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QGIS MUHITIDA RAQAMLI RELYEF MODELI ASOSIDA BERK BOTIQLIKLARNI ANIQLASH TEXNOLOGIK KETMA-KETLIGI VA UNING GIDROLOGIK ASOSLANISHI

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Annotatsiya. *Maqolada QGIS dasturida raqamli relyef modeli (RRM) asosida berk botiqliklarni aniqlash va ulardagi suv hajmini hisoblashning texnologik ketma-ketligi hamda har bir amalning gidrologik asoslanishi yoritilgan. Andijon shahri misolida to‘qqiz bosqichli ishlov tartibi keltirilgan: RRMni kesish, proyeksiyalash, chuqurchalarni to‘ldirish, oqim yo‘nalishi va akkumulyatsiyasini hisoblash, havzalarni ajratish, farq qatlamini olish, vektorlashtirish va zonal statistika. Amallar tartibining buzilishi natijaga qanday ta’sir qilishi ko‘rsatilgan. Metodika boshqa tekislik shaharlari uchun qo‘llanma sifatida foydalanilishi mumkin.*

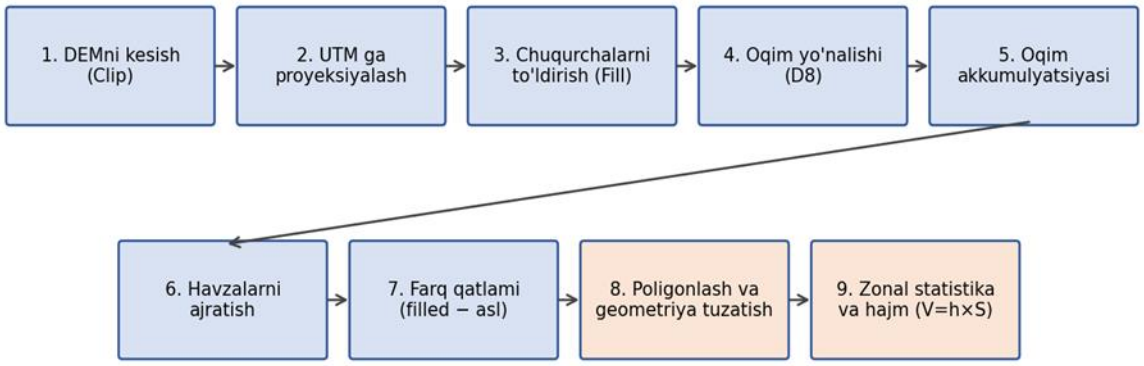
Kalit so‘zlar: *QGIS, raqamli relyef modeli, chuqurchalarni to‘ldirish, oqim yo‘nalishi, oqim akkumulyatsiyasi, zonal statistika, berk botiqlik.*

Kirish. GIS yordamida gidrologik tahlil qilishda natija sifati ishlov amallarining to‘g‘ri tanlanishiga va ularning ketma-ketligiga bog‘liq: har bir keyingi qatlam oldingisidan hosil bo‘ladi, shu sababli bosqichdagi xato keyingi bosqichlarga ko‘chib o‘tadi. Ushbu maqolaning maqsadi Andijon shahri misolida QGIS muhitida berk botiqliklarni aniqlash ketma-ketligini bosqichma-bosqich bayon qilish va har bir amal nima uchun bajarilishini gidrologik jihatdan asoslashdir. Maqola muallifning shahar hududidagi yuza suv oqimlari va berk havzalar bo‘yicha dissertatsiya tadqiqotining metodik qismini tashkil etadi.

Tadqiqot mavzusining dolzarbligi. Raqamli relyef modelidan oqim yo‘nalishi, akkumulyatsiya va havza chegaralarini olish ketma-ketligi GIS gidrologiyasining klassik sxemasi hisoblanadi [5; 10; 12; 17]. Relyefni raqamli tahlil qilishning nazariy asoslari [11; 18] va chuqurchalarni bartaraf etish algoritmlari [13; 15] bu sxemaning ilmiy poydevorini tashkil qiladi. Ochiq manbali QGIS dasturi [14] bu amallarni bepul bajarish imkonini beradi, biroq dastur ko‘plab vositalarni taklif qilgani sababli foydalanuvchi ko‘pincha qaysi vositani nima uchun va qaysi tartibda ishlatishni bilmay qoladi.

Muallif kuzatuvicha, o‘zbek tilidagi manbalarda bunday ketma-ketlik amaliy yo‘riqnoma sifatida gidrologik asoslanishi bilan birga kam yoritilgan. Shu sababli har bir amalning mantig‘ini tushuntirish nafaqat bu tadqiqotning natijalarini takrorlash, balki boshqa hududlarda shu usulni qo‘llash imkonini berishi bilan dolzarbdir. Tadqiqotda 30 m aniqlikdagi SRTM RRM [3] va Andijon shahri ma’muriy chegarasi vektor qatlamidan foydalanildi.

Muhokama va natijalar. QGIS'da bajarilgan amallar ketma-ketligi 1-rasmda, har bir bosqichning vositasi, hosil bo‘lgan qatlami va bajarilish sababi esa 1-jadvalda keltirilgan.



1-rasm. QGIS'da berk botiqliklarni aniqlash ishlov ketma-ketligi

1-jadval.

