öz mikroiqlimini hisobga oliş kerak. Yaponiya meteorologiya agentligining ClimatView bazasida NAVOI stansiyasi uçun iyun, iyul va avgust oylarining örtaça harorat me'yorlari mos ravişda 28,7; 30,8 va 28,2 °C sifatida berilgan [1]. Bu qiymatlar muayyan boğdagi kunlik harorat yoki joriy yil kuzatuvi örnini bosmaydi. Ular yozgi issiqlik fonini körsatuvçi hududiy ma'lumotdir.



1-rasm. NAVOI stansiyasining oylik örtaça harorat me'yorlari. Grafik JMA ClimatView jadvali [1] asosida tuzildi. Oçiq jadvalda me'yorning tayanç davri

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körsatilmagan; bu qator 2026-yilning amaldagi oylik ob-havosi sifatida talqin qilinmaydi.

Issiq mavsum şaroitida suğorişdagi uziliş va barglarga tuşadigan çangni kuzatiş ayniqsa muhim. Biroq havoning quruqligi barça kasalliklar xavfini yöqotmaydi. Qalin şox-şabba içida, uzoq namlanadigan barglarda yoki suv turib qoladigan ildiz zonasida patogen uçun qulay muhit saqlanişi mumkin. Şuning uçun kasallik xavfi butun viloyat uçun bir xil daraja bilan ifodalanmaydi; u alohida boğ bloklari böyiça baholanadi [2–6].

Manbalarni tanlaş va dalillar çegarasi.

Iş narrativ ilmiy şarh usulida bajarildi. Manba sifatida JMA iqlim jadvali, EPPO fitosanitar bazasi, Kaliforniya universitetining UC IPM tavsiyalari, Royal Horticultural Society ma'lumotlari, IRAC va FRAC hujjatlari hamda Özbekistonning ösimliklarni himoya qilişga oid qonuni tanlandi. Ma'lumotlar 2026-yil 31-oktabr holatida körib çiqildi. Tahlilda taşxis belgisi, tarqaliş yöli, kuzatuv obyekti va boşqaruv çorasi özaro soliştirildi.

Xorijiy qöllanmalardagi işlov sanalari, preparat me'yorlari va iqtisodiy zarar çegaralari Navoiy uçun tayyor me'yor sifatida köçirilmadi. Hudud böyiça dala qaydlari taqdim etilmagani sababli kasalliklarning uçraş foizi, zararkunandalarning avlod soni va kuraş samaradorligiga oid mahalliy raqamlar keltirilmadi. Keyingi bölimlardagi röyxatlar diagnostika va kuzatuv uçun ustuvor obyektlarni anglatadi.

Kasalliklarni farqlaş va infeksiya manbalarini kamaytiriş

Monilioz bilan boğliq gul va novda zararlanişida gullar sölişi, qisqa meva şoxçalari qurişi va nam havoda sporalar hosil bölişi kuzatiladi. *Monilinia spp*. qurib qolgan mevalar hamda zararlangan novdalarda saqlanişi mumkin. Daraxtda yoki yerda qolgan mumiyolangan mevalarni olib taşlaş keyingi mavsumdagi infeksiya manbasini kamaytiradi. Gullaş paytida namlaniş kuzatilgan va oldingi yillarda kasallik qayd etilgan bloklar alohida nazorat qilinadi [2].

Meva çirişida pöst şikastlanişi va mevalarning bir-biriga tegib turişi muhim omillardir. Şu bois mevaxör zarari, yiğimdagi eziliş va çiriş alohida qayd qilinsa-da, himoya dasturida birgalikda köriladi. Fungitsid zararlangan yoki çirigan mevani soğlom

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holatga qaytarmaydi; profilaktik çoralar infeksiya kirişi va yangi şikastlanişning oldini olişga qaratiladi [3].

Olxörida kasallikka öxşaş alomatlarni dastlabki farqlaş va tekşiriş yönalişlari

1-jadval.

Obyekt	Kuzatiladigan belgi	Tekşiriş va birlamçi çora
Monilioz *Monilinia spp.*	Gul va novda qurişi; mevada jigarrang çiriş va spora yostiqçalari.	Zararlangan a'zolarni ajratiş; mumiyolarni yiğiş; taşxisni tasdiqlaş [2, 3].
Teşik doğlaniş	Bargdagi doğ markazi tökiladi; ayrim novdalarda şikastlaniş böladi.	Zamburuğ, bakteriya va abiotik sabablarni farqlaş; namlanişni kamaytiriş [4].
Bakterial rak *Pseudomonas syringae*	Pöstloq nekrozi, yelim ajralişi, şoxlarning qurişi.	Soğlom va zararlangan töqima çegarasidan namuna; suv va oziqlaniş holatini tekşiriş [5].
Ildiz va ildiz böğzi çirişi *Phytophthora spp.*	Ösiş susayişi, söliş; ildiz böğzi töqimasi zararlanişi.	Drenaj va suğorişni tekşiriş; ildiz hamda tuproqdan laboratoriya namunasi [6].
Şarka Plum pox virus	Barg yoki mevada halqasimon doğlar, rang va şakl özgarişi.	ELISA yoki RT-PCR orqali tekşiriş; şubhali daraxtdan köpaytiriş materialini olmaslik [7].

Bargdagi har qanday teşikni klyasterosporioz deb baholaş notöğri. *Wilsonomyces carpophilus* bilan boğliq zararlaniş nam şaroitda rivojlanadi, ammo öxşaş alomatlarning boşqa sabablari ham bor. Yelim ajralişi ham mustaqil etiologik taşxis emas: mexanik şikastlaniş va fiziologik buzilişlar tekşirilişi kerak [4, 9].

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Bakterial rak va ildiz çirişini boşqarişda daraxtning suv rejimi hamda ildiz muhiti markaziy örin tutadi. Bakterial rakka qarşi kimyoviy işlovning işonçli davolovçi ta'siri kafolatlanmagan [5]. Şarka alomatlari gumon tuğdiradi, lekin laboratoriya tasdiğisiz uning Navoiyda mavjudligi haqida xulosa çiqarilmaydi [7].

Virus xavfini kamaytirişda tekşirilgan soğlom köçat va payvand materialidan foydalaniş asosiy çoradir. Şarka uçun boğda virusni bartaraf etuvçi davolaş vositasi mavjud emas; tasdiqlangan holatda hududiy fitosanitar xizmat körsatmasi asosida harakat qilinadi [7].

Zararkunandalar va foydali organizmlarni kuzatiş

Olxöri mevaxöri *Grapholita funebrana* EPPO bazasida Özbekistonda mavjud tur sifatida qayd etilgan, biroq uşbu yozuv uning Navoiy tumanlari kesimidagi tarqalişi va ziçligini körsatmaydi [8]. Liçinka meva içida oziqlanadi; meva kesilganda oziqlaniş izi, çiqindi va qurt aniqlanişi mumkin. Erta rang olgan mevalar tekşiriladi, ammo meva yelimlanişining özi mevaxörni tasdiqlamaydi [9].

Feromon tutqiç erkak kapalaklar uçişining boşlanişi va davomiyligini kuzatişga yordam beradi. Tutqiçdagi kapalak sonini mevaning zararlaniş foizi deb qabul qiliş mumkin emas. Feromonli monitoring meva tekşiruvi bilan birga olib boriladi; turga xos tutqiç va mahalliy mutaxassis tasdiği notöğri aniqlaş xavfini kamaytiradi. Tuxumdan çiqqan liçinka meva içiga kirib ulgurgaç, taşqi kontakt ta'sirning imkoniyati çeklanadi [9].

Kuzatuvda e'tibor beriladigan zararkunandalar va himoya qarori uçun dalillar

2-jadval.

Zararkunanda guruhi	Hisobga olinadigan belgi	Qarorni asoslaş
Olxöri mevaxöri *Grapholita funebrana*	Tutqiçdagi kapalak; kesilgan mevadagi qurt va oziqlaniş izi.	Uçiş dinamikasini yangi zararlaniş bilan soliştiriş [8, 9].

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Zararkunanda guruhi	Hisobga olinadigan belgi	Qarorni asoslaş
Şiralar *Brachycaudus helichrysi* va boşqa turlar	Yangi novdadagi tirik koloniya; buralgan barg; şira ajratmasi.	Tirik koloniya köpayişi va entomofaglar faolligini birga baholaş [10].
Örgimçakkanalar *Tetranychus spp.*	Barg ostidagi tirik kana; mayda oqiş nuqtalar, bronzalaniş yoki tör.	Kana bilan birga yirtqiç kanalarni sanaş; suv stressini tekşiriş [11].
Kaliforniya qalqondori *Comstockaspis perniciosus*	Pöstloqdagi qalqonçalar; tirik tana; yoş harakatçan liçinkalar.	Tirik zararkunandani böş qalqondan ajratiş; sezgir bosqiçni aniqlaş [12].

Şiralar bostirilgandan keyin ham avval buralgan barglar töliq yozilmasligi mumkin. Şuning uçun işlovdan keyingi baho eski taşqi belgiga emas, tirik koloniyalar va soğlom yangi ösuvga tayangan holda beriladi. Xonqizi, oltinköz va boşqa tabiiy kuşandalarning mavjudligi qayd qilinadi. Ularni saqlab qoliş uçun keng ta’sirli vositalarni asossiz qöllaşdan saqlaniş zarur [10].

Örgimçakkana köpaygan bloklarda bargning har ikki tomoni, ayniqsa pastki yuzasi lupa bilan köriladi. Yirtqiç kanalar yetarli bölsa, biologik nazorat zararkunanda ösişini çeklaşi mumkin; ayrim insektitsidlar bu muvozanatni buzadi [11]. Qalqondor kuzatuvida esa şoxdagi eski qobiqçalar sonidan köra tirik individ va harakatçan liçinkalar muhimroqdir [12].

Kuzatuv jurnalida zararkunanda topilgan daraxtning kodi va uning boğ çekkasida yoki içkarisida joylaşgani körsatilişi tavsiya etiladi. Bu qaydlar mavsum davomida öçoqning kengayişini aniqlaşga yordam beradi. Bir daraxtdagi yuqori ziçlik butun

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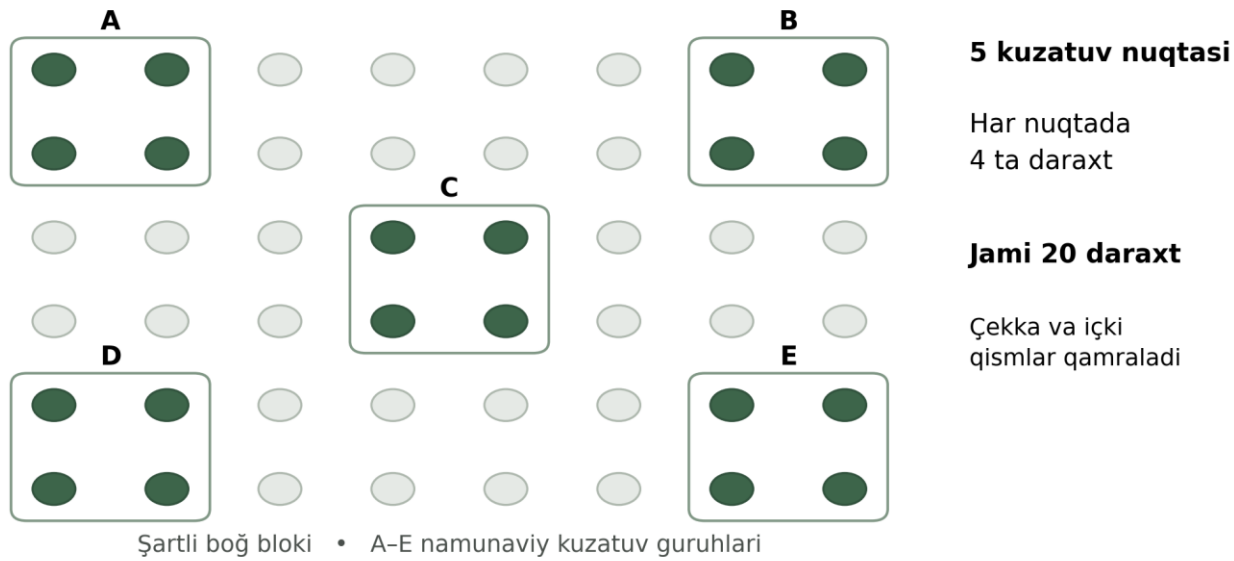
blokning örtaça holati deb olinmaydi. Şu bilan birga çekka qatordagi öçoq e'tiborsiz qoldirilmaydi: qöşimça tekşiruv uning çegarasini aniqlaşi lozim.

Dastlabki tur aniqlaşda şubha tuğilsa, namuna sanasi, daraxt kodi va zararlangan a'zo bilan birga entomologik tekşiruvga yuboriladi. Tur nomini faqat mevadagi teşik, barg rangi yoki umumiy xalqona atamaga qarab belgilaş keyingi himoya çoralarini notöğri tanlaşga olib kelişi mumkin.

Boğ monitoringini taşkil etiş

Har bir nav, daraxt yoşi va suğoriş şaroiti nisbatan bir xil maydon alohida kuzatuv bloki sifatida belgilanadi. Boşlanğiç amaliy variant sifatida blokning beş nuqtasida törttadan, jami yigirmata daraxtni tanlaş taklif etiladi. 2-rasmdagi sxema muallif tomonidan tuzilgan namunaviy reja bölib, rasmiy iqtisodiy zarar çegarasi yoki tajribada tekşirilgan tanlanma hajmi emas. Katta yoki notekis boğlarda nuqtalar soni oşiriladi.



2-rasm. Bir xil agrofonli boğ blokida kuzatuv daraxtlarini tanlaşning namunaviy sxemasi. Yaşil doiralar tekşiriladigan daraxtlarni bildiradi. Bu haqiqiy xöjalik xaritasi yoki dala kuzatuvi natijasi emas.

Har daraxtning turli tomonlaridan törtta yoş novda, beşta barg va meva mavjud davrda beşta meva tekşirilsa, bir kuzatuvda 80 novda, 100 barg va 100 meva baholanadi. Barglar faqat zararlangan joydan tanlanmaydi; tanlaş tartibi oldindan belgilanadi. Şubhali öçoqlardan olingan qöşimça namunalar umumiy kuzatuv tanlanmasidan alohida

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yoziladi. Mevaning içki zararlanişini aniqlaş uçun oldindan tanlangan namunalar kesib köriladi.

Kuzatuvni boşlanğiç tartibda haftasiga bir marta ötkaziş, gullaşdagi nam ob-havo yoki zararkunanda tez köpaygan davrda esa oraliqni qisqartiriş taklif etiladi. Bir xil belgilangan daraxtlarda takroriy tekşiruv özgarişni kuzatişga yordam beradi. Jurnalga sana, blok va daraxt kodi, fenologik bosqiç, tekşirilgan a'zolar soni, tirik zararkunanda, yangi alomatlar va tabiiy kuşandalar kiritiladi.

Zararlangan a'zolar uluşi ularning sonini jami tekşirilgan a'zolar soniga bölib, yuzga köpaytiriş orqali hisoblanadi. Kasallik tarqalişi bilan zararlaniş oğirligi alohida körsatkiçlardir: bitta mayda doği bölgan barg va katta qismi nobud bölgan barg tarqaliş hisobida bir xil birlik hisoblanadi. Oğirlikni baholaş uçun tanlangan şkala oldindan yoziladi va butun mavsum özgartirilmaydi.

Fenologik bosqiçlarga mos uyğunlaşgan himoya

Uyğunlaşgan himoya agrotexnika, sanitariya, biologik nazorat va zaruratga asoslangan kimyoviy usullarni bir tizimda qöllaşni anglatadi. Jadvaldagi bosqiçlar mahalliy daraxt holatiga qarab belgilanadi. Bir nav gullaşdan çiqqan paytda boşqasi gullayotgan bölişi mumkin; şu sababli butun xöjalikka bir xil kalendar sanasini belgilaş töğri kelmaydi.

Olxöri boğida mavsumiy kuzatuv va himoya tadbirlarining tavsiya etiladigan ketma-ketligi

3-jadval.

Rivojlaniş bosqiçi	Asosiy kuzatuv	Ustuvor amaliy tadbir
Barg tökilgandan kurtak börtişigaça	Mumiyolangan meva, qurigan şox, tirik qalqondor; drenaj holati.	Infeksiya manbalarini yiğiş; quruq ob-havoda zararlangan şoxlarni kesiş; asboblarni tozalaş.

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Rivojlanish bosqichi	Asosiy kuzatuv	Ustuvor amaliy tadbir
Kurtak börtişi va gullaş oldi	Oldingi yil zarari, qişlagan bosqiçlar, yangi barg va gullar.	Tutqiçlarni tur biologiyasiga mos vaqtda örnatiş; kuzatuv jurnalini boşlaş.
Gullaş	Gullarning qurişi; yomğir va namlaniş; çanglatuvçilar.	Asalarilarni himoya qiliş; kasallik xavfi bölsa faqat ruxsat etilgan profilaktik çorani tanlaş.
Meva tugiş va ösiş	Mevaxör uçişi, yoş liçinka zarari, tirik şira koloniyalari.	Zararlangan tökilgan mevalarni yiğiş; zarurat bölsa sezgir bosqiçga yönaltirilgan işlov.
Yoz va pişiş oldi	Kana va yirtqiçlar, suv stressi; yangi meva çirişi.	Suğorişni tekislaş; çangni kamaytiriş; hosilgaça kutiş muddatini hisobga oliş.
Hosil yiğimi va undan keyin	Soğlom hamda şikastlangan meva uluşi; şox va ildiz holati.	Ezilişsiz teriş va saralaş; mavsum xarajatlarini hisoblaş; keyingi yil rejasi.

Suğorişda barg va mevani ortiqça höllaşdan saqlaniş, ildiz böğzi yonida uzoq suv turişini bartaraf etiş lozim. Tomçilatib suğoriş qöllanganda ham suv sarfi, tomçilatkiç işlaşi va namlaniş çuqurligi tekşiriladi. Texnologiya nomining özi ildiz çirişidan himoyani kafolatlamaydi. Drenaj, payvandtag xususiyati va tuproqning havo rejimi birgalikda baholanadi [4, 6].

Şox-şabbani me’yorida siyraklaştiriş kuzatuv va yiğimni yengillaştiradi. Öğitlaş tuproq yoki barg tahlili hamda ösuv holatiga moslaştiriladi. Tabiiy kuşandalarni saqlaş biologik himoyaning boşlanğiç şartidir. Sotib olinadigan entomofag yoki biopreparatni qöllaş esa nişon tur, mahalliy moslaşuv, sifat va mahsulot yöriqnomasi böyiça alohida

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asoslanişi kerak [10–13]. Sanitariya tadbiri yakunida yiğilgan zararlangan mevalar boğ çetida oçiq uyum holida qoldirilmaydi. Ularni qayta infeksiya yoki zararkunanda çiqişi manbasiga aylantirmaydigan usulda boşqariş kerak. Kesiş asboblari tozalanadi, şubhali daraxtlar belgilanadi va ulardan köçat yoki payvand materiali olinmaydi. Yangi keltirilgan köçatlar hujjatlari hamda ildiz, tana va payvand joyining holati ekişdan oldin tekşiriladi [2, 7].

Har bir tadbir jurnalga bajarilgan sana, maydon, kuzatilgan sabab va keyingi tekşiruv muddati bilan kiritilişi tavsiya etiladi. Suğorişdagi nosozlik, sanitariya işlari va biologik kuzatuv ham qayd etiladi. Şunday yozuvlar himoya natijasini faqat dorilaş bilan boğlab yubormasdan, agrotexnik omillarning hissasini ham baholaş imkonini beradi.

Kimyoviy çoralarni tanlaş va natijani baholaş

Kimyoviy işlov zararkunanda yoki kasallik töğri aniqlanganda, kuzatuvlar xavf ortayotganini körsatganda va tanlangan tadbir kutilayotgan zararni kamaytira olganda rejalaştiriladi. Özbekiston qonunçiligi ösimliklarni himoya qiliş vositalarini röyxatdan ötkazişni nazarda tutadi [15]. Amaliyotda preparatning aynan olköri va tegişli zararli organizm uçun ruxsati, qöllaş me’yori, işlovlar soni hamda yöriqnomasi tekşiriladi. Uşbu şarh aniq mahsulot uçun mahalliy ruxsat yoki doza örnini bosmaydi.

Insektitsid va akaritsidlarni almaşlab qöllaşda savdo nomidan köra ta’sir mexanizmi muhimdir. Bir xil IRAC guruhidagi ikki mahsulotni ketma-ket almaştiriş rezistentlikni boşqariş uçun yetarli emas. Guruhlarni navbatlaştiriş zararkunandaning avlodlari va sezgir rivojlaniş davriga mos rejalaştiriladi [13]. Fungitsidlar uçun FRAC tavsiyalari, mavsumiy çeklovlar va faol moddalarning özaro ta’siri hisobga olinadi [14]. Işlov natijasi pasayganda taşxis, purkagiç qoplaşi va qöllaş vaqti ham tekşiriladi.

Hosil yiğimigaça kutiş muddati va işlov berilgan maydonga qayta kiriş muddati har bir mahsulot yöriqnomasi böyiça alohida bajariladi. Gullaşda çanglatuvçilarga zarar yetkazişi mumkin bölgan işlovlardan saqlaniş, purkaşning qöşni maydonlarga köçişini çeklaş va belgilangan himoya kiyimlaridan foydalaniş zarur. Aralaşmalar faqat

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yöriqnomada ruxsat etilganda tayyorlanadi. Yuqori harorat va suv stressidagi daraxtda fitotoksiklik xavfi ham baholanadi.

Samaradorlikni qayd etiş

Har bir tadbirdan oldin va keyin bir xil usulda yangi zararlaniş, tirik zararkunanda hamda foydali organizmlar qayd qilinadi. Meva yiğimida mevaxör zarari, çiriş, mexanik eziliş va quyoş kuyişi alohida guruhlarga ajratiladi. Bir mevada bir neçta şikastlaniş bölişi mumkinligi hisobga olinadi; şu sababli alohida sabablar uluşini qöşiş har doim umumiy yaroqsiz mahsulot uluşini bermaydi.

Ilmiy sinov rejalaştirilganda odatdagi xöjalik himoyasi bilan taklif etilgan monitoringga asoslangan tizim bir xil nav va agrofon şaroitida taqqoslanadi. Variantlar takroriy bloklarga tasodifiy joylaştiriladi; köplab barg yoki meva tekşirilgani mustaqil dala takrorlari soni sifatida olinmaydi. Karantin talabi va kuçli zarar xavfi mavjud joyda himoyasiz nazorat qoldirişga yöl qöyilmaydi. Tajriba hajmi oldindan kutilgan farq hamda maydon özgaruvçanligiga qarab asoslanadi.

Iqtisodiy bahoda sotişga yaroqli hosil qiymati bilan preparat, mehnat, yoqilği va monitoring xarajatlari soliştiriladi. Bir mavsumdagi yaxşi natija köp yillik samaradorlik kafolati emas. Turli ob-havo şaroitlarida olingan kuzatuvlar mahalliy qaror mezonlarini aniqlaştirişga xizmat qiladi.

Xulosa.

Navoiy olxöri boğlari uçun himoyaning asosiy yönalişi taşxis, muntazam hisob va agrotexnik parvarişni birlaştirişdir. Moniliozda infeksiya qoldiqlarini kamaytiriş, ildiz çirişida suv rejimini tuzatiş, mevaxörda uçiş va meva zararlanişini birga kuzatiş, şira hamda kanada tabiiy kuşandalarni hisobga oliş ustuvor hisoblanadi. Taklif etilgan jadvallar va monitoring sxemasi boğ böyiça qaydlarni tartibga soladi. Ularning mahalliy samarasi hamda işlov çegaralari esa Navoiy ilmiy-tajriba stansiyasi şaroitida ötkaziladigan kuzatuv va takroriy sinovlar bilan tasdiqlanişi kerak.

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SUN'IY INTELLEKTNING IQTISODIYOTGA VA ISH O'RINLARIGA TA'SIRI

Ilmiy rahbar: Shukurov Umidjon,
Andijon davlat texnika instituti
Iqtisodiyot kafedrasi assistenti,
O'rinboyev Islombek Ismoijon o'g'li
Andijon davlat texnika instituti
"Iqtisodiyot" yo'nalishi 4-kurs talabasi

Annotatsiya. Maqolada sun'iy intellekt (SI) texnologiyalarining iqtisodiy o'sish, mehnat unumdorligi va bandlikka ta'siri nazariy va amaliy jihatdan tahlil qilinadi. Xalqaro tashkilotlar hisobotlari va ilmiy adabiyotlarga tayanib, SI ta'sirida ish o'rinlarining qisqarishi hamda yangi ish o'rinlarining paydo bo'lishi yo'nalishlari o'rganilgan. O'zbekistonda SI texnologiyalarini rivojlantirish strategiyasi (2024-yil) ko'rib chiqilib, mehnat bozorini yangi sharoitga moslashtirish bo'yicha takliflar bildirilgan.

Kalit so'zlar: sun'iy intellekt, raqamli iqtisodiyot, mehnat bozori, bandlik, avtomatlashtirish, mehnat unumdorligi, kadrlarni qayta tayyorlash, O'zbekiston.

Abstract. The article analyses the impact of artificial intelligence (AI) on economic growth, labour productivity and employment. Based on reports of international organisations and academic literature, it examines both the displacement of jobs and the creation of new ones. The paper also reviews Uzbekistan's AI development strategy until 2030 and proposes measures for adapting the national labour market.

Keywords: artificial intelligence, digital economy, labour market, employment, automation, productivity, reskilling, Uzbekistan.

Kirish.

So'nggi yillarda sun'iy intellekt, ayniqsa generativ modellar, iqtisodiyotning deyarli barcha tarmoqlariga kirib bormoqda. Matn yozish, dasturlash, tarjima,

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ma’lumotlarni tahlil qilish, mijozlarga xizmat ko‘rsatish kabi ilgari faqat inson bajargan vazifalarning bir qismini endi algoritmlar bajara oladi. Bu jarayon bir tomondan mehnat unumdorligini oshirish va iqtisodiy o‘sishni tezlashtirish imkonini bersa, ikkinchi tomondan ayrim kasblarning yo‘qolishi va ijtimoiy tengsizlikning kuchayishi xavfini tug‘diradi.

Mavzuning dolzarbligi shundaki, SI ta’siri avvalgi texnologik to‘lqinlardan sifat jihatidan farq qiladi: avtomatlashtirish endi faqat qo‘l mehnati yoki oddiy takroriy ishlarni emas, balki bilim va tahlilga asoslangan, yuqori malakali kasblarni ham qamrab olmoqda [2]. Shu sababli davlatlar, tadbirkorlar va ishchilar uchun bu o‘zgarishni to‘g‘ri baholash va unga tayyorgarlik ko‘rish muhim ahamiyat kasb etadi.

Tadqiqotning maqsadi — sun’iy intellektning iqtisodiyotga va ish o‘rinlariga ta’sirini nazariy va qiyosiy jihatdan tahlil qilish hamda O‘zbekiston sharoiti uchun xulosa va takliflar ishlab chiqishdir. Maqsadga erishish uchun quyidagi vazifalar belgilandi: (1) texnologik o‘zgarishning mehnat bozoriga ta’siri haqidagi nazariy yondashuvlarni ko‘rib chiqish; (2) xalqaro tashkilotlarning prognozlarini taqqoslash; (3) O‘zbekistondagi siyosiy va institutsional asoslarni o‘rganish; (4) amaliy tavsiyalar berish.

Tadqiqot usullari: tahliliy-qiyosiy tahlil, tizimli yondashuv, ikkilamchi ma’lumotlarni umumlashtirish. Maqola ochiq manbalardagi nashrlar va rasmiy hujjatlarga asoslangan; O‘zbekiston bo‘yicha alohida birlamchi empirik tadqiqot o‘tkazilmagan, shu bois mamlakatga oid xulosalar tahliliy xarakterga ega.

Nazariy asoslar.

Texnologik taraqqiyot tarixan bir vaqtning o‘zida ayrim ish o‘rinlarini yo‘qotgan va yangilarini yaratgan. Sanoat inqiloblari davrida qo‘l mehnati mashinalar bilan almashtirilgan, ammo iqtisodiyot kengayib, yangi tarmoq va kasblar paydo bo‘lgan. D. Otor (Autor) fikricha, avtomatlashtirish ayrim vazifalarni almashtirsa-da, ko‘pincha insonning boshqa vazifalarini to‘ldiradi, unumdorlik va daromadni oshiradi hamda yangi sohalarda talabni kuchaytiradi, shuning uchun ish o‘rinlari umumiy hajmda yo‘qolib ketmaydi [5].

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K.Frey va M.Osborn (Frey, Osborne) AQSh misolida kasblarning kompyuterlashtirilish ehtimolini baholab, mehnat bozoridagi ish o‘rinlarining taxminan 47 foizi yuqori xavf toifasiga kirishini ko‘rsatgan [3]. Biroq keyingi tadqiqotlar kasbning emas, balki alohida vazifalarning avtomatlashtirilishini tahlil qilish to‘g‘riroq ekanini ta’kidladi: bir kasb ichida ayrim vazifalar mashinaga o‘tsa, qolganlari insonda saqlanadi.

D.Acemoglu va P.Restrepo vazifalarga asoslangan modelida texnologiyaning mehnatga ta’siri ikki qarama-qarshi kuch orqali tushuntiriladi: siqib chiqarish effekti (mashinalar avval odamlar bajargan vazifalarni o‘z zimmasiga oladi) va qayta tiklash effekti (texnologiya mehnat uchun yangi vazifalar va kasblarni yaratadi) [4]. Ish o‘rinlari va ish haqining dinamikasi shu ikki effektning nisbatiga bog‘liq. E. Brinyolfsson va E. Makafi esa «ikkinchi mashina davri»da kognitiv vazifalar avtomatlashtirilishi iqtisodiyotni tubdan o‘zgartirishini ta’kidlaydi [6].

Xalqaro valyuta jamg‘armasi (XVJ) mutaxassislariga ko‘ra, SI avvalgi avtomatlashtirish to‘lqinlaridan o‘zining yuqori malakali kasblarga ham ta’sir qila olishi bilan ajralib turadi; shu sababli rivojlangan mamlakatlar katta xavfga duch kelsa-da, SI imkoniyatlaridan foydalanish uchun ko‘proq salohiyatga ham ega [2].

SI iqtisodiy o‘sishga bir necha yo‘nalishda ta’sir ko‘rsatadi:

✓ mehnat unumdorligining oshishi — hujjatlarni tayyorlash, ma’lumotlarni qayta ishlash, dasturlash, mijozlarga xizmat ko‘rsatish kabi vazifalarda vaqt va xarajat tejaladi;

✓ xarajatlarning kamayishi — prognozlash, logistika, texnik xizmat ko‘rsatish va sifat nazoratida xatolar va yo‘qotishlar kamayadi;

✓ yangi mahsulot va xizmatlar — shaxsiylashtirilgan ta’lim, tibbiy diagnostika, aqlli qishloq xo‘jaligi va moliyaviy xizmatlar kabi yangi bozorlar shakllanadi;

✓ qaror qabul qilish sifatining yaxshilanishi — katta hajmdagi ma’lumotlarga tayangan tahlil boshqaruv samaradorligini oshiradi.

Goldman Sachs tahlilchilari generativ SI keyingi o‘n yil ichida jahon yalpi ichki mahsulotini taxminan 7 foizga oshirishi va o‘rtacha 300 million to‘liq bandli ish o‘rniga

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avtomatlashtirish ta’sirini ko‘rsatishi mumkinligini taxmin qilgan [7]. Bunday baholar kelajak haqidagi stsenariylar ekanini, ular qabul qilingan faraz va usullarga bog‘liq bo‘lishini unutmaslik kerak. Shu bilan birga, SI foydasi teng taqsimlanmasligi mumkin. Agar texnologiya asosan yuqori daromadli xodimlarning mehnatini to‘ldirsa va kapital egalarining daromadini oshirsa, boylik tengsizligi chuqurlashadi; XVJ tahlilida ko‘pchilik stsenariylarda SI umumiy tengsizlikni kuchaytirishi ehtimoli qayd etilgan [2]. Mamlakatlar o‘rtasida ham raqamli tafovut oshishi xavfi bor: infratuzilma va malakali kadrlar yetishmagan davlatlar SI afzalliklaridan kamroq foydalanadi.

Eng katta xavf takroriy, qoidalarga asoslangan vazifalar bajariladigan kasblarda kuzatiladi. Jahon iqtisodiy forumi (JIF) hisobotiga ko‘ra, ma’lumot kiritish xodimlari, bank kassirlari, kotib-ma’murlar kabi ofis va mijozlarga xizmat ko‘rsatish bilan bog‘liq kasblar kamayuvchi toifaga kiradi [1]. Generativ SI matn tuzish, tarjima, oddiy dasturlash, birlamchi tahlil kabi vazifalarni ham tezlashtirgani sababli, ilgari «xavfsiz» hisoblangan ayrim aqliy mehnat kasblari ham o‘zgarishga uchraydi. Texnologik o‘zgarish yangi talabni ham keltirib chiqaradi. JIF ma’lumotlariga ko‘ra, eng tez o‘sayotgan kasblar qatorida katta ma’lumotlar mutaxassislari, moliyaviy texnologiyalar muhandislari, SI va mashinali o‘qitish mutaxassislari bor [1]. Bundan tashqari, SI tizimlarini ishlab chiqish, sozlash, nazorat qilish, kiberxavfsizlik va ma’lumotlar sifatini ta’minlash bilan bog‘liq yangi vazifalar paydo bo‘ladi. Ya’ni Acemoglu va Restrepo ta’kidlagan qayta tiklash effekti amalda namoyon bo‘lmoqda [4].

Eng muhim muammo - ish o‘rinlarining umumiy soni emas, balki yo‘qolayotgan va yaratilayotgan kasblar o‘rtasidagi nomuvofiqlikdir. Bir sohada ishsiz qolgan xodim boshqa sohada yangi ish topishi uchun yangi ko‘nikmalarga ega bo‘lishi kerak. JIF hisobotiga ko‘ra, 2030-yilgacha ishchi kuchining katta qismi qayta tayyorlash yoki malaka oshirishga muhtoj bo‘ladi [1]. Analitik fikrlash, ijodkorlik, moslashuvchanlik, texnologik savodxonlik va hissiy intellekt kabi ko‘nikmalar qadrini oshiradi.

SI ta’siri turli guruhlarga turlicha bo‘ladi. XVJ tahlilida yosh ishchilar yangi imkoniyatlardan osonroq foydalana olishi, keksa ishchilar esa moslashishda qiyinchilikka duch kelishi mumkinligi qayd etilgan [2]. Shuningdek, ta’lim darajasi,

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kasb turi va hudud bo‘yicha farqlar ham ta’sir etadi; shu sababli davlat siyosati ijtimoiy jihatdan zaif guruhlarga alohida e’tibor qaratishi lozim.

Quyidagi jadvalda SI ning mehnat bozoriga ta’siri haqidagi asosiy xalqaro baholar jamlangan.

SI ning mehnat bozoriga ta’siri bo‘yicha xalqaro baholar

1-jadval.