Ishlov bosqichlari, natija qatlamlari va ularning maqsadi

№	Amal (QGIS vositasi)	Natija qatlami	Nima uchun kerak
1	DEMni shahar chegarasi bo‘yicha kesish (Clip raster by	Andijon_DEM_30m_clipped	Hisoblash hajmini kamaytiradi, tadqiqot obyektidan tashqari hududlar natijaga ta’sir qilmaydi

	mask)		
2	Metrik proyeksiyaga o‘tkazish (Warp/Reproject, UTM)	Andijon_DEM_UTM42	Geografik koordinatalarda (EPSG:4326) birlik gradus; yuza va hajm m², m³ da hisoblanishi uchun metrik tizim kerak
3	Chuqurchalarni to‘ldirish (Fill sinks)	Andijon_DEM_filled	Soxta chuqurchalar oqimni to‘xtatib qo‘yadi; uzluksiz drenaj sirti hosil qilinadi
4	Oqim yo‘nalishi (Flow direction, D8)	Andijon_Flow_Direction, Andijon_Drainage_Direction	Har bir katak suvi qaysi qo‘shni katakka oqishini belgilaydi
5	Oqim akkumulyatsiyasi (Flow accumulation)	Andijon_Flow_Accumulation	Har bir katakka yuqoridan yig‘iladigan maydonni hisoblab, drenaj chiziqlari va chiqish nuqtalarini ko‘rsatadi
6	Chiqish nuqtalari va havzalar (Watershed)	PointWatershed, watershed	Suv yig‘ish havzalari chegaralarini ajratadi
7	Farq qatlami (Raster calculator: to‘ldirilgan − asl RRM)	Botiqliklar_chuqurligi	Noldan katta piksellar — berk botiqliklar, qiymati — to‘lish chuqurligi
8	Poligonlash (Polygonize) va geometriyani tuzatish (Fix geometries)	Botiqliklar_vektor, Botiqliklar_Tuzatilgan_Doimiy	Zonal statistika uchun poligon kerak; noto‘g‘ri geometriya xatolarini bartaraf etadi
9	Zonal statistika (Zonal statistics) va hajm hisobi (Field calculator)	Berk_havzalar_suv_hajmi	Har bir botiqlik uchun o‘rtacha chuqurlikni topib, V = h × S formulasi bilan suv hajmi aniqlanadi

Amallar tartibi tasodifiy emas. Birinchi va ikkinchi bosqichlar ma’lumotni tayyorlaydi: kesish keraksiz hududni olib tashlasa, metrik proyeksiya (UTM) yuza va hajmni to‘g‘ri hisoblash uchun zarur, chunki EPSG:4326 da piksel o‘lchami gradusda beriladi [9]. Andijon shahri UTM 42 va 43 zonalari chegarasiga yaqin joylashgani sababli, aniqroq natija uchun 43-zona (EPSG:32643) ham qo‘llanishi mumkin, farq esa yuza hisobida juda kichik.

Uchinchi bosqich - chuqurchalarni to‘ldirish - eng muhim amallardan biridir. Xom RRMda tasodifiy shovqin va soxta chuqurchalar mavjud bo‘lib, ular oqim yo‘nalishi hisobida suvni tutib qoladi va drenaj tarmog‘ini uzib qo‘yadi [5; 13]. Shu sababli oqim yo‘nalishi (4-bosqich) faqat to‘ldirilgan RRM asosida hisoblanadi. D8 algoritmi har bir katak suvini eng tik qiyalikli qo‘shni katakka yo‘naltiradi [12]; u sodda va tez bo‘lsa-da, tekis relyefda oqimni bir yo‘nalishga majburlaydi, shu sababli ko‘p yo‘nalishli usullar [17] bilan taqqoslash tavsiya etiladi. Oqim akkumulyatsiyasi (5-bosqich) katta qiymatli kataklarni drenaj chiziqlari sifatida ajratadi, chegaraviy qiymat tanlanganda daryo tartibi tamoyillaridan [16] foydalaniladi. Bu qatlam havza chiqish nuqtalarini topish (6-bosqich) uchun asos bo‘ladi [10].

Berk botiqliklarning o‘zi (7-bosqich) to‘ldirilgan va asl RRM farqi orqali topiladi: aynan to‘ldirish jarayonida ko‘tarilgan piksellar suv tashqariga chiqa olmaydigan joylarni ko‘rsatadi, farq qiymati esa botiqlikning chuqurligiga teng [13; 15]. Olingan raster poligonga aylantirilgach (8-bosqich), geometriya xatolari (o‘z-o‘zini kesuvchi konturlar) tuzatiladi, aks holda zonal statistika ishlamay qolishi yoki noto‘g‘ri natija berishi mumkin. So‘nggi bosqichda har bir poligon uchun o‘rtacha chuqurlik h topilib, hajm V = h × S formulasi

bo‘yicha aniqlanadi. Ushbu ketma-ketlik Andijon shahrida 5510 ta berk botiqlik va ularning ≈19,25 mln m³ umumiy sig‘imini aniqlash imkonini berdi.

Amaliy tavsiya sifatida har bir bosqichdan so‘ng qatlamni vizual tekshirish, koordinata tizimlarining mosligini nazorat qilish va oxirgi jadvalda hajm yig‘indisini piksellar soni bilan solishtirish lozim. Cheklov sifatida 30 m aniqlikdagi RRM mayda botiqliklarni ko‘rsata olmasligini [11; 18] ta’kidlash kerak.

Xulosa. QGIS'da berk botiqliklarni aniqlash to‘qqiz bosqichli ketma-ketlikni talab etadi, bunda har bir amal keyingisi uchun to‘g‘ri kirish ma’lumotini tayyorlaydi: kesish va proyeksiyalash ma’lumotni tayyorlaydi, to‘ldirish drenajni uzluksiz qiladi, oqim tahlili havzalarni beradi, farq qatlami botiqliklarni topadi, zonal statistika esa hajmni aniqlaydi. Amallar tartibi va asoslanishining bayon etilishi metodikani boshqa tekislik shaharlarida ham takrorlash imkonini beradi.

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