Manba	Asosiy baho	Izoh
Jahon iqtisodiy forumi, 2025 [1]	2030-yilgacha ~170 mln yangi ish o‘rni yaratiladi, ~92 mln ish o‘rni siqib chiqariladi; sof o‘sish ~78 mln	O‘zgarish hozirgi ish o‘rinlarining taxminan 22 foizini qamrab oladi
XVJ, 2024 [2]	Global bandlikning deyarli 40 foizi SI ta’siriga duchor; rivojlangan mamlakatlarda ~60, rivojlanayotgan bozorlarda ~40, kam daromadli mamlakatlarda ~26 foiz	«Ta’sirga duchor bo‘lish» ish o‘rni yo‘qolishini emas, vazifalar o‘zgarishi ehtimolini bildiradi
Goldman Sachs, 2023 [7]	~300 mln to‘liq bandli ish o‘rni avtomatlashtirish ta’siriga duchor; jahon YaIM ~7 foizga o‘sishi mumkin	Taxminiy stsenariy, o‘n yillik gorizont
Frey va Osborn, 2017 [3]	AQShda ish o‘rinlarining ~47 foizi yuqori xavf toifasida	Kasblar darajasidagi baho; vazifalar darajasidagi tahlillarga nisbatan yuqori

Jadvaldan ko‘rinadiki, turli manbalarning baholari bir-biridan farq qiladi, chunki ular turli usul va ko‘rsatkichlarga tayanadi: ba’zilari kasblar bo‘yicha, boshqalari vazifalar bo‘yicha hisoblaydi; ba’zilari «ta’sirga duchor bo‘lish»ni, boshqalari ish o‘rinlarining haqiqiy yo‘qolishini baholaydi. Shu bois prognozlarni aniq natija emas, balki yo‘nalish ko‘rsatkichi sifatida qabul qilish to‘g‘ri. Umumiy xulosa shuki, SI ta’siri

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global miqyosda ish o‘rinlari sonini keskin kamaytirishdan ko‘ra, ularning tarkibini va talab qilinadigan ko‘nikmalarni o‘zgartirishi ehtimoli yuqori; bunda o‘tish davri ijtimoiy xarajatlar bilan kechadi.

O‘zbekistonda SI ni rivojlantirishga davlat darajasida katta e’tibor qaratilmoqda. 2021-yilda Prezident farmoni bilan SI texnologiyalarini jadal joriy etish uchun shart-sharoitlar yaratish chora-tadbirlari belgilangan bo‘lsa, 2024-yil 14-oktabrda PQ-358-son qaror bilan «Sun’iy intellekt texnologiyalarini 2030-yilgacha rivojlantirish strategiyasi» tasdiqlandi [8]. Strategiya «Raqamli O‘zbekiston — 2030» strategiyasi bilan uyg‘unlashtirilgan va SI ni ijtimoiy-iqtisodiy sohalarga keng joriy etish uchun qulay sharoit yaratishni ko‘zda tutadi; uning maqsadlari qatorida mamlakatni hukumatlarning SI tayyorgarligi indeksida dunyoning dastlabki 50 ta davlati qatoriga olib chiqish ham bor [8, 9].

XVJ tasnifiga ko‘ra, rivojlanayotgan iqtisodiyotlarda SI ning dastlabki ta’siri rivojlangan mamlakatlarga qaraganda kamroq bo‘ladi, lekin infratuzilma va malakali kadrlar yetishmasligi texnologiya afzalliklaridan foydalanishni cheklashi mumkin [2]. O‘zbekiston uchun quyidagi omillar muhim:

✓ yoshlar ulushining yuqoriligi — bu SI ni tez o‘zlashtirish uchun katta imkoniyat, ayni paytda har yili mehnat bozoriga kirayotgan yoshlar uchun yangi ish o‘rinlari yaratish zaruratini ham bildiradi;

✓ tarmoqlar bo‘yicha ta’sir — bank-moliya, savdo, aloqa, davlat xizmatlari, ta’lim va axborot texnologiyalari sohalarida takroriy vazifalar avtomatlashtirilishi ehtimoli yuqori, qishloq xo‘jaligi va sanoatda esa SI aniq dehqonchilik, sifat nazorati va prognozlash orqali samaradorlikni oshirishi mumkin;

✓ raqamli infratuzilma va kadrlar — internet sifati, hisoblash quvvati, ma’lumotlar markazlari va SI sohasidagi mutaxassislar sonini oshirish strategiya amalga oshishining shartidir;

✓ norasmiy bandlik va mehnat migratsiyasi — norasmiy sektorda band bo‘lganlar va chet elda ishlayotganlar ishlaydigan sohalarda SI ta’sirini alohida o‘rganish zarur.

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Shunday qilib, SI O‘zbekiston uchun ham imkoniyat, ham xavf manbaidir: u IT-xizmatlar eksporti, davlat xizmatlari sifati va tadbirkorlik samaradorligini oshirishi mumkin, biroq tayyorgarlik ko‘rilmasa, ayrim kasb egalari uchun ishsizlik va daromad kamayishi xavfini tug‘diradi.

Taklif va tavsiyalar.

Tahlil natijalariga ko‘ra, SI ning ijobiy ta’sirini kuchaytirish va salbiy oqibatlarini yumshatish uchun quyidagi choralar maqsadga muvofiq:

1. Ta’lim tizimining barcha bosqichlarida raqamli va SI savodxonligini joriy etish, o‘quv dasturlarini tanqidiy fikrlash, ijodkorlik va ma’lumotlar bilan ishlash ko‘nikmalariga yo‘naltirish;
2. Xavf ostidagi kasb egalari uchun qayta tayyorlash va malaka oshirish dasturlarini kengaytirish, ish beruvchilar bilan hamkorlikda amaliy kurslar tashkil etish;
3. SI ta’sirida ish o‘rnini yo‘qotganlar uchun ijtimoiy himoya va ishga joylashtirishga ko‘maklashish tizimini mustahkamlash (XVJ ham ijtimoiy xavfsizlik tarmog‘i va qayta o‘qitish dasturlarini tavsiya qiladi [2]);
4. Kichik biznes va startaplar uchun SI vositalarini joriy etishni rag‘batlantirish, soliq va moliyaviy imtiyozlar mexanizmlarini takomillashtirish;
5. Raqamli infratuzilmani (keng polosali internet, hisoblash quvvatlari, ma’lumotlar markazlari) rivojlantirish va ochiq ma’lumotlardan foydalanishni kengaytirish;
6. Kasblar va tarmoqlar kesimida SI ta’siri bo‘yicha mehnat bozori monitoringi tizimini yo‘lga qo‘yish, qaror qabul qilishda shu ma’lumotlarga tayanish;
7. SI dan foydalanishning huquqiy va axloqiy asoslarini (shaxsiy ma’lumotlar himoyasi, mas’uliyat, shaffoflik) takomillashtirish.

Xulosa.

Tadqiqot shuni ko‘rsatadiki, sun’iy intellekt mehnat unumdorligini oshirish va iqtisodiy o‘sishni tezlashtirish uchun katta imkoniyat yaratadi, biroq u mehnat bozorida jiddiy tarkibiy o‘zgarishlarni ham keltirib chiqaradi. Xalqaro prognozlar umumiy ish o‘rinlari soni bo‘yicha nisbatan ijobiy bo‘lsa-da, yo‘qolayotgan va yangi paydo

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bo‘layotgan kasblar o‘rtasidagi ko‘nikmalar tafovuti muhim muammo bo‘lib qolmoqda [1, 2].

O‘zbekiston uchun asosiy vazifa — SI ni rivojlantirish strategiyasini inson kapitalini rivojlantirish, qayta tayyorlash va ijtimoiy himoya choralari bilan uyg‘unlashtirishdir. Shunda texnologiya ish o‘rinlariga tahdid emas, balki bandlik sifatini va iqtisodiy samaradorlikni oshirish vositasiga aylanadi. Kelgusi tadqiqotlarda O‘zbekiston mehnat bozori bo‘yicha kasblar kesimidagi empirik ma’lumotlar asosida SI ta’sirini miqdoriy baholash maqsadga muvofiq.

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AYOLLAR TADBIRKORLIGINI MOLIYALASHTIRISH VA IQTISODIY IMKONIYATLARINI KENGAYTIRISH: MOLIYAVIY INKLYUZIYANING ROLI

Yusupova Dilnavo Nurbek qizi
Farg‘ona davlat texnika universiteti
“Iqtisodiyot” yo‘nalishi 3-kurs talabasi
e-mail: dilnavoxon.yusupova@gmail.com

Annotatsiya. Ushbu maqolada O‘zbekistonda ayollar tadbirkorligini moliyalashtirish va moliyaviy inklyuziyaning ayollarning iqtisodiy imkoniyatlarini kengaytirishdagi roli 2020–2025-yillardagi rasmiy hisobotlar, Jahon banki, BMTTD va O‘zbekiston Markaziy banki ma’lumotlari hamda xalqaro ilmiy adabiyotlar asosida tahlil qilinadi. Tadqiqot ikkilamchi ma’lumotlarga tayangan tavsifiy-tahliliy dizaynga ega bo‘lib, hisob egaligi, kredit hajmi va tuzilmasi, mulkchilik va kredit ulushlari nisbatini solishtiradi. Natijalar ko‘rsatadiki, hisob egaligi bo‘yicha gender tafovuti deyarli yopilgan (ayollarda 2021-yildagi 39 foizdan 2024-yilda 61 foizgacha), ayollarga berilgan kreditlar soni 2020–2025-yillarda taxminan to‘rt baravar oshgan, biroq ayollar MKO‘Klarning taxminan uchdan bir qismiga egalik qilgani holda MKO‘K kreditlarining atigi 14 foizini olmoqda. Demak, moliyaviy inklyuziyaning “kirish” bosqichi hal bo‘lmoqda, “foydalanish” va “moliyalashtirish” bosqichlari esa ortda qolmoqda. Ilmiy yangilik sifatida inklyuziyani uch bosqichda (kirish, foydalanish, moliyalashtirish) tahlil qilish sxemasi hamda kredit ulushining mulk ulushiga nisbatini ifodalovchi gender-moliyalashtirish pariteti (GMP) ko‘rsatkichi taklif etiladi. Amaliy jihatdan kredit kafolati, to‘lov ma’lumotlariga asoslangan skoring, natijaga bog‘langan imtiyozlar va qarov yukini yengillashtiruvchi vositalarni birgalikda qo‘llash tavsiya etiladi.

Kalit so‘zlar: ayollar tadbirkorligi, moliyaviy inklyuziya, kreditga kirish imkoniyati, gender tafovuti, MKO‘K, kredit kafolati, raqamli moliya, O‘zbekiston.

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Kirish.

Ayollar tadbirkorligi so‘nggi yillarda O‘zbekiston iqtisodiy siyosatining ustuvor yo‘nalishlaridan biriga aylandi. BMTTD ma’lumotiga ko‘ra, 2024-yilda mamlakatda 2,1 mln ayol tadbirkor faoliyat yuritgan va bu ko‘rsatkich 2020-yilga nisbatan yetti baravar yuqori. Markaziy bank hisobotida ro‘yxatdan o‘tgan 5,2 mln o‘zini o‘zi band qilgan shaxsning 2,1 mlni ayollar ekani qayd etilgan (Central Bank of the Republic of Uzbekistan [CBU], 2026), ya’ni ularning ulushi taxminan 40 foizni tashkil etadi. Jahon bankining 2024-yilgi gender bahosiga ko‘ra, ayollar va erkaklarning iqtisodiy ishtirokini tenglashtirish milliy daromadni taxminan 29 foizga oshirishi mumkin. Biroq ko‘lam moliyaviy imkoniyatlar tengligini anglatmaydi. Jahon banki ma’lumotiga ko‘ra, ayollar ro‘yxatdan o‘tgan MKO‘Klarning deyarli uchdan bir qismiga egalik qiladi, ammo MKO‘K kreditlarining atigi 14 foizini oladi; ayollar rahbarligidagi korxonalarning 23 foizi moliyaga kirishni asosiy to‘siq deb ko‘rsatgan, erkaklar rahbarligidagi korxonalarda bu ko‘rsatkich 10 foizni tashkil etadi. Shu bilan birga, Markaziy bankning o‘z tahlili moliyaga kirish asosiy cheklov emasligini, eng katta to‘siq ish va oilaviy majburiyatlar muvozanatidagi tafovut ekanini ta’kidlaydi. Bu holat savol qo‘yadi: moliyaviy inklyuziya ayollarning iqtisodiy imkoniyatlarini aynan qaysi bosqichda va qay darajada kengaytirmoqda?

Ushbu maqolada keltirilgan ulushlar va o‘sish sur’atlari sektorning ko‘lamini ko‘rsatadi, moliyalashtirishning mustaqil sababiy ta’sirini emas; bu cheklov tadqiqot davomida hisobga olinadi.

Mavzuga oid adabiyotlar tahlili.

Moliyaviy inklyuziya bo‘yicha xalqaro adabiyot uning samarasi vositaning turiga bog‘liq ekanini ko‘rsatadi. Demirgüç-Kunt va hammualliflar (2017) sharhida to‘lov va jamg‘arma xizmatlari uy xo‘jaliklarining barqarorligi uchun muhimligi, kredit orqali biznesga ta’sir esa ancha murakkab ekani bayon etilgan. Banerjee va boshq. (2015) olti mamlakatda o‘tkazilgan tasodifiy baholashlarda mikrokreditning o‘rtacha ta’siri kamtarona bo‘lganini, uni “o‘zgartiruvchi” vosita deb bo‘lmasligini aniqlagan. Aksincha, Suri va Jack (2016) Keniyada mobil pul xizmatlariga kirish iste’molni

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oshirib, uy xo‘jaliklarining taxminan 2 foizini qashshoqlikdan chiqarganini, bu ta’sir ayollar boshchiligidagi xo‘jaliklarda kuchliroq bo‘lganini ko‘rsatgan.

Ayollar kesimida de Mel va boshq. (2009) Shri-Lankada o‘tkazilgan tajribada ayollar mikrokorxonalarida kapitalning daromadliligi erkaklarnikidan past bo‘lganini topgan; bu natija ayollar moliyaviy cheklovga ko‘proq duch kelishi haqidagi sodda xulosani rad etib, faoliyat turi va korxona tuzilmasining ahamiyatini ko‘rsatadi. Duflo (2012) ayollarning iqtisodiy imkoniyatlari va iqtisodiy rivojlanish o‘zaro bog‘liq bo‘lsa-da, bu bog‘liqlik o‘z-o‘zidan ishlamasligini, maqsadli siyosat talab etilishini asoslagan. Chundakkadan va Sasidharan (2022) kross-mamlakat tahlilida moliyaga kirishdagi gender tafovuti madaniy, iqtisodiy va tartibga solish omillari majmuasi bilan shakllanishini ko‘rsatgan. Valencia-Arias va boshq. PRISMA 2020 uslubidagi tizimli sharhida garov va kredit tarixining yetishmasligi asosiy to‘siqlar sifatida qayd etilib, moslashtirilgan moliyaviy vositalar va gender nuqtai nazarini hisobga oluvchi dasturlar zarurligi xulosa qilingan; Rukmiyati va boshq. (2024) ham tafovutni ko‘p omilli hodisa deb baholaydi.

Raqamli moliya ayollar uchun kirish eshigi sifatida qaralmoqda. Global Findex 2025 ma’lumotlari asosida Norris va Sharma (2026) ayollarning yarmi birinchi hisobini ish haqi yoki davlat to‘lovini olish uchun ochganini, biroq hisobga kirish foydalanishni kafolatlamasligini ta’kidlaydi: past va o‘rta daromadli mamlakatlarda ayollar to‘lovni olgach, mablag‘ning to‘liq qismini yechib olishga erkaklarga qaraganda 7 foiz bandiga ko‘proq moyil.

O‘zbekiston bo‘yicha Avalova (2025) ayollar tadbirkorligini qo‘llab-quvvatlash dasturlarini (“Ayollar daftari”, “Har bir oila – tadbirkor” va boshqalar) tahlil qilib, moliyaviy, ta’limiy va texnologik qo‘llab-quvvatlash zarurligini ko‘rsatgan. BMTTD (2025) bahosi ayollar tadbirkorligining jadal o‘sishini, shu bilan birga ularning moliyaviy cheklovlar va ijtimoiy qarov yuki bilan bog‘liq muammolarini qayd etadi. Ko‘rib chiqilgan manbalar doirasida mahalliy tadqiqotlar asosan dasturlar va kredit hajmlarini bayon qiladi; inklyuziyaning bosqichlari (hisobga kirish, undan foydalanish,

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kredit olish) va kredit ulushining mulk ulushiga nisbati alohida tahlil qilinmagan. Mazkur maqola shu bo‘shliqni to‘ldirishga qaratilgan.

Maqolaning maqsadi O‘zbekistonda moliyaviy inklyuziya ayollarning iqtisodiy imkoniyatlarini qaysi bosqichlarda kengaytirayotganini va qaysi to‘siqlar tufayli samarasi cheklanayotganini baholashdir. Tadqiqot savollari:

✓ 2020–2025-yillarda ayollar tadbirkorligi va ularga berilgan kreditlar qanday o‘zgargan?

✓ Moliyaviy inklyuziyaning kirish, foydalanish va moliyalashtirish bosqichlarida gender tafovuti qay darajada saqlanmoqda?

✓ Davlat va xalqaro tashkilotlarning qo‘llab-quvvatlash vositalari qanday imkoniyat va cheklovlarni yaratadi?

Tahlil quyidagi takliflarga tayanadi: hisob egaligi bo‘yicha tafovut yopilgan bo‘lsa-da, kredit ulushi mulk ulushidan past qolmoqda; kredit sonining o‘sishi uning o‘rtacha hajmi va sifatining o‘sishini kafolatlamaydi; moliyalashtirishning samarasi nomoliyaviy to‘siqlarni (qarov yuki, ma’lumotdan xabardorlik, ko‘nikmalar) bartaraf etishga bog‘liq.

Tadqiqot metodologiyasi.

Tadqiqot tavsifiy-tahliliy dizaynda, ikkilamchi ma’lumotlar asosida o‘tkazildi. Birlamchi ma’lumot (so‘rovnoma, intervyu) yig‘ilmadi, shu sababli tadqiqot sababiy ta’sirni baholamaydi; u bog‘liqliklarni aniqlaydi va nazariy xulosalar bilan izohlaydi. Tahlil davri 2020–2025-yillarni qamrab oladi. Triangulyatsiya uchun uch guruh manba tanlandi: (1) milliy rasmiy hujjatlar, ya’ni Markaziy bankning WE-Finance Code bo‘yicha yillik hisoboti (2) xalqaro tashkilotlar materiallari, ya’ni Global Findex 2025 asosidagi tahlil, Jahon bankining FINGROW loyihasi bo‘yicha axborotnomasi, BMTTD hisoboti va Toshkent xalqaro investitsiya forumida keltirilgan ADB ma’lumotlari, (3) ilmiy adabiyotlar.

Tahlil to‘rt bosqichda amalga oshirildi. Birinchi, ko‘rsatkichlar dinamikasi boshlang‘ich va so‘nggi yil bo‘yicha solishtirildi. Ikkinchi, hosila ko‘rsatkichlar hisoblandi: o‘rtacha kredit hajmi = jami kredit hajmi / kreditlar soni; ayollar ulushi =

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ayollar MKO‘Klari soni / barcha MKO‘Klar soni; gender-moliyalashtirish pariteti GMP = ayollarning kreditdagi ulushi / ayollarning mulkdagi ulushi (GMP = 1 tenglikni, 1 dan past qiymat ayollar ulushi pastligini bildiradi). Uchinchi, moliyaviy inklyuziya kirish (hisob egaligi), foydalanish (to‘lovlar, faol foydalanish) va moliyalashtirish (kredit) bosqichlariga ajratildi. To‘rtinchi, siyosat vositalari maqsadi va mexanizmi bo‘yicha guruhlandi.

Tadqiqotning cheklovlari: manbalarda “ayollar egaligidagi” va “ayollar rahbarligidagi” korxona ta’riflari farq qilishi mumkin; ayrim ko‘rsatkichlar yaxlitlangan (masalan, 2022-yilda “taxminan 500 ming” MKO‘K); Markaziy bank hisoboti tashabbusning o‘zi koordinatori tomonidan tayyorlangan, shu bois uning natijalarini mustaqil manbalar bilan solishtirish zarur; manbalar o‘rtasida hisob egaligi bo‘yicha boshlang‘ich qiymatlar farq qiladi.

Tahlil va natijalar.

1-jadvalda ayollar tadbirkorligi va moliyalashtirishning asosiy ko‘rsatkichlari dinamikasi jamlangan.

Ko‘rsatkich	Boshlang‘ich qiymat	So‘nggi qiymat	O‘zgarish
Ayol tadbirkorlar soni, mln	taxminan 0,3 (2020)*	2,1 (2024)	taxminan 7 baravar
Ayollar MKO‘Klari soni, ming	187 (2022)	225,0 (2025)	+20,3%
Barcha MKO‘Klar soni, ming	taxminan 500 (2022)	801 dan ortiq (2025)	taxminan +60%
Ayollar MKO‘Klarining ulushi, %*	taxminan 37,4	taxminan 28,1	−9,3 foiz bandi
Ayollarga berilgan kreditlar soni	100 790 (2020)	403 872 (2025)	taxminan 4,0 baravar
Ayollarga berilgan kreditlar hajmi, trln so‘m	4,9 (2020)	22,7 (2025)	+364%

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Ko‘rsatkich	Boshlang‘ich qiymat	So‘nggi qiymat	O‘zgarish
O‘rtacha kredit hajmi, mln so‘m*	48,6	56,2	+15,6% (nominal)
Ayollarda hisob egaligi, % (Findex)	39 (2021)	61 (2024)	+22 foiz bandi

*Manba: UNDP (2025); CBU (2026); Norris va Sharma (2026) ma’lumotlari asosida muallif hisob-kitoblari. * belgisi hosila ko‘rsatkichlarni bildiradi: 2020-yildagi ayol tadbirkorlar soni “yetti baravar o‘sish” ma’lumotidan, ulush va o‘rtacha kredit esa manbalardagi qiymatlar nisbatidan hisoblangan.*

Birinchi natija: ayollar tadbirkorligi ko‘lami sezilarli kengaygan, ammo bu o‘sish asosan o‘zini o‘zi band qilish va mikro darajada to‘plangan. Ro‘yxatdan o‘tgan ayollar MKO‘Klari 2022–2025-yillarda taxminan 20 foizga oshgan, barcha MKO‘Klar soni esa taxminan 60 foizga ko‘paygan; natijada ayollar ulushi taxminan 37 foizdan 28 foizgacha pasaygan. Shu bilan birga, 2,1 mln o‘zini o‘zi band qilgan ayolga nisbatan 225 ming ayollar MKO‘Kli to‘g‘ri keladi, ya’ni o‘zini o‘zi band qilgan taxminan 9 ayolga bitta ro‘yxatdan o‘tgan korxona to‘g‘ri keladi (ikki ko‘rsatkich birligi bir xil emas, shuning uchun nisbat taxminiy). Bu ayollar tadbirkorligining rasmiylashuvi va masshtablanishi alohida muammo ekanini ko‘rsatadi.

2-jadvalda moliyaviy inklyuziya bosqichlari bo‘yicha holat keltirilgan.

Bosqich	Ko‘rsatkich	Holat	Baho
Kirish	Ayollarda hisob egaligi	61% (2024; 2021-yilda 39%); ADB bahosida 62% (2021-yilda 46%)	Tafovut asosan yopilgan
Kirish	Davlat to‘lovlarini hisobga olgan ayollar	20% dan 34% gacha (2021–2024)	Raqamli to‘lovlar kirishni tezlashtirgan

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Bosqich	Ko‘rsatkich	Holat	Baho
Foydalanish	Hisobdan faol foydalanish, raqamli to‘lovlar	Gender kesimidagi milliy ma’lumot manbalarda yo‘q; ADB raqamli foydalanish va moliyaviy savodxonlikdagi tafovutni qayd etadi	Ma’lumot bo‘shlig‘i
Moliyalashtirish	Ayollarning MKO‘K kreditidagi ulushi	taxminan 14% (mulk ulushi taxminan 28–33%)	GMP taxminan 0,42–0,50
Moliyalashtirish	Moliyaviy to‘siqni asosiy deb bilgan korxonalar	Ayollarda 23%, erkaklarda 10%	2,3 baravar tafovut

Manba: Norris va Sharma (2026); Ministry of Investment, Industry and Trade (2025); World Bank (2025a); CBU (2026) asosida tuzilgan; GMP muallif hisob-kitobi (14/28,1 ≈ 0,50 va 14/33,3 ≈ 0,42).

Ikkinchi natija: kirish bosqichida tafovut deyarli yopilgan. Global Findex 2025 bo‘yicha ayollarda hisob egaligi 2021–2024-yillarda 39 foizdan 61 foizgacha oshgan, erkaklarda o‘sish kichikroq bo‘lgan, ya’ni ayollar tafovutni yopgan. Ushbu tahlilga ko‘ra, davlat to‘lovlarini hisobga olish ayollarda hisob ochishning muhim sababi bo‘lgan. ADB keltirgan 46 foizdan 62 foizgacha o‘sish boshlang‘ich qiymati bo‘yicha Findex’dan farq qiladi, biroq 2024-yildagi darajaga yaqin ekani natijaning barqarorligini ko‘rsatadi. Raqamli infratuzilma ham kengaygan: Markaziy bank ma’lumotiga ko‘ra, 2025-yilga kelib aholining 44 foizdan ortig‘ida raqamli hisob bo‘lgan.

Uchinchi natija: moliyalashtirish bosqichida tafovut saqlanib qolmoqda. Ayollarga berilgan kreditlar soni 2020-yildagi 100 790 tadan 2025-yilda 403 872 tagacha, hajmi 4,9 trln so‘mdan 22,7 trln so‘mgacha oshgan. Biroq o‘rtacha kredit hajmi besh yilda nominal hisobda atigi 15,6 foizga o‘sgan; ya’ni o‘sish asosan kreditlar sonining ko‘payishi hisobiga ta’minlangan. Narxlar o‘sishi hisobga olinmagan, shu

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sababli real hisobda o‘rtacha kredit hajmi kamayganligi ehtimoldan xoli emas, bu keyingi tadqiqotda baholanishi lozim. GMP ko‘rsatkichi 0,42–0,50 oralig‘ida bo‘lib, ayollarning kreditdagi ulushi mulkdagi ulushining qariyb yarmiga teng. Bundan tashqari, Markaziy bank platformasi muammoli kreditlar ulushini ham kuzatsa-da, ochiq manbalarda uning gender kesimi topilmadi; shu sababli ayollar kreditlarining sifati haqida xulosa chiqarib bo‘lmaydi.

To‘rtinchi natija: qo‘llab-quvvatlash vositalari moliyaviy va nomoliyaviy yo‘nalishlarni qamrab oladi. Moliyaviy tomondan “Oilaviy tadbirkorlikni rivojlantirish” dasturi doirasida “Oila kredit” raqamli platformasi garovsiz kreditlarni onlayn berishni ta’minlagan, “Hamroh” va “Biznesga birinchi qadam” dasturlari kirish to‘siqlarini pasaytirgan; 2025-yildagi Prezident qaroriga (PQ-103) ko‘ra 250 ming ayolga kasbiy va tadbirkorlik o‘qitish, 1000 nafar murabbiy-tadbirkorga grant ajratish, onalik ta’tilidagi ayollar uchun kredit to‘lovi muddatini 10 oygacha uzaytirish nazarda tutilgan (CBU, 2026; manbalarda qaror sanasi 14 va 17 mart deb turlicha ko‘rsatilgan). Institutsional tomondan 2024-yildan WE-Finance Code tashabbusi joriy etilgan, a’zolar soni 3 tadan 19 tagacha oshgan, 15 tijorat banki ichki gender siyosatini qabul qilgan, 2 500 mahalla bankiri va 9 000 dan ortiq bank agenti xabardorlikni oshirish uchun jalb etilgan, 2025-yildagi o‘quv tadbirlarining 70 foizdan ortig‘i poytaxtdan tashqarida o‘tkazilgan (CBU, 2026). Jahon banki FINGROW loyihasi (100 mln AQSh dollari kredit va 5 mln dollar grant) kredit kafolatlari orqali 2030-yilgacha taxminan 7 000 MKO‘K, shu jumladan ayollar va yoshlar rahbarligidagi 4 500 korxonani moliyalashtirishni ko‘zda tutadi (World Bank, 2025a).

Natijalar.

Olingan natijalar adabiyotdagi xulosalar bilan asosan mos keladi. Birinchidan, hisob egaligidagi muvaffaqiyat Suri va Jack (2016) hamda Norris va Sharma (2026) topilmalariga muvofiq, to‘lovlar raqamlashtirilishi bilan bog‘liq ko‘rinadi; biroq hisob egaligi kreditga kirishni o‘z-o‘zidan ta’minlamaydi. Bu inklyuziyani bosqichlarga ajratish zarurligini asoslaydi: Findex ko‘rsatkichi “kirish” bosqichini o‘lchaydi,

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“moliyalashtirish” bosqichi esa alohida ko‘rsatkichlarni (GMP, o‘rtacha kredit hajmi, kredit sifati) talab qiladi.

Ikkinchidan, Markaziy bank hisoboti moliyaga kirish asosiy cheklov emasligini, asosiy to‘siq qarov yuki ekanini ta’kidlaydi; hisobotda McKinsey so‘roviga ko‘ra ayollarning uy va oila majburiyatlari biznesni boshlashga to‘sqinlik qilishini bildirish ehtimoli erkaklarnikidan ikki baravar yuqori ekani, Jahon banki bahosiga ko‘ra 60 foizdan ortiq ayol bolalar va keksalarga qarashni mehnat bozoridagi asosiy to‘siq deb atagani, BMTTD so‘roviga ko‘ra esa 48 foiz ayol ish va oila majburiyatlarini uyg‘unlashtirishda jiddiy qiyinchilik sezishi qayd etilgan (CBU, 2026). Jahon bankining ayollar rahbarligidagi korxonalarning 23 foizi moliyani asosiy to‘siq deb atagani ma’lumoti bilan birgalikda bu moliya zarur, ammo yetarli bo‘lmagan shart ekanini bildiradi. Bu xulosa Duflo (2012) va de Mel va boshq. (2009) qarashlariga mos: kapital qo‘shilishi o‘z-o‘zidan natija bermaydi, faoliyat turi va uy xo‘jaligi sharoitlari hal qiluvchi.

Uchinchidan, kreditlar sonining to‘rt baravar oshishi imtiyozli va garovsiz dasturlar ta’sirini aks ettirishi mumkin, biroq o‘rtacha kredit hajmining sekin o‘sishi mikro darajadagi kreditlar ustuvorligini ko‘rsatadi. Banerjee va boshq. (2015) mikrokreditning o‘rtacha ta’siri cheklangan ekanini ko‘rsatgan; shu sababli kichik kreditlarning ko‘payishi o‘z-o‘zidan biznesning o‘sishiga olib kelmasligi mumkin. Taxminlarimiz holati: birinchisi qisman tasdiqlandi (kirish bosqichida tafovut yopilgan, moliyalashtirishda saqlanmoqda); ikkinchisi kreditlar soni bo‘yicha tasdiqlandi, sifati bo‘yicha ma’lumot yetarli emas; uchinchisi manbalardagi dalillar bilan mos keladi, ammo birlamchi ma’lumotlar bilan tekshirilishi kerak.

Xulosa va takliflar.

O‘zbekistonda moliyaviy inklyuziya ayollarning iqtisodiy imkoniyatlarini kengaytirishga hisob va to‘lov infratuzilmasiga kirishni osonlashtirish, kreditga kirishni kengaytirish va nomoliyaviy qo‘llab-quvvatlashni birlashtirish orqali xizmat qilmoqda. 2024-yilda ayollarning 61 foizi hisobga ega bo‘lgan va hisob egaligi bo‘yicha tafovut yopilgan, ayollarga berilgan kreditlar soni 2020–2025-yillarda taxminan to‘rt baravar

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oshgan. Biroq ayollar MKO‘K kreditlarining atigi 14 foizini oladi (GMP taxminan 0,42–0,50), ro‘yxatdan o‘tgan korxonalar ulushi esa pasaygan. Moliyaviy inklyuziyaning samarasi kirish ko‘rsatkichlariga emas, foydalanish sifati, kredit tuzilmasi va nomoliyaviy to‘siqlar bartaraf etilishiga bog‘liq. Ushbu xulosalar tavsifiy xarakterga ega va sababiy emas; ularni birlamchi ma’lumotlar va ta’sirni baholash usullari bilan tekshirish kerak.

Shu asosda quyidagi takliflar ishlab chiqildi:

Birinchidan, ayollar moliyaviy inklyuziyasini bosqichlar bo‘yicha monitoring qilish tavsiya etiladi. Milliy ma’lumotlar platformasida hisob egaligi bilan birga faol foydalanish, kreditdagi ulush (GMP), o‘rtacha kredit hajmi va muammoli kreditlar ulushining gender kesimini ochiq e’lon qilish siyosatni ma’lumotga tayanib yuritish imkonini beradi.

Ikkinchidan, garovi yetarli bo‘lmagan ayol tadbirkorlar uchun kredit kafolati mexanizmlarini kengaytirish maqsadga muvofiq. FINGROW doirasida Tadbirkorlikni rivojlantirish kompaniyasi orqali taqdim etiladigan kafolatlar ayollar ulushini oshirish bo‘yicha aniq maqsad bilan bog‘lanishi lozim; bunda davlat kreditni to‘liq subsidiyalamaydi, balki bank riskining bir qismini bo‘lishadi.

Uchinchidan, hisobga kirishdan kreditga o‘tishni raqamli iz orqali ta’minlash zarur. Ayollarning 61 foizi hisobga ega bo‘lgani hisobga olinsa, to‘lovlar, mobil hamyon va soliq ma’lumotlariga asoslangan skoring garov o‘rniga pul oqimini baholash imkonini beradi; shu orqali ayollarning kredit tarixi yo‘qligi bilan bog‘liq to‘siq kamayadi.

To‘rtinchidan, imtiyozli dasturlarni natijaga bog‘lash va tadbirkorlarni “zinapoya” bo‘ylab ko‘tarish taklif etiladi: mikrokreditdan lizing va uzoq muddatli investitsion kreditga o‘tish, rasmiylashuvni rag‘batlantirish hamda murabbiylik va moliyaviy savodxonlik xizmatlarini kredit mahsuloti bilan birga taqdim etish. Qarov yukini yengillashtiruvchi choralar (kredit to‘lovini uzaytirish, bolalar va keksalarga qarash xizmatlari) samarasini esa tasodifiy yoki yarim eksperimental baholash orqali tekshirish maqsadga muvofiq.

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Umuman olganda, ayollar tadbirkorligini moliyalashtirish siyosatining maqsadi hisob yoki kreditlar sonini ko‘paytirish bilan cheklanmasligi, balki moliyaviy resurslarni ayollarning daromadli, barqaror va o‘sishga qodir bizneslariga samarali yetkazishi lozim.

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YASHIL MOLIYALASHTIRISH MEXANIZMLARINING BARQAROR IQTISODIY O‘SISHGA TA’SIRI: RIVOJLANAYOTGAN MAMLAKATLAR TAJRIBASI VA O‘ZBEKISTON UCHUN XULOSALAR

Yusupova Dilnavo Nurbek qizi
Farg‘ona davlat texnika universiteti
“Iqtisodiyot” yo‘nalishi 3-kurs talabasi
e-mail: dilnavonxon.yusupova@gmail.com

Annotatsiya. Ushbu maqolada yashil moliyalashtirish mexanizmlarining barqaror iqtisodiy o‘sishga ta’siri bo‘yicha rivojlanayotgan mamlakatlar tajribasi 2020–2026-yillarda e’lon qilingan empirik tadqiqotlar, OECD va UNDP hujjatlari hamda O‘zbekiston rasmiy manbalari asosida tahlil qilinadi. Tadqiqot ikkilamchi ma’lumotlarga tayangan tavsifiy-tahliliy dizaynga ega bo‘lib, tanlangan to‘rtta empirik ishni yashil moliya o‘lchovi, natija o‘zgaruvchisi, vaqt gorizonti va tanlanma bo‘yicha solishtiradi. Natijalarga ko‘ra, to‘rtta manbadan uchtasi yashil moliya va iqtisodiy o‘sish o‘rtasida ijobiy yoki qo‘llab-quvvatlovchi bog‘liqlikni, bittasi esa uzoq muddatda statistik ahamiyatli bog‘liqlik yo‘qligini qayd etgan. Muhokamada ta’sir texnologik innovatsiya, inson kapitali, energetika infratuzilmasi va kapital bozori chuqurligi kanallari orqali amalga oshishi, ammo yashil moliyaning o‘zi o‘sishni kafolatlamasligi asoslanadi. O‘zbekiston uchun yashil loyihalar jamlanmasini shakllantirish, taksonomiyani takomillashtirish, kapital bozorini chuqurlashtirish va ta’sirni monitoring qilish tavsiya etiladi.

Kalit so‘zlar: yashil moliya, barqaror iqtisodiy o‘sish, rivojlanayotgan mamlakatlar, yashil obligatsiyalar, kapital bozori, yashil taksonomiya, O‘zbekiston.

Kirish.

Hozirgi kunda rivojlanayotgan mamlakatlar iqtisodiy o‘sishni saqlash va ekologik barqarorlikni ta’minlash kabi ikki vazifani bir vaqtda hal qilishga majbur. O‘zbekiston

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uchun bu vazifa ayniqsa dolzarb. OECD (2023) hisobotiga ko‘ra, mamlakat iqtisodiyoti dinamik o‘sayotgan bo‘lsa-da, energiya va issiqxona gazlari bo‘yicha yuqori intensivlikka ega, iqtisodiy rivojlanish va iqlim o‘zgarishini yumshatish bo‘yicha qo‘yilgan maqsadlar esa, ayniqsa infratuzilmada, katta investitsiyalarni talab qiladi. Byudjet cheklovlari sharoitida bunday o‘zgarishni xususiy moliyalashtirishni ko‘paytirmasdan amalga oshirib bo‘lmaydi. Shu bois 2021-yildan boshlab yashil obligatsiyalar moliyalashtirish tafovutini yopish strategiyasining markaziy qismiga aylangan. Biroq bunday instrumentlarning iqtisodiy o‘sishga ta’siri haqidagi empirik dalillar bir xil emas va bu siyosat qarorlarini asoslashni qiyinlashtiradi.

Mavzuga oid adabiyotlar tahlili.

Moliya va o‘sish o‘rtasidagi bog‘liqlik bo‘yicha fundamental tadqiqotlardan biri King va Levine (1993) ishidir: ular 1960–1989-yillar uchun 80 ta davlat ma’lumotlari asosida moliya tizimi iqtisodiy o‘sishni rag‘batlantirishi mumkinligi haqidagi Shumpeter qarashiga mos dalillarni keltirgan. Yashil moliyani shu an’anaviy kanalning ixtisoslashgan shakli, ya’ni mablag‘larni ekologik jihatdan samarali loyihalarga yo‘naltiruvchi mexanizm sifatida talqin qilish mumkin. Bu talqin muallifniki bo‘lib, King va Levine ishida yashil moliya masalasi ko‘rilmagan.

Rivojlanayotgan mamlakatlar bo‘yicha so‘nggi tadqiqotlar bir xil xulosa bermaydi. Ali va boshq. (2024) 2000–2019-yillar uchun 13 ta endi rivojlanayotgan bozor iqtisodiyoti panel ma’lumotlarida yashil moliya, texnologik innovatsiya va inson kapitali yashil iqtisodiy o‘sishga yordam berishini, moliyaviy rivojlanish va iqtisodiy globallashuv esa bunday ta’sir ko‘rsatmasligini topgan. Pachiyappan (2025) Braziliya, Hindiston, Xitoy va Janubiy Afrika uchun panel ARDL usulini qo‘llab, uzoq muddatda yashil moliyaga yaqin ko‘rsatkichlarning hech biri YaIM bilan sezilarli bog‘liq emasligini, qisqa muddatda esa past uglerodli texnologiyalar savdosi YaIMga salbiy ta’sir ko‘rsatganini qayd etgan; mualliflar buni yashil loyihalarning katta boshlang‘ich xarajati va foydaning kechikishi bilan izohlaydi. Gafsi va Louhichi MENA mamlakatlarida 2010–2023-yillar uchun uzoq muddatli kointegratsiya borligini, yashil moliya va qayta tiklanuvchi energiya iste’moli YaIM bilan ijobiy bog‘liqligini hamda

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yashil moliya va iqtisodiy rivojlanish o‘rtasida ikki tomonlama sababiyat mavjudligini aniqlagan. Chen (2025) Xitoy, Hindiston va Braziliya uchun yashil moliya oqimlari past uglerodli o‘sishni va infratuzilma investitsiyalarini qo‘llab-quvvatlashi mumkin degan xulosaga kelgan, biroq bu konferensiya materiali bo‘lgani uchun qo‘shimcha dalil sifatida qaraladi.

Bu ishlar bir-biri bilan to‘g‘ridan-to‘g‘ri solishtirilishi qiyin, chunki ular yashil moliyani turlicha o‘lchaydi, turli natija o‘zgaruvchilaridan foydalanadi va turli vaqt gorizontlarini ko‘radi. Ko‘rib chiqilgan empirik namunaga Markaziy Osiyo mamlakatlari kirmagan, O‘zbekiston amaliyoti esa xalqaro dalillar bilan bog‘lab tahlil qilinmagan. O‘zbekiston misolida masala o‘ziga xos: OECD (2023) ma’lumotlariga ko‘ra, 2019-yildagi birinchi xalqaro obligatsiyadan keyin qisqa muddatda uchta tematik obligatsiya chiqarilgan, biroq davlatning iqtisodiyotdagi o‘ta katta roli va rivojlanmagan ichki kapital bozori xususiy mablag‘ni jalb qilishdagi asosiy cheklov bo‘lib qolmoqda. Shu sababli yashil moliyalashtirish hajmi emas, uning shartlari, ya’ni qaysi kanallar orqali va qanday muhitda ishlashi masalasi birinchi o‘ringa chiqadi.

Ushbu maqolaning maqsadi rivojlanayotgan mamlakatlar bo‘yicha empirik natijalardagi farqlarni tizimli solishtirish va O‘zbekiston yashil moliya amaliyotini shu kontekstda baholashdir. Tadqiqot savollari:

1. Yashil moliyaning iqtisodiy o‘sishga ta’siri qaysi shartlarda ijobiy bo‘ladi?
2. Qisqa va uzoq muddatli natijalar nima uchun farq qiladi?
3. O‘zbekiston amaliyoti xalqaro dalillar bilan qanday bog‘lanadi?

Tahlil quyidagi takliflarga tayanadi: yashil moliyaning ijobiy ta’siri uzoq muddatda yaqqolroq namoyon bo‘ladi; ta’sir kuchini texnologik va institutsional omillar belgilaydi.

Tadqiqot metodologiyasi.

Tadqiqot tavsifiy-tahliliy dizaynda, ikkilamchi ma’lumotlar asosida o‘tkazildi. Birlamchi ma’lumot yig‘ilmadi va mustaqil ekonometrik baholash bajarilmadi, shuning uchun tadqiqot sababiy ta’sirni baholamaydi; u mavjud natijalarni solishtiradi va ularni nazariy kanallar bilan izohlaydi. Manbalar 2026-yil noyabrida RePEc/IDEAS, DOAJ,

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nashriyotlar saytlari va xalqaro tashkilotlarning rasmiy sahifalari orqali qidirildi. Uch guruh manba triangulyatsiya uchun tanlandi. Birinchisi, rivojlanayotgan mamlakatlar bo‘yicha 2020–2026-yillardagi empirik ishlar (Ali va boshq., 2024; Pachiyappan va boshq., 2025; Gafsi va Louhichi, 2025; Chen, 2025). Ikkinchisi, xalqaro tashkilotlar hujjatlari (OECD, 2023; UNDP, 2023). Uchinchisi, rasmiy va mintaqaviy manbalar (Iqtisodiyot va moliya vazirligi, 2025; Murotov, 2025; AIFC Green Finance Centre, b.s.). Nazariy asos sifatida King va Levine (1993) ishi ishlatildi. Kiritish mezonlari: rivojlanayotgan yoki endi rivojlanayotgan mamlakatlar, yashil moliyaga yaqin ko‘rsatkich, iqtisodiy o‘sish yoki yashil o‘sish natijasi va e’lon qilingan natijalar. Natijalari hali e’lon qilinmagan ishlar chiqarildi, hakamlikdan o‘tmagan Adu-Gyamfi (2026) ishi esa asosiy namunaga kiritilmay, faqat qo‘shimcha ma’lumot sifatida qaraldi. O‘zbekiston bo‘yicha ma’lumotlar davri 2019–2025-yillarni qamrab oladi. Metodologik cheklovlar: namuna kichik (to‘rtta asosiy manba), ko‘pchilik manba annotatsiya darajasida baholandi, effekt o‘lchamlari bo‘yicha meta-tahlil o‘tkazilmadi, qidiruv Web of Science va Scopus orqali tizimli bajarilmadi, manbalar faqat ingliz tilidagi ishlardan iborat.

Tahlil va natijalar.

Birinchi, tanlangan empirik ishlar yashil moliya o‘lchovi, natija o‘zgaruvchisi, vaqt gorizonti va tanlanma bo‘yicha kodlandi. Ikkinchi, natijalar yo‘nalishi (ijobiy, ahamiyatsiz, aralash) bo‘yicha solishtirildi. Uchinchi, O‘zbekiston bo‘yicha tematik obligatsiyalar va institutsional baza xronologik tartibga solindi. To‘rtinchi, ular OECD (2023) aniqlagan cheklovlar bilan taqqoslandi.

1-jadval tanlangan empirik tadqiqotlarning qiyosiy tavsifini ko‘rsatadi.

Manba	Namuna va davr	Usul	Asosiy natija
Ali va boshq. (2024)	13 ta endi rivojlanayotgan bozor iqtisodiyoti, 2000–2019	Panel usullar (bog‘liqlik va geterogenlikni hisobga oluvchi)	Yashil moliya, innovatsiya va inson kapitali yashil o‘sishga yordam beradi; moliyaviy rivojlanish va globallashuv bermaydi

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Manba	Namuna va davr	Usul	Asosiy natija
Pachiyappan va boshq. (2025)	Braziliya, Hindiston, Xitoy, Janubiy Afrika	Panel ARDL	Qisqa muddatda aralash, uzoq muddatda ahamiyatsiz
Gafsi va Louhichi (2025)	MENA mamlakatlari, 2010–2023	Panel ARDL chegara testi, Granger sababiyligi	Uzoq muddatli kointegratsiya, ijobiy bog‘liqlik, ikki tomonlama sababiyat
Chen (2025)	Xitoy, Hindiston, Braziliya, so‘nggi o‘n yil	Siyosatni baholash doirasi (panel ma’lumotlar)	Past uglerodli o‘sishni qo‘llab-quvvatlashi mumkin (konferensiya materiali)

Manba: Ali va boshq. (2024); Pachiyappan va boshq. (2025); Gafsi va Louhichi (2025); Chen (2025) ma’lumotlari asosida tayyorlandi.

To‘rtta asosiy manbadan uchtasi yashil moliya yoki unga bog‘liq omillarning iqtisodiy o‘sish bilan ijobiy yoki qo‘llab-quvvatlovchi aloqasini qayd etgan. Bittasi uzoq muddatda ahamiyatli bog‘liqlik topmagan, qisqa muddatda esa turlicha natija olgan: past uglerodli texnologiyalar savdosi YaIMga salbiy, CO_2 emissiyasi va moslashish qobiliyati yetishmovchiligi esa ijobiy ta’sir ko‘rsatgan. Bu sonlar faqat ko‘rib chiqilgan manbalar sonini bildiradi va umumiy statistik xulosa emas. Mamlakatlar soni aniq ko‘rsatilgan ishlarda u 3 tadan 13 tagacha, tahlil davri esa 2000–2023-yillar oralig‘ida o‘zgaradi.

Natijalardagi farq to‘rt o‘lchov bo‘yicha izohlanadi. Birinchi, yashil moliya o‘lchovi: Chen (2025) moliyaviy oqimlarni, Pachiyappan va boshq. (2025) esa past uglerodli texnologiyalar savdosi kabi bilvosita ko‘rsatkichlarni olgan. Ikkinchi, natija o‘zgaruvchisi: Ali va boshq. (2024) yashil iqtisodiy o‘sishni, Pachiyappan va boshq. (2025) YaIMni tahlil qilgan; birinchi holda ekologik samaradorlik natijaning o‘ziga kiradi, shu sabab ijobiy bog‘liqlik ehtimoli yuqoriroq (muallif talqini). Uchinchi, vaqt gorizonti: faqat Pachiyappan va boshq. (2025) qisqa va uzoq muddatni alohida baholagan. To‘rtinchi, tanlanma tarkibi va usul: panel tahlil, ARDL va siyosatni baholash doirasi turlicha qo‘llangan.

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2-jadvalda O‘zbekistonda yashil moliya instrumentlari va institutsional bazaga oid asosiy ko‘rsatkichlar jamlangan.

Ko‘rsatkich	Qiymat
Birinchi xalqaro obligatsiya	2019-yil (OECD, 2023)
Suveren barqarorlik («SDG») obligatsiyasi	2021-yil
Birinchi korporativ yashil obligatsiya	2023-yil avgust, SanoatQurilishBank
Birinchi yashil suveren Yevrobondlar	2023-yil oktyabr, London fond birjasi, 4,25 trln so‘m; MDHda birinchi
«SDG» va «yashil» suveren obligatsiyalar jami	1,2 mlrd dollar (2021–2024)
«Yashil» belgili yevro obligatsiyalar	2025-yil fevral
Milliy yashil taksonomiya	2023-yilda tasdiqlangan
Qimmatli qog‘ozlar chiqarish qoidalari	2024-yil iyunda yashil moliya uchun yangilangan
Asosiy cheklovlar (OECD)	davlatning o‘ta katta roli; rivojlanmagan ichki kapital bozori; strategiyalarda xarajat hisob-kitoblari yetishmasligi
OECD hisoboti ma’lumotlari holati	2023-yil oktyabr

Manba: OECD (2023); UNDP (2023); Iqtisodiyot va moliya vazirligi (2025); Murotov (2025); AIFC Green Finance Centre (b.s.) ma’lumotlari asosida tayyorlandi.

OECD (2023) ma’lumotlariga ko‘ra, 2019-yildagi birinchi xalqaro obligatsiya chiqarilishidan keyin qisqa muddatda uchta tematik obligatsiya chiqarildi: 2021-yilda «Barqaror rivojlanish maqsadlari» deb nomlangan suveren barqarorlik obligatsiyasi va 2023-yilda ikkita yashil obligatsiya, biri suveren, biri korporativ. 2023-yil oktyabrida Londonda 4,25 trln so‘mlik yashil suveren Yevrobondlar joylashtirildi, bu MDHda birinchi yashil suveren obligatsiyalar edi (UNDP, 2023). Tushum suv tejovchi texnologiyalarni joriy etish, temir yo‘l va metro transportini rivojlantirish kabi loyihalarga yo‘naltirilishi ko‘zda tutilgan. Iqtisodiyot va moliya vazirligi (2025) 2021–2024-yillarda «Barqaror rivojlanish maqsadlari» va «yashil» toifalarida jami 1,2 mlrd dollarlik suveren xalqaro obligatsiyalar chiqarilganini xabar qilgan.

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Institutsional jihatdan Milliy yashil taksonomiya 2023-yilda Vazirlar Mahkamasi qarori bilan tasdiqlangan esa uni xalqaro ilg‘or amaliyot asosida takomillashtirishni tavsiya qiladi. OECD (2023) shuningdek, strategiyalarda ishonchli xarajat hisob-kitoblari va moliyalashtirish strategiyalari yetishmasligini qayd etadi, yirik quyosh va shamol energetikasi loyihalariga o‘xshash kelgusi loyihalarni esa yashil obligatsiyalarga kiritish uchun qulay yo‘nalish deb baholaydi. Hisobot 2023-yil oktyabrigacha bo‘lgan holatni aks ettiradi, shuning uchun keyingi chiqarilishlar unda yo‘q. Mahalliy birja bo‘yicha manbalar bir-biriga zid: AIFC Green Finance Centre (b.s.) Ipoteka-refinanslash kompaniyasining Toshkent fond birjasidagi 50 mlrd so‘mlik (taxminan 4 mln dollar) chiqarishini xabar qiladi, CAREC taqdimotida (Murotov, 2025) esa shu summadagi chiqarish boshqa emitent nomi bilan keltirilgan. Shu sababli bu ma’lumot miqdoriy dalil sifatida ishlatilmadi.

Tadqiqot uch asosiy natijani ko‘rsatdi. Birinchi, empirik dalillar yagona yo‘nalishga ega emas: to‘rtta manbadan uchtasi ijobiy, bittasi uzoq muddatda ahamiyatsiz bog‘liqlikni ko‘rsatadi, farq esa o‘lchov, natija o‘zgaruvchisi va gorizontdagi tafovutlar bilan bog‘liq. Ikkinchi, texnologik innovatsiya va inson kapitali hamda qayta tiklanuvchi energiya infratuzilmasi (Gafsi va Louhichi, 2025) ijobiy ta’sir shartlari sifatida ajraladi; institutsional omillarning moderatorlik roli ko‘rib chiqilgan manbalarning hech birida to‘g‘ridan-to‘g‘ri tekshirilmagan. Uchinchi, O‘zbekiston amaliyoti instrumentlarni yaratish bosqichida: taksonomiya, birinchi suveren va korporativ chiqarishlar mavjud, biroq OECD (2023) ko‘rsatgan institutsional cheklovlar saqlanib qolmoqda.

Birinchi taklif (uzoq muddatda yaqqolroq ta’sir) qisman tasdiqlandi: Gafsi va Louhichi (2025) uzoq muddatli kointegratsiyani, hakamlikdan o‘tmagan Adu-Gyamfi (2026) ishi esa uzoq muddatda YaIM o‘sishiga ijobiy ta’sirni qayd etgan, Pachiyappan va boshqalar esa buni tasdiqlamagan. Ikkinchi taklif (texnologik va institutsional omillar) bilvosita qo‘llab-quvvatlanadi. Yashil moliya o‘sishga quyidagi kanallar orqali xizmat qilishi mumkin.

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1. Texnologiya va inson kapitali. Ali va boshq. (2024) yashil moliyaning ta’siri texnologik innovatsiya va inson kapitali bilan birga namoyon bo‘lishini ko‘rsatadi. Shu sababli yashil moliyani ularni rivojlantirish siyosati bilan birga yuritish ta’sirni kuchaytirishi mumkin.

2. Energetika infratuzilmasi. Gafsi va Louhichi (2025) yashil moliya past uglerodli energetika infratuzilmasini qo‘llab-quvvatlashi orqali uzoq muddatli rivojlanishga xizmat qilishini topgan. Ikki tomonlama sababiyat esa o‘sish ham yashil moliyani jalb qilishini bildiradi, shu sabab bir tomonlama baholashlar ta’sirni oshirib ko‘rsatishi mumkin (muallif talqini).

3. Kapital bozori va investorlar bazasi. OECD (2023) keltirgan Jahon banki so‘roviga ko‘ra, tematik va barqarorlik bilan bog‘liq obligatsiyalar chiqargan 32 ta suveren emitentning asosiy motivi investorlar bazasini kengaytirish bo‘lgan. Tematik obligatsiyalarning xarajat afzalligi haqidagi dalillar esa hozircha cheklangan. Bu kanalning O‘zbekistondagi samarasi ichki kapital bozori chuqurligiga bog‘liq.

Xulosa va takliflar.

Rivojlanayotgan mamlakatlarda yashil moliyaning barqaror iqtisodiy o‘sishga ta’siri shartli bo‘lib, uning samarasi moliyaning qanday o‘lchanishi, o‘sishning nima deb olinishi, vaqt gorizonti hamda texnologik va institutsional sharoitlarga bog‘liq. Tahlil qilingan to‘rtta asosiy manbadan uchtasi ijobiy yoki qo‘llab-quvvatlovchi bog‘liqlikni, bittasi uzoq muddatda ahamiyatli bog‘liqlik yo‘qligini ko‘rsatdi. O‘zbekiston tematik obligatsiyalarni chiqarishda Markaziy Osiyoda yetakchi o‘rinlardan birini egalladi, biroq davlatning katta ulushi va rivojlanmagan kapital bozori xususiy mablag‘ni jalb qilishni cheklaydi. Ushbu xulosalar tavsifiy xarakterga ega va sababiy emas, shu sababli ularni mustaqil panel ma’lumotlari bilan tekshirish kerak.

Tadqiqot natijalari shuni ko‘rsatadiki, yashil moliya siyosatini faqat chiqariladigan obligatsiyalar hajmini oshirishga yo‘naltirish yetarli emas. Ta’sirni kuchaytirish uchun moliyalashtirishning mavjudligi bilan bir qatorda loyihalar sifati, institutsional muhit va kapital bozori chuqurligi ham hisobga olinishi lozim. Shu asosda quyidagi takliflar ishlab chiqildi.

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Birinchidan, yashil loyihalar jamlanmasini shakllantirish va taksonomiyani takomillashtirish maqsadga muvofiq. OECD (2023) vazirliklarning ustuvor infratuzilma loyihalari ro‘yxatiga tayanishni va yirik quyosh hamda shamol energetikasi loyihalariga o‘xshash loyihalarni yashil obligatsiyalarga kiritishni tavsiya qiladi. Milliy yashil taksonomiyani xalqaro ilg‘or amaliyotga muvofiq yaxshilash loyiha tanlovi va baholashni standartlashtiradi.

Ikkinchidan, ichki kapital bozorini chuqurlashtirish lozim. OECD (2023) uzoq muddatli rivojlanishni moliyalashtirish strategiyasini qabul qilishni, malakali kadrlar zaxirasini kengaytirishni va ikki savdo platformasini uyg‘unlashtirishni tavsiya qiladi. Bu shartlarsiz yashil moliyaning o‘sishga ta’siri cheklangan bo‘lib qolishi mumkin (muallif talqini).

Uchinchidan, ta’sirni monitoring qilish va texnologiya hamda inson kapitaliga investitsiyalarni uyg‘unlashtirish zarur. Pachiyappan va boshq. (2025) natijalaridagi uzoq muddatli noaniqlikni hisobga olib, yashil obligatsiyalar tushumining iqtisodiy va ekologik natijalarini muntazam hisobot qilish tavsiya etiladi (muallif tavsiyasi). Ali va boshq. (2024) natijalariga muvofiq yashil moliyani texnologik innovatsiya va inson kapitali siyosati bilan birga yuritish kerak.

Umuman olganda, O‘zbekistonda yashil moliyalashtirish siyosatining asosiy maqsadi chiqarilgan obligatsiyalar sonini maksimal oshirish emas, balki mablag‘larni iqtisodiy va ekologik natija beradigan loyihalarga samarali yetkazish bo‘lishi lozim. Buning uchun loyihalar jamlanmasi, taksonomiya, kapital bozori infratuzilmasi va ta’sirni monitoring qilish bir-birini to‘ldiruvchi mexanizmlar sifatida qo‘llanishi kerak.

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OLIY TA’LIM MUASSASALARIDA ILMIY RAHBAR VA TALABA HAMKORLIGINING TADQIQOTCHILIK KOMPETENSIYALARINI RIVOJLANTIRISHDAGI O‘RNI

Kobulov Ilxomjon Turg‘unboyevich
Andijon davlat texnika instituti
“Buxgalteriya hisobi” kafedrasi assistenti

Annotatsiya. Maqolada oliy ta’lim muassasalarida ilmiy rahbar va talaba hamkorligining tadqiqotchilik kompetensiyalarini rivojlantirishdagi pedagogik ahamiyati tahlil qilinadi. Ilmiy rahbarlikning maslahat berish, metodologik yo‘naltirish, fikr-mulohaza taqdim etish, akademik muloqotni tashkil etish va talabaning mustaqilligini qo‘llab-quvvatlash kabi yo‘nalishlari yoritiladi. Ilmiy adabiyotlar tahlili asosida samarali hamkorlikning asosiy tamoyillari hamda bosqichlari tizimlashtirilib, oliy ta’lim amaliyoti uchun takliflar ishlab chiqiladi. Maqola nazariy-tahliliy xarakterga ega; unda empirik tajriba natijalari da’vo qilinmaydi.

Kalit so‘zlar: ilmiy rahbar, talaba, hamkorlik, mentorlik, tadqiqotchilik kompetensiyasi, ilmiy muloqot, fikr-mulohaza, mustaqil izlanish, oliy ta’lim.

Kirish.

Oliy ta’lim tizimida talabalarning kasbiy tayyorgarligini chuqurlashtirish, mustaqil fikrlashini rivojlantirish va ilmiy faoliyatga jalb etish muhim vazifalardan biridir. Zamonaviy mutaxassis o‘z sohasidagi bilimlarni egallash bilan cheklanmay, yangi axborotni izlash, muammoni aniqlash, dalillarni tahlil qilish, asoslangan xulosa chiqarish va amaliy yechim taklif etish qobiliyatiga ham ega bo‘lishi zarur. Bu sifatlar tadqiqotchilik kompetensiyasining mazmunini tashkil etadi.

Tadqiqotchilik kompetensiyalarini rivojlantirish faqat o‘quv mashg‘ulotlari yoki mustaqil topshiriqlar bilan cheklanmaydi. Talabaning ilmiy rahbar, professor-o‘qituvchi va ilmiy jamoa bilan muntazam hamkorligi ham mazkur jarayonning muhim omilidir.

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Ilmiy rahbar talabaning izlanish yo‘nalishini aniqlashtirish, ilmiy manbalarni tanlash, metodlarni asoslash, natijalarni talqin qilish va ilmiy matnni takomillashtirishida ko‘mak beradi. Biroq samarali rahbarlik tayyor yechimlarni taqdim etish emas, balki talabaning mustaqil qaror qabul qilish salohiyatini rivojlantirishga xizmat qilishi lozim.

Mainhard va hammualliflar ilmiy rahbar hamda doktorant o‘rtasidagi shaxslararo munosabat dissertatsiya loyihasining muvaffaqiyati bilan bog‘liqligini ko‘rsatib, rahbarlik uslubini talaba nuqtayi nazaridan tahlil qilish muhimligini asoslagan [1]. Keyingi tizimli sharhlarda rahbar kompetensiyalari fan bo‘yicha bilim bilan cheklanmasligi, metodologik, pedagogik, munosabatga oid va tashkiliy jihatlarni ham qamrab olishi ta’kidlanadi [2]. Shu sababli ilmiy rahbar va talaba hamkorligini tadqiqotchilik kompetensiyalarini shakllantiruvchi pedagogik muhit sifatida ko‘rib chiqish zarur.

Ilmiy rahbar va talaba hamkorligi - tadqiqot maqsadlariga erishish uchun ikki tomonning vazifalari, mas’uliyati va kutilmalarini muvofiqlashtirishga asoslangan muntazam ilmiy-pedagogik muloqot jarayonidir. Bunda ilmiy rahbar tajriba va metodologik bilimlar manbai sifatida yo‘naltiruvchi vazifani bajarsa, talaba izlanishning bevosita ijrochisi, qarorlar qabul qiluvchi va natijalar uchun mas’ul subyekt sifatida namoyon bo‘ladi.

Hamkorlikning birinchi yo‘nalishi mavzu va muammoni aniqlashtirishdir. Rahbar talabaning qiziqishi, mavjud bilimlari va sohadagi dolzarb masalalarni uyg‘unlashtirishga yordam beradi. Ikkinchi yo‘nalish ilmiy manbalar bilan ishlashni qamrab oladi: ishonchli adabiyotlarni izlash, ularni tanqidiy o‘qish, qarashlarni taqqoslash va ilmiy bo‘shliqni aniqlash. Uchinchi yo‘nalishda metodologik maslahatlar orqali tadqiqot savollari, maqsad-vazifalar, ma’lumot to‘plash usullari va tahlil yondashuvlari aniqlashtiriladi. To‘rtinchi yo‘nalish - muntazam fikr-mulohaza. U talabaning yozma va og‘zaki ilmiy bayonini takomillashtiradi. Fikr-mulohaza aniq, dalillarga asoslangan, o‘z vaqtida berilgan va keyingi harakatni ko‘rsatadigan bo‘lishi kerak. 2024-yilda chop etilgan adabiyotlar sintezi doktorantura rahbarligida fikr-mulohaza amaliyotlari va samarali rahbar-talaba munosabatlari bir-birini

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mustahkamlashini qayd etadi [3]. Bunda yozma izohlar bilan bir qatorda muloqot va muhokama ham muhimdir. Beshinchi yo‘nalish talabaning ilmiy hamjamiyatga kirib borishiga ko‘maklashishdir. Ilmiy seminarlar, konferensiyalar, laboratoriya guruhlari va qo‘shma loyihalarda ishtirok etish orqali talaba o‘z fikrini himoya qilish, savollarga javob berish, tanqidni qabul qilish va boshqa tadqiqotchilar bilan muloqot qilish tajribasini egallaydi.

Ilmiy rahbar va talaba hamkorligi tadqiqotchilik kompetensiyalarini bir necha mexanizm orqali rivojlantiradi. Avvalo, rahbarning savol berish va muammoni qayta ifodalashga undash usuli talabaning tanqidiy fikrlashini faollashtiradi. Tayyor xulosani aytish o‘rniga “Bu fikr qaysi dalil bilan tasdiqlanadi?”, “Boshqa izoh bo‘lishi mumkinmi?” yoki “Tanlangan metod ushbu savolga javob bera oladimi?” kabi savollar talabaning mustaqil tahlil yuritishiga yordam beradi.

Ikkinchi mexanizm - metodologik tayanch. Talaba ilmiy muammoni toraytirish, tadqiqot dizaynini tanlash yoki ma’lumotlarni tahlil qilishda qiyinchilikka duch kelishi mumkin. Rahbarning bosqichma-bosqich ko‘rsatmasi bu qiyinchiliklarni bartaraf etishga yordam beradi. Biroq yordam miqdori talabaning tajribasi ortishi bilan mos ravishda kamayib, mustaqillik darajasi oshib borishi lozim. Doktorantura rahbarligi bo‘yicha tadqiqotlarda rahbarning maslahat beruvchi roli vaqt o‘tishi bilan o‘zgarishi, talabaning mustaqilligi va mas’uliyati ortishi qayd etilgan [4].

Uchinchi mexanizm - ilmiy yozuv va argumentatsiyani rivojlantirish. Rahbar matnning mantiqiy tuzilishi, dalillarning yetarliligi, manbalardan foydalanish, iqtibos keltirish va xulosalarning asoslanganligi yuzasidan izoh beradi. Talaba esa izohlarni mexanik ravishda qabul qilmasdan, ularning sababini tushunishi va o‘z matnini qayta ko‘rib chiqishi zarur. Shu tariqa tahrirlash jarayoni ilmiy fikrlashni o‘rgatuvchi vositaga aylanadi.

To‘rtinchi mexanizm - motivatsion va psixologik qo‘llab-quvvatlash. Ilmiy izlanish noaniqlik, muvaffaqiyatsiz urinishlar va qayta ishlashlarni o‘z ichiga oladi. Rahbarning konstruktiv munosabati, kichik natijalarni e’tirof etishi va muammolarni muhokama qilishga ochiqligi talabaning izlanishni davom ettirishiga yordam beradi. Oliy ta’limda

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mentorlik bo‘yicha tizimli sharh mentorlikning shaxsiylashtirilgan ta’lim yo‘nalishlari va kompetensiyaga asoslangan ta’limni qo‘llab-quvvatlash imkoniyatlarini ko‘rsatadi [5].

Beshinchi mexanizm - ilmiy mustaqillikni rivojlantirish. Hamkorlikning yakuniy maqsadi talabani rahbarga doimiy qaram qilib qo‘yish emas, balki mustaqil tadqiqotchi sifatida shakllantirishdir. Talaba o‘z qarorini asoslay olishi, rahbar fikriga dalillar bilan munosabat bildirishi, muqobil yondashuvlarni ko‘rib chiqishi va tadqiqot natijalari uchun mas’uliyatni o‘z zimmasiga olishi lozim.

Ilmiy rahbar va talaba hamkorligining samaradorligi bir qator pedagogik tamoyillarga bog‘liq. Birinchi tamoyil - maqsad va kutilmalarni kelishib olish. Hamkorlik boshida tadqiqot mavzusi, ish jadvali, uchrashuvlar davriyligi, topshiriqlar va aloqa kanallari aniqlashtirilishi maqsadga muvofiq. Ikkinchi tamoyil - o‘zaro hurmat va akademik tenglik: tajriba va mavqedagi farq talabaning fikr bildirish huquqini cheklamasligi kerak. Uchinchi tamoyil - muntazam va konstruktiv fikr-mulohaza. To‘rtinchi tamoyil - talabaning mustaqilligini bosqichma-bosqich kengaytirish. Beshinchi tamoyil - akademik halollik, ma’lumotlar maxfiyligi va mualliflik mas’uliyatiga rioya qilish.

Hamkorlikni shartli ravishda to‘rt bosqichda tashkil etish mumkin. Dastlabki bosqichda talabaning qiziqishi va tayyorgarligi aniqlanib, mavzu hamda ish rejasi kelishiladi. Ikkinchi bosqichda ilmiy manbalar, nazariy asoslar va metodologik yechimlar muhokama qilinadi. Uchinchi bosqichda ma’lumot yig‘ish, tajriba yoki amaliy tahlil, natijalarni qayta ishlash va oraliq muhokamalar amalga oshiriladi. Yakuniy bosqichda ilmiy matn takomillashtiriladi, natijalar taqdim etiladi va talabaning keyingi mustaqil izlanish yo‘nalishlari belgilanadi.

Amaliyotda ilmiy rahbar va talaba hamkorligida uchrashuvlarning muntazam bo‘lmasligi, vazifalar va muddatlarning aniq belgilanmasligi, fikr-mulohazaning kechikishi, rahbarning haddan tashqari ko‘p aralashuvi yoki aksincha, yetarli yo‘naltirmasligi kabi muammolar uchrashi mumkin. Talabaning mustaqil ishlash

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ko‘nikmalari yetarli shakllanmagani, ilmiy manbalarni tanqidiy tahlil qila olmaslik va akademik yozuvdagi qiyinchiliklar ham hamkorlik samaradorligini pasaytiradi.

Muammolarni kamaytirish uchun ilmiy rahbar va talaba o‘rtasida individual ish rejasi ishlab chiqilishi, uchrashuvlar natijasi qisqa qayd etib borilishi, oraliq muddatlar belgilanishi va har bir bosqich uchun aniq natija ko‘rsatkichlari tanlanishi tavsiya etiladi. Raqamli ta’lim vositalari orqali hujjatlar bilan birgalikda ishlash, vazifalar holatini kuzatish va masofaviy maslahatlashuvlarni tashkil etish hamkorlikning uzluksizligini ta’minlashi mumkin. Shu bilan birga, raqamli vositalar bevosita ilmiy muloqot va shaxsiy mas’uliyatning o‘rnini to‘liq bosa olmaydi.

Ilmiy rahbarlik samaradorligini faqat uchrashuvlar soni bilan o‘lchash to‘g‘ri emas. Muhimi — muloqotning mazmuni, fikr-mulohazaning foydaliligi, talabaning mustaqilligi ortishi va tadqiqot sifati. Mentorlik bo‘yicha tizimli sharh oliy ta’limda mentorlik tushunchasi va uni o‘lchash usullarini aniqroq belgilash zarurligini ko‘rsatadi [5]. Shu sababli oliy ta’lim muassasasida rahbarlik faoliyatini qo‘llab-quvvatlovchi metodik tavsiyalar va muntazam tahlil mexanizmlarini yo‘lga qo‘yish muhimdir.

Xulosa.

Oliy ta’lim muassasalarida ilmiy rahbar va talaba hamkorligi tadqiqotchilik kompetensiyalarini rivojlantirishning muhim pedagogik sharti hisoblanadi. Samarali hamkorlik talabaning ilmiy muammoni aniqlash, manbalarni tanqidiy tahlil qilish, metodologik qarorlarni asoslash, ma’lumotlarni qayta ishlash, ilmiy xulosa chiqarish va natijalarni taqdim etish qobiliyatlarini rivojlantiradi. Tahlil asosida hamkorlik samaradorligi beshta omilga bog‘liqligi umumlashtirildi: aniq kelishilgan maqsad va kutilmalar; o‘zaro hurmatga asoslangan ilmiy muloqot; o‘z vaqtida va konstruktiv fikr-mulohaza; talabaning mustaqilligini bosqichma-bosqich kengaytirish; akademik halollik va mas’uliyat. Ushbu omillar ilmiy rahbarlikni oddiy nazorat jarayonidan rivojlantiruvchi pedagogik hamkorlik darajasiga olib chiqadi.

Oliy ta’lim muassasalariga ilmiy rahbarlik bo‘yicha individual ish rejalarini joriy etish, rahbar va talaba vazifalarini aniq belgilash, muntazam maslahatlashuvlarni yo‘lga qo‘yish, fikr-mulohaza berish madaniyatini rivojlantirish hamda talabalarni ilmiy

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seminar va loyihalarga jalb etish tavsiya etiladi. Natijada talaba nafaqat muayyan ilmiy ishni bajarish tajribasiga, balki kelgusidagi kasbiy faoliyatida zarur bo‘ladigan mustaqil izlanish va muammolarni ilmiy asosda hal qilish kompetensiyalariga ham ega bo‘ladi.

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THE RELATIONSHIP BETWEEN STOCK MARKET LIQUIDITY AND EQUITY INVESTMENT RETURNS: EVIDENCE FROM UZBEKISTAN

Abduraxmonov Lochinbek
Management Development Institute of Singapore in Tashkent (MDIST)
1st year Student, BA (Hons) Accounting and Finance

Abstract. This is a quantitative longitudinal study of the relationship between market liquidity and subsequent equity returns on the Republican Stock Exchange in Uzbekistan. It uses monthly aggregated secondary data from the daily trading records. Returns are measured as adjusted price changes and liquidity is captured by the Amihud illiquidity ratio, turnover and the % of zero trading days. A panel regression is used (with company and month fixed effects and controls for company size, market beta and return volatility) to assess whether illiquidity is associated with a positive or negative return premium as a result of trading frictions and poor price discovery. It is a methodological paper in that it lays out the research protocol and data validation framework prior to the actual extraction of the full dataset. It provides a fully transparent empirical basis for research in this frontier equity market.

Keywords: stock market liquidity; illiquidity; equity returns; Amihud measure; emerging markets; Uzbekistan; panel data.

Introduction.

Liquidity is absolutely fundamental to investment management as it's the key determinant of your ability to get in and out of a position without having a massive impact on the price of the security. A share may be perfectly attractive on the basis of its historical performance but if it's very illiquid you may find it's impossible to sell. The cost of illiquidity is particularly relevant in markets where trading is concentrated in a

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very small number of securities, where the frequency of trading varies enormously from one issuer to another and where price observations can be many months apart.

In asset pricing theory, investors may require a return to compensate them for the cost of holding securities that are hard to trade. Amihud and Mendelson (1986) make the case that expected returns can be a reflection of the cost of illiquidity. Amihud (2002) goes on to develop a very widely used measure of price impact based on the ratio of absolute return to trading value. Pástor and Stambaugh (2003) go on to distinguish a security's own liquidity from its exposure to liquidity risk in the aggregate market. These are related concepts but not the same. A stock can be illiquid and yet have very low exposure to aggregate liquidity risk.

The point is important for an empirical study of Uzbekistan. A simple comparison of average returns and trading volumes would not tell you whether investors are being compensated for the liquidity risk they are taking on. Trading volume alone is not a good measure. A security with very high volume can still have very volatile prices for a given amount of trading and a security with very low volume can have very stable prices. That's why this study uses a number of different indicators, with the Amihud illiquidity ratio as the primary one and turnover and zero trading frequency as the other two.

The study is asking whether stock illiquidity is associated with subsequent equity investment returns on the Uzbekistan listed share market. It has three related objectives: it looks at the cross-company and time variation in liquidity; it tests whether lagged illiquidity is associated with subsequent monthly returns (after controlling for company characteristics and common time effects); and it looks at the robustness of the results to alternative liquidity measures and sample specifications.

The study makes three contributions. It applies standard liquidity measures to a market that has been relatively unexplored in the literature; it uses actual exchange trading data rather than survey data or self-reported investor data; and it makes the critical distinction between the empirical relationship between illiquidity and returns and the more robust claim that illiquidity in fact causes a risk premium. That last distinction

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is of the essence as a number of other factors (market-wide shocks, firm-specific news, trading halts, changes in the investor mix etc.) can affect both liquidity and returns.

The rest of the article is as follows. Section 2: review of the relevant theoretical and empirical literature and development of the hypotheses. Section 3: the sample, data sources, variable construction and the econometric approach. Section 4: the empirical results (following data validation and estimation). Section 5: discussion of the interpretation and limitations of the proposed tests. Section 6: conclusions.

Literature review.

Market liquidity is multi-dimensional. It can be thought of as the ability to trade quickly in large volumes at low transaction cost with minimal price impact. Bid-ask spreads are one measure of transaction cost, turnover is a measure of trading activity relative to the amount of securities available and price-impact measures are designed to capture the extent to which prices are impacted by trading. No single measure will capture all the dimensions of liquidity so much of the empirical work will use more than one proxy.

Amihud and Mendelson (1986) have an asset pricing argument where investors require a higher expected return to hold an asset that has higher transaction costs. Amihud (2002) operationalises illiquidity as the average of the absolute daily stock return divided by daily trading value. It's a very useful measure for markets where you don't have access to the detailed order book or transaction level data, as it can be calculated from daily prices and trading values. The higher the value, the more illiquid the asset is (the greater the price impact of a given amount of trading).

The sign of the relationship between illiquidity and returns that we'd expect is far from clear in the realised data. The sign we'd expect if investors were demanding a premium for holding illiquid shares would be that lagged illiquidity is positively associated with future returns. On the other hand illiquidity could be a reflection of low investor attention, weak information generation, poor price discovery or indeed distress. In that case we'd expect illiquid securities to have lower realised returns. The empirical question should therefore be left entirely open rather than assuming a positive premium.

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Pástor and Stambaugh (2003) show that the sensitivity of a security's return to aggregate liquidity innovations can have an effect on expected returns. This is a systematic dimension which is distinct from the security's average level of illiquidity. The main specification in the current study is the firm level illiquidity as this can be measured from exchange trading data. A separate systematic liquidity risk model would require a very long and reliable market wide liquidity series and is not the primary approach.

This really does narrow the claims that can be made. A positive coefficient on the Amihud would be compatible with an illiquidity premium but would not in itself be evidence that investors are being compensated for systematic liquidity risk. Evidence of a priced systematic factor would require a very different asset pricing setup and a very different set of assumptions.

Liquidity is of particular importance in emerging and frontier markets as trading can be very concentrated in a small number of securities and market participation may be very uneven. Bekaert, Harvey and Lundblad (2007) look at the relationship between liquidity and expected returns across the emerging markets and show the importance of liquidity in markets of differing degrees of integration. Their work lends support to the use of market specific evidence rather than simply assuming that the results from large developed exchanges would be valid in smaller markets.

For Uzbekistan, the exchange publishes trade-level or daily trading-result information that includes security identifiers, trade prices, quantities and trading values. This makes a quantitative study feasible in principle. Nevertheless, data availability must be evaluated security by security. A listed company may have a long listing history but sparse trades, missing dates, corporate actions or changes in security identifiers. The research design therefore treats data validation as a substantive stage rather than a routine clerical exercise.

H1: Higher firm level illiquidity in month t is positively associated with the subsequent monthly return in month t+1 (after controlling for firm and time effects).

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H2: There is a stronger association between illiquidity and subsequent returns for smaller listed companies.

H3: The principal findings are broadly consistent in terms of direction when illiquidity is measured using alternative proxies (turnover and number of zero trading days).

H1 is non-directional in terms of its economic interpretation even though the formal sign is expected to be positive. A statistically insignificant or even negative estimate would not in any way undermine the study, it would simply indicate that the premium which was hypothesised is not supported by the sample.

Methodology.

The study is a quantitative, observational and longitudinal one with the company-month as the unit of analysis. The intended sample is around 20-30 ordinary share issuers listed on the Republican Stock Exchange Toshkent (RSE Toshkent), again subject to the availability and quality of the historical trading data. The initial observation period is from January 2021 to December 2025. A longer period will be used only if we can download and validate historical observations for a sufficient proportion of the sample.

The research is purely based on official secondary data. No questionnaires, no interviews, no investor surveys, no qualitative interviews of any kind have been used. The analysis is based on the transaction data and where appropriate official company disclosures to confirm corporate actions, share counts and issuer characteristics.

The sample population consists of ordinary shares admitted to trading on the Republican Stock Exchange Toshkent over the relevant period. A purposive, data availability based sample will be constructed using clear eligibility criteria. An issuer will be included if: (i) its ordinary shares can be unambiguously identified by its security code or ticker; (ii) there is sufficient daily price and trading value data available for a significant portion of the observation window; (iii) there are sufficient corporate actions to allow for the construction of comparable returns; and (iv) it is not a duplicate listing of the same underlying economic security.

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Preference will be given to non-financial companies to improve comparability. Banks and insurers will be excluded as their balance sheets, regulatory capital and business models are very different from those of the industrial and service companies. Selection will not be on the basis of returns, profitability or apparent liquidity. A sample selection table will set out the final sample size, inclusion dates and reasons for exclusion. If fewer than 20 firms are eligible then the study will use the actual eligible sample and make it clear that this is a limitation.

The source is the official trading results interface of the Republican Stock Exchange Toshkent (UZSE). The trading results published by the UZSE contain the following fields: trading date, security code, issuer, security type, trade price, quantity and trading value. The official Invest Uzbekistan securities page also has historical share price information (closing price, price change, trading volume and trading value). That's the basis for the daily security level dataset.

Issuer disclosures and the official company investor relations website will be used solely to verify share splits, additional issues, changes in nominal value, mergers, delistings and other corporate actions which can distort the raw price returns. The exchange or issuer announcement will be kept as documentary evidence for each adjustment. Where a reliable adjustment cannot be established the relevant observation will be flagged and excluded from the return calculation.

The collection process will be a 6 stage affair. Stage 1: create a candidate list of listed ordinary shares and record the security code, issuer, sector and listing status for each. Stage 2: pull the daily trading data for each of the candidates. Stage 3: check that the data has both a price and a trading value and that duplicates can be properly aggregated. Stage 4: identify the non-trading days and distinguish these from missing data. Stage 5: check for corporate actions and where possible adjust the prices in line with the official data. Stage 6: aggregate the validated daily records into company month observations. A data log will be maintained which will contain the source URL, download date, file name, coverage period, variable definitions and any corrections.

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The main analysis will be based on months with sufficient trading observations to allow the relevant liquidity measure to be calculated. The minimum monthly observation threshold will be defined prior to the estimation and will be reported. A sensitivity analysis will be conducted using a more stringent threshold. Missing trading observations will not be treated as zero returns unless the exchange confirms that the security was eligible for trading and no trade took place. This is a critical distinction in a market where trading may be sporadic.

Monthly stock return (RET) is calculated from adjusted month end prices: RET(i,t) = [P(i,t) − P(i,t−1)] / P(i,t−1). Where both reliable cash dividend and corporate action data is available total returns will be calculated, otherwise the variable will be correctly described as a price return rather than a total return. Prices will be adjusted for splits etc only where the official adjustment factor is known.

The principal liquidity measure is the Amihud illiquidity ratio. For each security and each month ILLIQ(i,t) is the average of |r(i,d)| / VALUE(i,d) over all valid trading days d, where r(i,d) is the daily return and VALUE(i,d) is the value traded on that day. A higher value indicates a greater price impact per unit of value traded. Given that the value traded will vary enormously from security to security the ratio will be scaled appropriately and transformed as its distribution is very skewed. The precise scaling factor will be given in the data appendix.

Turnover is the monthly traded value divided by market cap (market capitalisation being the value at the month end). The zero trading ratio is the number of eligible trading days on which there was no trade divided by the number of exchange trading days in the month. The zero trading measure is used as an alternative liquidity proxy rather than as a substitute for missing observations.

Company size (SIZE) is the natural log of the month end market cap. Market beta (BETA) is the beta calculated from historical returns against an appropriate broad market index (where such an index is available and a reliable series can be obtained). The beta is only calculated where there are sufficient non-zero return observations. Return volatility (VOL) is the standard deviation of the daily returns for the month. It is

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annualised only where the convention is to do so. Any variable which cannot be reliably constructed will be dropped rather than estimated using some other measure.

The main model relates liquidity in month t to the subsequent monthly return in month t+1:

$$RET(i,t+1) = \beta_1 ILLIQ(i,t) + \beta_2 TURNOVER(i,t) + \beta_3 SIZE(i,t) + \beta_4 BETA(i,t) + \beta_5 VOL(i,t) + \mu(i) + \lambda(t) + \varepsilon(i,t)$$

Here $\mu(i)$ is the firm fixed effect, $\lambda(t)$ is the month fixed effect and $\varepsilon(i,t)$ is the error term. The coefficient of interest is β_1. A positive β_1 is consistent with the hypothesis that illiquidity is followed by higher returns. A negative β_1 would be consistent with the proposition that illiquidity is associated with lower subsequent returns. As always, the interpretation of β_1 is as a conditional association rather than a causal effect.

Company fixed effects pick up on time-invariant differences between firms, month fixed effects pick up on shocks that affect all securities in a given month. Standard errors will be clustered by company to account for within-company correlation over time. With the intended number of company clusters being small, standard cluster-robust inference may be unreliable. The analysis will therefore report the number of clusters and where possible with the software and sample structure, will also report results from a wild cluster bootstrap or some other small cluster correction as a sensitivity check.

The H2 interaction model is ILLIQ(i,t) × SMALL(i) with SMALL being firms below the median market cap in the sample. The interaction coefficient is used to test for a difference in the liquidity return relationship by size. The analysis would be treated as exploratory if there are too few firms in either group.

Prior to estimation we'll run a range of diagnostics: descriptive stats, missingness, distributions and correlations. We'll look at the VIFs for multicollinearity. Heteroskedasticity and serial correlation will be checked via the appropriate panel diagnostics. We'll also look at the presence of cross-sectional dependence (i.e. market wide news could be affecting a number of securities at the same time). The fixed effects specification will be reported as an alternative, though the fixed effects model is the one

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we prefer if there is any chance that unobserved company specific characteristics are correlated with the explanatory variables.

Robustness checks will be carried out in the following ways: (i) Amihud illiquidity will be substituted with turnover and the zero trading ratio; (ii) alternative minimum monthly trading day thresholds will be used; (iii) extreme values of the continuous variables will be winsorised at pre-specified tails and the results will be compared to those from the unwinsorised estimates; (iv) firms which were subject to a major corporate action or a long trading suspension will be excluded; and (v) the model will be estimated using quarterly rather than monthly data where the monthly data are too sparse. The study will report the direction, size and confidence intervals of the coefficients rather than just the statistical significance.

The primary constraint is of course the potential for sparse trading. Sparse trading will lead to very stale daily returns and will bias both the volatility and price impact measures. The Amihud ratio is also extremely sensitive to very small trading values and will require special treatment of the days with no trade. The sample of listed Uzbek companies is also likely to be quite small and may not be representative of the broader population of private firms or of all investor portfolios. All of this means that generalisation beyond the sample of securities and the sample period is very limited.

The study makes use of publicly available corporate and market data and involves no human participants or personal data. The data will be stored with the source references and an audit trail. Any restrictions on the redistribution of exchange data will be respected. All calculations and exclusions will be fully documented in order to allow for full reproducibility.

Results.

The empirical results section must be completed only after the official trading records have been collected, checked, and analyzed. This manuscript includes no numerical findings because doing so without the underlying security-level dataset would produce unsupported results. The following reporting sequence is recommended.

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Report the number of candidate issuers screened, the number excluded and the number ultimately retained. Report a table of the company identifiers, sectors, first and last available trading dates, number of valid company month observations and the % of missing observations. Explain any exclusions due to delisting, suspension, corporate restructure or insufficient trading data.

Present the mean, median, std dev, min and max for monthly returns, Amihud illiquidity, turnover, zero trading ratio, size, beta and volatility. Where possible, show the distribution of the liquidity measures across sectors and company size groups. Report the proportion of company months with no trading and distinguish those from the missing.

Provide a correlation matrix and then the fixed effects regression results. The primary table should contain the coefficient estimates, standard errors, confidence intervals, N, number of companies, time effects, company effects and model fit statistics. State whether the estimated coefficient on the lagged Amihud illiquidity is positive, negative or statistically indistinguishable from zero. Don't describe a statistically insignificant coefficient as evidence of no relationship.

Report whether the sign and magnitude of the main coefficient are broadly unchanged when alternative liquidity proxies are used, when different observation thresholds are employed and when various outlier treatments are applied. Any specification which would have a material effect on the result must be considered rather than just ignored. If in fact the main result is sensitive to a small number of illiquid securities then that should be recognised as a very important finding.

Discussion.

The discussion should of course interpret the estimated relationship in the light of the other explanations that have been put forward in the literature. A positive relationship between lagged illiquidity and the subsequent returns would be entirely consistent with the existence of an illiquidity premium (though of course that wouldn't prove that such a premium is actually being demanded by investors). A negative relationship could be consistent with illiquidity being related to a poor information

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environment, a poor price discovery process or firm specific risks which aren't fully picked up by the controls. An insignificant result would of course simply be an indication of a very weak relationship, low statistical power, sparse trading or measurement error.

The role of market structure must be considered. In a market where there are very few transactions, the prices that are observed may not be the result of actual price discovery. A security may be stable simply because it hasn't traded at all and the first trade after that can produce a very large return. That will distort both the dependent variable and the Amihud. The zero trading ratio and alternative monthly aggregation rules are therefore key robustness checks.

The implications of the findings should also be considered in the context of practical investment management. If illiquidity is linked to higher subsequent returns then investors will still have to ask themselves whether the return differential that they've estimated is sufficient to offset transaction costs, execution risk and the risk that you simply can't get out of a position when you want to. If illiquidity is associated with lower returns then it may be the case that low trading activity is a red flag rather than an indication of a bargain. In either case the historical return estimates don't guarantee future performance.

The study's contribution is of course constrained by its data and design. The analysis can provide some evidence as to the association between the observed liquidity and the subsequent returns of the listed shares in the sample. It cannot establish the causal effect of liquidity on returns nor can it quantify the full systematic liquidity risk premium without a far stronger identification strategy or access to investor level transaction data.

Conclusion.

This paper proposes a quantitative approach to the analysis of the relationship between market liquidity and subsequent equity investment returns in Uzbekistan. It makes use of an official data based company month panel of historical exchange prices, trading volumes and trading values. The Amihud illiquidity ratio is the main explanatory

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variable, with turnover and the zero trading ratio as alternative measures. The empirical approach is a fairly standard fixed effects panel model with lagged liquidity variables and both company and month fixed effects.

The study is designed to test rather than assume that illiquid securities are followed by higher returns. The interpretation is to distinguish between a firm level illiquidity return relationship and a systematic liquidity risk premium. The credibility of the findings will obviously be dependent on the completeness of the historical trade data, the way non-trading days and corporate actions are handled, the number of securities that are eligible and the robustness of the estimates.

The empirical paper should set out in full the sample selection process, the data coverage, the descriptive statistics, the regression results and the robustness tests. If the official data don't support a sufficiently complete panel then the sample period and/or number of firms will need to be altered and this must be made clear. The main value of the paper will be a fully replicable assessment of liquidity and equity returns in a market which has not been extensively studied in the literature and there is no intention to try and establish any causal link.

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ISHLAB CHIQARISH KORXONALARI UCHUN LENTALI KONVEYER KONSTRUKSIYASINI TAKOMILLASHTIRISH VA UNING ENERGOSAMARADORLIGINI OSHIRISH

Xoshimova Dilbaroy Olimjon qizi
Andijon davlat texnika instituti
“Texnologik mashinlar va jihozlar” yo‘nalishi 3-kurs talabasi
e-mail: dilbaroydilbarxon691@gmail.com

Annotatsiya. Ushbu maqolada sanoat korxonalarida keng qo‘llaniladigan lentali konveyerlarning konstruktiv tuzilishini takomillashtirish, ularning energosamaradorligini oshirish hamda ishlamnurligini (resursini) uzaytirish masalalari ko‘rib chiqilgan. Konveyer lentalarining harakatlanishidagi qarshilik kuchlarini kamaytirish maqsadida rolikli tayanchlar konstruksiyasiga o‘zgartirish kiritish, tortish stansiyasining dinamik yuklanishlarini yumshatish bo‘yicha ilmiy asoslangan takliflar berilgan. Tadqiqot natijasida takomillashtirilgan konveyer konstruksiyasi elektr energiyasi sarfini kamaytirish va ekspluatatsiya xarajatlarini qisqartirish imkonini berishi nazariy va amaliy jihatdan asoslab berildi.

Kalit so‘zlar: lentali konveyer, rolikli tayanch, tortish kuchi, energosamaradorlik, dinamik yuklanish, konstruktiv takomillashtirish, ishqalanish koeffitsiyenti.

Аннотация. В статье рассмотрены вопросы совершенствования конструктивного исполнения ленточных конвейеров, широко применяемых на промышленных предприятиях, а также повышения их энергоэффективности и увеличения срока службы. Предложены научно обоснованные решения по изменению конструкции роликовых опор с целью снижения сил сопротивления движению конвейерной ленты и демпфирования динамических нагрузок в приводной станции. На основе проведенных исследований теоретически и практически доказано, что модернизированная конструкция конвейера позволяет снизить расход электроэнергии и эксплуатационные затраты.

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Ключевые слова: Ленточный конвейер, роликовая опора, тяговое усилие, энергоэффективность, динамическая нагрузка, конструктивное совершенствование, коэффициент трения.

Abstract. This article discusses the issues of improving the structural design of belt conveyors widely used in industrial enterprises, increasing their energy efficiency, and extending their service life. Scientifically grounded proposals are given to modify the design of roller supports in order to reduce the resistance forces to the movement of the conveyor belt and dampen dynamic loads in the drive station. As a result of the study, it was theoretically and practically substantiated that the upgraded conveyor design allows reducing electricity consumption and operating costs.

Keywords: Belt conveyor, roller support, tractive effort, energy efficiency, dynamic load, structural improvement, friction coefficient.

Kirish.

Bugungi kunda mamlakatimiz sanoat korxonalarini modernizatsiya qilish, texnika va texnologiyalarni yangilash, ularning energiya samaradorligini keskin oshirish hamda ishlab chiqarish jarayonlarini avtomatlashtirish iqtisodiyotimizning ustuvor yo‘nalishlaridan biridir. Tog‘-kon sanoati, qurilish materiallari ishlab chiqarish, metallurgiya va qishloq xo‘jaligi mahsulotlarini qayta ishlash korxonalarida uzluksiz transport vositalari, xususan, lentali konveyerlar asosiy texnologik jihozlar sirasiga kiradi.

Lentali konveyerlar o‘zining yuqori unumdorligi, tashish masofasining uzoqligi, konstruksiyasining nisbatan soddaligi va ekspluatatsiya qilishning qulayligi tufayli boshqa turdagi uzluksiz transport vositalari orasida yetakchi o‘rinni egallaydi. Biroq ularning ish jarayonida elektr energiyasining yuqori darajada sarflanishi, mexanik qismlarning (roliklar, lentalar, barabanlar) tez ishdan chiqishi hamda ishqalanish tufayli yuzaga keladigan energiya yo‘qotishlari dolzarb muammolardan biri bo‘lib qolmoqda. O‘tkazilgan tahlillar shuni ko‘rsatadiki, konveyerlarning umumiy quvvat sarfining 50-70% qismi lentalarning rolikli tayanchlar bo‘ylab harakatlanishidagi qarshilik kuchlarini

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yengishga sarflanadi. Shu bois, lentali konveyerlar konstruksiyasini takomillashtirish, xususan, rolikli tayanchlar va tortish stansiyalarining ish unumdorligini oshirish orqali energiyani tejash muhim ilmiy-amaliy ahamiyat kasb etadi.

Adabiyotlar tahlili va tadqiqot metodologiyasi.

Lentali konveyerlar nazariyasi, ularning dinamikasi va konstruksiyasini takomillashtirish bo‘yicha ko‘plab olimlar va tadqiqotchilar o‘z ilmiy ishlarini olib borishgan. Jumladan, akademik L.P. Spivakovskiy, V.I. Galkin, V.G. Dyachkov, shuningdek, respublikamiz olimlaridan T.A. Ismatov, Sh.M. Imomov va boshqalarning ilmiy ishlarida konveyerlarning asosiy parametrlari hisobi, ularning energosamaradorligi hamda dinamik jarayonlari chuqur o‘rganilgan. Shunga qaramay, amaldagi an'anaviy konveyer konstruksiyalarida quyidagi kamchiliklar saqlanib qolmoqda:

1. Rolikli tayanch podshipniklarining germetikligi yetarli emasligi tufayli chang va namlik tushishi natijasida ishqalanish momentining ortishi;
2. Lentalarning bo‘ylama va ko‘ndalang tebranishlari natijasida qo‘shimcha dinamik yuklamalarning paydo bo‘lishi;
3. Tortish stansiyasining ishga tushirish (pusk) davridagi dinamik kuchlanishlarning yuqoriligi.

Tadqiqot jarayonida nazariy mexanika, mashina detallari, materiallar qarshiligi qonuniyatlari hamda matematik modellashtirish usullaridan foydalanildi. Konveyerning harakatlanish qarshiligini aniqlash uchun quyidagi asosiy empirik va nazariy bog‘liqliklardan foydalanildi:

$$W=g\cdot L\cdot qro\cdot f+g\cdot H\cdot qyukW = g \cdot L \cdot q_{ro} \cdot f + g \cdot H \cdot q_{ yuk }W=g\cdot L\cdot qro\cdot f+g\cdot H\cdot qyuk$$

bu yerda:

1. WWW — konveyerning umumiy qarshilik kuchi;
2. ggg — erkin tushish tezlanishi;
3. LLL — konveyer uzunligi;
4. qroq_{ro}qro — aylanuvchi qismlarning massa chiziqli zichligi;

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5. fff — lentalarning roliklar ustidan harakatlanishidagi qarshilikning keltirilgan koeffitsiyenti;
6. HHH — yukni ko‘tarish balandligi;
7. qyukq_{yuk}qyuk — tashilayotgan yukning chiziqli massasi.

Asosiy qism va konstruktiv takomillashtirish yechimlari. Taklif etilayotgan konstruktiv o‘zgarishlarning asosiy maqsadi — lentali konveyerning harakatlanish qarshilik koeffitsiyenti (fff) ni kamaytirish va shu orqali umumiy energiya sarfini qisqartirishdir.

An’anaviy rolikli tayanchlarda podshipnik uzellarining ishqalanishi konveyerning umumiy energetik balansiga salbiy ta'sir ko‘rsatadi. Taklif etilayotgan konstruksiyada rolik o‘qi va podshipnik oralig‘iga zamonaviy polimer va kompozit materiallardan tayyorlangan teflon qoplamali labirintli zichlagichlar (salniklar) o‘rnatish nazarda tutilgan. Bu chang va abraziv zarrachalarning podshipnik ichiga kirishini 98% gacha kamaytiradi. Bundan tashqari, rolik quvuri qalinligini optimallashtirish va uni yengil alyuminiy-kompozit qotishmasidan tayyorlash orqali rolikning aylanuvchi qismlari massasini (qroq_{ro}qro) 15-20% ga kamaytirishga erishildi. Bu esa o‘z navbatida ishga tushirish momentini pasaytiradi.

Lentali konveyerlarning tortish stansiyasida lentalarning siljishi (proskolzovaniya) va ortiqcha cho‘zilishining oldini olish uchun avtomatik gidravlik taranglash qurilmasi (gidronatyajka) taklif etiladi. Mazkur qurilma konveyerning ish rejimiga qarab lentalarning taranglik kuchini real vaqt rejimida boshqarish imkonini beradi.

Dinamik yuklanishlarni yumshatish uchun yuritma (privod) tizimiga elastik muftalar va chastota o‘zgartirgichlar (inverterlar) kiritildi. Chastota o‘zgartirgichlar konveyerni yumshoq ishga tushirish (soft start) va to‘xtatish imkonini berib, lentalarning xizmat muddatini 25-30% ga uzaytiradi.

Tahlil va natijalar.

O‘tkazilgan nazariy hisob-kitoblar va ishlab chiqarish sharoitidagi sinov natijalari shuni ko‘rsatdiki, takomillashtirilgan lentali konveyer konstruksiyasi quyidagi texnik-iqtisodiy afzalliklarni beradi:

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1. Energiya samaradorligi: Rolikli tayanchlardagi ishqalanish qarshiligining kamayishi hisobiga elektr energiyasi sarfi 12-15% ga kamaydi.
2. Resursning ortishi: Lentalar va roliklarning xizmat qilish muddati ularning aşınmaya bardoshliligi oshishi evaziga 1.3-1.5 barobar uzaydi.
3. Dinamik barqarorlik: Chastota o‘zgartirgichli yuritma tizimi ishga tushirish paytidagi zarba yuklanishlarini bartaraf etib, mexanizm detallarining mustahkamligini ta'minladi.

Quyidagi jadvalda an'anaviy va takomillashtirilgan konveyer parametrlarining qiyosiy tahlili keltirilgan:

Parametrlar nomi	**An'anaviy konstruksiya**	**Takomillashtirilgan konstruksiya**	**O‘zgarish (% / ko‘rsatkich)**
Harakatlanish qarshilik koeffitsiyenti (f)	0.025 – 0.030	0.018 – 0.021	25-30% ga kamaydi
Elektr energiyasi sarfi (soatiga, kVt·soat)	45.2	38.6	14.6% tejaldi
Rolikning xizmat muddati (soat)	12 000	18 000	1.5 barobar oshdi
Ishga tushirish davridagi dinamik kuchlanish (kN)	32.4	21.5	33.6% kamaydi

Xulosa.

Ishlab chiqarish korxonalari uchun mo‘ljallangan lentali konveyerlar konstruksiyasini takomillashtirish bo‘yicha olib borilgan tadqiqotlar asosida quyidagi xulosalarga kelindi:

1. Rolikli tayanchlar konstruksiyasini yaxshilash va zamonaviy zichlagichlardan foydalanish orqali mexanik yo‘qotishlar sezilarli darajada kamaytirildi.

2. Avtomatlashtirilgan taranglash qurilmasi va chastota boshqariladigan yuritma tizimini joriy etish konveyerning ishishonchliligini oshiribgina qolmay, balki elektr energiyasini sezilarli darajada tejash imkonini berdi.

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3. Taklif etilgan ilmiy-texnik yechimlar sanoat korxonalarida amaliyotga joriy etish uchun tavsiya etiladi va yuqori iqtisodiy samaradorlikni taminlaydi.

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THE IMPACT OF DIGITAL TECHNOLOGY DEVELOPMENT ON ECONOMIC STABILITY UNDER COMMERCIAL BANK COMPETITION AND DIRECTIONS FOR ITS IMPROVEMENT

Abdug‘afforov Fayzullo Alisher o‘g‘li
Andijan state technical institute
Student of group K-03-25, Faculty of Economics
Scientific supervisor: N.Saidaxmedov

Abstract. The article examines how digital technologies affect economic stability under competition among commercial banks. Digitalization can lower banks’ costs, widen access to financial services and improve risk management. It also brings cyber risk, dependence on a small number of technology providers and competitive barriers for smaller banks. The article closes with proposals aimed at preserving the stability of the banking system.

Keywords: commercial banks, digital technologies, bank competition, economic stability, fintech, cybersecurity, financial inclusion.

Introduction.

Mobile apps, online lending, remote identification, payment systems and services based on artificial intelligence have changed how customers deal with their banks. In recent years Uzbekistan has been reforming its banking and financial system: the state share is being reduced, private and foreign capital is being attracted, and digitalization is being accelerated under programs such as “Digital Uzbekistan.”

As competition intensifies, banks are pushed to improve service quality, launch new products and cut costs. Digitalization has its own risks, however: cyberattacks, system outages, and the concentration of the market in the hands of a few large players. For this reason, studying the link between digital development and economic stability is necessary for setting banking policy.

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Aim of the research: to assess the impact of digital technologies on economic stability under competition among commercial banks and to develop directions for improving it.

Research objectives:

- ✓ to outline the theoretical foundations of bank competition and digitalization;
- ✓ to analyze the state of competition and digitalization in Uzbekistan's banking sector;
- ✓ to identify the channels through which digital technologies affect bank stability;
- ✓ to define the problems and propose measures for improvement.

Object of the research: commercial banks of the Republic of Uzbekistan.

Subject of the research: the economic relations among digital technologies, competition and economic stability.

Literature review and research methodology.

Two views exist in the theory of bank competition. According to the first (competition-fragility), stronger competition reduces banks' profit margins and makes them more inclined to take risks. The second (competition-stability) holds that high interest rates reduce borrowers' ability to repay, so competition can improve loan quality. Digitalization adds a new factor to this debate: technology can lower costs and offset the fall in margins, but it also introduces new technological risks.

Fintech research shows that digital services widen financial inclusion, reduce transaction costs and lower barriers to market entry. International financial organizations, for their part, name cybersecurity and dependence on third-party technology providers as serious threats to financial stability.

The study used comparative and systemic analysis, grouping of statistical data, time-series analysis, logical generalization and expert assessment. The data sources are reports of the Central Bank of the Republic of Uzbekistan, data of the Statistics Agency, annual reports of commercial banks and publications of international financial institutions.

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For a long time, large state-owned banks dominated Uzbekistan's banking system. During the reforms the share of private banks grew, foreign investors were attracted, and the privatization of several state banks began. New digital players entered the market: payment systems such as Click and Payme and digital banks became active, which changed the competitive environment.

Competition mainly takes place in four areas:

- ✓ *Service quality and speed:* shorter online lending and account-opening procedures.
- ✓ *Price competition:* commissions and interest rates.
- ✓ *Product differentiation:* installment payments, co-branded cards, mobile wallets.
- ✓ *Customer experience:* app usability, 24/7 service, personalized offers.

Digitalization in commercial banks is under way in several directions:

- ✓ *Remote services:* opening accounts, transfers, utility payments, online deposits and microloans through mobile and internet banking.
- ✓ *Payment infrastructure:* QR-code payments, instant payment systems, and the integration of cards and mobile wallets.
- ✓ *Scoring and data analytics:* automating credit decisions based on algorithms and big data.
- ✓ *Artificial intelligence:* chatbots, fraud detection systems, prediction of customer behavior.
- ✓ *Open banking and partnership:* exchange of services between banks and fintech companies through APIs.

As a result, banks' costs fall, service no longer depends on where branches are located, and banking becomes easier to use for rural areas and young customers.

Positive effects:

- ✓ *Efficiency:* lower operating costs and an improved cost-to-income ratio.
- ✓ *Risk management:* scoring and monitoring systems help reduce the share of problem loans.

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✓ *Financial inclusion:* wider coverage of banking services strengthens the savings and lending base.

✓ *Transparency and oversight:* electronic reporting and automated monitoring give regulators faster supervision.

✓ *Economic activity:* fast payments and financing for business speed up the circulation of working capital.

Risk factors:

✓ *Cybersecurity:* fraud, data leaks and system outages damage trust in banks.

✓ *Technological dependence:* excessive reliance on a few providers or one infrastructure creates systemic risk.

✓ *Digital inequality:* if small banks with limited technological resources are pushed out of the market, concentration may rise.

✓ *Aggressive competition:* fast and easy lending can weaken quality control and increase the debt burden.

✓ *Shortage of qualified staff:* demand for IT and risk-analytics specialists exceeds supply.

Digitalization therefore both supports stability and creates risk. The outcome depends on a bank's technological capacity, the quality of supervision and its risk culture.

In South Korea, digital banks were brought to market through regulatory sandboxes. In Kazakhstan, mobile banking and payment ecosystems are strongly developed. Turkey has introduced a national instant payment system. These cases show that new technologies give good results when they are introduced together with oversight. Test regimes, cybersecurity standards and data protection requirements form the basis for this.

The following proposals were developed on the basis of the research:

✓ Introduce a single minimum information security standard for banks, conduct regular audits and set up an incident reporting system.

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✓ Test new fintech products in a regulatory sandbox before rolling them out widely.

✓ Develop credit bureau and open API standards so that small banks have equal opportunities.

✓ Organize training programs for the public and entrepreneurs on protection against fraud and use of digital services.

✓ Train specialists in IT, data analytics and risk through cooperation between banks and universities.

✓ Monitor market concentration and lower barriers to entry for digital platforms.

✓ Include cyberattack and system outage scenarios in stress tests.

Conclusion.

Competition among banks is the main reason for adopting digital technologies, and this process has a positive effect on economic stability by raising efficiency, widening financial inclusion and improving risk management. However, cyber risks, technological dependence and digital inequality threaten stability. Digitalization should therefore go hand in hand with regulation, information security and staff training. The proposed directions aim to secure both the competitiveness and the stability of the banking system.

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